RAN-R18-WS-non-eMBB-Overall - Version 0.0.1
RAN

3GPP TSG RAN Rel-18 workshop RWS-210655

Electronic Meeting, June 28 - July 2, 2021

Agenda Item: 4.2

Source: RAN Vice-Chair (AT&T)

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

Document for: Information

This NWM thread is not meant to handle Questions/Comments/Answers already handled in the related NWM threads before the RAN Rel-18 Workshop.

Per the RAN Rel-18 Workshop Management document in RWS-210002, the NWM thread is NOT intended to debate the list of topics! It is meant to focus on Q&A to address comments/questions common to multiple contributions and interactions among different topics.

The participants shall avoid asking questions/giving comments of supportive/unsupportive nature in order to influence any prioritization/promotion of the topic, as in this phase there is no prioritization discussion.

Timeline:

Questions/comments: June 28 08:00 UTC – June 30 8:00 UTC

Answers/comments: June 30 08:00 UTC – July 1st 12:00 UTC

Each company is expected to provide up to one input per topic covering the set of topics of interest in each of the above two windows.

An email discussion summary is to be uploaded right after July 1st 12:00 UTC.

1 Enhancements for XR

This section is targeted at identifying commonalities and interactions for Enhancements for XR.

Feedback Form 1: Questions/Comments

1 – Nokia Corporation

We can see clearly 3 different main areas emerging as common for XR for NR:

1. RAN awareness of traffic and application information (10 companies)
2. SPS/CG enhancements (11 companies)
3. CDRX configuration to support XR periodicity (11 companies).

Further there is area of mobility with DAPS enhancements for FR2 raised by many companies, though as topic might better fit with the dedicated mobility discussion going forward (but otherwise part of XR discussion)

2 – Classon Consulting

[for FUTUREWEI]

We are supportive of study (followed by normative work) in Rel-18, with the focus on capacity and power savings.

3 – ZTE Corporation

We have the following further questions/comments on XR below:

- For XR capacity enhancement, there have been quite some proposals on QoS enhancement such as incorporating priority as additional 5QI components, based on which adaptive resource allocation can be done to guarantee the capacity.
  - We wonder whether the proponents can clarify their view on extending their proposed 5QI modification to other services beyond XR to establish a unified framework and facilitate resource allocation for the coexistence of XR and other services.
- For the granularity of QoS enhancement, it's mentioned in several contributions this could be up to data stream level, application data unit level or PDU level. What are the supposed RAN normative work and differentiation corresponding to different granularity? Would additional traffic model and evaluation methodologies be carried out considering so far the Rel-17 XR evaluation assumptions focus on data stream level reliability/latency requirement and without any implication of priority of data stream?

4 – vivo Communication Technology

We are very supportive on XR in Rel-18. Some general questions and comments as below

1. It seems that network coding is proposed by companies in XR enhancement and also in cross function session. It would be good to clarify network coding will be discussed in XR enhancement or under network coding thread.
2. It would be necessary to clarify the where to handle the discussion of mobility enhancement for XR.

5 – Spreadtrum Communications

For the issue of UL triggering DL which was mentioned in several contributions (RWS- 210164, 210428), does every UL data trigger the DL burst? We consider whether the UL data triggers the DL burst or not depends on the actual content of UL data, so the 5G network entity shall read the application content of UL packet and then determine the DL burst. Will it have some potential specification impact?

6 – Lenovo Information Technology

For Rel-18 NR XR, we think the following high level aspects should be considered according to compaines' inputs:

- QoS Framework enhancements and more granular QoS differentiation (SA2 and SA4 should be involved□□)
- Multiple data streams synchronized transmission and scheduling (SA2 should be involved or only RAN issue□)
- RAN awareness of XR application information and cross layer enhancements
- UE power saving enhancement considering XR traffic pattern
  SPS/CG enhancements considering XR traffic pattern
- Mobility enhancement to provide high throughput during mobility procedure (may be handled in a separate mobility WI/SI□□)
- New XQI (SA4 should be involved□)

7 – AT&T

Other enhancement areas of relevance for XR: 1) network coding (i.e. intelligent/efficient packet duplication), 2) L1/L2 mobility (especially relevant for dense indoor deployment scenarios, 3) RAN+AI/ML (traffic shaping and optimized resource allocation), 4) positioning enhancements (for XR use cases which require absolute or relative position or localization)

8 – Guangdong OPPO Mobile Telecom.

* QoS enhancement is almost common understanding and maybe specified in SA. UL assistance information may impact higher layer.

* How to evaluate network performance? In other words, what metric will need to be defined?

* On capacity enhancement, SPS and CG enhancement, we think these are almost common understanding.

* On CA enhancement to exploit FR2 and flexible Tx/ReTx, they are common tools to improve capacity. Are they to be specified in CA or XR?

* On cDRX enhancement, we think it is almost common understanding. But comparing to R17 power saving solution, what additional gain can be achieved?

* On UL and DL alignment, the gain can be achieved by scheduling. What solution needs to be specified?

* On mobility enhancement, we think this can be done in mobility enhancement item instead.

9 – Apple GmbH

In general, we support a work item on XR in Rel-18. We can agree on the problems to solve and leave exact solutions to the work item stage. From discussions, we can see 1) enhancements on matching traffic arrival periodicity with NR air interface periodicity, 2) adapting control signaling monitoring according to traffic arrival and 3) adaptation of data transmission/reception to varying packet/frame size have received broad support.

Also 4) the introduction of UE assistance information on XR traffic and 5) RAN's awareness of XR traffic have broad support.

Under the NR air interface periodicity, we propose to examine the current NR design on SPS/configured grant, CDRX, CSI measurement/reporting. We would like to emphasize CDRX is one mechanism to regulate PDCCH monitoring, enhancement on CDRX solely may not work well for multiple data flow traffic.

We also see CSI feedback as an area for enhancement.

RAN1 and RAN2 should be tasked for the enhancements, with inputs from SA2/SA4.

10 – LG Electronics Inc.

The XR is important topic, and it should be studied in R18.

Our focus is as follows.

1. Traffic awareness
2. Traffic scheduling with finer granularity
3. Traffic synchronization
4. Power saving

11 – Beijing Xiaomi Mobile Software

We are quite interested in enhancement of XR services in Rel-18. From our understanding, at least enhancement on system capacity and power saving should be considered. Potential enhancements include CDRX enhancements, SPS/CG enhancement and cross-layer design. Good cooperation between RAN and SA would be a necessity to make Rel-18 XR WI success.

12 – CATT

We support NR enhancement for XR services in the areas of capacity enhancement, UE power saving, mobility enhancement, and coverage enhancement. However, we would like to have those are of NR enhancement first discussed with conclusion in the working groups based on the evaluation results and system analysis and captured in the TR of XR study. There is no discussion on NR enhancement for XR in the working group before the Rel-18 workshop.

13 – HuaWei Technologies Co.

There are wide interest to support XR. We see companies proposals and views are as below:

1. **Capacity enhancements with wide support on the below aspects:**

1) E2E QoS enhancements involving both RAN and CN to support multiple data streams per-application, including QoS flow association and multi-modality, importance/priority of packets etc. (RWS-210439, 0070, 0372, 0428, 0500, 0469, 0164, 0256, 0364, 0122 and 0061).

2) end-to-end traffic application awareness involving UE, RAN and CN to have more efficient radio resource management/scheduling, e.g. frame-level integrated transmission (RWS-210439, 0010, 0372, 0381, 0095, 0164, 0428, 0213, 0201, 0058, 0215).

3) SPS/CG enhancements to enhance the efficiency of radio resources (0010, 0070, 0372, 0381, 0164, 0041, 0500, 0272, 0191 and 0201)

There are also some proposals for other aspects, some of them are not specific to XR including network coding, DC/CA/SL enhancements etc, we see these proposals are diverging and can be discussed in other areas.

2. Metric/QoE enhancements

There is a good support to consider performance metric enhancements, including coordination with QoE enhancements (0439, 0411, 0256, 0201, 0282 and 0392). We therefore think this aspect can be considered and discussed further.

3. UE power saving

There is a good support to consider UE power saving specifically for XR. The CDRX enhancements got interest from companies (0010, 0070, 0372, 0381, 0164, 0500, 0272, 0191 and 0201). For other proposals, there is also some support on UL&DL alignment but we are wondering whether this can be network implementation?

There are also other proposals like coverage, mobility etc. and we understand these aspects are not specific for XR, they are rather generic enhancements and therefore we think these aspects should be discussed in the mobility area or other enhancements area to avoid duplicated comments here and there, or maybe proponents can clarify whether there are XR specific enhancements on these aspects.

14 – Samsung Electronics Co.

For traffic awareness, has it been shown to be feasible to propagate traffic characteristics through the U-plane stack and what are the requirements on inter-operability of network nodes?

For QoS differentiation of data packets, what is additionally needed beyond the Rel-17 support of two priority levels?

15 – MediaTek Inc.

Further work on XR and Cloud Gaming is indeed required in Rel-18:

- XR-specific focus should be put on **QoS-related improvements, application awareness operation and related cross-layer optimizations, in coordination with SA groups**
- Other ”radio-related” enhancements will be necessary to accomodate LLeMBB traffic - however these ought to be **generic enhancements** (e.g. mobility, efficient spectrum usage with CA/DC improvements, sidelink) that can be best handled in corresponding WI

16 – Rakuten Mobile

Thank you **@Huawei Technologies** for a good summary, We share the same views, especially on enhancements that are not directly related to XR.

17 – VODAFONE Group Plc

Assuming that the Rel 17 simulation work shows benefits for 'RAN awareness' then we see that there will be important system level (e.g. SA2) work needed to support this functionality in Rel 18. Adapting SPS/CG to the burstiness of CG/AR traffic also seems useful. However, given the likely power consumption of the receiver/transmitter and application processors for these high data rates, we do not expect that power savings in the idle mode tasks (DRX) to be of significant benefit for CG/AR.

18 – Ericsson LM

We think there is a large number of areas and ideas in the XR arena. However, given the current results in the Study Item, we think that capacity is likely to be the main bottleneck for XR. Without addressing the capacity issue, XR service might be difficult to be supported in NR. Thus, we think that 3GPP should primarily focus on finding and evaluating solutions addressing the capacity limitation. Throughout the contributions, there are many solution proposals; proper study is needed to identify the proposals that can enhance the e.g. capacity. This is the reason we prefer to have a first Study Item phase to focus on studying solutions and finding out how beneficial the proposed solutions are. This is lacking at this stage and we should not go into a work item phase without analyzing the solutions and finding those with most potential.

Here, we think that 3GPP needs to investigate what traffic characteristics may be beneficial to the RAN to get (traffic awareness in RAN) and how this information can be used to maximize the capacity and limit the waste of NW resources. Examples for how to use this information are: studying if and how to drop late ADUs, how more accurate BSR can assist to improve grant sizes, how multi-slot scheduling can reduce signaling, how CG/SPS can be utilized in combination of the dynamic grant to reduce latency. In this latter aspect, we do not think CG and SPS by themselves are, in general, solutions for XR traffic. Thus, enhancements in these features should be compared against what the current mechanisms can offer. We also see that the bounded latency requirements in combination with the XR data rates puts new requirements on the link adaptation that are different from the requirements of eMBB as well as the requirements of factory-type IIoT applications.

When it comes to power savings, we also agree that this is an area of interest. As in the previous case, 3GPP should investigate and study the different solutions which specifically bring benefits for XR services without increasing latency, for instance. Considering the high demands XR services require from the network, power saving solutions should not result in stricter requirements to the network, high complexity to manage, or frequent signaling.

Last, mobility is also an important area. Yet, we think this could be taken together in a separate study with other services. The mobility challenges for XR may be very similar as for other use cases.

Feedback Form 2: Answers/Comments

1 – Qualcomm Incorporated

Without any doubt, XR is one of the most critical applications for 5G NR. So, it will be highly beneficial to enhance specifications in Rel-18+ to better support XR in 5G NR, tailored to XR traffic characteristics and their QoS requirements such as tens of Mbps, quasi-periodic packet arrival (e.g., 60fps) with jitters, PDB of 10-15ms, etc.

We agree with comments from some companies that the primary focus of the potential Rel-18 XR work item should be on enhancements of capacity and power.

For capacity enhancements, proposals proposed by many companies are:

- CG/SPS enhancements
- Application (or ADU) aware RAN, RAN aware application
- QoS enhancements

For power enhancements, proposals proposed by many companies are:

- Enhancements to CDRX w/ better jitter handling
- DL/UL alignment
- Rel-17 DCI based power enhancements

Many companies are proposing to enhance CDRX to solve the issue of mismatch between typical XR periodicities (e.g., 60fps) and the CDRX cycles supported by the current specifications. CDRX should be a powerful power saving technique when traffic arrival is periodic. However, jitter (e.g., range of 8/10ms per RAN1 assumption) may substantially decrease the effectiveness of CDRX in UE power saving. So, it is desirable to make CDRX more effective with jitter, e.g., introduce low power WUS and/or introduce sparse PDCCH monitoring during CDRX on-duration until 1st PDCCH is detected.

As to DL/UL alignment, most of companies seem to agree with the benefit of DL/UL alignment for UE power saving purpose, but it is often questioned whether it can be fully realized by proper gNB implementation. We generally agree with this, but we think there are still some room to further facilitate DL/UL alignment by spec enhancements. For instance, the following enhancements may be useful: introduction of additional UE behavior of UL transmission (e.g., CG, SR, etc.) to be confined to CDRX active time, DCI based limitation of HARQ reTx in the uplink for the last packet of a video frame.

2 – Facebook

As many companies have mentioned, XR is one of the most critical services in NR. Hence, we are supportive for a followup work item after the conclusion of XR over NR study phase. Additional input could be based on SA1/2/4 QoS studies and SA4 study items such as XR studies or 5G glass types devices. In general, we think that power saving, XR/traffic aware RAN and better QoS adaption are the most important areas to be enhanced in Rel. 18.

3 – vivo Communication Technology

General comment:

We are very interested in enhancement for XR.

We think following areas can be focused as starting point

<u>For capacity aspect</u>

- o QoS enhancement for XR
- o Application awareness and RAN awareness transmission

Including potential enhancements for scheduling, UE reporting, packet discarding, DL reception

- o CG/SPS enhancement
- o CSI enhancement

<u>For power saving aspects</u>

- o Enhancement for DRX and dynamic DRX behavior
- o Handling of jitter

o UL and DL alignment

Note: For mobility and coverage, if identified, aspects specific to XR can be studied

Answer to #5 (Spreadtrum)

It is not necessary that every UL data will trigger the DL reception. Actually, the DL would be triggered by a given UL transmission, e.g. by a given SR, a UL transmission associated with a given logical channel, or a UL transmission containing given indication/information from L2/upper layer. NW does not need to read the application content of UL burst.

Answer to #8 (OPPO) and #13 (Huawei)

Regarding UL&DL alignment, we think study and specify the mechanisms to support UL and DL

alignment for power saving will be beneficial for XR, although some UL and DL alignment can be gNB implementation. For example, CG/SPS is confined within the DRX active time or PDCCH monitoring duration. Besides, for HARQ-ACK transmission, aligning with other DL or UL transmission is also beneficial for power saving. E.g. HARQ-ACK for dynamic scheduled PDSCH transmission can be aligned with DL reception via gNB scheduling, but at the point of time when DL grant is sent, gNB may not have the decision on the subsequent PUSCH/PDSCH scheduling, so HARQ-ACK for PDSCH may not be time aligned with PDSCHPUSCH transmission. Moreover, SPS HARQ-ACK timing is configured/indicated by activation DCI semi-statically. In order to align with DL reception, mechanisms e.g. deferring the HARQ-ACK feedback to close to the the subsequent DL reception occasion can be considered. In addition, UL data/CSI report can also be considered to align with DL reception.

4 – HuaWei Technologies Co.

Regarding ZTE and Samsung's questions on RAN impact for QoS:

We understand the CN may have some coordination with application layer and identifies the relationship with different QoS flows, such relationship can be informed to the RAN side so that gNB can understand the data transmission needs coordination for these QoS flows. If these QoS flows are mapped to a single DRB, the CN may inform the RAN which packets are important/essential, and thus the RAN can understand which packets should be transmitted timely and which can be discarded.

Regarding OPPO's question on what metric to be defined for XR:

For evaluate network performance, PER and PDB is mainly used for capacity evaluation in R17, but they are not sufficient to evaluate user experience, e.g. the loss of important packets would result in different feeling compared with the loss of non-important packets. So a metric with extra XR-specific information, e.g. considering packet importance, can be useful for XR quality evaluation and this can be discussed in coordination with SA4.

Regarding CATT and Ericsson's question on Rel-18 XR work:

We understand the Rel-17 study is mainly to identify the traffic model and conduct performance evaluation for XR services, which potentially deduces requirements like capacity enhancements etc. So we think those aspects with wide interest can be proceed for Rel-18.

5 – Guangdong OPPO Mobile Telecom.

XR is one of the most critical services in NR. Hence, we are supportive a work item for XR . As many companies mentioned, potential Rel-18 XR work item should focus on enhancements of capacity firstly.

For capacity enhancement, we agree with scope proposed by QC. In addition, considering XR traffic characteristics, i.e. large packet size, multiple slots for multiple TBs scheduled by one DCI or in one period of SPS/CG should be considered.

For power enhancement, in our understanding, R17 power saving solution can save power significantly. The additional gain from potential tools, e.g. CDRX enhancement, UL and DL alignment, is not clear. Especially for UL and DL alignment, we agree with most companies' view, it almost can be implemented by gNB smart scheduling. So we prefer to determine whether or how to improve power efficiency after gain from potential technics is identified during R17 XR SI.

For coverage enhancement and mobility enhancement, XR specific enhancement is not identified. So we don't think they can be in further XR WI scope.

6 – Sony Europe B.V.

XR surely represents one of the areas that will stress the 5G system in terms of latency, and heavy traffic. This puts requirements on the network side to provide enough capacity and on the UE side on not only processing but also e.g. power consumption.

Based on the ongoing RAN1 and SA4 XR studies, further work in the form of study or work items would preferably cover Capacity and UE power saving, but also RAN awareness area to handle QoS aspects and heavy Uplink traffic.

7 – Beijing Xiaomi Mobile Software

In addition to the previous comments, we agree with other companies comments that the enhancements specific for XR services/applications should be the focus of this WI. General enhancements without considering XR specific characteristics could be handled in other corresponding topics.

2 Sidelink enhancements (excluding positioning)

This section is targeted at identifying commonalities and interactions for Sidelink enhancements (excluding positioning).

Feedback Form 3: Questions/Comments

1 – Nokia Denmark

Sidelink relay functionality such as UE-to-UE, an essential feature for public safety and key functional element for multi-hop, has been deprioritized from the Rel. 17 SL relay WID. For Rel.18, UE-to-UE and multi-hop SL relaying should be in scope of sidelink relay enhancements in addition to enhancement of UE-to-NW relay. Nokia proposes to focus the sidelink relay enhancements for public safety to enable fast, scalable, energy and cost-efficient solution.

Furthermore, the use of licensed spectrum for sidelink communications will impact Uu capacity, therefore it is desirable that sidelink communications can take place over unlicensed spectrum. This will allow sidelink communication to take advantage of the bandwidth available in unlicensed bands to enable higher throughput and enable more reliable SL communication through time and frequency diversity across licensed and unlicensed bands.

Additional SL power saving enhancements regarding the DRX functionality, such as the introduction of

short DRX and wake-up/go-to-sleep signaling will enable further energy savings in SL operation.

2 – MediaTek Inc.

We see the need for general sidelink enhancements as well as further development of the relay concept (note that some topics, like mode 2d, could be covered under either area).

For sidelink enhancements, we think the highest-priority items are as follows:

- Sidelink in all spectrum, licensed and unlicensed
  - In priority order: SL-U sub-7 GHz, FR2, SL-U sub-71 GHz
- Low latency and high data rate enhancements
  - MIMO (CSI enhancement, >2 layers)
  - CA support (including SL+SL-U)
  - Mode 2d (UE scheduling UE) for reduced latency

The critical goals for relaying are to extend network coverage and service availability to any point where the service is needed, including full support of mobility. Thus we see the following topics as priorities:

- L2 UE-to-UE relay
- Mode 2d, if not included under SL enhancements
- Topology enhancements
  - Multi-hop for deep coverage holes
  - Multi-path (PC5+PC5, PC5+Uu) for reliability
  - Inter-gNB path switch
  - Mobility of remote UE between relay UEs

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Mobile SL relays

A network coding mechanism could also be considered in the multi-path environment to support reliable communication without high latency costs for retransmissions.

3 – FirstNet

For Rel.18, UE-to-UE with multi-hop SL relaying should be in scope of sidelink relay enhancements to enhance sidelink coverage extension for public safety.

4 – Huawei Tech.(UK) Co.. Ltd

The list of tdocs discussing SL enhancements is: RWS-210010, 0036/0037, 0041, 0058, 0070, 0095, 0122, 0164, 0191, 0201, 0213, 0256, 0272, 0282, 0324, 0364, 0372, 0381, 0392, 0411, 0428, 0439, 0469, 0500. The topics discussed most extensively are SL CA, unlicensed, FR2, and power saving enhancements. There may also be some leftovers or extensions from Rel-17 inter-UE coordination which would naturally be considered in Rel-18. These seem appropriate for follow-up email discussion. In particular, points to be resolved include:

(1) Since there is a high level of interest in introducing full FR2 operation for sidelink, it makes sense to handle both FR1 and FR2 for unlicensed sidelink in the same release, to have a unified design without backward or forward compatibility constraints – dealing with which can in themselves be time-consuming in RAN WGs. In terms of use cases, it makes sense to pursue the much higher data rates available in FR2 due to its bandwidth, which will finally provide full support for the upper-end V2X use cases, as well as other services which can utilize sidelink. It is possible to consider limiting FR2 unlicensed work to FR2-2, focusing on 60 GHz.

(2) Given the high interest in specifying FR2, introducing SL CA is a natural technical complement, particularly considering the restricted spectrum available at least to V2X in FR1. It seems likely that there is not much additional standards work in the same release for FR1+FR2 CA once FR1+FR1 is being specified. As with introducing unlicensed operation, avoiding a need to handle backward and forward compatibility constraints is also desirable.

(3) It appears necessary to analyze the targeted use cases for power saving, and to find the commonalities among companies' proposals.

(4) For inter-UE coordination, at least it is clear that having gNB provide resources to be used by a UE for coordinating UE's subject to its control is not part of the Rel-17 discussions, and this can be included as part of the Rel-18 discussions. Other inter-UE aspects can be developed during H2-2021.

5 – Classon Consulting

[for FUTUREWEI]

As commented on the GTW, it is important to better use available spectrum for all use cases, so unlicensed and FR2 enhancements should be included.

6 – ROBERT BOSCH GmbH

From our analysis to companies' contributions under SL enhancements, we observed the following:

1- Improved SL power saving supported by multiple sources:

- Use case: VRU devices, RedCap with SL, wearable devices, consumer devices, etc.

- Solution includes WUS/GTS in SL and BWP adaptation and/or multi-SL configurable capability:
  Bosch comment: *include micro-mobility/e-Bike to VRU power saving for SL and RedCap with SL.*

2- Multiple sources considered SL for IIoT including flexible low-latency scheduling (e.g., sub-slot), enhanced reliability (e.g., duplication), intra/inter-UE prioritization, etc.

3- RWS-210215/0217/218 (Bosch) propose to consider functional safety requirements (e.g., TSCAI requirements including Survival time, CSA, CSR, etc.) to further enhance SL reliability and SL monitoring. ***Bosch comment:*** *consider extending and enhancing Rel-17 IIoT QoS parameters (e.g., CSA/Survival time) to sidelink Mode 1 and Mode 2.*

4- At least one source (0347, CMCC) requests to introduce RSU-like network node allowing RSU backhauling to gNB via network interface and introducing:

- Mobility between RSUs and gNBs

- mutli-connectivity between RSU-like (SL) and gNB (Uu)
  Bosch comment: *we support RSU-like network node and we believe it is very useful for automotive use cases. We recommend further discussion in 3GPP and LS 5GAA for possible use cases and applicability.*

5- Mode 1 and Mode 2 operation including:

- Mode 1 carries SL inter-UE assisting information (e.g., UE Scheduling Another UE)

- Mode 1/2 spectrum dynamic spectrum sharing

- Mode 1 / 2 enhancements to increase reliability

6- UE Scheduling Another UE over Sidelink: ***Bosch comment:*** *consider for SL-IIoT.*

7- Support to multi-carrier operation, CA for SL including: duplication, multiplexing, dynamic BWP, etc.

8- UE-to-UE relay introduction and UE-to-NW relay further enhancements including: multi-hop, relay selection (multipath), group mobility (UE2NW), etc.

9- Multiple sources consider Multi-connectivity, e.g., via UE-to-NW/UE-2-UE, to enhance reliability.

10- Band requirements: FR2 SL operation including beam management: ***Bosch comment:*** *consider for SL-IIoT/URLLC and commercial use cases*

11- Band requirements: SL-U support in unlicensed spectrum: ***Bosch comment:*** *consider at least for SL-IIoT/URLLC nd commercial use cases, focus on 6 GHz band*

12- DAS: at least RWS-210244 and RWS-210360 proposes DAS and/or multi-panel management for SL (at least for automotive use cases)

13- Few sources discuss the need for

- HARQ feedback enhancement including PSFCH enhancements, >1-bit PSFCH, less-occasion (for power saving), etc..

  Bosch comment: *HARQ can be revisited (with minimum impact) if needed, e.g., for SL-U, multi-carrier operation, etc.*

- CSI enhancements

14- NR V2X and LTE-V2X dynamic spectrum sharing: no change in LTE-V2X, Rel-18 detects LTE-V2X transmission.

15- NR V2X support for adjacent-channel coexistence with other technologies

7 – LG Electronics Inc.

We observed that there are many proposals for the sidelink enhancements and thus it is likely that the group will discuss the balance between the workload and the detailed enhancement areas. We would like to ask the following for potential future discussions:

Q1: We think there can be various operation scenarios for sidelink on an unlicensed band, and we have observed so far that the operation scenario is affected by the frequency range (FR1 and FR2), resource allocation mode (mode 1 and mode 2), assistance from another band (licensed-assisted operation and unlicensed-standalone operation), etc. Will there be other factors that may affect the operation scenario?

Q2: There were proposals to enhance sidelink for FR2 operations. Besides the sidelink beam management which may also be beneficial in FR1, what topics do companies see as potential technical issues in operating sidelink in FR2?

8 – ZTE Corporation

Based on the contributions and two rounds of email discussion, it is observed that sidelink is expected to support more use cases and services and the following sidelink topics are summarized to address these use cases and requirements:

1) General sidelink enhancements, such as multi-carrier and carrier aggregation, enhancement on FR2 to support beamforming, improved power consumption, enhanced MIMO, enhancements for latency reduction and coverage extension.

2) Sidelink in Unlicensed spectrum, including the LBT design for new sidelink slot structure and physical channel design, enhancement to the PHY and MAC layer procedures.

3) SL relay, including the enhancement to UE-to-Network relay and new design of UE-to-UE relay. For the UE-to-UE relay, both UE type relay and gNB/DU type relay are proposed. In addition, the support of multi-hop, multi-path and service continuity are proposed for SL relay.

4) SL co-channel/adjacent channel co-existence to address the co-existence of LTE V2X and NR V2X, or NR V2X with non 3GPP ITS technology.

5) Other enhancements: UEs with reduced capability, UE scheduling another UE, predictive QoS, enhancements for vehicle DAS UE, etc.

Considering various potential topics for sidelink, we need to identify the status of these issues, analyze their dependencies and list their prioritization. To be specific, the following insights are given for the subsequent email discussion:

- Some topics may directly go to WI phase while others require a study phase. To our understanding, the beam management for FR2 was excluded from the R16 NR SL SI due to time limitation. On the other hand, the unlicensed spectrum support for sidelink has not been studied yet in both LTE and R17. It seems a study phase is necessary for them. On the other hand, for the multi-carrier and improved power consumption, similar study has been covered by LTE and R17. So it may directly go to WI phase.
- Some topics have dependencies with other topics and it is suggested to start from the most basic building blocks. For example, it would be better to start the study of multi-carrier and FR2 enhancement from licensed spectrum. When the study of licensed spectrum is completed, it is time to check whether additional efforts are required to support unlicensed spectrum. Similarly, for the UE-to-UE relay, it is suggested to start from single hop UE-to-UE relay. When the study of single hop UE-to-UE relay is ready, the multi-hop UE-to-UE relay may be considered. Furthermore, the multi-hop UE-to-Network relay may be considered after the study of multi-hop UE-to-UE relay. In a word, gradual approach is suggested for the sidelink study.
- The prioritization of the sidelink topics is expected. It is not realistic to include all the aforementioned topics in Rel-18. It is suggested to list the prioritization of sidelink topics and start from the one with the most popularity and commercial interests in Rel-18. For the remaining topics, it may be further considered in Rel-19.

9 – vivo Communication Technology

1□ Considering that in Rel-17 SL relay is a separate topic from SL enhancement, it would be good to clarify whether sidelink relay would be discussed in SL enhancement or under the thread of "Additional topological improvements".

2□ If SL relay would be discussed here, another question is that should MBS relay be discussed here or under the thread of "Evolution for Broadcast and MBS services".

3□ Some companies propose the enhancement of supporting SL in MR-DC scenario. Considering that the changes would mostly be in Uu interface, it would be good to clarify whether it should be discussed here or under "CA/DC enhancements".

10 – Spreadtrum Communications

A lot of contributions (RWS-210005, 210046, 210072, 210244, 210445, etc.) proposed different views for Sidelink enhancements, including SL-U, Redcap SL, SL Relay, FR2, CA, WUS/GTS for power saving and so on. Obviously, SL Relay shall be a separate WI, which lead by RAN2. But, for some PHY layer enhancements, such as SL-U, which with a heavy workload and relatively independent function, shall we also consider it to be a separate WI?

11 – AT&T

Support for U2U relays and service continuity (inter-cell mobility optimization) for U2N relays should leverage and/or align with eIAB features and enhancements when possible to allow tight integration of

infrastructure-based and UE-based L2 relays under a common management framework to support complementary deployment scenarios including range extension and disaster response.

12 – Apple GmbH

Overall, we think sidelink needs to be further enhanced in Rel-18, especially in the domains of sidelink coverage enhancement, sidelink operations on unlicensed band, sidelink multi-carrier operations and sidelink relay enhancement (UE-to-UE relay and Rel-17 leftovers for mobility enhancements).

Some contributions, e.g., RWS-210006 from Qualcomm, mention NR-LTE V2X co-channel coexistence. We have a question on "dynamic spectrum sharing" between LTE V2X and NR V2X. Considering waveform, channel coding and frame structures are quite different in NR V2X and in LTE V2X, how could NR V2X devices detect the transmissions of LTE V2X, given the assumption of no changes on LTE V2X devices and no hardware changes to NR V2X devices?

Some contributions, e.g., RWS-210047 from OPPO, mention the enhanced power saving for sidelink which includes power control enhancement. Considering the sidelink unicast PSCCH/PSSCH power control could be based on either Uu link or Uu/SL links in Rel-16/17 NR V2X, is the additional sidelink unicast power control to be enhanced in Rel-18, limited only to PSFCH?

Regarding the predictive QoS support for sidelink communication in RWS-210215 and RWS-210360, we wonder how it can work over PC5 communication? The understanding is that predictive QoS is studied in 5GAA mainly for Uu-based V2X, aiming for in-advance notification of QoS based on UE reporting. This mechanism is broken when UE enters OOC area, and then real-time QoS prediction for PC5 communication will be infeasible. If the focus is only on MDT reporting of SL communication, why not just moving this enhancement to Rel-18 SON/MDT discussions?

For the contributions discussing multi-hop and multi-path relay support, our question is that shall the work focus only on L2 relay, as it seems quite trivial for L3 relay to support multi-hop or multi-path, and there is no obvious RAN impact for L3 solutions on those objectives? Then regarding the MBS relay support mentioned by multiple companies, do we want to support a L2-based solution, or L3-based solution or both? Are there any particular advantages foreseen by having a L2 specific U2N relay for MBS?

13 – Guangdong OPPO Mobile Telecom.

Based on our review of SL enhancement related contributions, it is evident there is a strong interest in expanding the use of NR sidelink technology in more vertical domains, applications, and device types, as well as continuing enhancing sidelink to better support in traditional areas of V2X and public safety. To us, it is important for 3GPP to continue working in this direction of supporting features / enhancing SL capability that are common and needed across different services, as well as addressing some urgent deployment needs. To this end, we have come up with several questions that in our view should be addressed during this email discussion to help with identifying topics and the scope for future discussions after this RAN workshop.

1. (Question related to organizational) As it is clear from the list of topics for non-eMBB, SL positioning is not part of SL enhancement and it is to be handled under the topic of "expanded and improved positioning". Should the topic of RedCap for SL be also discussed under the topic of "RedCap evolution"?

2. For supporting SL operation in unlicensed spectrum, which one(s) of unlicensed spectrum bands (e.g. 5, 6 and/or 60GHz) should be supported for NR sidelink in R18?

3. On the scope of multi-carrier operation for SL,

- Should the work include CA and/or packet duplication?

- What is the scope of licensed assisted operation in NR SL (e.g. Mode 1 scheduling DCI is on a licensed carrier, or SL cross-carrier scheduling from a licensed carrier)?

4. For supporting beam management / multi-beam operation in SL, should the work include only FR2/FR2-x frequency bands (e.g. SCS = 60kHz and above) or FR1 bands (e.g. SCS = 15 and 30 kHz) should be also included?

5. For supporting LTE/NR V2X co-channel coexistence,

- Should the work covers the case when NR-V2X is operating in Mode 2 only? Or does it include Mode 1 as well?

- Should the work also cover the case when LTE-V module does not perform sensing (e.g. under network scheduling Mode 3)?

On SL relay, in Rel-18, besides 1) the Rel-17 leftovers (e.g., to enhance the mobility support for U2N relay, and/or to support unicast U2U relay for a single hop), there are some other aspects that not fully covered by Rel-17 yet, where 2) some are only related to L2 relay at RAN side which have been partly touched/discussed during Rel-17 SI discussion although not fully studied and thus not captured, e.g., multi-path U2N relay architecture, plus 3) others are not touched at all during Rel-17, e.g., the support of multi-hop relay and the relaying of groupcast/broadcast for U2N and/or U2U relay. What is companies' view on the ranking of these 1) / 2) / 3) components (or subset of these components), and especially when it comes to component 3) (or maybe 2) as well), do you foresee the need of study item/phase in Rel-18?

As did in Rel-17, it is justified to have SL relay item as a separated item from the others related to general SL enhancement due to the clearly different focus / target.

14 – Beijing Xiaomi Mobile Software

We are quite interested in introducing new SL features in Rel-18. Use cases including V2x, public safety and commercial services should be considered. We are rather interested in capacity improvement and enabling new devices/services (e.g. Redcap supporting) for sidelink. But we are also open to further discuss supporting URLLC services in sidelink, by further enhancing the performance of reliability and latency. Potential enhancements including SL unlicensed□CA, flexible BWP, and further SL relay enhancement (U2U, multi-hop,) are with our high interest.

15 – CATT

On SL enhancement

We think sidelink enhancement is an important aspect of the next phase of 5G evolution starting from Rel-18. The objectives of the enhancement should be carefully selected and they should also be as specific as possible. Ideally, they should also be relatively straightforward and achievable in the sense of both time line and should be within the TU budget of each WG group. With these considerations, we think the following should be prioritized in rel-18 time frame:

1) Carrier aggregation

2) FR2 enhancement which focus on beam management

The use of sidelink feature to enhance other legacy WI, for example, IIOT etc, can be considered as enhancement of that specific WI in its future releases.

On SL Relay

Based on the previous discussions, the following areas seem to get wide support for SL relay enhancement in Rel-18

1) For U2U relay, including

+Relay discovery and (re-)selection

+Relay/remote UE authorization

+Adaption layer design

+Control plane procedures

2) For U2N relay, including

+Service continuity enhancements, which includes inter-gNB mobility, indirect/indirect switching and group mobility;

+Support of Relay UE forwarding 5MBS to remote UE;

3) For both U2U and U2N, including

+Support of multi-path

+Support of multi-hop

Then there may be some other aspects that may require further discussions/clarifications, for which we have the following questions.

Question 1: For U2U relay, we think it useful to also consider QoS management. We'd like to know companies view on this particular aspect.

Question 2: For U2N relay, it seems necessary consider non-3GPP access in PC5. Our understanding is that SA may work on this first. Maybe it could be discussed what is the impact from RAN point of view?

Question 3: For both U2U and U2N, some companies are discussing DC support. Our understanding is that this might not be very urgent based on the R17 mechanism. If supported, then we need to discuss whether SL is controlled only by MN or it can also be SN. Also it might be more complex if working together with multi path. So we'd like to know companies view on whether to support the combination of Uu DC and SL relay in Rel-18.

Also, we have a general comment based on previous discussions.

Comment 1: We are open to discuss other potential motivations and enhancements for SL relay. But we expect some refinement/prioritization in a later stage, in order to form a practical scope that we can complete in Rel-18.

16 – DOCOMO Communications Lab.

From our side, there are three comments/questions.

1) Power saving is proposed by several companies. Regarding this, Rel-17 SL focuses on power saving as well. So we would like to know why Rel-18 needs to work same direction, e.g. required performance difference, or Rel-17 progress, etc.

2) On LTE-V2X/NR-V2X coex. As commented at GTW, our understanding is that the intention to study/-work the coex is to enable same time/freq resources among them with some collision avoidance mechanism e.g. NR-V2X detects LTE-V2X. Rel-16/17 supports semi-static TDM/FDMed resource pools between LTE and NR, thereby the mentioned objective for Rel-18 should be different from this of Rel-16/Rel-17. If this understanding is incorrect, please let me know kindly.

3) We understand many potential topics for SL, but we need to consider workload. Available TU is limited, then we think companies should consider this aspect further. It should be noted that Rel-17 SL progress is not so good currently. To avoid same situation, less objectives are preferable.

17 – Samsung Electronics Co.

Regarding UE-to-UE relay, depending on the target scenario the required functionalities can be different. Could we get some clarification whether the UE-to-UE relay is to extend SL direct communication coverage or the UE-to-UE relay is to extend UE-to-NW relay coverage.

- Regarding sidelink enhancement, we realize that many companies have considered various scenarios and then increasing data rate and extending coverage are key common factors for most of scenarios. Therefore, we think that unlicensed band/CA/MIMO and UE2UE are important features for Rel-18.

- Regarding co-existence between LTE-SL and NR-SL, We can have co-existence by using separate resources for LTE-SL and NR-SL in the same carrier (e.g. TDM or FDM), this can be done by implementation with no or minimal standard support. An alternative proposed by some companies is to have LTE-SL and NR-SL share the same resources and use sensing to avoid resources used by the other technology, this not only involves standardization support, but could have a bigger impact on the devices, possibly also impacting LTE devices. We would the proponents of the later scheme to justify the extra complexity and motivation of using same resources for LTE-SL and NR-SL.

- Regarding RedCap sidelink, which enhancements should be further considered beyond 1) Rel-16/17 sidelink or 2) other sidelink enhancements for Rel-18?

18 – Sony Europe B.V.

Many companies have proposed latency and reliability enhancements on sidelink. What feature(s) should be supported and specified?

19 – HuaWei Technologies Co.

Regarding SL relay enhancements, we see benefits on having multi-path and mobility enhancements for U2N relay. For U2U relay, as Rel-17 has not yet specified anything, we think it can first focus on the fundamental aspect, e.g. support of single hop and keep it future compatible for having multi-hop. For supporting unlicensed spectrum, we are wondering what are specific impacts on SL relay, we understand if the PC5 supports unlicensed spectrum, it already provides the feature and there seems nothing specific for SL relay?

20 – Intel Corporation (UK) Ltd

Based on review of contributions we have identified the following topics of interest for NR sidelink evolution:

- Potential sidelink evolution directions

1. Sidelink support for URLLC in licensed and unlicensed frequency bands
2. Sidelink RedCap UEs
3. Sidelink communication in unlicensed spectrum
4. Sidelink multi-carrier operation

5. Sidelink power saving (Wake-up signals / sidelink bandwidth parts / DRX enhancements)

6. LTE-V2X / NR-V2X cochannel coexistence

7. Sidelink relaying enhancements (support of UE-to-UE relaying and further UE-to-NW enhancements)

8. Sidelink scheduling UEs

9. Sidelink enhancements for FR2

10. DAS support for V2X use cases

11. R17 leftovers

The following major use cases are considered for sidelink enhancements:

- V2X, PS, I-IoT, private/personal networks, XR, wearables, UAVs

The full scope is very broad and require further discussion on prioritization including use cases/operation scenarios. In terms of use cases, we think that sidelink evolution for V2X/PS use cases should continue. In our view, additional promising use case is sidelink URLLC for I-IoT. For V2X/PS track, items 4-6 are beneficial. For additional sidelink evolution, items 1-3 are suggested for prioritization and further discussion.

21 – China Mobile Com. Corporation

Thanks for the organizing the discussion. The scope of the Rel-17 sidelink relay work item is limited and there is strong motivation to further enhance sidelink relay in Rel-18.For Rel-18 sidelink relay enhancement, CMCC thinks the following enhancement aspects can be considered as high priority:

1) Inter-gNB path mobility

2) group mobility

3) Multi-path (PC5+PC5, PC5+Uu) for reliability

4) path switch between Relay UEs

5) L2 UE-to-UE relay

6) MBS relay

7) CHO and DAPS

8) RSU-like relay

The following aspects are with low priority:

1) UE scheduling other UE

2) Multi-hop for deep coverage holes

22 – Ericsson LM

We have concerns with the ”expanded commercial use cases”. One proposed use case is to use sidelink in smart factories in a type of IIoT/URLLC scenario. As commented in that section (7.2), we do not think sidelink is the proper solution here and additionally we think introducing a second technology/solution (sidelink) for the smart factory this use case when it is just taking off might fragment the market. We do not see that as beneficial. We think 3GPP should stick to the current use cases V2X and Public Safety.

23 – VODAFONE Group Plc

We observe only little market traction from sidelink. Hence we believe that the amount of TUs allocated to further enhancing sidelink should be limited.

24 – Fujitsu Limited

Based on our review of the tdocs, many use cases have been envisioned for Rel-18 sidelink, such as V2X, public safety, NCIS, XR, IIoT, smart home, wearable, drone, healthcare, in-vehicle network, and many topics have been proposed, including SL-U, CA, FR2, relay, power saving, MIMO, coexistence between NR V2X and LTE V2X, mode 2d, Redcap, enhancement for URLLC/IIoT, HARQ enhancement, etc.. Among the topics, the follows have been mentioned by more than 10 companies, including: SL-U, CA, FR2, relay, and power saving. Generally, we feel the same for the importance of these mostly interested topics. SL-U, CA and FR2 have a common point on utilizing additional spectrums to adapt to more use cases. How to organize them for study and also keep a good compatibility is worth more discussions. As for relay, we think it can be a separate RAN2 topic which is the same as what we did for Rel-17 relay. In our view, some other topics are also worth to be studied, e.g., WUS for power saving which was proposed but not included in Rel-17, coexistence between mode 1 and mode 2 which was supported in LTE V2X but not in NR V2X.

25 – Philips International B.V.

We think it is indeed good to discuss sidelink enhancements and sidelink relay enhancements separately, as was done during the work in release 17. In many of the contributions and comments above, people seem to focus on enabling higher throughputs, reducing latency, and so on. We agree that these are important topics, but we think it is equally important to not forget the support for small wearable devices. We have not tested RedCap yet, but we noticed that in practice current cellular IoT technologies (NB-IoT/LTE-M) still lack coverage and have poor connections e.g. deep indoors. In particular for healthcare use cases, if you have a patient in critical condition the last thing you want is loss of communication. We think that supporting LTE-M/NB-IoT/RedCap) within the sidelink relay ecosystem could greatly improve the coverage. It would be nice to hear other companies' opinion about this.

26 – Lenovo (Beijing) Ltd

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Based on the contributions and relevant Q&A session on sidelink enhancement in Rel-18, we can see quite a lot use cases are proposed, e.g., commercial sidelink case, V2X, IIoT, etc., and associated sidelink topics. It seems that many companies propose FR2 support, SL power saving, resource allocation based on mode 2d, multi-carrier operation including CA and packet duplication, NR/LTE V2X co-channel coexistence, enhanced U2N relay, UE-to-UE relay, feedback enhancement, as well as using unlicensed spectrum for sidelink communication.

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It is impossible to include all the above topics in one release and some prioritization work is needed. From the business point of view, we prefer FR2 including 60GHz unlicensed spectrum, NR/LTE co-channel coexistence, multi-path/multi-hop in U2N relay and UE-to-UE relay. Support of multi-carrier operation is then straightforward based on FR2 and unlicensed spectrum. Support of multi-path/multi-hop in U2N relay is the natural continuation of Rel-17 sidelink relay. UE-to-UE relay is used in public safety case. Meanwhile, whether Rel-18 sidelink relay is a separate item from sidelink enhancement as Rel-17 is open to us.

27 – Volkswagen AG

Thank you for having this discussion. For any sidelink enhancements related to V2X the 5.9GHz ITS band should be seen as the primary band for initial deployments. Existing ITS technologies (e.g. LTE-V2X,

802.11p) which are already operating in this band need to be considered for the Rel-18 work. Consideration in this context needs to be understood that existing ITS technologies are not harmed by any Rel-18 sidelink communication. Further it needs to be carefully evaluated to which extend NR-V2X (Rel-16/17) sidelink device need to communicate with Rel-18 devices.

Feedback Form 4: Answers/Comments

1 – Qualcomm Incorporated

We would like to reply to the following question from Apple:

[Question] Some contributions, e.g., RWS-210006 from Qualcomm, mention NR-LTE V2X co-channel coexistence. We have a question on "dynamic spectrum sharing" between LTE V2X and NR V2X. Considering waveform, channel coding and frame structures are quite different in NR V2X and in LTE V2X, how could NR V2X devices detect the transmissions of LTE V2X, given the assumption of no changes on LTE V2X devices and no hardware changes to NR V2X devices?

[Answer]: We expect a Rel-18 device capable of dynamic spectrum sharing between LTE V2X and NR V2X to support both LTE V2X and NR V2X, similar to Rel-16 devices that support in-device coexistence between LTE V2X and NR V2X.

2 – LG Electronics Inc.

We would like to reply to some questions in the following:

Questions on LTE/NR coexistence (Apple, OPPO, DOCOMO, Samsung)

Answer: As we responded to some companies during the previous Q&A, we view this co-channel coexistence as an extension of LTE/NR V2X in-device coexistence specified in Rel-16, i.e., the device supports both LTE-V2X and NR-V2X and the two RAT exchanges information, including the information included in the detected SCI, inside the device. So no significant hardware changes are expected from the device perspective. We think this is in line with the 3GPP assumption that LTE-V2X is used for basic safety and NR-V2X is used for advanced use cases.

We think at least NR sidelink mode 2 should be able to coexist with LTE sidelink as this coexistence should be possible outside network coverage. As we assume no change to LTE side, there will be no difference between coexisting with LTE sidelink mode 3 and mode 4 in designing NR sidelink in Rel-18.

We understand several companies mentioned that LTE and NR sidelinks can coexist by configuring non-overlapping resource pools. However we think this is not a practical way at least in some V2X use cases as it effectively means that the LTE resource pool will shrink and its performance will be degraded. In our understanding, all the subframes and PRBs of a carrier are assumed to be used in LTE V2X operations, e.g., according to EN 303 613 and SAE J3161/1, and in such an environment, dynamic resource sharing is necessary to allow the coexistence.

Questions/comments on the organizational matter (ZTE, Spreadtrum)

Answer: We think that the level of maturity/clarity is different in different proposed topics, and some can directly enter the WI phase while some others may require study phase. We propose to make an assessment on this aspect and consider whether a single item will cover all the topics or several separate items need to be created.

Questions on sidelink carrier aggregation (OPPO)

Answer: We think that RAN should start from importing the LTE sidelink carrier aggregation features in NR including handling limited TX capability, TX power determination, synchronization across aggregated

carriers, packet duplication. For the licensed-assisted operation, we view this as a part of sidelink unlicensed operation, and transmissions such as S-SSB and sidelink HARQ feedback can be sent over the licensed band if supporting them on the unlicensed band will cause more complicated problem due to the LBT failure.

Questions on beam management (OPPO)

Answer: We think SL beam management needs to be supported in FR1 to cover some useful cases like vehicular distributed antenna systems.

3 – Huawei Tech.(UK) Co.. Ltd

To reply to Apple:

Question: Regarding the predictive QoS support for sidelink communication in RWS-210215 and RWS-210360, we wonder how it can work over PC5 communication? The understanding is that predictive QoS is studied in 5GAA mainly for Uu-based V2X, aiming for in-advance notification of QoS based on UE reporting. This mechanism is broken when UE enters OOC area, and then real-time QoS prediction for PC5 communication will be infeasible. If the focus is only on MDT reporting of SL communication, why not just moving this enhancement to Rel-18 SON/MDT discussions?

Answer: The study of predictive QoS in 5GAA covers both Uu and sidelink. In case of sidelink mode 1 and mode 2 when UE is in the network coverage, the prediction of sidelink QoS can be supported by additional signaling from the base station. Further, the mechanism for in-advanced notification of QoS change is not necessary based on the real-time UE reporting. Historical measurement data from both UE and base station can be used to support the prediction. The notification of QoS change can be provided to the UE in advance when it is still in the network coverage. Therefore, it can also work for OOC. Hence, the enhancement may not only affect the MDT reporting, Discussion on SON/MDT only is not sufficient.

Question: For the contributions discussing multi-hop and multi-path relay support, our question is that shall the work focus only on L2 relay, as it seems quite trivial for L3 relay to support multi-hop or multi-path, and there is no obvious RAN impact for L3 solutions on those objectives? Then regarding the MBS relay support mentioned by multiple companies, do we want to support a L2-based solution, or L3-based solution or both? Are there any particular advantages foreseen by having a L2 specific U2N relay for MBS?

Answer: Our answer is Yes. We think L3 relay means invisibility of remote UEs by the network and thus multi-path is out of RAN scope. RAN work on multi-path can focus on L2 U2N relay.

To CATT:

Question 3: *For both U2U and U2N, some companies are discussing DC support. Our understanding is that this might not be very urgent based on the R17 mechanism. If supported, then we need to discuss whether SL is controlled only by MN or it can also be SN. Also it might be more complex if working together with multi path. So we'd like to know companies view on whether to support the combination of Uu DC and SL relay in Rel-18.*

Answer: We think there is sufficient support to have multi-path mechanism including indirect and direct path. We do not think there is sufficient motivation to support DC on Uu interface and this is not relevant to multi-path discussion.

To OPPO:

Question: For supporting SL operation in unlicensed spectrum, which one(s) of unlicensed spectrum bands (e.g. 5, 6 and/or 60GHz) should be supported for NR sidelink in R18?

Answer: We would prioritize the 60 GHz band, due to the wide bandwidth allowing support of the Gbps rates required for high degrees of automation in V2X. Such services are not supportable in the

available bandwidths of FR1. It may be possible to have unlicensed for FR1 and FR2 in the same release.

4 – Guangdong OPPO Mobile Telecom.

Our summary of top supported/prioritized features for R18 SL enhancement during the ”question/comment” round during this WS week include:

- Sidelink operation in unlicensed spectrum (FR1/FR2/FR2-2)
- SL-relay (U2U, L2/L3)
- Multi-carrier operation / CA (FR1+FR1; FR1+FR2)
- Power saving (WUS/GTS, power control enh., BWP adaptation)
- LTE/NR V2X co-channel coexistence
- Beam management
- Leftovers from R17 (mode 2d / UE scheduling another UE)

As it has been clarified the main intended outcome of this week (and this WS) is to identify the 2nd order approximation (list of topics e.g., SL enh., positioning, RedCap, etc) and some details of the 3rd order of approximation (SL enh. related areas listed above). Therefore, it is not necessary to debate on the exact set of SL enhancement areas which is suppose to be discussed during the subsequent post-WS email discussion in August/September. It is also our understanding that how to consolidate or split them into different WID/SID is to be further discussed from RAN#93-e.

To answer some of the questions raised from other companies during this week:

Answer to #7 (LGE)

In our understanding, additional factor that would affect SL operation in unlicensed spectrum also includes COT sharing according to regional regulation. And beside beam management that would have impact to SL opeation in FR2, CA (FR1+FR2, HARQ feedback) is another feature.

Answer to #9 (vivo)

1. Based on the latest summary by Chairman, we understand SL relay is a part of “SL enhancement” instead of “Additional topological improvement”, it is reasonable way to handle this issue from our perspective.

2. We did not identify related discussion in MBS part yet, so assume the discussion can be still in the SL part.

3. If MR-DC is pursued, the change is mainly on SL part instead of on Uu part. So it seems more fit for the SL part here instead of the CA/DC enh part which is more for Uu improvement.

Answer to #12 (Apple)

Regarding the power saving question related to RWS-210047, for unicast power control, PSFCH is one area. We can further consider power control without RSRP feedback, which can be ideal for groupcast scenario, too.

Answer to #15 (CATT)

Q1: thanks for raising this. Our understanding is that for L3 relay, if one follows the TR 38.836 conclusion, there is little RAN impact for QoS, and possible impact for L2 relay which can be considered if needed.

Comment to #17 (Samsung)

We have similar Q when observe the proposals. There are indeed some proposals seeing U2U as a way to achieve multi-hop U2N relay. Yet maybe more comprehensive if separate the two for further consideration/discussion later.

Answer to #19 (Huawei)

Yes, that is also our understanding.

Comment to #22 (Ericsson)

The support of SL operation in IIoT can/should be seen as a complimentary to Uu operation in smart factor (not as a competing solution, but as a integrated solution), where sidelink is mainly used for data traffic that is intended from one factory device to another factory device (without all traffic routing through the central node / gNB) for offloading. Hence improving Uu resource utilization efficiency. And this offloading can be fully managed and controlled under SL mode 1 operation. Furthermore, by direct SL communication, the end-to-end communication latency is reduced from 2 hops to 1 hop. If SL is not utilized, other options include wired connection or Wi-Fi. which is not integrated into the NR network.

5 – ZTE Corporation

We still have the following comments with the SL enhancements:

1) Various SL enhancements are proposed to support various use cases and scenarios. For example, SL positioning, SL over unlicensed spectrum, SL for MBS forwarding, SL for reduced capability UE. Now the SL positioning is discussed under the general positioning topic. It is not clear if other enhancements should also be discussed under each of the specific topics, such as NR-U, redcap, MBS or all the SL relevant topics should be discussed within one umbrella of sidelink enhancement. It is suggested to clarify the criteria for the SL study division.

In our opinion, multi-carrier enhancement, FR2 support, SL-U support should be of high priority. For the UE-to-UE relay, the gNB/CU based sidelink traffic relay should also be considered in addition to the UE type relay. With regard to the co-channel co-existence, we think the separate resource pool configuration for LTE and NR V2X should be enough. The benefits and motivation for shared resource pool of LTE and NR V2X needs to be clarified.

6 – CATT

Our response to companies' comments/questions on SL relay

Thank you all for your valuable input.

On #2 (MediaTek)

Mode 2d seems more like a sub-topic under SL enhancements.

And currently it is not quite clear what needs to be done for mobile SL relay. Maybe some further discussions will be helpful.

On #12 (Apple)

We agree that the main work for L3 is on SA side. Then for MBS support, currently we think if we do this it can be done for both L2 and L3, but again the RAN impact is perhaps mainly for L2.

On #17 (Samsung)

We think both. But maybe starting point is to focus on U2U, that is to extend direct link via SL, and then we could consider U2U+U2N, by means of multi hop. It seems some further discussions will be helpful on these aspects.

On #8 (ZTE), and #19 (HW)

We tend to think starting form single hop is reasonable. Also we agree that (also we commented in previous round) some prioritization/refinement is needed in a later stage.

Our observation on discussions so far on SL relay

Based on the discussions so far, we observe a good level of interests in SL relay enhancements. Regarding next step discussions we could perhaps use the following as a starting point.

Some Rel-17 leftover aspects should be considered, which are listed below:

1) U2U

+Relay discovery and (re-)selection;

+Relay/remote UE authorization;

+Adaption layer design;

+Control plane procedures.

2) U2N

+Service continuity enhancements, which includes inter-gNB mobility, indirect/indirect mobility and group mobility.

Then some further enhancements, listed below:

- Multi-paths;
- Multi-hops;
- Relay UE supports forwarding 5MBS to remote UE;
- Non-3GPP access in PC5.
- Power saving between relay and remote UE;
- Support DC in Uu;
- Inter-RAT control of SL.

Again as many commented some refinement/prioritizations would be needed in a later stage. We are open to discuss with companies.

7 – Sony Europe B.V.

#10: We think PHY layer enhancements for SL should be worked in the same WI as much as possible in order to avoid time overlapping during online meeting.

#18: We think the latency and reliability enhancements in sidelink are necessary for industrial-IoT use-case. We also think some URLLC features in Uu link could be baseline. Especially mini-slot based transmission in sidelink should be supported for low latency communication. For the reliability enhancement, the hierarchical structure where one UE schedules the transmission of another UE should be supported if it is not supported in Rel-17. We also think the inter-UE coordination proposed in RWS-210379 can improve the reliability as well as the throughput.

8 – Beijing Xiaomi Mobile Software

We would like to reply to the following questions:

Apple GmbH

[Question] Shall the work focus only on L2 relay, as it seems quite trivial for L3 relay to support multi-hop or multi-path, and there is no obvious RAN impact for L3 solutions on those objectives?

[Answer] Our preference is that the multipath and multi hop enhancements be studied for L2 relay. The additional routing decisions are likely to require additional consideration for the underlying QoS for the remote UE service(s).

[Question] Then regarding the MBS relay support mentioned by multiple companies, do we want to support a L2-based solution, or L3-based solution or both? Are there any particular advantages foreseen by having a L2 specific U2N relay for MBS?

[Answer] L2 relays (U2N and U2U) need to support MBS and groupcast delivery

Guangdong OPPO Mobile Telecom

[Question] On SL relay, in Rel-18, besides

1) the Rel-17 leftovers (e.g., to enhance the mobility support for U2N relay, and/or to support unicast U2U relay for a single hop), there are some other aspects that not fully covered by Rel-17 yet, where

2) some are only related to L2 relay at RAN side which have been partly touched/discussed during Rel-17 SI discussion although not fully studied and thus not captured, e.g., multi-path U2N relay architecture, plus

3) others are not touched at all during Rel-17, e.g.,

• the support of multi-hop relay and

• the relaying of groupcast/broadcast for U2N and/or U2U relay.

What is companies' view on the ranking of these 1) / 2) / 3) components (or subset of these components), and especially when it comes to component 3) (or maybe 2) as well), do you foresee the need of study item/phase in Rel-18?

[Answer] In general support for enhancements supporting more verticals adoption of NR-PC5 should be prioritised. E.g. increased data rates (CA, flexible BWP, unlicensed carrier), power saving, enhanced reliability, redcap, multi-hop, multi-link. Whilst automatic adoption of R17 left overs for relay should not be guaranteed, certainly some of the R17 left overs such as service continuity, inter-gNB mobility, group mobility, U2U L2 relay should be considered with a higher priority. We do agree some study phase for multi-hop and multi-link may be required, although groupcast and broadcast may be relatively easier to proceed with directly in a work item phase.

Samsung Electronics Co., Ltd

[Question] Regarding RedCap sidelink, which enhancements should be further considered beyond 1) Rel-16/17 sidelink or 2) other sidelink enhancements for Rel-18?

[Answer] We think at least some enhancements on sidelink BWP framework or resource pool configuration should be considered to enable sidelink communications between UEs with different capacity (e.g. Maximum bandwidth).

9 – Classon Consulting

To Ericsson #9:

On the RedCap SL, it should be able to be optionally supported with Rel-17 RedCap, if desired. It is unclear if there is any critical compatibility issue to be solved, and any further enhancements would be a low priority in Rel-18.

To Spreadtrum #13:

Though you may not like the outcome of the cost calculation, it is probably best to stick to the agreed methodology for cost analysis. If we do try to modify further, we should also consider how to capture the impact of economy of scale.

3 RedCap evolution

This section is targeted at identifying commonalities and interactions for RedCap evolution.

Feedback Form 5: Questions/Comments

1 – Nokia France

There is clearly substantial interest in taking a next step in RedCap evolution in Rel-18.

A key motivation highlighted by many companies is to expand the ecosystem for RedCap devices to fill a widely-perceived gap between NR-eMBB and LPWA (eMTC/NB-IoT), targeting data rates roughly in the region 5-20 Mbps. There is no interest in rivalling the existing LPWA technologies.

Target use cases for Rel-18 RedCap include low-end surveillance cameras, industrial sensor networks, controllers and wearables.

This leads to a few **key technology components** which stand out, each being identified by around 20 companies:

1. Positioning for RedCap: important characteristics identified are both accuracy within the available bandwidth and low power consumption.

2. Power saving: wake-up enhancements and a lower power class stand out as the greatest needs identified to enable longer battery life and more flexible power sources.

3. Reduced bandwidth to 5 or 10 MHz: to reduce cost/complexity and match better the target data rates. Can be combined with other cost/complexity reduction enhancements such as peak rate reduction and processing time relaxation.

Other second-tier enhancements, which attract some support but significantly less than the top three, include introducing RedCap support for **Sidelink**, **NTN** and **Unlicensed**, and some papers under other threads also raise **SDT** aspects that may be relevant to RedCap. These second-tier aspects could also be considered if capacity permits.

2 – TELECOM ITALIA S.p.A.

Strong concern with the proposal from Oppo to have 40 MHz channelization. The maximum channelization was the result of a very painful compromise, and I do not understand the gain to re-open the discussion. This will bring more fragmentation to the eco-system and increase of costs. More in general, taking into account the long life cycle for industrial applications, we should see some market uptake and feedback from the field before bringing improvements - unless the feature does not work as specified in Rel 17.

3 – Dish Network

We see Redcap evolution important in Real-18. We would like to make one clarification on supported BW's; In Rel-17 the max supported BW for FR1 is 20MHz; Rel-17 UE's supporting 20MHz need also to support 5/10/15MHz BW's for applicable bands. This is 100% similar to "full fledged NR" where max BW is 100MHz, still UE's support BW's from 5/10MHz upward up to 100MHz to account operator spectrum holdings.

To make Rel-18 discussion clear, would we use wording "Max supported BW" instead of "supported BW"/"reduced BW"/etc?

4 – HUGHES Network Systems Ltd

Agree with Nokia to target for reduced bandwidth to 5 or 10 MHz: to reduce cost/complexity and match better the target data rates. Also should consider expanding RedCap enhancement to include support for **NTN.**

5 – Deutsche Telekom AG

Similar to Telecom Italia: just as we are discussing a new release we should not try to get everything in we intentionally excluded from Rel-17 (i.e. wider than 20 MHz CBW for REDCAP). What should guide us is the need of the markets and the uptake of a certain solution we developed. We also see the development of smaller CBW for REDCAP critical as the next step is then to ask for coverage extension (to compensate the loss created by reduction of antennas) and then going to LPWA type of applications which are better addressed with Cat-M devices for which networks exist (see also Nokia comment).

6 – FirstNet

Improved positioning is crucial for first responders and the redcap devices/sensor devices embedded in personal protection equipment (PPE) may come to rescue in locating a fallen responder.

7 – Huawei Tech.(UK) Co.. Ltd

There are many tdocs proposing enhancements or further development of RedCap UEs: RWS-210007, 0037, 0050, 0057, 0085, 0109, 0116, 0122, 0213, 0215, 0223, 0238, 0262, 0267, 0269, 0277, 0296, 0302, 0313, 0324, 0362, 0378, 0392, 0409, 0422, 0444, 0476, 0504. The main topics discussed are further reductions in UE complexity, primarily by bandwidth reduction, and power saving. Therefore the main points warranting further email discussion are:

(1) Which lower bandwidth(s) should be introduced in Rel-18? It seems that 5 MHz has wide support. Thera are a few contributions discussing 10 MHz UE, and analysis of distinction and market size compared to 5 MHz would be useful.

(2) Among the power saving proposals, identifying which are particular to RedCap UEs, thus being candidates for a RedCap enhancement WI, and which can be considered under a more general UE power saving WI.

Note: We address RedCap positioning in Section 6.

8 – Classon Consulting

[for FUTUREWEI]

As commented in the GTW, we need to take great care with a possible RedCap enhancement in Rel-18. Claims that Rel-17 is missing something due to "limited time" are not accurate. In the RedCap study we made an informed decision *not* to work on features that only offer small gains, and in the work item we have made informed decisions *not* to support 40MHz, and *not* to have extra redcap UE types which will fragment the market. These decisions are all still relevant for rel-18. Rel-17 RedCap should be given time to develop in the market, and economy of scale can make up any 10% additional cost reduction.

Furthermore, since Rel-17 RedCap UE should be able to support other existing optional NR features, there should ideally be no need for a stream of follow on RedCap WIs. However, if you introduce 5MHz devices into NR, then there may be lots of compatibility issues to resolve and we may need many special follow on WIs to handle 5MHz unlicensed RedCap, 5MHz sidelink RedCap, etc etc. The branching may be similar to the start of the LPWA path in LTE, which may better wait for when NR looks to replace eMTC LPWA.

We do support assessing RedCap positioning performance in positioning, and studying big improvements in power consumption (applicable to RedCap devices) with wake-up-radio.

9 – Ericsson LM

For **energy efficiency improvements** for RedCap UEs, we would like to study the following enablers for operation using energy harvested from the environment and low-power wake-up receivers:

- Lower UE power class(es)
- L2/L3 protocol optimizations for highly energy-constrained devices
- Wake-up radio at least in RRC_IDLE to allow the device to shut down its main receiver and possibly also main processor while maintaining network reachability

As stated in the GTW session, for potential additional cost reduction from further **UE bandwidth reduction**, several companies have provided a cost analysis based on the established cost evaluation methodology in TR 38.875, and most of these companies (CATT, DoCoMo, Ericsson, Intel, Lenovo, Sharp) seem to agree that there is no significant further cost reduction: <10% if the baseline is Rel-17 RedCap (equivalent to <4% if the baseline is the Rel-15 NR reference UE). Similarly for the potential power saving, we don't see that any potential gain from hardcoded UE bandwidth reduction to 5-10 MHz compared to what can be achieved from simply configuring the UE-specific bandwidth part to 5-10 MHz. Furthermore, we have concerns with the specification impacts and implementation impacts from further UE bandwidth reduction, which we expect to be substantial. We think it is important to avoid fragmenting the RedCap UE ecosystem and to ensure that Rel-18 RedCap preserves backwards compatibility with Rel-17 RedCap.

Regarding side-link support for RedCap UEs, we have several concerns:

- Regarding commercial viability, we note that alternative technologies based on unlicensed band operation exist, e.g. over-the-top solutions using Wi-Fi, BLE, or NR-U, and it is hard to justify use of licensed spectrum.

- Regarding UE implementation aspects, the required side-link support impacts the UE cost/complexity and its power consumption.
- Regarding deployment considerations, the operator may give permission to use side-link for RedCap UEs, but the actual operation may not be under operator control. The resulting interference scenarios may be hard to manage.
- Finally, regarding specification impacts, major specification work is foreseen.

10 – Verizon UK Ltd

If 5M maximum BW RedCap is introduced, we would like it to be able to coexist with regular NR UEs in a 10/15/20MHz band. Also, as in the R17 RedCap case, such UE shall be known by the NW as early as possible.

11 – ROBERT BOSCH GmbH

Note: Bosch contribution RWS-210215 was not listed in the initial table under this section.

Reading the contributions, we endorse the following:

1- RedCap in Rel 18 should support further power saving including wake-up and reduced bandwidth down to 5 MHz (digital or RF; check also compatibility issues)

2- RedCap in Rel-18 should support SL, even with the further possible enhancements (e.g., reduced BW, Wake-up, etc.). ***Bosch comment:*** please consider VRU devices (e.g., u-mobility/e-bike).

3- Support positioning enhancements for RedCap (also positioning section)

4- Support further RedCap latency reduction for, e.g., light-weight IIoT devices, reduced cost AGVs, and wireless mics.

12 – ZTE Corporation

One RedCap related contribution RWS-210007 mentions small data enhancement e.g. SDT in IDLE state. We think it is beneficial to consider these enhancements but these should be also applicable to non-RedCap UEs as well. There are five SDT related tdocs submitted to different agenda items. Based on the latest guidance from the RAN Chair, this part is now discussed under “others” of eMBB thread in NWM discussion. Please refer to ZTE’s input on SDT there.

Here we would like to provide more comments regarding further complexity/cost reduction, sidelink, positioning and MBS support of RedCap UEs below.

1) Like many other companies pointed out, lower cost terminals can attract more vertical industries to use 5G networks. Therefore, we think it is important to continue the study in Rel-18 on how to further reduce UE cost and complexity, e.g. 5MHz, reduced number of processes, etc. Even that further lower data rate is considered, RedCap is not trying to replace LPWA since the data rate is still not overlapping with most of the LPWA use cases. In addition, NR can provide something which LPWA cannot support e.g. meeting URLLC requirements and having more spectrum access, etc.

2) There have been discussion on sidelink support and positioning support for RedCap UEs. Due to the limitation of RedCap UE bandwidth and 1Rx, RedCap may affect the unicast transmission and scheduling and sidelink identification. The focus is on the impact of sidelink related standards.

For positioning, some RedCap dedicated position solutions (e.g. frequency hopping) may affect the unicast transmission and scheduling, channel measurement and CSI feedback of RedCap UEs. The focus is on the impact of RedCap related standards. We think one general question is whether we need to define different requirement dedicated to RedCap positioning.

So RedCap positioning should be considered in R18 RedCap and RedCap sidelink should be considered in R18 sidelink.

3) Due to the limitation of RedCap UE bandwidth, if multicast and unicast are still transmitted under the one BWP , the peak rate of unicast and multicast will be limited. So, study on how to effectively support multicast IoT applications for RedCap should be considered in R18 RedCap.

13 – Spreadtrum Communications

Regarding R18 RedCap evolution, we have three questions for clarification or high level guidance.

Q1: For use cases, many contributions (RWS-210223, 210324, 210362, 210057, 210085, 210267, 210116, 210378, 210504, etc.) show their interest in some new use cases except for R17 use cases, should it possible to introduce new use cases for R18 RedCap or not?

Q2: For cost reduction, many contributions (RWS-210007, 210116, 210378, 210050, 210223, 210262, 210269, 210057, etc.) proposed to consider further complexity/cost reduction features (e.g. BW reduction). It is also worth noted that the cost reduction in Rel.17 is related to RF and BB, however, the RF and BB are only a portion of the whole chipset. Should it possible to introduce additional cost evaluation methodology for R18 RedCap or not (in addition to 38.875, may include more components, e.g. memory)?

Q3: Almost all the contributions proposed different enhancement or views in cross areas for RedCap, including positioning, power efficiency, SDL RedCap, UL enhancements, security, unlicensed band, SDT, NTN and so on, whether to define and if defined, what are the principles to deal with these cross areas enhancements in potential different R18 items/projects?

14 – Apple GmbH

As proposed in RWS-210504, the following objectives were proposed for enhancement in Rel-18

- **Improve the power efficiency**

o We support to improve power efficiency for Redcap to enable longer battery life and more flexible power sources to meet the battery life requirement of Rel-17.

o The 'low-power wake-up radio' is a new technology that may potentially benefit all types of the stationary devices or even in low mobility. In our view, it is reasonable to start with a Rel-18 study item to investigate the use cases and analyze the potential power saving gain on top of Rel-17 PS scheme.

- **Support a 'flexible bandwidth for Redcap**

o Originally, we proposed to study both reduced BW and a larger BW e.g., 40MHz to provide flexibility to achieve high demanding peak data rate for Redcap.

o Based on comments from some companies in earlier rounds, companies' positions seem to remain the same as in Rel-17. Therefore, we are ok to prioritize the reduced BW to 5 or 10MHz for Rel-18 Redcap enhancement.

- **PDSCH/PUSCH/CSI processing timeline relaxation**

o This is mainly motivated to reduce both Redcap device complexity and the power consumption.

15 – vivo Communication Technology

1. **Regarding UE power saving features:** In Rel-17, there were UE power saving features developed in both RedCap WI and UE power saving WI, with the understanding that the features developed in UE power saving WI are generally applicable to both redcap and non-redcap devices, for example paging early indication, TRS for IDLE/INACTIVE UEs, etc. In the Rel-18 WI/SI scoping discussion, we can consider the similar approach. In particular, the ultra-low-power radio proposals as presented in RWS-210168/210169 can be designed as generic feature applicable to all UE types and not restricted to redcap devices only, so suggest to discuss it in the UE power saving thread.

2. **Regarding lower UE power class:** we think two papers (0171, 0135) are quite relevant to redcap devices, and suggest to consider them in the discusison

3. **Regarding UE BW reduction,** we think this is an area that can be considered in Rel-18, about whether to reduce the RF BW, or just peak data rate reduction in baseband, maybe we can discuss and decide in the working group. We also see the demand from vertical for narrowband NR (e.g. RWS-210035), which also provides an justification for 5MHz devices, as it does not seem to be cost/power efficienct to use an 20MHz device in an 3 5MHz narrow band network deployment.

4. **Regarding sidelink support:** We see many companies discussed sidelink support for eRedCap devices, it is our understanding that on-going Rel-17 discussion does not prevent a redcap UE (20MHz capable UE) to declare its support of sidelink operation, it seems a UE capability discussion, unless we intentionally disalow such combination. It would be good to hear other companies view on this point, as well as what they have in mind for enhanced sidelink support for Rel-18 eRedCap. It would also be good to clarify which email thread is intended to discuss such issue, sidelink enhancement or eRedCap.

5. **Coverage recovery:** We are open to consider coverage recovery in Rel-18, as several features will cause degradatation in coverage, e.g. lower UE power calss, BW reduction, etc. The target for coverage recovery can be further discused.

6. **Rel-17 leftovers:** We think several techniques which were not specified in Rel-17 can still be discussed in Rel-18 for cost and pwoer effieciency specific to redcap devices, such as UE processing time relaxation, reduced number of HARQ processes, serving cell RRM relaxation

In sumamry, we are supportive of Rel-18 eRedCap WI and propose the following as potential objectives for further consideration

a) Peak data rate reduction by RF BW reduction or baseband BW reduction (e.g. RB or TBS restriction)

b) Lower UE power class (e.g. 20dBm, 14dBm)

c) UE processing time relaxation for data and CSI

d) Reduced number of HARQ processes

e) Serving cell RRM relaxation for stationary devices

f) Coverage recovery (target TBD)

g) enhanced sidelink support for Redcap, if identified (TBD in redcap WI or SL WI)

h) Positioining performance requirement for redcap devices (TBD in redcap WI or positioning WI)

Note that Redcap devices can leverage the features developed in the UE power saving item.

16 – Guangdong OPPO Mobile Telecom.

For RedCap UE, power efficiency is also an important factor. Reducing RX to 1 can significantly reduce the UE power consumption and complexity(cost). Further reduction of the bandwidth would be also useful. To support different lower levels of complexities and power efficiency, Rel-18 introduce more bandwidth capabilities for RedCap devices: 5MHz and 10MHz.

For In the existing wearable devices of 4G, devices of 150/50 Mbps level are already been deployed in network. One of the scenarios is the video call through smart watches. 40MHz is to support e same level of throughput. To address some operators' concern, this can be bundled with 1RX in Rel-18 and the capability will be much lower than normal smart phone.

For better power efficiency, we also propose study low power wake-up signal for RedCap devices.

Questions(Clarification): In contribution (0409), there is same complexity estimation for 20MHz and 5 MHz in RF. Can you clarify why there is NO different? Since the RF play significant roles in the complexity, we think the evaluation does not reflect the actual complexity. Genearally, the reduction of 5MHz is reasonable if we considered all the RF aspects.

17 – Lenovo (Beijing) Ltd

We see clear interest on further complexity reduction and power saving for Rel.18 RedCap.

- For further complexity reduction, the interest focuses on lower UE BW. 5MHz maximum UE BW has been widely supported.
- For power saving, the candidates include e.g., low power wake signals and low power class UEs. Besides, it is also mentioned widely that power saving gain is obtained also from reduced UE BW.

When combining reduced BW with other potential complexity reduction features such as reduced HARQ process etc., it is expected that there is noticeable complexity reduction gain. Then one question is what are the combined complexity reduction features Rel.18 RedCap could support.

Companies also show interests on RedCap enhancements in cross areas e.g., in sidelink, in NRU, RedCap positioning, etc. The question here is that if need to be studied, whether they should be in Rel.18 RedCap or in the respective other agenda items.

18 – Beijing Xiaomi Mobile Software

Comment 1: It seems further cost reduction is one potential directions for R18 eRedCap. We think we could focus on the solutions which bring significant cost reduction and avoid touching the topics which we have full and deep discussion in Rel-17.

Comment 2: there are also some cross-project topics, for example positioning in RedCap. For these kind of topics, we need to consider which project will handle these topics. In our view, we think the previous principle can be reused. For Redcap-specific enhancement, we think it should be handled by Redcap project.

19 – CATT

We observe common interest in extending RedCap capability in many aspects, including positioning, power saving, etc.

Heated discussions on further UE BW modification (e.g. 5/10/40MHz) are also observed, but still seem to be controversial due to the non-negligible specification impact, risk of market fragmentation and the uncertain cost reduction.

In our view, the following items can be prioritized for Rel-18 RedCap evolution:

1) Positioning enhancement for RedCap (in Rel-18 positioning item)

+ Aiming at same accuracy performance as non-RedCap UE.

2) Power saving enhancement for longer battery life

+Continuation of Redcap power saving based on Rel-17 framework.

+Other possible techniques to further improvement.

20 – Samsung Electronics Co.

For RedCap evolution, we think the target use cases, justification need to be discussed, as well as the impact to the network.

- **Power saving:** Power consumption is one of the most important aspects for RedCap UEs, e.g., for watches. We are open to techniques for power consumption reduction. The common solutions for other type of devices, e.g., eMBB UEs, can be discussed in power saving WI (if there is one), and RedCap specific solutions can be discussed in RedCap WI (if any).
- **Efficiency improvement:** Due to the reduction of number of Rx, some spectral efficiency and capacity loss had been observed. Some enhancements can be considered in Rel-18, to increase the capacity and efficiency. For example, SB-CSI feedback, fast BWP switching/wider BWP operation can be considered, to obtain scheduling gain. On the other hand, scheduling overhead can be reduced, e.g., multiple TB scheduling. In the meanwhile, the impact on the complexity need to be balanced for RedCap UE.
- **Support of low bit rate:** There were some proposals on further cost reduction to support low bit rate, e.g., similar as LTE Cat 1 bis. If this is justified, the cost reduction techniques need to further study and compared, e.g., further bandwidth reduction, TBS restriction, PRB restriction, etc. Moreover, the impact to the network and coexistence issue with non-RedCap and RedCap in Rel-17 needs to be carefully studied.
- **Coverage enhancement:** In principle, the techniques specified in Rel-17 CE WI can be optionally supported by RedCap. If some enhancement for RedCap UE is needed, it can be considered in Rel-18. On the other hand, DL coverage recovery/enhancement can be considered in Rel-18, aiming to provide a better DL coverage, at least including PDCCH.
- **Others:** Pos for RedCap can be discussed in positioning SI, as well as the support of optional features for eMBB UEs. This can be discussed later after Rel-17 RedCap design is clearer.

21 – QUALCOMM JAPAN LLC.

For R18 eRedCap UE, companies have shown a clear interest in UE complexity reduction, power saving enhancement, positioning enhancement and co-existence enhancement.

Since the potential use cases for R18 eRedCap UE are different from those of R17 RedCap UE and LPWA, it is important for us to identify the UE features and procedures that contribute most significantly to complexity/cost reduction and power saving. Meanwhile, the generic and use case specific performance requirements should be clearly specified, such as peak data rates, latency, positioning accuracy, DL/UL coverage and etc.

Regarding the proposals for LP-WUR (with or without energy harvesting), we think a careful study is required to identify whether or not it can provide significant power saving gain beyond the solutions introduced in NR R16/17. Besides, the cost/size of LP-WUR (if different from the main radio), coverage, RRM measurement and mobility should be jointly considered.

22 – LG Electronics Inc.

For Rel-18 RedCap, we would like to focus on the following directions to fill the gap b/w LPWA and Rel-17 RedCap.

- Further reduced maximum UE bandwidth (e.g., down to 5MHz)
- Enhancements to power saving

23 – VODAFONE Group Plc

We have observed from the NB-IoT vs GSM IoT market that economies of scale are very important in this area. Hence we are nervous about introducing extra RedCap device categories, e.g. at 5 MHz.

Feedback Form 6: Answers/Comments

1 – Qualcomm Incorporated

To Ericsson (on Sidelink support):

Thanks for sharing your concerns about SL support for RedCap/eRedCap UEs.

In our view, it is beneficial to extend SL support for RedCap/eRedCap UEs. Following are our comments on your concerns:

- Sidelink over licensed spectrum could offer better coverage, QoS management and reliability, which could be crucial for some use cases. NR Sidelink could also provide additional functionalities such as integrated PC5 positioning and/or joint Uu-PC5 positioning, which could be critical for some RedCap use cases. We further expect it to provide scalable throughput/performance/cost to match the device function and help removing the need for supporting different technologies in the same device.
- Considering the shorter distances between the UEs over sidelink as compared to Uu, power saving is naturally expected. In addition, we consider further power saving enhancements as one of the key areas for consideration for SL.
- R18 RedCap sidelink should be designed to ensure seamless coexistence between Uu and SL and potential enhancements for both Mode 1 and Mode 2 operations can be specified.
- The most critical power saving enhancements can be prioritized to balance the workload.

To ZTE (on SDT):

We agree it is beneficial to consider SDT enhancements, which should be also applicable to non-RedCap UEs. We think possible topics for study can include SDT in RRC Idle, further enhancements to CG-SDT (e.g. contention-based CG for SDT, which can be beneficial for eRedCap UEs), and backhaul signaling enhancements. We are also open to study MT SDT, if there are enough interest from companies.

2 – Facebook

We are supportive to the contributions from Apple and OPPO that wider bandwidth such as 40MHz is critical for the success on the development and commercialization of high end wearables - an important segment yet to be properly addressed by 3GPP.

We agree that although the topic has been discussed in March plenary, it was agreed not to include the feature for Rel. 17 as a compromise. However, we are talking about Rel. 18, the timeline for the products is in 2025+ with increasing varieties of use cases, compact form factors and applications such multimedia sharing or video conferencing. Also note that the availability of wider bandwidth such as 40MHz is mostly in midband, i.e. around 3.5GHz/TDD spectrum, which is shared between UL/DL traffic.

3 – CEPRI

As an electrical power company, we cosign contribution RWS-210057. In R18, there is an SI "Study on 5G Smart Energy and Infrastructure" in SA1. And the related TR 22. 867 has defined a lots of important use cases for smart grid, such as advanced metering, line current differential protection, etc. We prefer R18 RedCap can take the use cases in 22.867 into consideration, especially from RAN side. Thanks.

4 – Spreadtrum Communications

Comments to #1 (Nokia)

1. For target use cases, we agree that the controller is a new use case for R18 RedCap, in addition, we think other new use cases should not be excluded, e.g. some smart grid use cases, and the suitable KPIs should be considered and decided at early stage.

2. For power saving part, we should carefully consider to include RedCap specific power saving enhancements in RedCap WI and include the general power saving enhancements in UE power saving SI/WI.

3. From our observation, a lot of companies also shows their interest to other enhancements or cost/complexity reduction features including some R17 leftovers.

Comments to #9 (Ericsson)

For cost reduction, as commented on the NWM 2 rounds Q&A, we have the following observations and views,

1. We analysed the cost reduction for further reduced BW from 20 MHz to 5 MHz based on the established cost evaluation methodology (TR 38.875), the result is around 13% (for TDD) if the baseline is Rel-17 RedCap, CATT's result is also higher than 10% (i.e. 11.26% for TDD). It is worth noted that the mid/low-tier IOT scenarios are very sensitive to the cost, a cost reduction of 10% is very attractive and meaningful.

2. The cost reduction evaluation in Rel.17 is related to RF and BB, RF and BB are only a portion of the whole chipset. When the BW is further reduced, the peak data rate can be reduced, which means lower memory requirement, then the cost of memory can be reduced significantly. From our view, the cost evaluation methodology in TR 38.875 is not enough for Rel.18 RedCap, additional cost evaluation methodology for R18 RedCap is needed.

3. 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.

Comments to #15 (vivo)

1. Regarding UE power saving features, our view is that RedCap specific power saving should be in RedCap WI, and for general part (for both redcap and non-redcap devices), we share vivo's view.

2. For R17 leftovers, we think the following objectives should be considered for R18:

- TBS restriction
- UE processing time relaxation
- Reduced HARQ number/buffer size
- Open to others, e.g. spectrum efficiency

3. For cross-function enhancements for RedCap, such as Sidelink support, UL enhancement, SDT, slice/security support, etc, any features or enhancements are highly relevant to RedCap should be discussed and specified in RedCap WI. Those general cross functions can be discussed and specified in the respective SI/WI, for example, coverage recovery can be considered in CE item.

Comments to #16 (OPPO)

1. We share OPPO's view that more BW capabilities should be introduced for R18 RedCap. In addition, unlicensed band should also be considered.

Comments to #18 (Xiaomi)

1. We fully agree with Xiaomi's view that Redcap-specific enhancement should be handled by Redcap WI. This is one of important principles to solve cross-function enhancements for RedCap.

Comments to #19 (CATT)

1. For market fragmentation, we have different understanding with CATT. Firstly, we share the OPPO's answer on NWM: "*In Rel-17, UE can report different UE capabilities (the details still pending): Supporting of 1RX or 2RX (Non-RedCap can support 4RX), HD-FDD or FD, Modulation Order, 20MHz (Non-RedCap support 100MHz for FR1). We see this as quite large range of capabilities and no fragmentation issues raised*". Secondly, as well known, LTE has defined 30 40 categories with different capabilities, but LTE still achieved big success in market. It has no evidence that defining multiple capabilities will lead to a negative impact on the market expansion. On the contrary, different capabilities can match different requirements of different use cases, this is helpful to achieve a better balance between costs and requirements, thus will be helpful to the market.

Comments to #21 (Qualcomm)

For R18 RedCap use cases and the relevant KPIs, we share Qualcomm's views that we should identify the UE features and procedures that contribute most significantly to complexity/cost reduction and power saving, and the generic and use case specific performance requirements should be clearly specified.

The following use case examples can be considered:

- Industrial controller: very small date transmission (Message size 1k byte), very low latency (<10ms), high availability (99.999 9% to 99.999 999%) , UE speed (stationary).
- Advanced metering for smart grid: user experienced data rate (UL<2M; DL<1M), latency<3s, reliability>99.99%, connection density (<50000-100000/km2).

5 – MediaTek Inc.

The proponents for the introduction of <20MHz bandwidth justify the need to do so on the basis of cost and power consumption reduction.

- However, as pointed out by Ericsson above, the cost reduction is fairly low (<10%). Furthermore as highlighted by Futurewei, RAN made an active choice to have a single device type to leverage economies of scale to further bring the cost of the device down. Economies of scale is a very important factor for cost, and this point has been a lesson learnt from LPWA deployments as highlighted by Vodafone above.
- Similarly, from a power consumption perspective, a Rel-17 RedCap UE can be configured with 5MHz BW operation to get similar power consumption gains, while not breaking the economies of scale aspect of RedCap UEs.

We should be very careful when discussing fragmenting the RedCap market with new device types, to avoid inadvertently increasing the cost of RedCap UEs.

6 – CATT

Answer to #16

Thanks for the question. Our evaluation strictly follows the methodology in TR 38.875. During Rel-17 SI, most companies (including us) hold the view that reducing BW mainly contributes to the BB cost reduction, but cannot reduce the RF cost. Eventually, the RF cost reduction from 100MHz to 20 MHz is about 3%, averaged among all companies.

We do not see things change much for 5/10MHz, so we leave the RF cost unchanged compared to 20MHz case. Furthermore, even if BW reduction may bring some RF cost reduction, the difference should be marginal (see RWS-210313).

Comment to #8

Echoing Futurewei, we would like to point out that the specification impact of '20MHz to 5/10MHz' will be much larger than 'from 100MHz to 20MHz', due to the potential redesign of SSB&CORESET#0, and painful co-existence with non-RedCap UE and R17 RedCap UE (e.g. complicated early identification/cell barring for the 5/10MHz RedCap UE).

7 – Xiaomi Communications

Comment#1 (to companies which show concerns on SL RedCap):

(1) Supporting SL RedCap could establish direction connection between smartphone and wearables to save the power of wearables and extend the coverage. We think this kind of benefit is difficult to be provided by the WIFi or BLE

(2) For the aspects of cost increase, operator concern and standardization effort, we think they are not specific for RedCap. It is the general question to support sidelink in the NR system

Comment#2 (on support of 5MHz)

Before we say yes, we think careful study is needed. The aspects to be studied could contain the cost, power, impact on the coverage and so on. The evaluation methodology defined in R17 SI could be a starting point

Comment#3 (on the new use case expansion for RedCap)

We think expanding the use cases of RedCap is quite important to prosper the eco-system of RedCap. At current stage, we don't need to rush to preclude some use cases. All the proposed used cases including SL RedCap, unlicensed RedCap and so on should be discussed.

8 – vivo Communication Technology

For power efficiency, it seems many companies share the same view that eRedCap WI should include the redcap specific power saving features, if any, while other generic power saving features will be studied/specified in the UE power saving item.

Regarding lower UE power class, we think it is more about cost reduction (as captured in TR 36.888) , rather than power efficiency.

9 – Nokia France

Responses

We agree with remarks on co-existence, e.g. from Verizon, that new 5MHz max-BW RedCap UEs should be able to co-exist on a wider-band carrier with other RedCap and non-RedCap UEs, similarly to Rel-17 RedCap UEs co-existing with non-RedCap UEs, and we do not see any reason to doubt that this would be possible.

In response to comments on possible market fragmentation, there is of course a trade-off between expanding the ecosystem by widening the applicability of RedCap devices on the one hand, and introducing too many variants on the other; overall, we (and clearly many other companies) consider that the benefits of introducing one new lower maximum bandwidth for RedCap outweigh any risk.

Overall, the comments suggest that there remains substantial interest in taking a next step in RedCap evolution in Rel-18. We update our summary slightly below, taking into account some of the helpful comments.

Summary

A key motivation highlighted by many companies is to expand the ecosystem for RedCap devices to fill a widely-perceived gap between NR-eMBB and LPWA (eMTC/NB-IoT), targeting data rates roughly in the region 5-20 Mbps. There is no interest in rivalling the existing LPWA technologies.

Target use cases for Rel-18 RedCap include low-end surveillance cameras, industrial sensor networks, controllers and wearables.

This leads to a few **key technology components** which stand out, each being identified by around 20 companies:

1. Positioning for RedCap: important characteristics identified are both accuracy within the available bandwidth and low power consumption (note that this is also identified under the "expanded and improved positioning" topic).

2. Power saving: wake-up enhancements and a lower power class stand out as the greatest needs identified to enable longer battery life and more flexible power sources.

3. Reduced max supported bandwidth to 5 (or 10 MHz): to reduce cost/complexity and match better the target data rates. 5 MHz has the greatest support. This can be combined with other cost/complexity reduction measures such as peak rate reduction and processing time relaxation.

Other second-tier enhancements, which attract some support but significantly less than the top three, include introducing RedCap support for **Sidelink**, **NTN** and **Unlicensed**, and some papers under other threads also raise **SDT** aspects that may be relevant to RedCap. These second-tier aspects could also be considered if capacity permits.

10 – Guangdong OPPO Mobile Telecom.

Thanks for the companies providing views and suggestions. Among the list of the proposed topics, we think the following should be treated in R18 with higher priority.

1) supporting UE without GNSS capability. This was discussed during the R17 NTN SI phase and potential issue was identified, e.g. GNSS function failure. For NTN-IOT, we should look at a wider service scope in R18, such as device requiring high throughput or staying longer in connected mode. Thus, GNSS measurement may pose a remarkable performance limitation due to the half-duplex operation. Therefore, relaxing the GNSS capability not only is for UE power consumption reduction/cost reduction, but also for optimizing UE user experience.

2) beam management, R17 uses R15 BM as a baseline but it is less efficient for operating in NTN system, which does not consider NTN system specific feature and requirements. At the end, R17 NTN BM operation becomes quite heavy in terms of signaling overhead and also restricted, e.g. the number of BWP to be configured for frequency reuse greater than 1. In R18, we should break this baseline and try to design a more efficient BM mechanism tailored to NTN system.

3) regenerative payload: to fully explore LEO NTN deployment, regenerative payload should be considered and ISL should also be supported. R17 NTN ignored this aspect, which already lapped reg-payload structure behind the market. If R18 does not support reg-payload, it would put 3GPP NTN market penetration in danger.

11 – ZTE Corporation

1. Regarding cost saving gain of further reducing bandwidth to 5 MHz, for baseband, besides ADC/DAC and FFT/IFFT, the cost of post FFT buffering and LDPC decoding would also be reduced. We have observed 5.5% cost saving gain if the baseline is Rel-15 NR reference UE and the % gain would be larger if the reference is Rel-17 RedCap UE.

2. Regarding spec impacts of further reducing bandwidth to 5 MHz, 5 MHz RedCap UE can be prioritized for 15 kHz subcarrier spacing case. For 30 kHz subcarrier spacing case, 5MHz RedCap UE can have a unified solution discussed in '7.3 Narrowband in Dedicated spectrum'

3. Energy efficiency improvements for RedCap UEs can be discussed in UE power saving topic to avoid redundant discussion.

4. For positioning, multi-cast and sidelink for RedCap, whether this topic is to be discussed in RedCap depends on any spec impacts on unicast transmission of RedCap UE. We think a topic should be discussed in RedCap WID if it has spec impacts on unicast transmission of RedCap UE.

12 – Guangdong OPPO Mobile Telecom.

Please ignore the above reply due to copy-paste error into wrong section. It is meant for NTN in the next section.

13 – Fraunhofer IIS

Answer to #13 (Spreadtrum) , also partly #1 (Nokia), #5 (DTAG), #11 (Bosch), #21 (Qualcomm), #22 (LG Electronics) - Use Cases:

Use cases considered for Rel-17 RedCap WI are mentioned in the justification section are only a small portion of the envisioned use cases for 5G. Some verticals have not been considered yet that need specific features in a RedCap device, i.e. satellite communication, long-life IWSN, etc.

We see the reservation of some companies due to assumed competition between LPWAN technologies in LTE and low-complexity 5G RedCap devices. Very few corner cases are close in requirements and features but still do not overlap. IWSN requirements are usually more demanding than LTE-M w.r.t. latency and data-rate, but share a similar demand for extended battery lifetime.

Companies that install a 5G NPN campus network will most likely not use LTE-M for industrial sensors. We understand that operators with an already mixed network do not see this issue. From a commercial perspective, adding LTE features to a 5G campus network can be a deal breaker for a lot of NPN deployments (cost and complexity). Therefore, we see low-complexity RedCap devices as a market opportunity and not as market fragmentation.

We strongly support considering VRU as RedCap use case (#11) and also sidelink support.

Answer to bandwidth reduction (e.g. #7 Huawei, #23 Vodafone):

5 MHz seems to be a common number seen in a lot of contributions that consider bandwidth reduction. In 0035 Anterix presented a new use case for RedCap devices with lower bandwidth that was not considered in the Rel-17 WI. We also mentioned these ”special licensed bands” in 0324. Also, wide-area satellite frequency allocations are usually not wide-band. For less than 5 MHz, RAN WGs should probably study the required changes first and get more market insights to take an informed decision.

We do not see a strong need to have 40 MHz of bandwidth for RedCap. Given the efficiency of modern video codecs the data rate would probably not be the limiting factor for wearabels but computational complexity and therefore battery lifetime.

14 – Sony Europe B.V.

#2, #4. We think that there does not need to be a link between bandwidth and data rate. If the target data rate for Redcap were 10Mbps, then why not just specify that the device only supports 10Mbps? This is what we did for eMTC, where the max data rate is 1Mbps. A 10Mbps device could support a wider bandwidth to allow it to receive thart data rate at the cell edge.

#5, #8, #12. We think that Redcap should not overlap with LPWA use cases. eMTC and NB-IoT are the 5G technologies for support of LPWA in 3GPP.

#15. Low power WUS and energy harvesting are applicable for various types of device. Hence we think that these power saving features can be handled under a standalone power saving SI/WI. We understand that this position is in line with your view.

#27. We think the LP-WUR can be studied in a Rel-17 UE power saving SI. The conclusions could motivate a Rel-18 UE power saving WI.

15 – Everactive

Regarding RedCap power saving, we agree with the majority of companies that this should be addressed in a Rel-18 WI. In our view, the largest impact on power will be adopting a wake up signal that can be detected with a low-power receiver. This reduces the potential power ”floor” of UEs by orders of magnitude. Lower power TX classes are also helpful for reducing the active power for data intensive applications. #1, #8, #9, #14, #15, #16, #17, #21 support wakeup signaling.

#9: We share the same views on improvements to energy efficiency.

#11: One comment regarding latency reduction in RedCap. The addition of low-power wakeup signals can also reduce latency without impacting the average power by scheduling more frequent DRX cycles and offloading the monitoring of the channel to a low-power receiver.

#13: Regarding the question on use cases that refers to our contribution - our future roadmap includes a wireless camera that operates solely from harvested energy, which aligns with the RedCap use case. We are interested in the higher peak data rates of RedCap over NB-IoT, paired with power saving features such as low power wakeup signals.

#21: Agree a careful study should be done on both the wakeup signal itself as well as the impact on power and cost of the UEs. We would also comment that wakeup signals and ultra-low power receivers does not necessarily imply reduced coverage.

16 – Huawei Tech.(UK) Co.. Ltd

Answer to Ericsson on 5 MHz UE cost saving:

The suggestion that the 10% saving for a 5 MHz bandwidth UE is vs. the Rel-17 RedCap UE is incorrect. Based on the model of TR38.875, our analysis of a 5MHz UE is from about 7%-15% (combination of 1/2Rx and TDD/FDD) if the baseline is Rel-15 eMBB UE, and thus 20% if the baseline is Rel-17 RedCap UE. We do not think Ericsson's representation of other companies' comments and papers is reasonable or correct either, and at least several of those companies actually have indicated their support for further reduced bandwidth in RedCap (DOCOMO, Intel, Sharp, Lenovo…). A legitimate debate can be had on whether 10% vs Rel-15 (i.e. 20% vs. Rel-17) is a valuable enough saving to justify this further work – and because it will extend the value of RedCap into mid-tier IoT, which is a market where cost sensitivity is much higher than the cases for which Rel-17 RedCap is developed, our view is that it does indeed offer value across the 3GPP ecosystem.

Answer to vivo regarding sidelink for RedCap:

We think in Rel-17, optional support of sidelink features for RedCap can be left to UE features discussions. It might need re-checking for Rel-18 according to which further RedCap complexity reduction(s) are introduced.

Vodafone comment: W*e have observed from the NB-IoT vs GSM IoT market that economies of scale are very important in this area. Hence we are nervous about introducing extra RedCap device categories, e.g. at 5 MHz.*

Answer: Indeed, economies of scale are important. At present, the mid-tier IoT market we see for a e.g. 5 MHz RedCap UE is not served by Rel-17 RedCap because the Rel-17 cost is too high. Thus introducing 5 MHz UE in Rel-18 would not reduce the economies of scale which can be enjoyed by the market addressable by RedCap in Rel-17.

4 NTN evolution (NR & IoT)

This section is targeted at identifying commonalities and interactions for NTN evolution (NR & IoT).

Feedback Form 7: Questions/Comments

1 – THALES

We assume that both NR-NTN and IoT-NTN will be addressed in two distinct items during Rel-18. As per the summary of Thales related email discussion on NTN Rel-18 captured in in RWS-210600, a number of enhancements for NTN have been proposed by 21 companies.

For NR-NTN, the following enhancements were proposed:

- Support of UE without GNSS
- Regenerative payload
- NTN-TN or NTN-NTN mobility enhancements
- Support of Dual Connectivity & Carrier Aggregation
- Network based UE positioning
- Beam management and BWP association
- Coverage enhancement
- DL PAPR reduction
- High performance UE
- NTN-TN spectrum sharing
- Discontinuous coverage
- Protocol simplification for VoNR
- MBS in NTN
- NR-NTN above 10 GHz
- Relay-based architecture for NTN
- RedCAP channel BW reduced
- UL/DL performance Enhancement (Optimized CSI feedback to deal with CSI aging, Optimized DM-RS configuration)
- Coordinated transmission
- Half Duplex FDD
- Pre paging alert
- On-board edge computing

For IoT-NTN, the following enhancements were proposed

- SIB acquisition
- UE without GNSS
- Regenerative payload
- Mobility enhancements
- HARQ enhancements
- NOMA
- IoT-NTN in new bands (e.g. L band)

For the down selection of Rel-18 NTN enhancements, Thales suggests:

For NR-NTN, to

- **Prioritize performance optimization enhancements**
  - Throughput per UE, network capacity, UE power saving, service continuity, availability and reliability
- **Address in priority new capabilities to**
  - meet requirements associated to regulated services: e.g. Reliable & accurate UE location service
  - address specific spectrum opportunities (e.g. above 10 GHz)

For IoT-NTN, to

- **Prioritize performance optimization enhancements**
  - **UE power saving**
- **Address in priority new capabilities to**
  - **Support store and forward service (based on regenerative payloads)**

Question 1: Should other enhancements be considered as part of the discussion on Rel-18 for respectively NR-NTN and IoT-NTN ?

Question 2: In the respective list of enhancements for NR-NTN and IoT-NTN, should some enhancements be grouped together ?

Question 3: Any views on Thales proposed priorities for respectively NR-NTN and IoT-NTN ?

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2 – MediaTek Inc.

For Rel-18 NTN IoT

Prioritize the following:

· Disabling of HARQ feedback to mitigate impact of HARQ stalling on UE data rates

· Improved GNSS operations for a new position fix for UE pre-compensation during long connection times

· Support of (Rel-17) neighbour cell measurements and corresponding measurement triggering before RLF for NTN.

· Support of (Rel-17) NB-IoT carrier selection based on the coverage level, and associated carrier specific configuration for NTN.

· Support legacy (Rel-16) LTE Conditional Handover (CHO) for eMTC and RLF/reestablishment mechanisms for NB-IoT to mitigate packet interruption for NTN

De-prioritized the following:

· NOMA enhancement: To our understanding Rel-16 Contention-Based Preconfigured UL Resources (PUR) can be supported in very low UL SNR cases in NTN with proprietary implementation of NOMA in the eNB.

· DL capacity enhancements: cellular IoT releases specified numerous spectral efficiency enhancements benefiting both UL and DL – i.e. Rel-15 EDT, Rel-16 PUR, Rel-17 specified 16QAM on DL and UL, Rel-16 multi-TBS scheduling,

For Rel-18 NTN NR:

Prioritize the following:

· Regenerative architecture to support very dense LEO satellite deployment (LEO satellites greatly outnumbers GateWays on the ground, or no GateWay in the middle of oceans)

· HD-FDD based on RedCap while avoiding BW/antenna restrictions

· Support Voice Over NR with packet interruption mitigation due to low UL SNR and beam / cell switching for NTN

· Support (Rel-17) Multicast Broadcast Service for NTN

De-prioritize the following:

· Support of UE without GNSS would require new RACH and closed-loop frequency correction with numerous RACH transmissions in connected for high-velocity UEs, high impact on RACH capacity

· Network-based positioning (use GNSS)

· Beam management and BWP association (in scope of Rel-17)

· Coverage enhancement with higher slot aggregation / repetitions (up to 32 considered in Rel-17 NR Coverage Enhancements)

· DL PAPR reduction assuming NR waveform is implementation based technique, new waveform should be out of scope as would require new air interface

· Discontinuous coverage seems contradictory to mature LEO constellation, regenerative architecture

· RedCap channel BW reduction < 5 MHz would require new SSN design, proponent of this topic may consider using LTE eMTC

3 – SoftBank Corp.

The contribution from Thales (RWS-210600) is a good summary. However, it looks to us that the preference from Satellite companies are captured while it says the terminology ”NTN”, which includes HAPS by definition, is utilized. Their priority does not apply to HAPS in our understanding. Therefore, we would suggest to clarify that this section (section 4) focuses only on Satellite (LEO, MEO, GEO), and other categories are separately discussed (e.g. HAPS in section 7.6) . Please note that the separation of WI/SI can be decided after seeing the outcome of the scope discussions.

4 – MediaTek Inc.

Study TN-NTN spectrum sharing including:

- Target spectrum
- Regulation status
- Scope of RAN and core architecture impact.

5 – HUGHES Network Systems Ltd

NR in General

The NR waveform enhancement is important to improve spectral efficiency for NTN however this may not necessarily be part of NTN study or work item. Interested companies may initiate or resume studies on the topic of NR waveform enhancement and incorporate all vertical needs/requirement including NTN.

Spectrum in General

The issue of 7.125 to 24.25 GHz for NR in general should be addressed in Release 18. Additionally, many companies showed interest in the studies for NTN bands >10 GHz, this work should be prioritized

in Release 18 and that 3GPP may also consider studies for definition of frequency range 10 – 52.6 GHz as "FR2-NTN" taking into account outcomes of TR 38.820.

Rel-18 NTN Deployment Scenarios

- Ensure support for hybrid architecture in Rel-18 – GEO and NGSO (LEO and MEO).
- To complement the hybrid solutions, MEO should be added in the NTN-NR scenarios as how it had been in NTN-IoT (TR 37.763)
- Both earth-fixed and earth-moving beams are prioritized for NGSO and earth-fixed for GEO

Rel-18 NTN-NR Enhancement

In addition to the Rel-17 leftovers:

- Prioritize performance optimization enhancements to include Throughput per UE, network capacity, UE power saving, service continuity, availability and reliability
- Address in priority new capabilities to meet requirements associated to regulated services: e.g. Reliable & accurate UE location service
- Address specific RF characteristics for NTN spectrum above 10 GHz
- Support of Dual Connectivity & Carrier Aggregation
- Enhance support for VSAT UEs in high frequency satellite bands to enable as relays

Rel-18 NTN-IoT Enhancement

In addition to the Rel-17 leftovers:

- Prioritize performance optimization enhancements including UE power saving and connected mobility

6 – Lockheed Martin

Having carefully reviewed the proposals and priorities of various R18 NTN-topics from several companies, and considering our (LMC's) own suggestions made in RWS-210207, we (LMC) would like to offer the following set of our preferences:

- Regenerative Payload with both Full- & Split-gNB functions (NTN-NR & NTN-IOT)
- 5GC support for NTN-IOT
- UE without GNSS (NTN-NR & NTN-IOT)
- Increase bandwidth granularity to support smaller bandwidth (< 5 MHz) configurations (as the current 5 MHz minimum bandwidth is too large for some system architectures)
- MEO use cases should also be considered. (NTN-NR & NTN-IOT)
- Dual connectivity to support service continuity between NTN and TN
- Evaluate additional lower rate vocoders for VoNR over NTN links that have data rate constraints
- Evaluate additional MCS combinations for NTN links that have link closure constraints.

7 – FirstNet

NTN requires to support both broadcast and mission critical services to reach public safety personnel scattered in open areas attempting to extinguish raging wildfires or performing search and rescue operations in valleys and canyons etc., to save lives.

8 – Omnispace

We propose that the following features be given high priority for consideration in the NTN Rel 18 Enhancement:

- Regenerative payload for NTN : This feature is supported by many companies.
- HPUE to be included in NTN bands: The will enhance coverage and enable new use-cases
- Reduced NR bandwidth < 5 MHz : This feature is supported by companies in number of verticals i.e. Satellite, Public Safety, Utilities/Public infrastructure.
- NTN-IoT 5G core support enhancement beyond the EPC solution in Rel 17 : This was not considered within Rel17 framework due to time restrictions.
- MEO Use case: Add MEO use cases to NR NTN to remain consistent with the addition of a MEO satellite to Rel 17 IoT cases

- Service continuity between NTN and TN (CGC/ATC)
- NTN optimized support for VoNR

9 – Intelsat

We anticipate that NTN, and NTN-IoT will be addressed as Work Items (WI) in Release 18. We would also support the consideration for a study item (SI) of frequency bands outside FR2, either as a part of the NTN SI, or as an independent NTN related SI.

For the selection of topics for NTN in Release 18 the following are suggested in prioritized order,

· NR-NTN above 10 GHz

· · There are frequencies from 7.125 to 24.25 GHz that are inherently a part of satellite operations. This has also been referred to as 'outside' of FR2. It is imperative that the issue of the use of NTN bands be resolved in Release 18. The issue of bands outside of FR2 has impeded progress in RAN 4, as well as the determination of co-existence studies since 2017. This issue has impaired the progress of NTN in Release 17, and will continue to do so if it is not resolved quickly in Release 18. This may be done as an independent SI if it is required, however a resolution is required quickly.

· Regenerative payload

· In Rel-17 we restricted ourselves to a bent pipe architecture. Rel-18 should consider a regenerative architecture to allow the investigation of further enhanced performance.

· HARQ Optimizations (ACK, NACK)

· For GEO the delay can cause considerable inefficiencies. Methods for optimizing with no ACK feedback are desirable.

· DL PAPR reduction (May be limited to DL)

· SC-FDMA, UW SC-FDMA, F-OFDM

· May be done as part of a Waveform study for NTN

· This does not necessarily imply there would be a backward compatibility issue, a waveform study is already considered for > 50 GHz, since this could be restricted to bands above 10 GHz in NTN there would not be a compatibility issue.

· NTN Supported AIB

· DL NOMA (Enhanced Coverage)

· NOMA was studied extensively in Rel-15. These studies may be leveraged to investigate their benefit for NTN.

· RedCAP channel BW reduced

· Multicast/Broadcast over NTN

We suggest to de-prioritize the following,

· Support of UE without GNSS

· NTN-TN or NTN-NTN mobility enhancements

- Support of Dual Connectivity & Carrier Aggregation
- Network based UE positioning
- Beam management and BWP association
- Coverage enhancement
- High performance UE

10 – ZTE Corporation

For NTN evolution, according to the discussion in Rel-17, overall topics should be organized separately with items for NR and IoT part. For the NR-NTN part, more clear description is preferred to identify the case that whether the HAPS related part is covered or not.

W.r.t the detailed scope:

For NR-NTN, firstly we need to focus on the leftover part from R17 (e.g., beam management, TN-NTN/NTN-TN mobility) and try to further extend the usage of NTN on following:

- Support of UE without GNSS
- Regenerative payload: For this part, we need to focus on the specific scenarios with high interests, e.g., full-gNB on board.
- Support of Dual Connectivity
- UL/DL performance Enhancement (Optimized CSI feedback to deal with CSI aging, Optimized DM-RS configuration)
- Coverage enhancement and others to enable the VoNR via NTN
- Discontinuous coverage
- Network based positioning.

W.r.t other aspects, further optimization based on the future commercial deployment can be done in later phase.

For the IoT-NTN, before the discussion on the scope, we need to identify the key commercial needs and requirement firstly, e.g., traffic type and UE density. Without clear requirement or if we just take the KPI for TN, it will lead to over-enhancement. In our views, enhancement on following should be addressed firstly.

- Power saving

- Issue for long connected UE including service continuity, beam management and synchronization
- Synchronization without consideration on GNSS

11 – Spreadtrum Communications

Regarding NTN evolution (NR & IoT) evolution, we have two questions for clarification or high level guidance.

Q1: Many contributions (RWS-210011, 210186, 210207, 210232, 210238, 210321, 210394, 210408, 210501, 210468) propose that R18 NTN should support regenerative payload and ISL. We want to clarify whether both R18 NR NTN and R18 IOT NTN need to support regenerative payload and ISL?

Q2: Many contributions (RWS-210011, 210074, 210158, 210186, 210194, 210200, 210232, 210238, 210284, 210321, 210394, 210408, 210468)proposed different enhancement in cross areas for NTN, including power efficiency, coverage enhancements, mobility enhancements, multiple connection and so on, what's principles to deal with these cross areas enhancements in potential different R18 items/projects?

12 – Lenovo (Beijing) Ltd

We share the view that NR-NTN and IoT NTN should be 2 distinct items in Rel-18 considering respective progress and requirements.

For Rel-18 NR NTN, we think the following enhancements can be prioritised:

- Regenerative payload;
- Support of UE without GNSS;
- Mobility enhancements, e.g. for NTN-TN continuity;
- Multi Connectivity & Carrier Aggregation;
- Beam management;
- Coverage enhancement;
- Network based UE positioning;
- MBS in NTN;
- Support of Redcap UE, including channel BW reduced and half duplex FDD;

- SON enhancements for NTN mobility (may be handled in Rel-18 SON work item).

For Rel-18 IoT NTN, we think the following enhancements can be prioritised:

- UE power saving;
- Discontinuous coverage;
- Support of UE without GNSS;
- Throughput Performance enhancement.

Questions:

1. For NTN-TN spectrum sharing we have concerns on spectrum policies and possible interferences if shared. What are the motivations or potential benefits of spectrum sharing between NTN and TN? And how to appropriately constraint the spectrum sharing for remote or populated areas, especially when NTN and TN belong to different operators or countries?

13 – Apple GmbH

Overall, we think NTN needs to be further enhanced in Rel-18, especially in support of UE without GNSS and regenerative payload.

Some contributions, e.g., RWS-210074 from Thales, mention the support of RedCap UEs in NTN. We would like to know more about the potential enhancements (beyond Rel-17 RedCap) needed for the support of RedCap UEs in NTN?

We would like to know how networks plan to evolve and have compatibility between Rel-17 UEs with GNSS as a requirement vs. Rel-18 UEs which might not have the same requirements.

From the RAN4 perspective, we should recognize that progress with the Rel-17 NTN work item is challenging, and we already saw RAN #92 approve the NTN IoT work item without any RAN4 scope in addition. Sufficient time to stabilize the requirements in Rel-18 for NTN should be made available before defining requirements for additional features newly added since Rel-17 NTN.

14 – Guangdong OPPO Mobile Telecom.

We agree with support of non-GNSS UEs, coverage enhancement for NR smartphone with -5dBi antenna gain, regenerative load, beam management, and throughput enhancement (IoT) as part of NTN evolution in R18.

On inter-working NTN/TN (NR), e.g. CA/DC, or dynamic spectrum sharing, or mobility enhancement for handing over between NTN/TN, we agree that the NTN/TN inter-working is an open issue. But not sure about the priority of the topic. Is it necessary to be addressed in R18?

On NTN positioning (NR), indoor positioning may not be a first target for R18 and outdoor positioning could be prioritized. Suggest to start with a study phase before agreeing on the WI scope.

15 – Beijing Xiaomi Mobile Software

We do see companies have diverse views on the potential enhancements on NTN and IoT NTN in Rel-18. From our perspective, we think enhancements on data rate enhancement per UE to support new service, positioning enhancement to resolve the GNSS unavailable/regulation issue, coverage enhancement to support smart phone in NTN and mobility enhancement between TN/NTN considering the power consumption and handover interruption should be considered in Rel-18.

One question is that many companies proposed to have some evaluation on potential enhancements such as coverage and positioning in Rel-18, is it possible to have a study phase during Rel-18 WI on NTN?

16 – CATT

For Rel-18 NR-NTN

It is observed that many enhancement proposals have been made on the topic. In order to form a practical work scope, it seems necessary to consider some prioritization, so that the Rel-18 NTN can achieve both performance improvement and commercial success.

Among the proposed enhancements, the following ones seem to get wide support.:

+ Support of Regenerative Payload and ISL;

+ Positioning enhancement (UE without GNSS capability, or GNSS is not available for the GNSS capable UE);

+ Beam management enhancement;

+ Coverage enhancement;

+ TN-NTN coordination;

+ DC operation;

Then we have some questions for further discussions/clarifications

1) Which Regenerative option to be supported in Rel-18? Any expected spec change to support ISL?

2) For TN-NTN coordination, what's the most essential enhancement to do? Enhancement for handover between TN/NTN? Or DC operation?

3) For DC operation, scenario and use cases should be further clarified/confirmed (e.g. TN + NTN, LEO +LEO, GEO + LEO). The RAN impact should be evaluated.

Then we also believe in a later stage we could discuss, if needed, how to proceed the work for positioning enhancement, i.e., to put it here or separately in positioning enhancement topics.

For IoT NTN

Firstly, our view is that we should focus on the leftovers or essential enhancements on top of Rel-17 (pending to Rel-17 WI progress);

Secondly, we could do some additional enhancements from NR NTN, e.g. the support of Regenerative architecture, coverage enhancement, etc. For which the spec impact and complexity should not be very large.

17 – DOCOMO Communications Lab.

Before questions/comments, we concern on this discussion direction. Chairman's guidance is **NOT** to discuss topic list (i.e. each company's preference) in our understanding...

As questions/comments for NR NTN, let me put the following.

1) We see that several companies propose performance enh as coverage, PAPR, UL/DL performance, etc. On these, our question is whether there are certain targets by using numerical values. To enhance them, the reason should be clarified like current Rel-17 is insufficient for this service or for that scenario. However currently we are not sure what is not sufficient in Rel-17 NTN.

2) On regenerative type or others, the mechanism would be same between satellite and HAPS. Currently HAPS is treated in this document separately, so how to manage them should be considered further.

18 – Samsung Electronics Co.

Regenerative payload with inter-satellite link

We think that regenerative payload and ISL are one set to be supported, where regenerative payload is a pre-requisite for ISL. The fulladvantage of regenerative payload cannot be utilized and the actual coverage of a satellite constellation is not extended compared to transparent payload. RAN WG3 will first discuss on which architecture will be used for regenerative payload among 1) gNB atsat (adaptation may be needed in NG), gNB-DU at sat (adaptation may be needed in F1), and 3) IAB-like sat (possible to support multi-hop routing, but large spec impact).

Operation without GNSS

Without GNSS capability at the UE side, Rel-17 NTN cannot be utilized because Rel-17 NTN is based on the assumption of GNSS positioning.But low cost terminals and for the case of weak GNSS signal may not be capable of GNSS positioning. In order to scale up the range of users that can access NTN, the related enhancement is necessary. This might have large spec impact since new PRACH format,new TA mechanism, and new handling of Doppler shift are needed.

Multi-connectivity

We see multi-connectivity for NTN mainly for mobility enhancements. Similar to EN-DC, for example, the link with GEO could be the mainanchor while the link with LEO could be the secondary. For spec impact perspective, the required features could be similar for multi-connectivity with GEO/LEO, LEO/LEO, and NTN/TN.

Power saving, coverage enhancement, mobility enhancements

We see these items are what each WG will review on which parts of specifications should be enhanced for NTN from Rel-17 (e.g., CHO enhancements,traditional handover enhancements, and neighbor search enhancements). Some of the features introduced in Rel-16/17 may be directly applicable for NTN without enhancements, and some of R17 features would need enhancements specific to the NTN.

Rel-17 leftovers (including HARQ for IoT over NTN)

Depending on the conclusion of Rel-17, some enhancements might be needed to further optimize and improve the performance in NTN environments. For example, the capacity per NTN cell may need to be increased by increasing # of RNTIs (while minimizing transitions between RRC*CONNECTED and*

*RRC*IDLE/RRC_INACTIVE states to reduce the associated signaling load and resource consumption). The overall signaling overhead for the NTN should be addressed by reducing the amount of UE-specific signaling in the downlink and the uplink, because the impact of per-UE signaling is magnified due to a large number of UEs in an NTN cell.

In addition, SON has traditionally addressed features that have been defined inprevious release(s). Since NR-based NTN deployments would be novel, there would be a need to optimize NTN-specific parameters.

19 – Rakuten Mobile

@Docomo: For us the goal of coverage enhancement is to support Direct Access to Smart phone. It seems many companies are interested in this. Good explanation provided by OPPO in this paper RP-210257.

20 – Gatehouse Satcom A/S

We do support the view to run NR-NTN and IoT NTN as 2 distinct items in Rel-18 to support the capturing and progress on different requirements, though continue to seek for a common base.

Spectrum discussion and definition of implementation proposals have proven to be challenged, mostly due to differences between region regulations (countries). We are not convinced that it would be good to align the use of spectrum for both NR-IoT and NTN-IoT.

For IoT-NTN we prioritize:

• Power consumption enhancements (UE power saving, enhancements for discontinuity coverage)

• Regenerative payload – store and forward

• Support for additional bands (e.g. L, Ku)

21 – Sony Europe B.V.

General

While some motivations for NTN enhancement might be common between IoT-NTN and NR-NTN, we think that the specific enhancements to IoT and NR would be handled under different work items.

IoT-NTN

There are various proposals on latency / power consumption etc. At this stage, we think that we should be deciding which metrics we want to improve in Rel-18. After that, we can consider specific proposals to address those metrics.

Given that the Rel-17 study on IoT-NTN was cut short in order to focus only on essential minimum functionality, we think that it would starting Rel-18 with a study phase on those enhancements that can help to meet the mMTC KPIs.

NR NTN

Many companies have proposed an NTN use case that targets UEs with a smartphone form factor. The main limitation in Rel17 for this is the actute link budget, with GEO being the worst. What is to be done to increase the link budget for eMBB-type throughputs in NTN?

22 – Intel Corporation SAS

Many thanks for discussion, and special thanks to Thales for providing the summary and the list of proposals.

In general, proposed features are clear, there is some uncertainty for some proposals on the necessary changes to the specifications, however this discussion is too detailed and requires more analysis.

We have one question for the proponents to support UEs without GNSS. Is there any analysis available for benefits of such feature (e.g. power consumption, GNSS coverage/availability, portion of devices without GNSS)? If so, could you please refer us to it, it will certainly help us to better understand the motivation behind this proposal.

In our view support of UEs without GNSS should be well justified since it has some negative implications on system performance due to larger PRACH overhead, UL TA and UL frequency offset indication overhead.

23 – Rakuten Mobile

Also, We believe that NTN-TN spectrum sharing should be prioritized as it could very well become the key to rapid NTN deployment.

24 – HUAWEI TECHNOLOGIES Co. Ltd.

1) Regarding support of UEs without GNSS in Rel-18, it seems companies understand that a UE without GNSS cannot access Rel-17 NTN network. Before RAN agrees to work/study on UE without GNSS in Release-18, it should be clarified that whether the potential power saving gain justifies the limitation of not being able to access Rel-17 NTN network. Apart from the access issue on air interface, there is also impact on NG interface. For example, UE location is mandatory information to perform UE access to the core network, i.e. the user location is need for RAN to select the AMF CN. If UE GNSS information is not available, some other location mechanism(s) must be introduced, which may require considerable standard effort (if at all feasible).

2) Smaller bandwidth is mentioned in RWS-210421. According the email Q&A discussion, it seems the main motivation to support smaller bandwidth is that due to power limitation, existing satellite communication system supports smaller bandwidth, e.g. BGAN system and Satcom system. The bandwidth per UE can be as low as 40/50 KHz. Our understanding is that to support such smaller bandwidth for NR-NTN or IoT NTN, considerable redesign is needed. It would be good that proponents can elaborate a bit more what is the performance gap with existing NR and NB-IoT in comparison to deployment requirement if smaller bandwidth is not introduced for NR/IoT NTN.

25 – China Mobile Com. Corporation

NWM question from CMCC about NTN/IoT-NTN:

Thales's summary about NTN and IoT-NTN in RWS-210600 is great. However, from our perspective, for both NTN and IoT-NTN and UE without GNSS also need to be given first priority. We are supportive on the study of regenerative payload. However, considering the work load of the on board gNB architecture and protocol stack split design, this can be set as second priority. R17 only focus on UE with GNSS and transparent payload, so it is very necessary to study UE without GNSS and regenerative payload in R18. And for IoT-NTN, mobility enhancements for eMTC devices and HARQ enhancements are demanded to be discussed with high priority.

26 – Nokia France

Across all the contributions, a very wide and diverse set of enhancements is suggested for NTN and IoT-NTN by different companies.

First, it is clear that careful prioritisation and selection is needed, to focus on a small but genuinely useful set of enhancements.

Among these:

- **Support of UEs without GNSS** (either without GNSS capability, or out of GNSS reception) is widely supported. Note that this improves coverage to indoor and similar locations, where GNSS reception is the limiting factor. Closely related to this is the support of network-based non-GNSS UE location, and support of RedCap UEs.
- **Mobility enhancements** are widely seen as necessary, and support for multi-connectivity and/or co-ordination between satellite links and/or between NTN & TN seems to have some interest.
- Consideration of coverage enhancements for smartphone voice/text connectivity is seen as interesting by some companies, although the precise assumptions and solutions are not so clear and would probably need some study first.
- UE power consumption aspects are seen as important for both smartphones and IoT devices.
- There is interest in supporting regenerative architectures and ISLs, which are also applicable for HAPS.

On spectrum, a few companies mention TN-NTN spectrum sharing, but it is important to highlight that this is primarily a regulatory matter; those contributions suggesting it do not address the question of precisely where this is possible from a regulatory perspective, and that should be understood before starting any study in 3GPP.

27 – Ericsson LM

We believe further evolution of NTN should continue to be guided by the conclusions of TR 38.821 and the status of discussions for the ongoing WI. In particular, RAN3 did not identify any particular area where current Xn functionality is missing for TN-NTN interoperation. This means that current Xn specification can be reused for TN-NTN interoperation if a suitable implementation allows it. There is specific functionality (e.g. TN-NTN DC) which was studied and considered unfeasible due to the imbalance between the satellite and terrestrial legs. On the other hand, there is a set of Xn functions (including DC, CA, load balancing, and others) which may be beneficial for intra-NTN (i.e. inter-satellite) operation. For this reason, we believe the regenerative architecture with full gNB on board should be pursued in Rel-18. This is also the only regenerative option which has ”no showstoppers” according to the TR 38.821 conclusions.

Furthermore, we see enough overlap between satellite and HAPS scenarios to justify a common item and to make it impractical with separate items.

28 – Inmarsat

We would like to highlight that guidance of this NWM discussion was explicitly to focus on Q/A and not on prioritization. However, very few if any technical/specific questions have been asked so it’s difficult to progress. There clearly needs to be more time allocated for discussion given the complexity of the topic.

Any Rel-17 leftovers from either NR NTN or IoT NTN should be prioritized. RAN 4 aspects in particular that may have to be addressed in the Rel 18 timeframe. These should be handled as Release-independent Work Items.

NTN spectrum (release-independent):

- Complete framework for NR NTN in frequency bands above 10 GHz with a Release-independent approach, including addressing FR2 definition wrt NTN. We agree with Intelsat that this issue has hampered RAN4 progress in Release 17 and should be resolved, but should not be tied to Rel-18 completion. We consider this a Rel-17 leftover.
- For IoT NTN - complete support of L band in a release-independent WI

Rel-18 NTN generalities:

- Generalize support for multiple GSO and NGSO satellite orbits with fixed and moving beams. This should not be restrictive but include GEO/GSO, MEO, LEO and HEO. NTN specs should support the vast majority of orbit types, leaving sufficient flexibility to implementation.
- Identify regulatory requirements that were not addressed in Rel-17 and may need RAN work.

Rel-18 NR NTN (in order of priority):

- Performance enhancements including
  - at the waveform level, such as DL PAPR reduction (including DFT-s-OFDM). Has benefits to other verticals (e.g. >52 GHz) and can be addressed as optional feature for backwards compatibility.
  - Throughput per UE, network capacity, UE power saving, service continuity, availability and reliability
- Enhance VSAT UE support and different NTN UE classes
- Support for Dual-connectivity and CA (inc. intra-satellite CA)

- Increase bandwidth granularity to support smaller bandwidth (< 5 MHz) configurations (as the current 5 MHz minimum bandwidth is too large for some system architectures)
- Beam management and BWP enhancement
- TN-NTN service continuity
- IAB Relay based NTN architecture
- HD-FDD
- Regenerative architecture based on on-board DU
- Protocol simplification for VoNR

Rel-18 IoT NTN

- Performance and efficiency enhancements (including NOMA-like UL - if this can be supported using existing features from prior releases such as PUR, even better, but we should consider as overall performance enhancements and signalling overhead reduction)
- HARQ feedback disabling
- UE power saving enhancements
- Better mobility support

Answer Thales Question 2: Yes we see a benefit in grouping enhancements as much as possible to avoid fragmentation or duplication of the workload. If there are any features from other areas in current or previous releases that can be leveraged and ported to NTN, this should be used as a starting point.

If there are enhancements that can benefit other NR or IoT applications additionally to NTN, these should be considered.

For example we consider performance, coverage and overhead reduction enhancements should be grouped together.

Question 1: How do we handle RAN4 items that have been neglected as part of Release 17, such as proper framework to support >10 GHz operation?

Question 2: There are many different satellite orbits. 3GPP spec should be generalized and cannot address every single orbit, but should support all or most of them, including ones not explicitly included in Rel-17 WI such as HEO and MEO. How can we address this in a more generalized way?

29 – NOVAMINT

We support the idea to have separate and distinct items between NR-NTN and IoT NTN as not addressing the same use cases though some common base should be sought when possible as done in Release 17.

For NR-NTN, we believe the following enhancements should be considered for release 18 (organised by priority)

- Regenerative payload
- Support of UE without GNSS
- Discontinuous coverage (for initial constellation - may be important as well in the future when several releases are supported)
- NTN-TN or NTN-NTN mobility enhancements
- Support of Dual Connectivity & Carrier Aggregation
- Network based UE positioning
- Spectrum efficiency & NTN-TN spectrum sharing
- RedCAP channel BW reduced
- On-board edge computing

For IoT-NTN we believe the following enhancements should be considered for release 18 (organised by priority):

- alignment with mMTC Release 17
- Regenerative payload (store & forward)
- Power consumption enhancements (UE power saving, enhancements for discontinuity coverage)
- IoT-NTN in new bands (e.g. L band)
- UE without GNSS
- Support of Critical and no delay tolerant use cases
- HARQ enhancements
- Mobility enhancements
- 5GC support

30 – ESA

It is evident that NTN enhancements are required, as well as further optimizations after Rel.17 completion. There are several common keywords among 3GPP companies. Few comments on the most recurrent.

1) UE without GNSS: surely relevant, but compatibilities issues must be clarified and justified.

2) BW<5MHz: very important, also because linked to other verticals needs. Huawei (just above) correctly said the UE bandwidth can be as low as few RBs, however the initial synchronization (e.g., SS block) occupies 240 carriers (i.e., 240x15 = 3.6MHz), and a similar large bandwidth is necessary for the PRACH procedure.

3) HD-FDD: very useful to reduce the power consumption and smart enhancements to mitigate FDD operations in FR2 (where TN deployments and chipsets are TDD based).

31 – CEWiT

We support enhancement in NTN in Rel 18 on following aspects:

- Support of UE without GNSS
- NTN-TN or NTN-NTN mobility enhancements
- Adoption of IAB- architecture for NTN

one question,

Regarding the beam management we would like to understand the companies' thoughts on what are the new aspects required to be specified apart from the Rel 17 beam management techniques in the NTN? What will be the key consideration for the beam management enhancement in the NTN Rel 18?

Feedback Form 8: Answers/Comments

1 – TURKCELL

We support the separate and distinct items for NTN NR and NTN IoT. The following enhancements can be studied in Rel-18:

- Mobility enhancements related with NTN-TN or NTN-NTN.
- Support for UEs without GNSS
- Regulation of spectrum sharing between NTN-TN

2 – THALES

General considerations

- *NR-NTN and IoT-NTN should be handled as separate items in release 18*
- *HAPS can be treated along with satellite in the same NTN items at least for RAN1, 2 and 3 aspects since there are likely similar architecture and mobility issues*
- *De prioritization shall be proposed for RAN#93-e plenary to scope reasonable NR-NTN and IoT-NTN work items*

Responses to questions from companies

- *@Inmarsat (Q1): RAN#92-e agreed to start a study on the deployment of NTN in above 10 GHz band in March 2022. A study item proposal shall be discussed during RAN#93-e.*
- *@Inmarsat (Q2), We believe that MEO is already covered by addressing LEO and GEO. Please advise what MEO specific issues have not been addressed in release 17. As per HEO, some reference scenarios should be defined and characterized*
- *@Apple: Actually RedCap UEs in NTN relates to the support of channel bandwidth as low as 5 MHz*
- *@Firstnet: what specific issues need to be address to support mission critical services ?*

- *@Lenovo: About TN/NTN spectrum sharing, we believe that further discussion is needed for example to clarify which spectrum and what coexistence/spectrum sharing scenario to be considered as reference taking into account the regulation aspects*
- *@Spreadtrum (Q1): For IoT-NTN, it is beneficial to consider the eNB on board for store and forward capability however without ISL. For NTR-NTN, further discussion is needed to identify the most relevant architecture taking into account the complexity/constraints on board.*
- *@Spreadtrum (Q2): We believe that some enhancements are specific to NTN and as such should be addressed as part of NR-NTN and/or IoT-NTN work items. However, some other enhancements are not specific to NTN and could be addressed in other WI or in NTN WI (e.g. ReDCAP channel bandwidth reduction, IAB, , ..). This needs further discussion*
- *@Xiaomi: We do agree that for some enhancements, a study phase would be need before normative work can take place*
- *@CATT (Q1): see response to Q1 of Spreadtrum*
- *@CATT (Q2): As regards to TN-NTN coordination, we recommend to consider in priority mobility enhancements and de prioritize TN/NTN multi connectivity*
- *@CATT (Q3): As per asynchronous dual connectivity, we do recommend to consider in priority NG-SO/NGSO and NGSO/GEO scenarios. Please have a look at RWS-210600 for the detailed justification and objectives*
- *@Docomo (Q1): We recommend to undertake a preliminary study phase (including evaluation) aiming at identifying any further issues associated to the support of smart phones. For example, the currently defined features as part of the on-going Rel-17 Coverage enhancements may not be sufficient. For example enhancement to the PRACH may be needed*
- *@Docomo (Q2): We agree that regenerative payload may cause similar spec impacts in both satellite and HAPS based network*
- *@Sony: To improve the link budget, UE performance can be upgraded especially for specific vertical applications (e.g. public safety), other features streamlining the protocol for example to support Voice will also contribute to improve the spectral efficiency. Last we need to consider repetitions and diversity techniques for all channels.*
- *@Intel: Please have a look at RWS-210600 for the detailed justification and objectives associated to the support of UE without GNSS*
- *@CeWIT: Compared to Rel-17 objective wrt beam management, Rel-18 may consider specific BWP configuration per beam in a multi beam per cell context*

Considerations on specific proposed NTN enhancements

- *NR channel bandwidth (5 MHz or less): if also considered for other use cases (e.g. FRMCS, private networks like Anterix), and related use cases can't be addressed by NTN-IoT, it may be also considered for NTN*
- *HD FDD: Further discussion would be beneficial about it for NTN deployment especially for bands above 10 GHz but not limited to.*
- *Support of UE without GNSS: Further discussion is needed about the expected benefits of this feature compared to the technical issues/spec impacts identified. If GNSS cannot be received (e.g. indoor), it is most likely that NR-NTN or IoT-NTN signal won't either be received*
- *DL PAPR reduction: At this stage, there is no clear understanding of the issue to be solved. Further discussion can take place based on simulation results.*
- *TN-NTN spectrum sharing: Further discussion is needed for example to clarify which spectrum and what coexistence scenario to be considered as reference*

· *Network based UE location: Note that this is a different feature compared to "UE without GNSS". It is necessary to meet requirements associated to the regulated emergency call*

Thales recommends for the preparation of the RAN#93-e plenary

· *to consider at least the following enhancements*

o *For NR-NTN: Multi Connectivity & Carrier Aggregation; Coverage enhancement (incl. PRACH enhancements, UL/DL performance Enhancement); Mobility enhancements; Network based UE positioning; HD-FDD; MBS*

o *For IoT-NTN: UE power saving, regenerative payload (eNB on board)*

· *To de-prioritize proposals on new waveform*

· *To further discuss on other candidate enhancements*

3 – HUGHES Network Systems Ltd

We share the view with many companies that NR-NTN and IoT-NTN should be handled as separate items in Rel-18.

Following comments and suggestions from companies, we think it is necessary to carefully down-select on realistic set of enhancements and taking into consideration its commercial deployment. We recommend at least the following:

Rel-18 NTN-NR Enhancement

- Leftover from Rel-17: add MEO scenario to verify the inference in TR 38.821 as covered by LEO and GEO
- Prioritize performance optimization enhancements including throughput per UE, network capacity, UE power saving, service continuity, availability and reliability
- Dual Connectivity to support service continuity between NTN and TN
- Enhance support for VSAT UEs in high frequency satellite bands to enable as relays
- Address requirements associated with regulated services for accurate UE location service

Rel-18 NTN-IoT Enhancement

- Leftover from Rel-17: including HARQ enhancements to support higher UE data rates and enhancements to mitigate impact on power consumption
- Mobility enhancements based on Rel-17 NB-IoT/eMTC

We support UE without GNSS in Rel-18, but have a question if a UE without GNSS can access Rel-17 NTN network.

For TN-NTN spectrum sharing, it is hard to envisage this proposal without regulatory context. An example with scenario using a particular band would be useful but without this clarity the study should be de-prioritized.

4 – MediaTek Inc.

We think Thales and Hughes prioritization for NTN NR and NTN IoT are helpful.

NTN NR:

· @Thales and Hugues : What is the type of dual connectivity between NTN and TN considered? - i.e. asynchronous without slot / subframe alignment because TN and NTN can be expected to have very different delays

· @ Hugues: What are the types of relays for VSAT UEs in high frequency band to enable relay considered?

· @ Thales: We also think support of MBS to expand capabilities can be priority for NTN. We also think support of Voice over NR (VoNR) for NTN as supported by several companies can be priority.

NTN IoT:

We think Hugues prioritizations are helpful. We have the following clarifications

- Disabling of HARQ feedback should be prioritized for higher UE data rates
- Enhancements to mitigate impact on UE power consumption can be optimization of use of GNSS during UE long connection time
- Mobility enhancements based on Rel-17 NB-IoT/eMTC - i.e. with minor adaptations of
- Neighbour cell measurements and corresponding measurement triggering before RLF
- NB-IoT carrier selection based on the coverage level, and associated carrier specific configuration.

@ Hugues: UE without GNSS is corner case scenario (e.g. indoor UEs) and can be de-prioritized. To our understanding, UE with no GNSS capability is not backward compatible with Rel-17 network and may not be able to access the satellite cell.

@ Thales: new waveform should be de-prioritized to high impact on specifications and being not backward compatible with Rel-17 network

TN-NTN spectrum sharing: Motivation is as follows

- Acute shortage of FR1 spectrum for both TN and NTN, esp. in low bands. (i.e. share cellular spectrum for satellite access)
- Opportunity for operators to provide global service across TN/NTN with multimode devices (Same core network can be used for cellular access and satellite access)

TN-NTN spectrum sharing requires identification of the target spectrum and regulatory status, and scope of RAN and core architecture impact

5 – Beijing Xiaomi Mobile Software

We also think Thales' summary is a good starting point for further discussion. Also we share the view that separate WIs for NR-NTN and IoT-NTN should be considered.

For the NTN enhancement:

Regarding the performance enhancements, some companies have concerns on the use case/target on some specific area such as positioning, data rate and coverage. We share the concern to some extend, that's why we think a study phase before nomative work is needed in Rel-18. However, we are hesitate to take some enhancements that have large impact to the legacy UEs such as waveform and bandwidth lower than 5MHz in Rel-18.

Regarding the HAPS, we are open to discuss if it is in a separate SI/WI with NTN or not, this is dependent on the issues that identified.

For the IoT NTN enhancement, we think at least the enhancements on the power saving and discontinous transmissions should be considered in Rel-18.

6 – CATT

To Thales:

Thanks for the carefully checking and the answer.

Regarding to the TN-NTN coordination, we share the same view that we could focus on the mobility enhancement and de prioritize the TN/NTN DC, as we understand that when UE is in TN coverage, it's not necessary to apply DC between TN and NTN cells, accessing via TN is the simplest way.

Regarding to the DC operation between two LEO cells, we assume it's feasible and may bring some benefits for two earth fixed LEO cells. But if earth moving cells are deployment, the MN and SN will both change frequently for a UE, it's not easy to manage the DC operation. What's your view for this?

And for the "recommendations for preparation of the RAN#93-e", we see the regenerative architecture should also be taken as one of the essential topics, and should be prioritized for NR-NTN(also for IoT NTN) in Rel-18.

7 – Nokia France

As listed by Thales in the first round, there are very many different suggestions for NTN and/or IoT-NTN evolution in Rel-18. Progress towards identifying priorities will be necessary and helpful. In the responses above, @Thales, the suggested priorities have one obvious omission which has widespread support, namely support of NTN without relying on GNSS; among the other items some further prioritisation would still be needed.

Summary

Having considered all the contributions, including the motivations and degree of support for each aspect, we would suggest the following for the top 5 in order of decreasing priority. (Note that overall workload and capacity constraints in the WGs will in the end have to determine how many of these can be addressed in practice.)

-

Support of UEs without GNSS (either without GNSS capability, or out of GNSS reception) is widely supported. Note that this improves coverage to indoor and similar locations, where GNSS reception is the limiting factor. Closely related to this is the support of network-based non-GNSS UE location, and support of RedCap UEs.

- **Mobility enhancements** are widely seen as necessary, and support for multi-connectivity and/or coordination between satellite links and/or between NTN & TN seems to have some interest.
- **UE power consumption** aspects are important for both smartphones and IoT devices.
- Consideration of coverage enhancements for smartphone voice/text connectivity is seen as interesting by some companies, although the precise assumptions and solutions are not so clear and would probably need some study first.
- There is interest in supporting regenerative architectures and ISLs, which are also applicable for HAPS.

8 – Guangdong OPPO Mobile Telecom.

Thanks for the companies providing views and suggestions. Among the list of the proposed topics, we think the following should be treated in R18 with higher priority.

1) supporting UE without GNSS capability. This was discussed during the R17 NTN SI phase and potential issue was identified, e.g. GNSS function failure. For NTN-IOT, we should look at a wider service scope in R18, such as device requiring high throughput or staying longer in connected mode. Thus, GNSS measurement may pose a remarkable performance limitation due to the half-duplex operation. Therefore, relaxing the GNSS capability not only is for UE power consumption reduction/cost reduction, but also for optimizing UE user experience.

2) beam management, R17 uses R15 BM as a baseline but it is less efficient for operating in NTN system, which does not consider NTN system specific feature and requirements. At the end, R17 NTN BM operation becomes quite heavy in terms of signaling overhead and also restricted, e.g. the number of BWP to be configured for frequency reuse greater than 1. In R18, we should break this baseline and try to design a more efficient BM mechanism tailored to NTN system.

3) regenerative payload: to fully explore LEO NTN deployment, regenerative payload should be considered and ISL should also be supported. R17 NTN ignored this aspect, which already lapped reg-payload structure behind the market. If R18 does not support reg-payload, it would put 3GPP NTN market penetration in danger.

9 – ZTE Corporation

Answer to #1

Thanks for your questions.

For Q1: The proposed list from your side seems to cover all interests and we may need to further justify the needs and priority for each item.

For Q2: It's still preferred to separate the discussion on the enhancement for NR and IoT over NTN since each of them belongs to different track.

For Q3: We are generally fine with the list. But for the NR case, the needs for power saving is not significant comparing to others. And for IoT, regenerative relevant discussion can be postponed since it may not be realistic to enable the advanced payload for satellite serving the IoT usage.

Answer to #11

Thanks for your question.

For Q1: In our view, supports on regenerative payload is meaningful for NR-NTN case and can be postponed for IoT with consideration on the cost of satellite serving IoT.

For Q2: W.r.t the cross areas for NTN, we need to prioritize the item, which requires more enhancement to deal with the NTN specific scenario, e.g., multiple connectivity.

Comment to #9

As discussed in GTW session, we are still not be convinced on the needs to introduce a new waveform for DL in NTN case. If such action is done in R18, all R17 UEs will be precluded for accessing the NTN network in next release and the timeline for real commercial deployment will be further delayed.

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10 – Sony Europe B.V.

The following comments are "support / not support" list of company priorities and hence do not need to be considered further as statements of "support / not support" are not consistent with the scope of the email discussion: #1, #2, #6, #8, #9, #12, #20, #25, #28, #29

From the "questions" round

#1. The lists of proposed enhancements is selective. For IoT-NTN, power consumption enhancements, latency enhancements and throughout enhancements were also proposed by various companies.

#5. It is not clear why we would add further scenarios, such as MEO. We think that scenarios are only necessary when they push the envelope of the technology.

#11 (Spreadtrum). Q2: we assume "cross areas for NTN" refers to functionality that is common to both IoT-NTN and NR-NTN. There is sufficient coverage of eMTC and NB-IoT already, but we would be open to seeing whether there are some small adjustments that can be made to improve the coverage of CE Mode A in eMTC. For power efficiency enhancements, we think that the reduced latency requirements for IoT-NTN can lead to different solutions than for NR-NTN. We could envisage some common solutions between IoT-NTN and NR-NTN for mobility enhancements and the support of multiple connections. The issue of mutliple connections for IoT-NTN is likely to be more focussed on initial access issues whereas the issue for NR-NTN is likely to be more focussed on spectrum efficiency.

#14 (Oppo). With an antenna gain of -5dBi, we think that an already difficult link budget will be further compromised. We expect that coverage enhancement will be assoicated with lower data rate. This raises the quesiton of what data rate can be served by a coverage-enhanced NTN-smartphone with a -5dBi antenna.

#15 (Xiaomi). Given that the IoT-NTN Rel-17 study was cut short in order to focus only on essential minimum functionality, we think that it would be reasonable to start Rel-18 with a study on enhancements, since enhancement were not really studied in Rel-17.

#16 (CATT). It is not clear how much IoT-NTN coverage enhancement is possible with respect to eMTC / NB-IoT. We would be open to seeing whether there are some small adjustments that can be made to improve the coverage of CE Mode A in eMTC.

#17 (DoCoMo). We totally agree that we should not be discussing a topic list as this is against the chairman's guidance.

#18 (Samsung). In terms of the signalling overhead (in the Rel-17 leftover section), there is also the issue of PRACH congestion after signalling of ephemeris / position&velocity in IoT-NTN. We think that this needs to be addressed in Rel-18.

#28 (Inmarsat). We would like to understand why there needs to be consideration of specific satellite orbits, unless some orbit pushes the boundaries of the NTN work. The boundaries seem to be defined by GEO and LEO-600. Other orbits would only need to be conisdered if they changed led to specification changes.

From the "answers" round

#2 (Thales). If UE performance is upgraded for specific vertical applications, then should we assume that you are not considering a "normal" smartphone? The link budget for GEO and some LEO constellations (in IoT-NTN at least) already only support low data rates. Repetition will further decrease the data rates. It is unclear what diversity techniques you are considering. What diversity is available in an "open skies" AWGN channel? How "smart" is a smartphone that only supports voice data rates?

11 – Eutelsat S.A.

We think NR NTN and IoT NTN should continue being addressed via separate work item streams, even though synergies between the two are still expected and should be encouraged.

Focusing on IoT-NTN, the Rel-18 work should include the following enhancements:

· Discontinuous coverage improvements (on top of the Rel-17 baseline) to further optimize Satellite-UE coverage periods coordination and power savings

· SIB acquisition / assistance information provision improvements (on top of the Rel-17 baseline)

· Further power saving / spectrum efficiency / HARQ optimizations

- Network based location improvements (e.g. to supplement GNSS-based location, to allow network access without (accurate-enough) GNSS fix, to provide GNSS anti-spoofing assistance)

· Mobility enhancements (including w.r.t. NTN-TN mobility)

· Store and Forward - Regenerative architecture

5 Evolution for Broadcast and MBS services

This section is targeted at identifying commonalities and interactions for Evolution for Broadcast and MBS services.

Feedback Form 9: Questions/Comments

1 – ABS

From 5G-MAG's RWS-210205, we can see it proposes "Receive-only mode/Free-to-air for MBS" in Rel-18. MBS in ROM/FTA mode is actually broadcast not multicast, isn't it?

If NR broadcast is supported, I think HPHT will be more efficient than LPLT in the coverage perspective just as what Broadcast Network Operater (MNO) have chosen.

So further extend the NR broadcast which is proposed in your Tdoc RWS-210205 to support both LPLT and HPTH might give more deployment option especially for BNO. This point is also proposed in RWS-210653 by ABS.

2 – MediaTek Inc.

Thanks for organizing the discussion for Rel-18 MBS enhancement.

We see the following subtopics for Rel-18 from the perspective of MBS evolution :

(1) Support inter-cell based SFN in a larger area (e.g. inter-DU SFN). Extended CP may be needed. Both normal CP and extended CP can be co-existing in order to avoid backward compatibility for legacy UEs

(2)Some continuation of Rel-17 MBS discussions, E.g. L2 reliability with L2 feedback and retx at PDCP or RLC; Multicast support for Inactive/Idle mode UEs

(3)New study on the DL superposition coding (DL MUST/NOMA alike) scheme between two or multiple MBS services, and between unicast and broadcast services.

- Basically two services can be multiplexed at the same frequency resources. E.g. they can be modulated by different MCS and then map to different OFDM symbols.
- Two services are transmitted at two different layers (one is core layer, and the other is enhanced layer)
- Some UEs can just receive the core layer (e.g. low MCS) and other UEs can receive both core layer (e.g. low MCS) and enhanced layer (e.g. high MCS).

3 – BBC

BBC believes that multiple companies have requested the following features be considered for Release 18:

- MBS Receive-only mode to support Free-to-Air broadcast service;
- the study of non-orthogonal techniques in relation to Broadcast/Multicast and Unicast Superposition Transmission (e.g. BMUST);
- to complete potential leftovers from MBS work under Rel-17; and

-

to prioritise transparency to UE hardware in any new techniques.

4 – FirstNet

Public safety personnel require Multicast support for Inactive/Idle mode UEs. In addition, first responders also require broadcast and multicast services even when they are out of cellular network coverage areas.

5 – ZTE Corporation

1. By looking back on MBS support in 3GPP, we have already two different tracks, with each focusing on one specialized scenarios namely: Terrestrial broadcast in Rel-16 and mixed/dynamic broadcast in Rel-17. Therefore, we shall be careful about how to map the market needs to the coming evolution of the techniques, e.g., to avoid possible overlapping techniques/solutions to the same or similar scenarios. This guideline or principle can be applied to the technique choices for the scope of Rel-18 NR MBS. Take MBSFN in NR for example, we believe it is beneficial based on our initial simulation. However, there should be a balance between the spec impacts (e.g., network architecture: how to allocate the SFN resources across network nodes), and how to meet the market needs which can be further discussed.

2. Based on the pre-workshop discussion, Multicast reception in RRC INACTIVE got lots of attention: with the majority support during Rel-17 NR MBS RAN2 discussion, and there is explicit support from verticals like MCPTT. Therefore we suggest Multicast reception in RRC INACTIVE as one of the key issues to be supported in Rel-18 NR MBS, scope of which can be further discussed in later stage to better meet the vertical needs.

6 – Spreadtrum Communications

For R17 Leftover issue, some contributions (RWS-210015, 210126, 210205, 210374, 210406, 210473) proposed to support RRC_INACTIVE multicast service reception in R18. We want to clarify whether or not RRC_IDLE state can be supported for multicast service reception in R18 as well?

7 – vivo Communication Technology

1. For FTA, We have supported Broadcast in idle/inactive UE, what would be the enhancements for FTA in RAN?

2. For L2-based retransmissions to support reliability for multicast, considering that had been discused in R17 what is the benefit with huge complexity?

3. For “Introduce necessary changes to connect LTE-based 5G broadcast to 5GC”, how to evaluate RAN3 impacts ? Is there a MCE entity needed in 5G?

4. For “Dynamic control of the broadcast transmission area”, would be understand better the justification, and how dynamic it would be?

5. For “SFN support for inter-gNB/DU scenarios”, what is spec impact? Is there a sync protocol needed?

8 – Guangdong OPPO Mobile Telecom.

-

R-18 MBS is also RAN2-lead project, which is similar with R-17 MBS. How is R-18 MBS work suppose to impact other WGs work, e.g. RAN1?

- Some companies proposed to continue doing the potential leftovers in R-17 MBS, e.g. HARQ-ACK feedback designs. It is not expected to introduce further complexity design to the current reliable mechanism.

- On support of multicast reception by [RRC_IDLE] / RRC_INACTIVE UEs, from RAN1's perspective, there is no difference between RRC_IDLE and RRC_INACTIVE states. Furthermore, RRC_IDLE state UEs receiving multicast is not feasible. It is supposed that RRC_INACTIVE state can be kept. How to realize power saving and resource efficiency by supporting multicast reception when UEs in RRC_INACTIVE states? Since some companies also proposes to support feedback mechanism (e.g. ACK/NACK or NACK-only based FB) for RRC_INACTIVE UEs, potentially L1 feedback for a UE in RRC_INACTIVE state consumes extra UL transmission power.

- For intra-CU SFN, some companies consider ECP for coverage enhancement. Intra-CU SFN is RAN3 related work to study synchronization issue for different transmitters in different DUs.

- On Free-to-Air (FTA) / Receive-only mode, Obj. B is not discussed / supported in R-17 MBS because of lack of discussion time, it is technically reasonable to support it in R-18 MBS. How FTA impact other RAN WGs besides RAN2? Currently it is supposed to be mainly/purely RAN2's normative work, how about other groups can be involved, e.g. RAN1?

9 – Beijing Xiaomi Mobile Software

We are quite interested in the MBS enhancements. We think that it is important to support the MBS for MR-DC, as it seems that the Rel-17 MBS will not be able to support all MR-DC architectures and bearer types due to the very limited discussion time in Rel-17.

10 – CATT

Observation on NR MBS enhancements discussions

The following directions seem to get wide support in the previous discussions on Rel-18 NR MBS enhancements

1) FTA support

2) Multicast reception in RRC_INACTIVE/IDLE state

3) Improvements to reliability and efficiency (R17 leftover from both physical layer and higher layer)

4) SFN enhancement

Some observation for next step discussions.

Observation 1 Some of the aspects (e.g., 1 and 2 above) may require work scope alignment between RAN and SA in Rel-18. Then the exact work required in RAN can be further discussed.

Observation 2 Some analysis or evaluations may be needed to better understand which solutions can achieve a better balance between performance and complexity (e.g., for 3 and 4 above).

Then we observe some other aspects have also been discussed. We suggest further discussions and alignment on companies understanding on motivations/impact in the next step.

a) MBS+DC,

b) Improved efficiency for MBS in RAN sharing scenario,

c) Transmission area adaptation for broadcast

d) Mobility enhancements, and

e) Other potential enhancements (e.g., simultaneous MBS and Unicast, Power saving for MBS, etc.)

General comment on NR MBS

A general comment from our side is that we should first align companies' views on those aspects that have wide support. For the other aspects, further discussions would be helpful, taking into account both motivation and complexity analysis.

Question on some aspects for NR MBS enhancements

In order to better understand companies' views and figure out a list of possible areas for next step discussions, we have the following questions.

Question 1 Which aspects do you see that some alignment in SA and RAN is needed to support them in Rel-18, e.g., including FTA, multicast in idle in Rel-18, and maybe some other aspect?

Question 2 What is your view on the main targeted scenario if NR SFN is studied, e.g., is it high tower or typical cellar in urban or rural area?

Question 3 Which of a-e) below do you see a strong need to include in Rel-18?

a) MBS+DC,

b) Improved efficiency for MBS in RAN sharing scenario,

c) Transmission area adaption for broadcast

d) Mobility enhancements, and

e) Other potential enhancements (e.g., simultaneous MBS and Unicast, Power saving for MBS, etc.)

11 – China Mobile Com. Corporation

Thanks for the organizing the discussion. Regarding the target scenario of broadcast and multicast, CMCC thinks LTE based terrestrial broadcast is used in HPHT scenario and mixed mode NR MBS should focus on LPLT scenario operating by MNOs.

For Rel-18 NR MBS, CMCC thinks the following enhancement aspects can be considered as high priority:

1) Leftovers from Rel-17, including L2 reliability, multicast in RRC_IDLE/INACTIVE which have been excluded in Rel-17 and may also contain L1 HARQ-ACK feedback enhancement, HARQ process management and multicast beam management depend on further Rel-17 outcome.

2) Intel-cell SFN support, we prefer not introducing new numerology.

3) FTA/ROM support.

4) UE Power saving for MBS service, e.g., DCP for MBS DRX cycle

5) Support of RAN Sharing in NR MBS

The following aspects is with low priority:

1) Resource optimization for RAN sharing scenario.

2) MBS in DC.

3) Advanced multiplexing scheme between MBS and unicast.

4) Dynamic adaptation of broadcast area.

12 – Samsung Electronics Co.

- We think multicast in IDLE/INACTIVE is useful especially for local dense deployment scenario, (e.g. FS_PALS defined in SA1) and public safety/critical communications. Also, solutions to be developed in WG may depend on our target scenarios/use cases. Are there any other scenarios/use cases for this?

- We think, for FTA/ENTV, Rel-17 broadcast mode can be highly reused. Then, what additional functionality is required from RAN perspective? Especially does NR PHY need to be enhanced?

- For MBSFN-like mode, Rel-17 broadcast mode can replace it, so additional MBS mode may not be needed. We think MBSFN-like mode will give huge specification impact to both RAN1/2/3. Is there essential use case?

- Regarding reliability enhancements beyond Rel-17, we do not see any change of requirements for Rel-18 MBS. We think Rel-17 MBS can meet most of requirements by various features defined in RAN1 and RAN2 (e.g. HARQ FB, PTP transmission, Split MRB, etc.) Is there any reason to ensure enhanced reliability?

13 – Sony Europe B.V.

We would like to suggest for the next round that any enhancement should be clearly labelled if it is for LTE or NR or both.

14 – HUAWEI TECHNOLOGIES Co. Ltd.

[Huawei, HiSilicon] LTE-based Terrestrial broadcast connecting to 5GC was proposed only by 4 contributions. We observed that in the email Q&A phase, several companies asked for clarification of the business motivation. It would be good for proponents to clarify whether there is any operator who deployed 5GC that requested LTE-based Terrestrial broadcast to connect to 5GC due to business needs.

15 – Lenovo (Beijing) Ltd

- Regarding Broadcast/Multicast and Unicast Superposition Transmission (BMUST), we have some concerns: Seemingly, same time-frequency resource are simultaneously used for both multicast and unicast. Are they differentiated by different layers? For RRC idle/inactive UEs, how can they suppress the interference from unicast? Compared to the time-frequency resource solely used for unicast transmission, e.g. via MIMO, is there performance degradation for unicast transmission when it is shared with multicast transmission?

- Regarding the extended CP, we are supportive of ECP in Rel-18 for coverage enhancement.

- We agree UE power saving is important for multicast reception for both connected mode UE and idle mode UE. However, we are not sure which of the existing Rel-16/Rel-17 UE power saving technologies will be applied as starting point.

16 – Ericsson LM

We think the work should progress with the existing use cases. There is one HPHT solution in enTV/FeMBMS and one multicast/LPLT solution for NR. There are proposals to connect enTV/FeMBMS to 5GC. We don't see the justification for doing so given the high architectural and security impacts. Enhancements, especially those which have a heavy architectural impact, have to be commercially justified. In order for Rel-17 broadcast/multicast to be timely deployed and used we think it is important that any additions or enhancements in Rel-18 can be easily added on top of a Rel-17 deployment.

Feedback Form 10: Answers/Comments

1 – Qualcomm Incorporated

Regarding the comments on EnTV connected to 5GC, we would like to clarify the following:

- The architecture work (SA2) can be reused between MBS and EnTV.
- The impact in RAN is restricted to RAN3. We should strive to make this change as small as possible.
- Regarding the need for this enhancement, we would like to mention that EnTV is introduced quite late in the LTE lifespan (R14, 16, 17), so the motivation of being able to connect it to the 5GC should be clear.

2 – Intel Corporation (UK) Ltd

We support MBS enhancements in general. In high level directions, we agree with Qualcomm's categorization in RWS-210013 and Ericsson's comments that there are separate tracks for terrestrial broadcast (as in LTE based 5G terrestrial broadcast) and mixed mode (as in NR MBS). They are targeted for different deployment scenarios, and we should avoid introducing overlapping features for the two tracks in Rel-18.

With above principle in mind, following are our views on two proposed enhancements:

- Introduction of inter-DU SFN in NR MBS: our understanding is that large scale SFN is already supported in terrestrial broadcast track (as in LTE FeMBMS), and there is no need to introduce SFN above DU in NR.
- Connecting LTE terrestrial broadcast to 5GC: given that RAN and SA architectures are tightly coupled for both LTE FeMBMS and NR MBS, it is better to wait for SA conclusion (e.g. regarding architecture aspects) before considering any work in RAN WGs.

From contributions and email discussion, we observe that following NR MBS enhancements have wide support and propose to include these enhancements in Rel-18 work:

- Support of multicast in RRC_INACTIVE: the topic was actually supported by many companies during RAN2 Rel-17 discussion and was deprioritized due to lack of time. This topic gains very wide support for Rel-18. One discussion point for Rel-18 is whether to support multicast in RRC_IDLE as well, which needs the input from SA2.
- Reliability and radio efficiency enhancements in L2 and physical layer.
- Power saving enhancements: the exact scope might depend on outcome of Rel-17 discussion.

Other NR MBS enhancements (e.g. mobility enhancements) can be also considered.

3 – HUAWEI TECHNOLOGIES Co. Ltd.

[Huawei] Here are our final considerations, trying to answer most of the questions raise in this round.

Summary of Questions

MBS broadcast optimization for FTA deployment got wide support from companies reply. Some questions were raised about the expected RAN impacts for FTA, especially what enhancements are needed for FTA on top of DM2 specified in Rel-17, and whether there would be work/enhancement in other groups than RAN2 (e.g. RAN1).

Our Answers

Huawei's view is that Rel-17 DM2/broadcast can in general be used to deploy FTA. However, in order to share the capabilities for unicast and FTA, as specified in LTE, the UE should report the capability reduction for unicast due to FTA carrier reception and it is yet unclear whether this will be supported in Rel-17.

On the impact to other groups, we think RAN1 might need to be involved for the discussion on the capability sharing between unicast capability and FTA reception capability. However, we think no additional functionality is required to be introduced in NR PHY. SA2 might need to be involved as well, but the aspects of the work in RAN WGs and SA2 are rather independent, i.e. no major inter-dependencies or coordination are expected.

Summary of Questions

Concerns were expressed on the feasibility of multicast reception in RRC_IDLE mode and power saving gains in case of L1 feedback to be supported, as proposed by some companies.

There was a question to confirm whether RRC_IDLE state can be supported for multicast service reception in R18 as well.

There was also a question on the target scenarios/use cases for multicast in IDLE/INACTIVE in addition to the local dense deployment scenario and public safety/critical communications.

Our Answers

Huawei's view is that this enhancement is for the network congestion scenario and no other cases have been identified by us yet. In this case, we think it would be acceptable that the reliability/QoS requirement is relaxed compared to multicast delivery for UEs in RRC CONNECTED state and therefore the uplink feedback is not essential for such a scenario.

On multicast in IDLE, Huawei's view is that since in Rel-17 multicast is supported only in NAS CM*CONNECTED, the support of multicast in IDLE would require also some work in SA2 in Rel-18. We are open to discuss whether to also support RRC*IDLE, in addition to RRC_INACTIVE (which is simpler and has got more support).

Summary of Questions

Questions were raised about the intended scenarios (HPHT or LPLT), use cases, and expected specifications impacts.

Our Answers

On the intended scenarios and uses cases for SFN enhancement, our view is that SFN enhancement is targeted for cellular network. SFN improves SNR of the MBS transmission which translates into improved spectral efficiency and/or coverage, which is beneficial for all the MBS use cases. In particular, the use cases which we think require inter-gNB SFN deployment are wide area live TV/video broadcast, group communication, regional live video, V2X and so on.

On the possible specification impacts, ECP would require RAN1 work and how to achieve network synchronization among sites would require more discussion when scoping the WI, for example, by RAN based sync, LTE-like sync protocol, or even implementation based approaches.

On the comment from one company "*We think MBSFN-like mode will give huge specification impact to both RAN1/2/3*", we think there might be some misunderstanding on the SFN support for NR MBS. It should be noted that we can already support SFN by implementation in Rel-17 without specific PHY change. We do not intend to develop new PHY channels/signal for SFN operation (like it was done for LTE MBSFN). Our view is to adopt the common PHY design (e.g., PDCCH and PDSCH) and framework as in unicast for broadcast/multicast from both single and multiple cells SFN transmission (i.e. as in Rel-17 MBS).

Summary of Questions

Questions were raised about the benefit/motivations for further enhancements in Rel-18.

Our Answers

We see some use cases from 5GAA WG1 where very high reliability requirements (10ms latency and 99.9999% reliability) are needed. Rel-17 NR MBS WI has an objective to support high reliability for Multicast and the solutions are being discussed in RAN WGs. We are open to discuss further enhancements to reliability in Rel-18 if the solutions specified in Rel-17 cannot meet all the reliability requirements of the above V2X use cases.

Several more questions and comments were raised on different aspects, here we show our views on some of them below.

BMUST

In general, BMUST could potentially improve capacity but there are some issues that need to be studied, including RRC states applicability, if BMUST is included in the scope. Also the impact in WGs needs to be carefully considered.

RAN sharing improvements

Improved efficiency for MBS in RAN sharing scenario: this feature is quite simple and the gains are very clear. In addition there are some real deployments that could benefit from this feature. We see some small impact in SA2/RAN3.

Power saving

We think that existing Rel-16/Rel-17 power saving technologies such as DCP or wake up signal may also be beneficial for G-RNTI DRX or group paging, so can be considered for MBS. Nevertheless, we can check at a later stage whether these can be applied to MBS already in Rel-17 or some additional work can be considered for Rel-18.

4 – Guangdong OPPO Mobile Telecom.

Answers to the questions of MBS:

1 - ABS

A: Yes.

FTA service can be considered/treated as a broadcast service according to the definition of broadcast defined in 23.757.

Furthermore, supporting FTA is not equivalent to supporting HPHT/LPLT. The relationship between power/tower and broadcast service can be further discussed and defined.

10 - CATT

A1: N/A

A2: Both high tower and typical cellular in urban or rural area can be considered based on various requirements and targets.

A3: e) simultaneous MBS and unicast, Rel-17 leftovers, SFN, and FTA/ROM can be included in Rel-18.

11 - CMCC

A: We share the similar views on the prioritized topics by CMCC. The other issues are considered with low priority that is not necessary to be touched in Rel-18.

12 - Samsung

A1: N/A.

A2: There seems none or not so much work needs to be done in RAN WGs (especially in PHY layer) perspective when supporting FTA. We also consider that FTA less RAN impact.

A3: Whether MBSFN is supported or not in Rel-18, huge specification impact/work is not expected by companies. It is not a good idea to support a feature by dramatically increasing the normative work. A more proper way is that how to support something by applying the current system/mechanism as much as possible.

A4: If the reliability requirements for Rel-18 MBS is not change, there is not clear motivation to further enhancement by considering Rel-17 reliability improvement mechanism.

14 - Huawei

A: Similar view on supporting LTE-based terrestrial broadcast in Rel-18 MBS. The motivation/benefit is not clear.

5 – CATT

Our response and comments to companies' input in the previous round

On #1

Yes we also think FTA is for broadcast, not multicast.

On #2, #3

Agree with many of the points. For enhancements like MUST we tend to think more discussions are needed on its motivation/benefit and potential complexity.

On #4, #12

We agree that idle state support also needs to be considered. In previous discussions, its potential impact (to RAN and SA) has already been clarified.

On #2, #5, #12

We agree that SFN enhancement could be further discussed. As previously commented we need to first align on scenarios. Then we agree with comment in #5 that it shall aim at a balance between benefits and complexity.

On #7, question 4

As discussed in previous weeks, R17 mechanism has limited and it is rather static, which is not very efficient. We see room for efficiency improvement with limited extra complexity. We'd like to discuss further with companies on this direction.

Our observation based on the discussions so far

It seems in the next step we could further discuss NR MBS enhancement in the following directions.

Firstly, some aspects that seem to have wide support

1) FTA/ROM support

2) Multicast reception in RRC_INACTIVE/IDLE state

3) Improvements to reliability and efficiency (R17 leftover from both physical layer and higher layer)

4) SFN enhancement

The, some other aspects in the discussions so far.

a) MBS+DC,

b) Improved efficiency for MBS in RAN sharing scenario,

c) Transmission area adaptation for broadcast

d) Mobility enhancements, and

e) Other potential enhancements (e.g., simultaneous MBS and Unicast, Power saving for MBS, etc.)

Last but not least, as we have commented we agree with many that in a later stage we need careful dimensioning of the scope for NR MBS enhancements in Rel-18. Such discussions should take into account both potential benefits and complexity, to really provide high quality standards based on market needs.

6 – ZTE Corporation

1. For Rel-18 the baseline shall be recognizing any valuable leftover in Rel-17 due to the not-so-productive meeting progress, e.g., Multicast reception in RRC INACTIVE, and meeting the need from verticals that was not covered in Rel-17, e.g., SFN/FTA/ROM.

2. For cross DU/gNB SFN, it will be a huge impact for network architecture interfaces, e.g., what is the coordination node to allocate the resources, which interface to handle the coordination (e.g., for Xn, the availability of which might be a concern, it is going to be an limitation of network deployment.). However, intra-DU/gNB SFN requires smaller specification impact, which can be considered for Rel-18 from our perspective.

3. For Multicast reception in RRC IDLE, although it is doable after some coordination with SA2, it is not suggested to do so: allowing reception of Multicast in RRC IDLE makes Multicast no different from Broadcast from both AS layer and 3GPP network capability exposure's perspective, which is a bit against the initial decision that 3GPP differentiated Multicast from Broadcast in the beginning. That being said, we are open to hear more opinions from companies and other WGs.

4. One scenario suggested by companies is MBS for out of coverage, we believe this can be met by NR V2X/Sidelink in Rel-16 and enhancement in Rel-17, in which broadcasting to other UE around or groupcasting to a group of UE is possible.

7 – CBN

Thank you companies for the active contribution to the topic. Based on the previous discussions we have the following comments.

1) We appreciate companies proposals to NR MBS enhancements in Rel-18. Among the many proposals, we observe the following get relatively wide support for further consideration

- Better support of FTA
- Support multicast in idle/inactive state (the impact of idle has been clarified in previous discussions).
- SFN enhancement

We also support these aspects.

Then we'd suggest RAN to further discuss on other important aspects as we listed in RWS-210195, e.g., for improvements towards scenarios such as RAN sharing and new services such as XR. We are happy to discuss with companies further on this.

2) On LTE EnTV related enhancement we are not sure about its urgency, and we observe that in the previous round there were similar comments from companies. In general, we believe when planning the R18 work scope we need to take the TU into account, so that 3GPP provides high quality standards that meet the market requirement.

8 – BBC

In general, we also agree and support the two-track approach in relation to MBS and that these target different deployment scenarios. We would see NR MBS enhancements as targetting cellular networks. We think that the list provided by China Mobile sensibly summarises the main points but think that, in general, further discussion is needed on prioritisation.

Regarding the questions relating to BMUST from Lenovo (#15), yes, it is envisaged that multicast and unicast are indeed carried in two layers. The multicast layer is decoded assuming the unicast is treated as noise.

Finally, regarding Huawei's answer (#3) and comments from others relating to SFN operation of NR MBS, perhaps a study would be the best approach to come to a common understanding of the potential benefits and impacts of a 'basic' SFN operation.

6 Expanded and improved Positioning (incl. SL and RedCap Positioning)

This section is targeted at identifying commonalities and interactions for Expanded and improved Positioning (incl. SL and RedCap Positioning).

Feedback Form 11: Questions/Comments

1 – DanKook University

From the past Q&A session, we found clear interest and support on the subject of carrier phase positioning. Although there are some issues raised, that's the reason why 3GPP needs a comprehensive study on the carrier phase-based positioning in release-18.

In our perspective, we propose that the following issues should be dealt in release-18 positioning.

- sidelink positioning
- carrier phase positioning
- RedCap positioning
- machine learning for positioning

Note that the carrier phase-based method may also be included as one enabling technology in sidelink, RedCap, and machine learning.

2 – FirstNet

For public safety services, accurate location determination is of paramount importance not only when the personnel are in-coverage but also while they are in partial-coverage and out-of-coverage scenarios. This must be one of the top priority topics for Rel-18.

3 – ROBERT BOSCH GmbH

Note: our TDoc RWS-210216 (SL-positioning) was not listed in section.

- It is clear from most of SL enhancements contributions that SL positioning is supported for all coverage scenarios using at least UE-based SL positioning (SL positioning only) or SL positioning assisting Uu.
- At least two sources (RWS-210322 (Fraunhofer) and RWS-210215 (Bosch) considered supporting techniques and methods to reduce network/infrastructure positioning complexity including: 5G nPositioning Reference Devices (PRD) or 5G DL-PRS beacons (at least for IIoT scenarios)

4 – ZTE Corporation

Based on our review on companies' tdocs, we think the following high level aspects should be studied or specified in Rel-18. Some questions and comments are provided under each high level aspect.

1. Sidelink positioning

Should we specify sidelink positioning based on Rel-17 sidelink structure? Specifically, should we specify sidelink positioning in unlicensed spectrum in Release 18? Since unlicensed spectrum is not supported for sidelink until now, it is better to specify sidelink positioning in ITS spectrum and licensed spectrum in Rel-18, and further consider unlicensed spectrum for sidelink positioning in the future release based on Rel-18 sidelink outcome.

2. RedCap positioning

Some RedCap dedicated positioning solutions (e.g. frequency hopping) may affect the unicast transmission, scheduling, channel measurement and CSI feedback of Redcap UEs. This impact will cause Regular RedCap related standards effort. Whether/how to handle such enhancement which has impact on the

regular RedCap UE behaviours other than positioning? In our view, it is better to let RedCap experts handle this kind of discussion.

3. Integrity of RAN-dependent positioning

This is very important based on the feedback from market and operators, the high accuracy positioning without integrity info is not acceptable to verticals. So our view is that the feature should be studied and specified in Rel-18 for the commercial use case. We would like to hear other companies' views.

4. Enhancement for higher accuracy positioning, low latency, and low power consumption

After reviewing companies' tdocs, both FL/carriers aggregation and carrier phase based positioning attract much interest for high positioning accuracy. Positioning on DRX/inactive/idle is also proposed for the sake of low latency, etc. So many enhancements are proposed. We suggest to list all candidates and further discuss.

5. Should we study/specify machine learning under positioning discussion?

From our view, a dedicated SI for machine learning is expected in Rel-18. All interesting physical layer use cases including positioning should be identified and evaluated in that SI first.

5 – vivo Communication Technology

1. Positioning over unlicensed is one of most important enabling technology for more commercial, industrial, and other potential scenarios with high interest. We think the Rel-18 item should consider such aspects. The specification should include both unlicensed band below 7GH and unlicensed band at 60GHz considering the large amount of bandwidth available.

2. Sidelink positioning should consider both commercial scenarios and other scenarios. XR positioning requires ultra-high accuracy and ultra-low latency positioning with low power consumption for better user experience. Further enhancement on sidelink positioning should consider these aspects. For V2X and public satefy scenarios, power consumption should be considered, especially considering the pedestrian UEs and first responders in extreme conditions.

3. For redcap positioning, how to handle it (e.g. in which WI) will depend on the expected work, if only RAN4 requirement is considered (for reduced BW UE, 1Rx), we can include it in the eRedCap WI. Otherwise, if there is some techincal enhancement needed (so far it is not very clear to us what technical enhancement would be but we are open to hear other companies views), we could discuss it in ePositioning WI.

6 – Apple GmbH

In general, we are supportive of further positioning enhancements, particularly for SL positioning, RedCap positioning and positioning accuracy improvement. We have some questions on the detailed proposals.

Some contribution, e.g., RWS-210315 from Ericsson, mentions support for "RAT-dependent positioning integrity". We would like to understand more about the urgency and necessity of this work. GNSS community developed the GNSS integrity solution w/o any support of 3GPP before Rel-17. Similarly, if there are some real business interests for tracking the system reliability of RAT-dependent positioning solutions, application layer approaches can be built on the top of current 3GPP solutions. If this integrity KPI is mature enough and widely adopted for RAT-dependent LCS systems, then we can consider to have some signaling support in 3GPP. It is pre-mature to standardize this in Rel-18.

Some contribution, e.g., RWS-210429 from InterDigital, mentions "Unlicensed band assisted positioning", we would like to get some further clarification on this concept, e.g., whether it means the support of positioning based on NR-U and/or NR sidelink

Regarding positioning using higher frequencies (i.e., >52.6 GHz), in our view, it is an interesting topic from a technical point of view, but perhaps it is better to wait until, at least, some initial deployments in those bands materializes before designing positioning schemes, especially if those will require substantial changes.

7 – Guangdong OPPO Mobile Telecom.

Based on the tdoc reviews, companies show interest in the following fields: positioning for RedCap UE, low power positining, further improving positioning accuracry, carrier-phase based positioning, in unlicensed band, SL positioning.

Regarding the RedCap UE positioning, we woud like to understand what specific enhancements are needed here. The PRS specified in rel16 can support minBW = 24 PRB and that seems to be sufficient to support RedCap UE. If aggregation of PRS in different band is considered for RedCap UE, that would increase the UE complexity significantly due to extensively requirement on timing and phase offset between different RF chains.

Regarding the carrier phase positioning: we would like to understand that in the NR deployment scenarios with rich multipath or NLOS, does the carrier phase positioning has extra performance gain over the existing NR positioning method?

8 – Beijing Xiaomi Mobile Software

1. According to contributions in positioning session, we can find that many companies proposed NTN positioning, narrowband/redcap positioning and sidelink positioning. We think it is necessary to decide in which WI these topics should be discussed first in order to control the scope of each WI. And for the accuracy improvement proposed from some companies, could you please provide more details on the application scenario?

2. Based on the rel-18 workshop contributions, both redcap UE positioning and low power high accuracy positioning are proposed. Some use cases for LPHA positioning are dolly tracking, assert tracking and tool tracking, we think the IoT devices for these use cases are also with low bandwidth and low processing capabilities, so we are wondering whether positioning methods for lower power high accuracy positioning can be reused for redcap positioning and whether new UE type for low power high accuracy positioning will be introduced?

3. SA1 has finished the Ranging Work Item, a set of KPIs and functional requirements are captured in TS22.261 v18.3.0. Compared to V2X and public safety use cases, for commercial use case, ranging has some unique requirements for IOT devices on power consumption (for IoT devices to be able to work for months), low cost (e.g. large positioning/ranging signal bandwidth but small communication bandwidth, or RedCap UE support), security (for some IOT devices, its location is not linked to the user, secure link may not be needed when performing positioning/ranging), capacity (the density of IoT devices can be considerably larger than V2X/public safety devices, system capacity need to be taken into account). Ranging also provides a set of functional requirements that RAN can take into account, e.g. one hop ranging, one-2-many ranging, ranging discovery, mutual ranging etc. As such, do you agree that sidelink positioning should consider not only V2X, public safety use case, but also commercial use cases as defined in Ranging in TR 22.855/TS22.261?

4. Due to the high bandwidth requirement for high accuracy positioning/ranging(e.g. 400MHz), do you agree that unlicensed spectrum up to 71GHz should be considered?

9 – Nokia France

Considering all the contributions, the following are identified in terms of **requirements** (in roughly decreasing order of popularity):

1. Ranging
2. Low-power positioning
3. Accuracy enhancements (down to cm-level)
4. RAT-dependent positioning integrity
5. Latency reduction

For **ranging**, the most identified technique by far is **sidelink-based**, although it is also noted by some companies that ranging can also be provided over the network (if coverage is available), with or without sidelink assistance.

Low-power positioning is primarily targeted at **RedCap** devices, but may also be applicable to other devices. Support for positioning in RRC_IDLE is the most identified technique here.

The main techniques proposed for **accuracy enhancement** in general (apart from sidelink assistance) are terrestrial **carrier-phase positioning**, **PRS/SRS bandwidth aggregation**, and the use of **wide bandwidths at 60 GHz** (which also implies the ability to transmit PRS in unlicensed spectrum, which is also seen as relevant for sidelink positioning).

It would therefore be a reasonable expectation that Rel-18 work on positioning could include at least:

- sidelink-based and sidelink-assisted positioning,

- low-power positioning, including for RedCap devices

- carrier-phase positioning and/or PRS/SRS bandwidth aggregation,

- PRS transmission in unlicensed spectrum, including 60 GHz.

10 – Guangdong OPPO Mobile Telecom.

On SL Positioning:

Companies discussed the use cases, how to organize the item, carrier, etc. We would like to make following comments based on our interest:

- SL positioning for commercial use cases can be also useful/beneficial, and should be included in the scope.
- If wide bandwidth is required, SL PRS signal could be possibly transmitted using more than one carrier (not necessarily always over unlicensed).

11 – CATT

According to the previous email discussion, many companies are interested in achieving higher positioning accuracy, e.g. via NR carrier phase positioning, supporting positioning in new vertical cases, e.g. V2X, public safety, high-speed train etc., and extending positioning to new types of devices, e.g., RedCap and LPHAP. The main aspects are summarized as below:

- NR carrier phase positioning;
- RedCap positioning;

- Low power high accuracy positioning (LPHAP);
- High speed train positioning;
- AI/ML-based NR positioning;
- Sidelink positioning;
- Rel-17 leftovers.

NR carrier phase positioning:

In our view a number of key issues need to be investigated, including: a) whether it is sufficient to reuse existing DL/UL positioning reference signals for supporting the NR carrier phase positioning; b) whether to introduce new reference signals specific for carrier phase measurements; c) the methods for resolving potential challenging issues, such as the impact of network time/frequency synchronization errors, the integer ambiguity resolution, the cycle slip detection, the impacts from phase discontinuity in time-domain, etc.

Question 1: Do you think there is any other issue to be clarified or investigated for the NR carrier phase positioning?

RedCap positioning:

In our view there is a need to discuss whether to simply reuse of R17 positioning resolutions for RedCap positioning (in this case the main workload is in RAN4 for specifying the performance requirements), or there is a need to have further improvements of RedCap positioning, including the increase of the accuracy, and reduce of latency, UE complexity and/or UE power consumption in RedCap positioning.

Question 2: We would like to know companies' opinions on what aspects should be enhanced for RedCap positioning.

Low power high accuracy positioning (LPHAP):

At this moment it seems there is a need to further discuss the methods that are able to support high-positioning accuracy in one hand, while have very low power consumption on the other hand. In our view, there is a need to first define the target KPIs of LPHAP (accuracy, power consumption, potential battery life, etc.) and then study the proper solutions to achieve the target KPIs.

Question 3: What's your consideration on the work for LPHAP?

High-speed train positioning:

There is a need to further discuss the motivation and the challenges for high-speed train positioning. In our view, for some special RF environment of high-speed train, e.g., SFN mode, where all TRPs within a cell transmit the same DL reference signals, the existing R16/R17 positioning solutions may not be good enough. There is a need to further investigate the effective approaches, e.g., the use of Doppler information to support high-speed train positioning.

Question 4: Do you see any other issues for high-speed train positioning case?

AI/ML-based NR positioning:

We consider it has the potential for improving NR positioning accuracy under strong multipath/NLOS environment, and to integrate different techniques to provide a comprehensive positioning solution. We also prefer to include AI/ML-based NR positioning in positioning SI/WI because AI/ML models/algorithms are highly application-specific.

Question 5: Could you share your view on AI/ML-based NR positioning aspect?

Sidelink positioning:

It seems most companies consider sidelink positioning should be supported for absolute/relative positioning for in coverage, partial coverage and out of coverage scenarios, and for public safety, V2X and commercial use cases. Many issues, including the target accuracy and latency requirements, evaluation scenarios, sidelink positioning reference signals, measurements, architecture and solutions (UE assisted/UE based, distributed, cooperative, etc.), resource allocation/coordination, sidelink positioning techniques (e.g., SL-RTT, SL-AoA/AOD, sidelink carrier phase positioning) and the spectrum (e.g., ITS, licensed & unlicensed spectrums, FR1, FR2) should be discussed.

Question 6: Do you think there is any other issue to be studied for sidelink positioning?

Rel-17 leftovers:

For some other enhancements that were discussed in Rel-17 SI, but not included in Rel-17 WI, e.g., RAT-dependent positioning integrity, the enhancements of SRS for positioning (e.g., phase rotation mechanism for staggered SRS structure), we think it is beneficial to consider these enhancements in Rel-18.

Question 7: Do you think one/some/all of them is/are urgent to be studied and specified?

12 – Motorola Mobility Germany GmbH

[Lenovo, Motorola Mobility]:

Majority of interested companies and applicable verticals have shown the need for supporting relative positioning using SL.

In addition, the following consolidated aspects should be generally considered for the expanded positioning study in Rel-18:

- The study should target a uniform SL positioning framework that caters as best as possible to the different use case requirements (as already documented in TS22.186, TS22.261, TR22.855 and TS22.104).
- Consider cooperative positioning techniques by exploiting both Uu and SL to improve the overall UE location estimate.

-

The differences between RedCap positioning and Low Power and High Accuracy Positioning (LPHAP) should also be clarified, e.g. in terms of latency requirements, accuracy and bandwidth requirements, battery life expectations and positioning update intervals. LPHAP and Redcap positioning should also aim to support absolute and relative positioning requirements.

13 – Samsung Electronics Co.

Sidelink Positioning ->we think the first step is to discuss the target use scenario and related KPIs (e.g., the absolue/relative position or ranging), which we can start from the latest updated TR38.845. then we can discuss whether reuse current positioning methods and/or potentially introduce new method.

Redcap Positioning -> we think the target use scenario together with the positioning requirement should be firstly discussed and have clear common understanding, e.g., whether the redcap type UE should share the same level of positioning accuracy and/or latency requirement as listed for current R17 ePos.

Continuous positioning improvement -> some potential leftover items from current release could be considered later on when further progress in current R17 work item has been made. We are open to discuss whether new positioning method could be adopted for NR.

14 – Huawei Tech.(UK) Co.. Ltd

General Rel-18 enhancements for DL/UL positioning for power efficiency (i.e., SA1 LPHAP) may have different requirements from Redcap positioning. For example, LPHAP requires high accuracy as well as long battery life (e.g., few years). Redcap positioning may be more focused on increasing positioning accuracy for UEs with low cost/complexity. Rather than discussing Redcap vs. non-Redcap framework, the discussion should start from identifying the use cases and the requirements. What UE type(s) would eventually be needed is not so urgent to discuss. SA1 has defined requirements for LPHAP, so those requirements are known and available. For RedCap positioning, it should first be clarified what the proposed targets are.

15 – China Mobile Com. Corporation

By reviewing companies' contributions and from the 2 rounds of Q&A, we believe that the following issues can be further investigated in Rel-18:

#1 Sidelink-based positioning

As the study on sidelink positioning in RAN plenary will be finished by the end of RAN#93 meeting, which investigates the positioning use cases and requirements for V2X and public safety, we believe that it is reasonable to further discuss the enhancements in Rel-18. In our view, the following aspects should be clarified regarding the scope of the sidelink-based positioning:

- Use cases (Whether to focus on V2X and public safety that identified in TR38.845, or to extend to other commercial use cases such as XR / IoT?)
- Scenarios (Support SL-only and/or SL-assisted positioning? Regarding the RAT coverage case, in-/partial /out-of-coverage, support some or all of them?)
- Requirements (3 sets of KPIs are identified in TR 38845 for V2X scenarios, support all of them or down-select to some of them?)
- Band (whether to focus on licensed band, or to study unlicensed band as well?)

#2 Redcap positioning

Many companies proposed to consider positioning enhancements for redcap devices, which is for devices with low BW, low processing capability and low power consumptions. In our views, basic functionalities have already been supported in Rel-16/17 Positioning. To be specific, all positioning features are optional and up to UE capability, the minimum DL PRS and SRS pos BW can be as small as 24 PRB, the Rel-17 is working on the improvements on device efficiency, etc. Therefore, we would like to know what should be further enhanced to support Redcap positioning?

On the other hand, we are interested in the enhancement on low power and low cost redcap positioning as well, especially for indoor scenario in vertical industry use cases.

During our field trial inside the factory, we observed that, even though the TRPs are deployed indoor, most of the radio channels are still NLOS inside the factory, these result in the decrease of positioning accuracy. That's why we are expecting some enhancement on the indoor NLOS scenario.

My question is that is there any technique in Rel-18 can improve the positioning accuracy for indoor NLOS scenario?

#3 Rel-17 leftovers

We think that some issues that are down-scoped from R17 positioning WI phase can be further investigated in Rel-18, including the RAT-dependent integrity (we believe that it is an important metric to ensure the reliability of a positioning system), PRS/SRS carrier aggregation (need to first study the feasibility to support larger FFT point and to reduce the TAE requirement of the intra-band contiguous CA), carrier-phase positioning, etc.

16 – Intel Corporation (UK) Ltd

It is good to see high interest to further NR positioning evolution among companies and intensive discussion on possible directions for NR positioning work in Rel.18. In our view, at least the following topics should be included for further discussion on Rel.18 scope:

- Integration of sidelink-aided positioning to NR RAT-dependent solutions
- Support of NR positioning in unlicensed spectrum for both Uu and PC5
- Integrity of RAT-dependent solutions for both Uu and PC5
- Aggregation of positioning reference signals
- Positioning support for RedCap UEs
- Machine learning for positioning (study only)
- Rel.17 leftovers, if any

17 – CEWiT

Most of the companies support the SL based positioning enhancement for absolute and relative positioning as well as ranging. We believe it should include public safety requirements, V2X use cases as well as commercial use cases under the objectives and TR TS22.186, TS22.261, TR22.855 and TS22.104 can be base line to it. Below aspects should be considered for the SL positioning,

1. It should include UEs in an in-coverage, partial coverage and out of coverage scenarios with sufficient accuracy and high reliability of positioning service availability.

2. Possible architecture enhancements for the SL position should be considered and should be uniform across different use cases/ scenarios.

3. Coordination between Uu link positioning SL link position should be specified for positioning accuracy improvement at least in partial coverage and in-coverage scenarios.

4. UE based and UE assisted positioning should be considered

5. Support of AI/ML for positioning including SL positioning should be studied. One question here is that what is the standard impact of AL/ML is expected in positioning including SL positioning ?

18 – MediaTek Inc.

Regarding the RAT-dependent integrity proposal from multiple companies, in the past it was identified that more study from RAN1 would be needed to identify the error sources, before RAN2 could proceed with specification work.

Please could the proponents indicate whether they would plan to follow the above approach in Rel-18, i.e. with some study carried out by RAN1 first?

19 – Ericsson LM

So far, two releases have worked on enhancements of NR positioning. It is now time to see the market development of NR positioning before starting large work on further enhancements. Hence, Rel-18 should be very the focused with focus on **integrity** and **RedCap positioning**.

Regarding RedCap positioning, before studying potential positioning accuracy enhancements, we think that at least 1-Rx RAN4 requirements for existing positioning methods/signaling/procedures should be specified (in line with the CATT contribution RWS-210414 presented under heading 8.6 below).

Regarding SL positioning, it is obvious that SL positioning as a standalone method cannot be a reliable and accurate solution due to the uncertainty of the SL link being in LOS/NLOS condition. SL positining can only be justified as an add-on to other methods, such as GNSS or RAT-based solutions it; hence the commercial value of SL positioning is very unclear.

20 – Philips International B.V.

Next to all the great proposals to improve the position accuracy, e.g. using sidelink, which we are very supportive of, we should not forget about some leftovers from release 17. During release 17 the topic of cellular position integrity was taken out due to lack of TUs reserved to do a proper RAN1 study. During release 18 we should do a better job in scheduling the TUs to allow time for this topic, and other topics to be handled properly.

Feedback Form 12: Answers/Comments

1 – Ericsson LM

Comment to #6 (Apple) regarding the urgency and necessity of RAT-dependent positioning integrity:

Thanks for the comment. We agree that the topic may have not been well-developed in Telecom industry compared to GNSS community, however, now that 3GPP decided to support RAT-independent positioning integrity in Rel-17, we believe that the baseline for the support of RAT-dependent positioning integrity has already been analyzed and can be developed in Rel-18. The importance of positioning integrity and reliability in many indoor use-cases such as IIoT is of course known and has been already captured in the Rel-17 TR. While more study is needed on the topic, we think that compared to many other topics presented as Rel-18 positioning scoping, this is one of the most matured topics to handle within Rel-18 time frame.

2 – Samsung Electronics Co.

Comment to #8

Since Rel-17 RAN study about sidelink positioning is for the use cases of V2X and public safety, Rel-18 work needs to focus on these use cases. Sidelink positioning targeted for V2X and public safety cannot be applied for all use cases identified in TR 22.855 due to various different requirements but we think sidelink positioning can cover many use cases identified in 22.855.

3 – Fraunhofer IIS

We would like to share our view on discussions and questions about positioning including sidelink and RedCap positioning. Please find our responses and comments below:

Answer to #4, comment to #12 and #13 on sidelink positioning:
We support #12, Motorola, in proposing a uniform SL positioning framework, which could be scalable for frequency ranges, applicable bands and bandwidths (including ITS, licensed and unlicensed bands). We particularly see benefits of sidelink positioning in out of coverage scenarios, for which the existing positioning methods are not available or cannot be used reliably. Therefore, sidelink positioning could be treated as a positioning method on its own (comment to #13 Samsung). If available, the reported information can be combined with existing uplink / downlink positioning methods to enhance the positioning results. The framework should enable SL communications and positioning in a single carrier as well as in a split fashion with SL positioning carried out in a different band (e.g. using a wider bandwidth). Therefore, as a starting point, SL positioning should be based on the Rel-17 SL frame structure (question by #4, ZTE).

Comment to #11 on RedCap-Positioning:
On question 2 by #11, CATT, we think that the existing positioning methods in Rel-17 shall be the starting point for discussions on positioning for RedCap devices.

Answer to #11 on enhancements for low-power and high accuracy positioning:
On question 3 by #11, CATT, we agree to first clarify the target KPI and then to move on to work on solutions. We see potential in many of the discussed possible enhancements, especially narrowband communication / wideband positioning, PRDs (simpler positioning reference devices providing densification), positioning in DRX, inactive and idle states and support of fingerprinting (not limited to RSRP), among others.

Comment to #1, #7 and #11 on carrier phase aided positioning:
As a comment to #1, DanKook University, #11, CATT question 1, and others, we have also observed a wide interest in the community regarding carrier phase aided positioning and share the same opinion about its high potential for enabling high accuracy, under certain conditions. We agree with CATT on the need to investigate these issues, including the influence of channel conditions (NLOS, multipath) on carrier phase measurements. (see #7, Oppo).

Comment to #5 on integrity of RAT-dependent positioning:
We are of the opinion that 3GPP positioning integrity started in Rel-17 for GNSS (as RAT-independent method) should be expanded to RAT-dependent methods during Rel-18. As a comment to #5, Apple GmbH, we believe that integrity-aware positioning is crucial for several application areas (including V2X, IIOT and public safety). We also note that the integrity framework is under development for GNSS methods

in Rel-17. It is natural that the unified approach for RAT-dependent method is pursued in Rel-18. As an additional benefit, we think that such integrity concept is especially useful when several methods are available and the network can process them in a hybrid fashion. This way, meaningful choice of methods assists to achieve seamless positioning when moving between environments (e.g. outdoor to indoor) and helps to avoid overhead by turning off ineffective methods.

Comment to #4 on AI/ML for positioning:
In reply to #4, ZTE, bullet 5, we share the view to let a dedicated study item for AI/ML go first to cover all relevant physical layer use cases including positioning. In our view, positioning is one of the most promising use cases of application to AI/ML on the physical layer. A lot of research has been done in this area that shows advantages of using AI/ML, especially for non-line of sight scenarios. Subsequently, the specification impact to support AI/ML-powerd positioning (e.g. signaling) has to be identified.

Comment to #15 and #16 on Rel-17 left-overs:
Multiplexing UEs using cyclic shift is resource efficient way to support multiple UEs in uplink. In Rel. 16, the issue with phase correction needed for properly destaggering the staggered SRS transmission was identified but a solution was not addressed. This is one of the important topics that needs to be addressed in Rel-18.

4 – Beijing Xiaomi Mobile Software

Comment to #1(DanKook University)

We are also interested in sidelink positioning, carrier phase positioning and RedCap positioning. Regarding the machine learning for positioning, a dedicated SI for AI/ML is expected, so we should first study the AI/ML and then consider to introduce it for positioning.

For Redcap positioning/sidelink positioning, we think not to limit to redcap UE, but a low cost UE in general, to allow the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel. So, we suggest to reword as low cost positioning.

Comment to #2 (FirstNet)

We also think partial-coverage and out-of-coverage scenarios are very important and the ranging service should be considered for these scenarios.

Comment/Answer to #4(ZTE):

Answer to Q1: For sidelink positioning on unlicensed band, a possible way forward is that we only specify positioning/ranging signal transmission on unlicensed band, and other signals are transimitted on licensed band. This will simplify the work on unlicensed band.

Comment to Q2: For Redcap positioning/sidelink positioning, we think not to limit to redcap UE, but a low cost UE in general, to allow the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel. So, we suggest to reword as low cost positioning/ranging.

Answer to Q5:

For question 5, we share the same view with ZTE that we should first discuss the AI/ML in the dedicated SI and then consider to introduce it in positioning.

Comment to #5(vivo)

For Redcap positioning, RAN1/RAN2 work will be involved to improve the accuracy with low bandwidth, e.g. frequency hopping. Also, there is no need to limit to redcap UE, but a low cost UE in general, to allow the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel. So, we suggest to use the term "low cost positioning/ranging".

Answer to #7(OPPO)

For Redcap positioning, one enhancement area is to improve the accuracy,e.g. by frequency hopping.

Besides, there is no need to limit to redcap UE, but a low cost UE in general, to allow the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel. So, we suggest to use the term " low cost positioning/ranging".

Comment to #9(Nokia)

For Ranging, we prefer to use sidelink-based and sidelink-assisted positioning/ranging, to embody that only to measure one component of distance/angle is possible and that distance and angle accuracy can be different.

For low-power positioning, we prefer to include also low cost positioning. Because the intention to support Redcap UE is not just power consumption driven, but also cost driven. Also, we think there is no need to limit only to redcap UE type, other low cost solution, e.g. the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel, should not be preclude. So, we suggest to reword as low-power and/or low-cost positioning/ranging, including RedCap and/or other low cost UEs.

Answer to #11(CATT)

Q1:We are still not clear how much the accuracy can be improved by carrier phase positioning compared to other solutions(e.g. TDOA)in multi-path environment.

Q2: For example, improve the accuracy by frequency hopping.

Q3: We think low cost is one interesting area to consider for both positioning and SL positioning/ranging.

Q4: except special RF environment of high-speed train case, whether the Rel-16/17 positioning solutions can meet the positioning requirements of high-speed train case.

Q5: we think we should fist discuss the AI/ML models/algorithms in the AI/ML SI.

Q7: it depends on the progress of Rel17 and we think positioning in RRC idle can be considered in Rel-18.

Answer to #12(Motorola Mobility)

One difference between RedCap positioning and Low Power and High Accuracy Positioning (LPHAP) is that for low cost, redcap positioning reuse redcap UE type while LPHAP defines a new UE type with high positioning RS bandwidth but low communication bandwidth.

Answer to #15(CMCC)

For Redcap, one enhancement area is to improve the accuracy,e.g. by frequency hopping.

For low power and low cost redcap positioning, we also agree that both power consumption and cost should be reduced. For low cost, one solution is to use Redcap UE type, another solution is to define a new UE type with high positioning RS bandwidth but low communication bandwidth to ensure the high accuracy.

Regarding NLOS scenario, currently no matter SL positioning with large bandwidth or carrier phase positioning, accuracy cannot be guaranteed in NLOS scenario.

Comment to #16(Intel)

For Positioning support for RedCap UEs, On one hand, SL positioning/ranging can also support Redcap UE. On the other hand, we think not to limit to redcap UE, but a low cost UE in general, to allow the option of high bandwidth of positioning/ranging signal & low bandwidth of communication channel. So, we suggest to use low cost positioning/ranging.

Comment to #18(MediaTek)

If RAT-dependent integrity is in the Rel-18 positioning scope, we think RAN1 should be involved.

5 – LG Electronics Inc.

Considering the industrial needs and companies' interest shown in NWM discussion, we think at least the following topics need to be included in Rel.18 positioning.

SL positioning

We are in line with most of companies' view on the need of sidelink positioning for Rel.18 positioning. Sidelink positioning needs to be support for in-coverage, partial coverage and out-of-coverage scenarios for public safety, V2X service, and commercial use cases.

Positioning of multi-panel UE

Use of multiple panels has been discussed in wide range of use cases including V2X application. Especially for a vehicle, the use of distributed multiple panels are thought be important for safety, design flexibility, radio performance, etc. For safety purpose as an example, it may be critical to mount the distributed multiple panels on a vehicle in order to enable V2X communication work even in case when one of the panels is damaged or out of function.

If UE is equipped with multiple panels, current specification cannot provide accurate positioning of such UEs because only a single-panel based positioning is supported. High accuracy positioning is discussed among companies as one of the important features that should be supported in Rel.18, and we think that positioning enhancement is necessary for accurate localization of multi-panel UE for this purpose.

Multiple panels can be used for both Uu link and sidelink, and the distance between panels from zero (e.g. handheld device) to several meters (e.g., vehicle DAS) can be taken into account for positioning, depending on the device type/use case.

6 – Huawei Tech.(UK) Co.. Ltd

On sidelink positioning:

In response to the comments on NR RAT-dependent sidelink positioning, although SL positioning can be used in coverage to assist NR RAT-dependent solutions, SL positioning (alone) should also be considered for in-coverage, partial coverage, and out-of-coverage.

On ZTE's point about SL positioning in unlicensed, we would expect sidelink positioning to be supported in unlicensed bands, but it seems like a high workload to have that in Rel-18, at least because of the standardization management of how to have enough time after sidelink unlicensed has progressed far enough to allow meaningful work on adding positioning.

On other positioning aspects:

Xiaomi asked whether positioning methods for lower power high accuracy positioning can be reused for redcap positioning and whether new UE type for low power high accuracy positioning will be introduced?

Answer: the main different requirement for LPHAP is long battery life. Redcap positioning may be more focused on increasing positioning accuracy for UEs with low cost/complexity. As long as the battery life can sustain years as defined in SA1 for LPHAP, what UE type(s) would eventually be needed for LPHAP is not so urgent to discuss.

Answer to CMCC's question about technique that can improve the positioning accuracy for indoor NLOS scenario? We think the existing multi-path reporting and LOS/NLOS identification in Rel-17 have already provided sufficient standardization support for NLOS positioning.

The remaining could be rather implementation-based, e.g. using artificial reflector(s) to create a strong single-reflecting path, yet the requirement for NLOS scenarios should be relaxed compared with LOS scenarios.

Answers to CATT's question 2 on what aspects should be enhanced for RedCap positioning: Rel-17 redcap UE can optionally support the positioning feature by reporting the capability (the signaling is up to RAN2) and the requirements for 1Rx may be further defined by RAN4. Also, we are supportive of REDCAP based positioning to achieve high accuracy, to enable the low cost and high accuracy positioning for some IIoT-positioning use cases with low communication requirement, e.g. asset tracking, inbound logistics. For accuracy enhancement, e.g. frequency hopping transmission/reception to approach a larger bandwidth, can be considered.

Answers to CATT's question 3 on consideration on the work for LPHAP: The use cases and requirements of LPHAP currently captured in TS 22.104 include those listed in the table below. So in our view, the typical KPI for LPHAP should be 0.3 meter with 90% accuracy and 1 year of battery life, but we are open to discuss the KPI as part of the study. The study could also primarily cover the evaluation methodology of UE power efficiency to achieve the battery life KPI.

Use case #1 Process automation: Dolly tracking (outdoor)

Horizontal accuracy: 10 m

Corresponding service level (22.261): Service Level 1

Positioning interval/ duty cycle: on request

battery life time/ minimum operation time: 24 months

Use case #2 Process automation: Asset tracking

Horizontal accuracy: 2 m to 3 m

Corresponding service level (22.261): Service Level 2

Positioning interval/ duty cycle: < 4 seconds

battery life time/ minimum operation time: > 6 months

Use case #3 Flexible modular assembly area: Tool tracking in flexible, modular assembly areas in smart factories

Horizontal accuracy: < 1 m

Corresponding service level (22.261): Service Level 3

Positioning interval/ duty cycle: no indication

battery life time/ minimum operation time: 1 work shift - 8 hours (up to 3 days, 1 month for inventory purposes)

Use case #4 Process automation: Sequence container (Intralogistics)

Horizontal accuracy: < 1 m

Corresponding service level (22.261): Service Level 3

Positioning interval/ duty cycle: 1 second

battery life time/ minimum operation time: 6 - 8 years

Use case #5 Process automation: Palette tracking (e.g. in turbine construction)

Horizontal accuracy: < 1 m

Corresponding service level (22.261): Service Level 3

Positioning interval/ duty cycle: 5 seconds - 15 minutes

battery life time/ minimum operation time: 18 months

Use case #6 Flexible modular assembly area: Tracking of workpiece (in- and outdoor) in assembly area and warehouse

Horizontal accuracy: < 1 m

Corresponding service level (22.261): Service Level 3

Positioning interval/ duty cycle: 15 s to 30 s

battery life time/ minimum operation time: 6 - 12 months

Use case #7 Flexible modular assembly area: Tool assignment (assign tool to vehicles in a production line, left/right) in flexible, modular assembly area in smart factories

Horizontal accuracy: 30 cm

Corresponding service level (22.261): Service Level 5

Positioning interval/ duty cycle: 250 ms

battery life time/ minimum operation time: 18 months

Use case #8 Flexible modular assembly area: Positioning of autonomous vehicles for monitoring purposes (vehicles in line, distance 1.5 meter)

Horizontal accuracy: 30 cm

Corresponding service level (22.261): Service Level 5

Positioning interval/ duty cycle: 1 second

battery life time/ minimum operation time: 6 - 8 years (no strong limitation in battery size)

7 – Nokia France

In response to the question from CATT on the work necessary for terrestrial carrier-phase positioning, indeed it would be necessary to decide whether new RS are needed or not; our preference is to reuse existing PRS and/or SRS. You can find the detailed list of objectives on slide 3 of RWS-210117.

Regarding RedCap positioning, we see this mainly overlapping with low-power positioning. For RedCap devices, the constraints of narrower bandwidth and reduced number of antennas will set limits on the achievable accuracy, and the RAN4 requirements should be checked; we should aim for the highest accuracy possible within the device constraints. Low power consumption for positioning is important for both RedCap and smartphone devices.

Overall, we believe the following remains a reasonable summary of the most important aspects for Rel-18. The number of items covered would of course depend on the overall workload and capacity available in the WGs:

Fine-tuning our summary slightly, the following are identified in terms of **requirements** (in roughly decreasing order of popularity):

1. Ranging
2. Low-power positioning
3. Accuracy enhancements (down to cm-level)
4. RAT-dependent positioning integrity
5. Latency reduction

For **ranging**, the most identified technique by far is **sidelink-based**.

Low-power positioning is primarily targeted at **RedCap** devices, but may also be applicable to other devices. Support for positioning in RRC_IDLE is the most identified technique here.

The main techniques proposed for **accuracy enhancement** in general (apart from sidelink assistance) are terrestrial **carrier-phase positioning**, **PRS/SRS bandwidth aggregation**, and the use of **wide bandwidths at 60 GHz** (which also implies the ability to transmit PRS in unlicensed spectrum, which is also seen as relevant for sidelink positioning).

It would therefore be a reasonable expectation that Rel-18 work on positioning could include at least:

- sidelink-based and sidelink-assisted positioning;

- low-power positioning, including for RedCap devices, including positioning in **RRC_IDLE** as well as RRC_INACTIVE**;**

- carrier-phase positioning and/or PRS/SRS bandwidth aggregation;

- PRS transmission in unlicensed spectrum, including 60 GHz.

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8 – CATT

General consideration on positioning organization:

Many potential directions have been discussed so far. There were comments regarding how the positioning topics are arranged in Rel-18. This can be discussed in a later stage, when the technical scopes are clearer. But as a general comment, some refinement/prioritization would be needed as well. We should aim at good balance between the benefits with all the enhancements and the work load/complexity.

Some response to other companies:

@ DanKook University: We share the similar view as DanKook that carrier phase-based method can be considered in sidelink positioning.

@ ZTE Corporation:

We think sidelink positioning should be investigated based on Rel-16&Rel-17 NR sidelink & NR positioning framework.

For enhancement for higher accuracy positioning, low latency and low power consumption, we share the same view with ZTE that all candidates should be further discussed.

For AI/ML-based positioning, in our view it might be better to be included in positioning SI/WI.

@ Guangdong OPPO Mobile Telecom: Similar to DL-TDOA/UL-TDOA methods, we assume there is a need to study how to mitigate the impact of multipath on NR carrier phase positioning. Our understanding is that there have been many investigations on how to mitigate the impact of multipath on GNSS carrier phase positioning. We may consider taking the advantages of these investigations when we study the NR carrier phase positioning. By the way, our understanding is that we may not expect to achieve cm-level accuracy with the carrier phase positioning in all deployment scenarios (e.g., pure NLOS scenarios), just as that we may not expect the target R17 accuracy can be achieved in all deployment scenarios.

@Beijing Xiaomi Mobile Software: For 2, in our view, we may expect some of the positioning methods for lower power high accuracy positioning could be reused for redcap positioning if the RedCap UE has the capability to support the feature specifically developed for LPHAP. This issue may be discussed after we have developed the positioning methods that support the performance requirements for LPHAP. For 3, in our view, we should target to have a unified framework for SL positioning to support different uses cases including commercial use cases.

@Motorola Mobility Germany GmbH: please see our response to Xiaomi above.

@ Huawei Tech.(UK) Co.. Ltd: please see our response to Xiaomi above.

@China Mobile Com. Corporation:

For RedCap positioning, please see our response to Xiaomi above.

For R18, we assume one of the promising techniques for dealing with multipath/NLOS is the use of AI/ML approaches, especially for the environment when there are rich but relatively stable multipath/NLOS RF environment.

@ MediaTek Inc: please see our general consideration, and investigation work can be started in RAN1 earlier than other working groups.

@Ericsson LM: Yes, we share the similar view with Ericsson that we can first study whether there is a need to have performance enhancements by checking the gap between the target performance requirements for RedCap positioning and the achievable performance with existing positioning methods/signaling/procedures, and then further study the performance enhancements if needed.

Consideration on specific proposed objectives:

From the discussions so far, the following aspects seem to get wide interests, for which more discussions on the exact scope are needed.

- NR carrier phase positioning;
- Low power high accuracy positioning (LPHAP);
- RedCap positioning;
- Sidelink positioning;
- RAT-dependent integrity;

Then there are also other aspects that companies are proposing, e.g.,

- High speed train positioning
- AI/ML-based NR positioning

More discussions on these may also be helpful in the next phase.

9 – ZTE Corporation

Comment to #1, and all others, so far, at least the following potential aspects should be included in Rel-18 positioning SI/WI based on our observation:

· SL positioning and ranging

· Further accuracy improvement including carrier phased positioning and PFLs/carriers aggregation

· Integrity of RAT-dependent positioning

Regarding AI/ML for positioning use case, more companies had shown interest in another email thread, we should avoid redundant discussion here.

Regarding RedCap positioning, as commented by many companies, what kind of enhancements needed are not clear yet. We expect RAN4 work is mainly involved to define some new requirements for reduced cost/complexity/Rx/bandwidth UEs. However, this kind of discussion should be under RedCap SI/WI rather than here.

Regarding positioning using higher frequencies (i.e., >52.6 GHz), we believe it is beneficial because of potential very large bandwidth. However, it seems not very attractive so far. As Apple pointed it out, it is premature and better to wait until some initial deployments in those bands.

Regarding SL positioning in unlicensed spectrum, we suggest to defer it in next Release since the regular SL in unlicensed spectrum will be discussed in Rel-18 SL enhancement. SL positioning can rely on the outcome of the Rel-18 SL SI/WI later. Otherwise, the discussion will collide to each other.

Comment to #17 CEWiT, for question 5, we think the spec impact for AI/ML based positioning can be very small. It can just optimize the UE report on the PRS measurements, e.g., UE reports more number of measured paths where each path may include arrive timing, power and phase probably, etc. Actually, more discussion on AI/ML based positioning can be found in some other email threads [RAN-R18-WS-crossFunc-Overall and previous NWM discussion] which focus on all potential AI/ML use cases including positioning.

Comment to #18 MediaTek, we think it is reasonable to start RAT-dependent integrity discussion in RAN1 first for identifying error sources. Further, we think RAN2 should be involved as well.

7 Misc. RAN1/2/3 improvements: set 2

7.1 UAV

This section is targeted at identifying commonalities and interactions for UAV.

Feedback Form 13: Questions/Comments

1 – SoftBank Corp.

We think UAV features are very important considering the market demand, while it is really unfortunate that pre-Rel-18 NR failed to introduce this functionality. It is suggested to use RP-192451 (lated draft WID, which aims to import LTE UAV to NR) as a baseline for our further discussion. On top of that, we can discuss further which additional features are beneficial for NR UAV.

2 – Nokia Corporation

We see commonalities first with the Release 15 based solutions as the baseline.

Additionally (beyond Release 15 LTE) the need to consider interference / co-existence and UAV identification is covered in several contributions related to UAS/UAV/drones/aerial support in NR. Further the SA originating subscription based identification would need to be covered as also suggested in multiple papers . In order to ensure a futureproof system for UAVs we propose RAN to look at reliability improvements, enabling RAN to ensure good reliability along the flight path. The reliability aspects were not clear in the contributions from others (even if raised with some other areas), thus we would welcome views from other companies if you see that important for UAVs over 5G to be considered further

3 – Deutsche Telekom AG

UAV support in NR is missing until now and features defined for LTE UAV shall be enabled for NR in the first step. Further enhancements are subject to needs discussion.

4 – FirstNet

UAV support is very essential for public safety personnel when it comes to extinguishing wildfires in open areas or high-rise buildings or conducting search and rescue operations in valleys and canyons.

5 – ZTE Corporation

For the UAV part, based on the pre-workshop discussion and contribution review, it's clear that following should be prioritized:

1. Solution and issue identified from LTE.
2. Enhancements to improve the interference;
3. Mechanism to satisfy the security needs

Moreover, study and potential issue identification to support the platoon communication is also needed to enlarge the market.

W.r.t the study for dedicated spectrum, it can be postponed once the regulation and deployment mode is clear.

6 – Verizon UK Ltd

We also see strong market demand for UAV NR support. We agree with Nokia that Rel-15 LTE UAV can be used as the baseline but it is not sufficient. Additional enhancement suggested by Nokia is a good start.

7 – Apple GmbH

Is the generic view that UAV standards will evolve to be supported by NR similar as LTE NB-IoT which is evolved to be supported by NR- NTN? Or is the companies' view to redo standards in a more backward compatible way. Given the high likelihood that UAVs will evolve into a form where we can have both sidelink and IAB relay kinds of architectures, co-existing depending on the scenario (and may potentially have both together), where would R18 cover this topic? Under sidelink? Or as a separate category?

8 – Lenovo Mobile Com. Technology

1. Most companies proposed to introduce LTE UAV features in to NR system, and we also agree with this. Corresponding tailors for NR system should also be taken into account, e.g. beam management specific for UAV use case. Further, using PC5 for UAV UE to ground identification is also needed to fulfill FAA requirement.

2. Furthermore, we think UAV swarm use cases can be studied, consider UAV swarm is widely studied and used for scenarios of logistics, agriculture, aerial mapping, emergency rescue etc. Issues caused by UAV swarm e.g. signaling overhead, interference or mobility enhancement could be studied for these cases.

3. Also, we think drone based relay can be studied, which is useful for practical scenario e.g. emergency network coverage extension. UAV specific issues can be studied based on sidelink or Uu interface between remote UE and relay.

9 – Samsung Electronics Co.

Question 1) On specification works: most of proposals mentioned that UAV design in LTE can be a baseline for NR UAV. Then question is which aspects need to be further considered for NR UAV on top of the baseline.

Question 2) On PC5 enhancement for UAV: main motivations of having this are to support remote ID broadcast over PC5 and to avoid collisions among UAVs. Then question is which aspects need to be further enhanced for NR UAV on top of current sidelink design including Rel-17

10 – vivo Communication Technology

We are fine to support UAV in NR, by reusing the LTE design as the baseline. Regarding the additional enhancement proposed by multiple contributions, e.g. interference, co-existence, beam specific, or PC5, need further studies considering the real deployment and market requirements.

11 – HUAWEI TECHNOLOGIES Co. Ltd.

[Huawei, Hisilicon] Similar to some other comments, we are open to define UAV support in NR based on what we have previously done for LTE. The need for further enhancements is subject to discussion and careful evaluation on requirements and technical costs/benefits analysis of the proposals.

12 – VODAFONE Group Plc

We support that NR is at least provided with the levels of functionality that LTE has.

Feedback Form 14: Answers/Comments

7.2 IIoT/URLLC

This section is targeted at identifying commonalities and interactions for IIoT/URLLC.

Feedback Form 15: Questions/Comments

1 – Nokia Corporation

Please note (as clarified by the RAN chairman) Resilient timing as relevant topic for this discussion, reflected at least in RWS-210115 and also at least in RWS-210032 and RWS-210033. Mentioned as ”(SA1) 5G Timing Resiliency System – enh. Time Sync via UE as a Service”

2 – Nokia Corporation

On the commonalities: URLLC profiles were notable widely supported in RAN#92e, while not concluded there, thus would be natural to consider further in this discussion depending on Release 17 conclusions (as also discussed in the WS).

Mobility seems widely recognized issue with URLLC (also XR etc.), especially for FR2, but as mobility is having own discussion perhaps best to continue elaborating further areas for investigations there

Data channel scheduling enhancements, including SPS/CG enhancements and flexible HARQ operation over multiple carriers seem to be covered in many contributions. There is some relationship to the on-going XR discussions as well.

Uplink heavy traffic & dealing with interference between UL/DL was also raised in several contributions. This is related to handling CLI between gNBs (or interference management with flexible UL/DL use)

Last but not least is the resilient timing, which besides being mentioned in multiple contributions, is also being progressed in SA side, thus would be natural to consider covering the RAN impacts here (relation to URLLC with the propagation delay compensation as TSG RAN chairman stated).

3 – MediaTek Inc.

We see the following enhancement areas are essential for improving the system’s capacity and efficiency for latency-critical applications.

Enhancement-Area#1: Improved DL control efficiency.

- **CSI feedback for PDCCH.**
- **Introducing intermediate PDCCH aggregation levels (currently limited to 5 aggregation levels).**

Enhancement-Area#2: NR-U Enhancements.

- **Increase UL Tx opportunities (PUSCH, PUCCH, SR) in frequency/time domain.**
- **PDCCH monitoring enhancements across LBT bands.**
- **Enable NR-U features via compact DCI.**

Enhancement-Area#3: UE processing time reduction for FR2.

4 – Classon Consulting

[for FUTUREWEI]

As commented in the GTW, there are many features in Rel-15/16/17 that improve reliability and latency. However, none of these features can be counted on to actually be supported in devices. This issue was discussed and recognized in rel-16 and resulted in basic features discussions for NRU and V2X scenarios, but not for URLLC. The issue was again discussed for Rel-17 in this past RAN, and again there was no resolution for URLLC. As a bare minimum, for rel-18 we can take care when studying newly proposed features to ensure they show gains on top off the existing features, and consider to include in the work description that these relevant features are considered as pre-requisites for the new features. Otherwise we just spend big efforts in standards making more features that are not being used.

5 – ROBERT BOSCH GmbH

Note: our TDoc RWS-210215 and RWS-210218 (SI on RAN-Assisted Functional Safety communication / TSC further enhancements).

We consider the following enhancements

1- SL-IIoT (please refer to SL enhancements section)

2- RedCap with further reduced latency (5ms) for light-weight IIoT devices/AGVs, etc. (please refer to RedCap section)

3- Relation to XR enhancements: e.g., SPS/CG enhancements, mobility, etc.

4- SI RAN-Assisted Functional Safety Communication (for reliability enhancements); consider studying the following on the top of OoS (e.g. survival time) objective in Rel-17 IIoT WI:

- For RAN-Assisted FuSa communication in Uu (Further enhancements):
  - Study further enhance QoS parameter for TSC on the top of Rel-17 IIoT (e.g., existing discussion in RAN2)
- For support of RAN-Assisted FuSa communication in Sidelink:
  - Extend survival time concept to Sidelink; hence, study possible SL-UE survival time monitoring and triggering mechanism
- General (Uu and SL) (on top of Rel-17 IIoT-QoS):
  - □□Study enhanced reliability increase mechanisms when triggering survival time in SL and Uu
  - Study reporting of survival time to upper layers (if any, which information to convey and how)
  - Study enhance radio link monitoring (e.g., introduce heartbeats, monitoring at RX-UE, joint TX-RX UE monitoring, etc.)

- Extend traffic model to aperiodic-deterministic (as in SA1 TS 22.104)

6 – ZTE Corporation

We think it is important to support scenarios requiring high system capacity/data throughput and meeting certain URLLC requirements at the same time. Can any of the proposed enhancements (e.g. SPS, CG or FR2-specific enhancements listed in the URLLC/IIoT tdocs, e.g. RWS-210071, boost system capacity in addition to the reliability/latency benefit? If yes, is this applicable to the scenario with XR traffic as well?

7 – Motorola Mobility UK Ltd.

We propose a Rel-18 study item focusing sidelink for IIoT that improves the resource efficiency of the overall system with lowered latency to support some of the demanding factory applications such as closed loop motion control, cooperative carrying robots use cases, etc. Following are the objectives to be studied for sidelink for IIoT:

· Study on the reliability and latency enhancement needed in the sidelink physical channels and procedures

· Study on the needed enhancement to support sidelink based time sensitive networking

In addition, we think that complementary UL/DL configurations on different serving cells from the same band or on different BWPs on the same serving cell can be discussed under evolution of duplex operation.

8 – vivo Communication Technology

1. CG and SPS enhancements for non-integer periodicities has been proposed in both XR and IIOT/URLLC, would be good to clarify the difference between the two use cases to avoid duplicated discussion.

2. Regarding enhanced URLLC/IIOT features in CA deployment, Rel-17 only addressed PUCCH carrier swtiching, which is not complete in our view, as it only address HARQ-ACK latency but not for data retrransmisison. Therefore we have proposed in our paper (0167) to work on cross-carrier PUSCH/PDSCH retransmission and potentially PUSCH/PDSCH repetitions across CCs.

9 – Apple GmbH

Overall, we think the necessity to have a separate WI on URLLC/IIOT enhancements needs to be discussed, and the overlapping with other WIs (e.g. XR) should be carefully considered.

The current proposals from companies cover a very diverse range of enhancements, and many of them had been discussed before but not agreed to be introduced. Learning from the past experience in URLLC, the benefit of an enhancement needs to be clearly demonstrated to be included in a WI, and study-like objective(s) should be avoided as much as possible.

10 – Guangdong OPPO Mobile Telecom.

- What's the relationship between XR and R18 IIoT and URLLC? Use case and requirement are different but similar direction, e.g. high data rate. Similar technical tools can be expected.

- On CA/DC enhancement, e.g. carrier switching, repetitions over multiple CCs, complementary TDD configurations, it is more like CA enhancement.
- For SPS collision issue, reasonable SPS configuration, including resource and configuration, can solve SPS drop or cancellation issue. For example, a SPS with lowest SPS index but support larger TB size is configured in collision slot. Moreover, dynamic PDSCH can override all collided SPS resource, it is another way. The motivation of new specified solution is not clear.
- We should also be clear which R17 leftover(s) to be worked on in R18, e.g. deprioritized SPS HARQ-ACK enhancement solution?

11 – CATT

Although various enhancements are proposed by companies for Rel-18 IIoT/URLLC, it seems to us that the views are quite divergent. Instead of discussing the detailed enhancement techniques directly, we think it would be useful to first discuss and identify the target scenarios/use cases for potential enhancements and the gap between the requirements and the performance provided by existing techniques. In addition, the intersection between IIoT/URLLC and other items e.g. XR, sidelink enhancements should also be taken into account.

12 – DOCOMO Communications Lab.

Similar comments with other companies like Apple and CATT.

1: We think it should be discussed whether separate WI for URLLC/IIoT is needed or not from other WIs such as XR. Even if the necessity of separate WI is identified, the intersection between URLLC/IIoT and XR needs to be carefully considered since there would be overlapping potential enhancements such as CG/SPS enhancements for capacity improvement.

2: It would be useful to discuss/identify target use case/scenario/requirement first for Rel-18 URLLC/IIoT in order to avoid consuming time for down-selection from many proposals, of which targets are diverse.

13 – Samsung Electronics Co.

What are required enhancements that cannot be potentially considered in other candidate Rel-18 WIs (e.g. MIMO, XR, mobility, sidelink)?

14 – Sony Europe B.V.

High throughput URLLC has been proposed by a few companies. How do we support high throughput URLLC at the cell edge where there is typically low SNIR?

15 – HUAWEI TECHNOLOGIES Co. Ltd.

There are quite some interest to further enhance IIoT/URLLC. The tdocs discussing IIoT/URLLC include RWS-210016, 0067, 0071, 0108, 0115, 0167, 0193, 0204, 0218, 0277, 0304, 0328/0380, 0377, 0417, 0442. However, it seems no wide support for each single proposal yet, further discussion on the motivations for each proposal are still needed. Our views on some of the proposals are given as below:

· SPS/CG enhancements (RWS-210071, 0193, 0328, 0377, 0380). In general, we are supportive of SPS/CG enhancements since they are key features for URLLC/IIoT. As to the detailed enhancements, further discussion are needed to identify the set of beneficial enhancements. However, we noticed that

there are some proposals on SPS/CG enhancements for XR also, we may need to discuss where to include this enhancements if supported in Rel-18.

· Scheduling related enhancements (RWS-210108, 0167, 0377, 0442), e.g. flexible initial transmission and re-transmission on different serving cells, repetitions over multiple carriers and DL control efficiency. In our understanding, flexible initial transmission and re-transmission on different serving cells is worth to further discuss since it can help reduce the latency largely as shown in our paper RWS-210442. DL control efficiency is worth to further discuss also, since based on the study in previous release it is clear that DL control capacity is a problem. As to the detailed proposals for DL control efficiency, some enhancements like new/finer granularity and two-stage control channel are mentioned, however further discussion are needed to identify the set of beneficial enhancements.

· Rel-17 left over (RWS-210067, 0071, 0108, 0193, 0377, 0442), including CSI enhancements, codebook size reduction, left over for intra-UE multiplexing, etc. What to be included would depend on the progress for Rel-17. In general it is expected there would be some left over and it is worth to continue with some of the left over especially for those with clear benefits but not done in Rel-17 due to limited time.

· FR2 for URLLC (RWS-210071, 0108, 0377). In general we agree that it is important to consider FR2 for URLLC. However, further discussion is required to identify whether/what enhancements is needed on top of the existing mechanisms.

· There are proposals related to mobility (RWS-0442, 0071, 0380, 0377). We understand most of them are duplicated in mobility discussion and can be discussed in mobility area. Specifically we think the data forwarding needs to be improved as shown in RWS-210442, as currently the latency caused by Xn/X2 interface for data forwarding would bring around 10ms delay, the similar issue was also described in 0078. To facilitate the services like URLLC, this aspect is worth consideration.

· We also see value for define URLLC profiles (0071) to promote the vertical market by identifying essential features for UEs since Rel-15.

· Complementary TDD (RWS-210442). From interference management perspective, complementary TDD is quite similar as sub-band full duplex/xDD discussed under section of duplex operation, which got quite some interest. It seems better to discuss complementary TDD and sub-band full duplex/xDD together at least from interference management perspective, e.g. in duplex operation section.

16 – Intel Korea

We strongly believe that there are URLLC/IIOT use cases and scenarios not addressed by current NR. Among them, the scenarios with mixed QoS of traffic at the UE, unlicensed operation in potential presence of other incumbent technologies, non-zero survival time QoS services, etc. We expect RAN to study/work on further enhancements in this direction.

We admit that the scoping discussion should carefully consider overlap with other items, such as XR, and should avoid broad formulations of objectives with unconstrained study phases. In the same time, we could not agree that if something was not specified in prior releases then it does not need to be considered in future releases (e.g. processing time reductions, out-of-order scheduling, etc.) since new scenarios still demand these types of operation.

17 – Ericsson LM

We find resource scheduling enhancements and further CSI enhancement for faster channel state measurement and reporting would be beneficial for URLLC applications.

On URLLC for sidelink, for all URLLC use cases it is already possible to reach reliability&latency requirements without SL. There are only few scenarios where SL can potentially improve efficiency. Moreover, SL efficiency is also questioned because of too simplistic mechanisms of RRM.

On PUCCH repetitions proposed enhancements e.g. over multiple CCs, there are challenges for realizing the Chase combining of Polar codes that impacts the expected gain.

On PDSCH repetitions proposed enhancements e.g. early termination, the expected gain is compromised with increased overhead.

On TDD coexistence issue proposed solutions, the problem as such is generic for deployment scenarios.

On PDCP duplication proposed enhancements, we believe the current specification already offers an adequate toolbox to efficiently handle this feature, i.e. MAC CE for fast activation/deactivation of duplication on 1-4 carriers per DR

18 – China Mobile Com. Corporation

Firstly, our contribution RWS-210346 Motivation of study for real-time multiple-UE backup which listed in "others" relevant to this sub-agenda item as well:

a. To ensure the high reliability of data delivery, URLLC was introduced in Release 15, NR URLLC is further enhanced in Release 16 and Release 17 within the Industrial IoT/URLLC work items. RAN or the UE always transmits duplication data through radio links to the target side simultaneously or within the delay-tolerant time range.

b. However, duplication transmission is not resource-efficient in air interface for network capability and it face the challenge of failing to meet the high reliability depends on the successful reception just relying on only one terminal in real scenarios. Therefore, actually, more than one terminal is deployed and utilized to receive repetitive content to ensure the reliability as backup. However, this results in high cost of existing backup mechanism for high Reliability.

c. The above use cases therefore can motivate the introduction of an real-time multiple-UE backup mechanism:

d. Under normal circumstances, terminal 1 and terminal 2 are responsible for different services respectively. If the data/signalling can not be successfully received by the terminal 1, then the subsequent associated terminal 2's action is that the terminal2 is to take over or start/activate the service(s) of the terminal1 declaring in abnormal state.

Secondly, XR characterize a new type of traffic with burst traffic in (slightly) loose latency requirement. We think it should targets more on capacity and XR specific opimization, e.g. multi-slot scheduling, RAN awareness of traffic, DL/UL alignment, DRX enhancement.

URLLC should not stop its pursuit of even lower latency and higher reliability, it can focus on latency and reliability features like SPS/CG enhancements, FR2 support.

All these features may be applied together in reality.

Feedback Form 16: Answers/Comments

1 – Nokia Corporation

Overall, a relationship of any URLLC enhancements and their XR relation (i.e. to prevent any overlap) has been mentioned by most in their phase 1 replies (incl. #2, #5, #6, #8, #9, #10, #11, #12, #13, #15, #16, #18).

URLLC profiles were notable widely supported in RAN#92e, while not concluded there, thus would be natural to consider further in this discussion depending on Release 17 conclusions (as also discussed in the WS and noted by #15).

Mobility seems widely recognized issue with URLLC (also XR etc.), especially for FR2, but as mobility is having own discussion perhaps best to continue elaborating further areas for investigations there as also noted by #13, #15.

Data channel scheduling enhancements, including SPS/CG enhancements and flexible HARQ operation over multiple carriers seem to be covered in many contributions. There is some relationship to the on-going XR discussions as also noted in the comments by #5, #6, #8, #12, #15 specifically for CG/SPS enhancements. While we are supportive of SPS/CG enhancements in Rel-18, we think the benefits of flexible HARQ operation over multiple carriers (and PUCCH/PUSCH/PDSCH repetition across CCs) suggested in #8 and #15 would need to be carefully assessed considering the rather large impact on gNB and UE architecture and implementation.

Uplink heavy traffic & dealing with interference between UL/DL was also raised in several contributions. This is a generic issue (i.e. not URLLC specific) and related to handling CLI between gNBs (or interference management with flexible UL/DL use) as also noted in the comments by #7, #15, #17.

Last but not least is the resilient timing as also discussed in the Wed GTW session in the Deutsche Telekom as well as our URLLC/IIoT presentations, which besides being mentioned in multiple contributions, is also being progressed in SA side, thus would be natural to consider covering the RAN impacts here (relation to URLLC with the propagation delay compensation as TSG RAN chairman stated).

Moreover, Nokia would like to still provide the following additional comments on some raised issues / proposals:

•From our perspective, potential sidelink related URLLC enhancements as discussed by #5, #7, #11 should be handled as part of the Rel-18 sidelink evolution (as also noted by #11, #13).

•As discussed in the Wed GTW session, we don't see a strong need for DL control related enhancements (suggested in #3 & #15) for URLLC in Rel-18 as the suggested enhancements to boost the PDCCH capacity /efficiency are not really URLLC specific.

2 – China Mobile Com. Corporation

To Nokia□ again, please consider our proposal in our contribution RWS-210346 (Motivation of study for real-time multiple-UE backup) which listed in "others" relevant to this sub-agenda item as well. The detail proposal is indicated in the above comment list, which is a real requirement from port and other industrial factory.

3 – Guangdong OPPO Mobile Telecom.

Flexible HARQ operation over multiple carriers is benefit to reduce latency. And we also agree with Nokia that it has large impact on gNB and UE architecture and implementation. So we prefer to review this aspect further, including whether it is specified in URLLC or CA enhancement.

R17 leftover should be considered. Some useful tools in R17 have to be down-scoped due to limited time.

In addition, use cases and potential technics are overlapped for URLLC/IIoT and XR to some extent. e.g. R17 leftovers can improve system efficiency, which is also benefit to increase capacity. So if only one item, XR or IIoT and URLLC, is decided, we prefer to combine all potential tools in one item.

4 – Sony Europe B.V.

@Futurewei: The features in Rel-16 & Rel-17 URLLC did undergo evaluation. In addition to gain, complexity was also discussed and it in some cases, e.g. in Rel-17, we spent more time discussing these than we did in specifying the feature. It is good to ensure features introduced are beneficial, easy to implement and something the market wants. However, it isn't clear what the new criteria are in Rel-18 to admit a feature.

@ Apple: Agree that we should minimise objectives in the WID that are open ended and lead to extensive time spent evaluating numerous proposals instead of spending time specifying them.

@OPPO, CATT, DOCOMO: On the overlapping between XR and URLLC, our view is that URLLC provides mainly L1 support for XR and so at least in RAN1, XR can be part of URLLC. However, we believe that XR is more than just L1 requirements and higher layer aspects can be handled as a separate WI in RAN2.

@ZTE: Agree that high capacity/throughput URLLC is important for numerous use cases (XR, VIAPA, medical) and this aspect was not considered much in Rel-16 & Rel-17. We should consider this in Rel-18 to ensure NR URLLC covers wider applications.

7.3 Narrowband in Dedicated Spectrum

This section is targeted at identifying commonalities and interactions for Narrowband in Dedicated Spectrum.

Feedback Form 17: Questions/Comments

1 – Anterix

Comments from Anterix: We want to note that we support verticals and operators that have 3GPP networks or allocated FDD bandwidths less than 5 MHz. This includes Band 26 PPDR in Europe, Band 28 in the USA (SouthernLinc), GSM-R in Europe and 900 MHz - Band 8/n8 in the USA for Anterix electric utilities. Other use cases like NTN are also potential candidates for using this proposed feature/functionality.

2 – Nokia France

As NR moves to the next phase with 5G-Advanced in Rel-18, it is a good time to ensure that important new areas of the 5G ecosystem are covered for the future. Three new domains have been highlighted, namely **railway communication**, **smart grid control** and **public safety**, with four clear synergies:

1. Spectrum allocations dictate the ability of NR to operate in bandwidths in the range 3-5 MHz;
2. Investment and deployment timeframes are long-term;
3. Device constraints are substantially different from RedCap, in that form factor, power consumption and complexity are not the primary concerns for these domains (although the ecosystem would also benefit from the existence of 5 MHz RedCap devices);
4. There is clear interest and commitment to make use of the NR ecosystem and capabilities (for example, the rail industry in Europe has decided to move straight from GSM-R to NR with a 10-year migration plan beginning around 2025, and a deployment lifetime likely to last decades).

Together, these synergies create a substantial opportunity for NR ecosystem expansion for the long-term, and Rel-18 seems the appropriate timeframe to ensure that NR is adapted to meet it.

3 – HUGHES Network Systems Ltd

We support studies for Narrowband in Dedicated NR Spectrum (FDD bandwidths), this will be useful and can be used for NTN scenarios.

4 – Deutsche Telekom AG

We only see a need for smaller than 5 MHz channelisation in very particular bands, which might not be the main bands used by public network operators. Especially in Europe the allocation of spectrum has been considered a min. of 5 MHz channels in the reautions since years and the spectrum arrangements were made in a way that they are muliples of 5 MHz. Hence besides GSM-R bnd there might not be any need (in Europe at least).

We should also not call it ”Narrow-Band” as this might imply 180/200 kHz carriers as we know from NB-IoT !

5 – T-Mobile USA Inc.

This should be discussed in the context of REDCAP enhancements, enabling CBW’s< 5MHZ requires considerable work.

6 – Ericsson LM

In order to benefit from the economies of scale of the 3GPP ecosystem, any solution must rely on minimal changes to the existing NR design. Hence, investigations should be along the lines of blanking resource blocks within the already defined 5 MHz bandwidth option.

7 – ZTE Corporation

We have some further questions on this topic:

1) Do we need to define a new UE type so that it can be identified by the network? And whether this type of UE will only access the dedicated narrowband spectrum (< 5MHz), or it could also access the normal bandwidth network?

2) If a 5MHz UE can be supported in the system with 3MHz bandwidth, can we adopt the similar method for Rel-18 RedCap UEs (5MHz) to work in 30kHz SCS scenarios?

3) In narrowband, if PUSCH hopping is enabled, do we need to consider collision problems such as for PUSCH and PRACH?

4) For the smart grid use scenario where both URLLC and mMTC are concerned, we believe some physical layer enhancements (e.g. PRACH, DMRS, procedure) can be considered to meet such requirements.

8 – vivo Communication Technology

We understand the market demand for this. However, techically, the boundary between Narrowband NR (e.g. 5MHz) and Redcap BW reduction (e.g. 5MHz as proposed by many companies) is not very clear.

1. While there might be some additional requirement to be done from NW side, but from UE perspective, it seems we can leverage the Rel-18 eRedCap UE BW reduction feature (e.g. to 5MHz) to address the requirement?

2. Reduced NR operation BW to for example 3 5MHz will definitely decrease the frequency diversity and frequency selective scheduling gain, do the proponent companies see the need to do additional enhancement, e.g coverage recovery scheme to compensate the loss?

9 – Guangdong OPPO Mobile Telecom.

Is the proposal for the dedicated network which does not require the public access? For our point of view, we should know if the narrow bandwidth is applied to normal public network UE. If that is only allow for special UE, then the standardization work in 3GPP should be justified.

10 – Beijing Xiaomi Mobile Software

1: What is the requirement or KPI for service provided by the narrowband NR system

2: What kind of devices will be supported by the narrowband NR system. RedCap devices or non-RedCap devices?

11 – Samsung Electronics Co.

We need to have better understanding on use cases and scenarios of this proposal because some companies have mentioned mission critical communications (including rail-way communications) and Public Safety but others have mentioned LPWA kind of services (e.g., smart grid). Different scenarios have different requirements which impacting design approach and it needs to be clarified first.

12 – Huawei Tech.(UK) Co.. Ltd

The primary common requirement is support for NR in channel bandwidths < 5 MHz. Limitation of impacts on SSB and CORESET0, are identified as design constraints, and it is indicated there may be other RAN4 impacts from channelization and sync raster, etc. We would like to understand how much additional standards work is foreseen when assuming those constraints are met, e.g. whether there is much work in common to the further reduction of RedCap UE bandwidth, compared to how much is work specifically for the <5 MHz case.

13 – VODAFONE Group Plc

Migration aspects (e.g. use of DSS) should be considered to ensure that the end specifications are actually of value.

14 – MediaTek Inc.

Could the proponent(s) point us to the relevant regulations that mandate the use of NR?

Feedback Form 18: Answers/Comments

1 – Swiss Federal Railways Ltd

UIC contribution RWS-210280 clarifies the need for channel bandwidth less than 5MHz from rail perspective.

The working name can be adapted to avoid misunderstandings e.g. reduced NR CBW etc.

RedCap may also envisage smaller channel bandwidth portions but narrowband NR functional spectrum, e.g. train speed up to 500km/h, remains unchanged in comparison to standard e.g. 5MHz channel bandwidth use. It is not anticipated that a specific UE is required because such UE may also utilize other channel bandwidths e.g. 5MHz or 10MHz. Certain flexibility is very welcome.

The use of 30kHz SCS in this context is not envisaged. Under certain mobility conditions, the use of 30kHz SCS will not bring advantages in the resulting throughput. Furthermore, there are limitations in the NR design in the 30kHz context. 15kHz SCS support might be sufficient. Potential limitations and necessary efforts, e.g. PUSCH hopping etc. are to be addressed during a study phase proposed by RWS-210035 and RWS-210280. The general intention is not to ask for a NR redesign.

The demand for reduced NR CBW results from certain verticals in association with their spectrum constraints. The use of reduced NR CBW would be open to individual use by the various frequency bands (see comment received from Deutsche Telekom AG).

The regulation regarding Rail Mobile Radio spectrum can be found under ECC Decision (20)02. Further explanations are also in RWS-210280.

2 – Southern Linc.

As presented by Anterix during their presentation, Southern Linc is a supporting partner for FDD bandwidths less than 5MHz to be added to NR. We have been a 3GPP member since the very beginning of B26.

We currently operate a 3MHz LTE system in FDD B26. We also have a trial deployment of a 3MHz LTE FDD B8 system. Our network supports a lot of different use cases such as VoLTE, eMBMS, PTT, smart grid, video, and mobile broadband. Our network also offers roaming to other operators, so we support full functionality across commercial bands. We do not desire a separate device and look to utilize the same device in our band(s) that we use when roaming. Adding 3MHz channel bandwidth to NR will give us a migration path from LTE. Thanks for your input on this topic.

3 – Anterix

Anterix Response:

Question by DT: As presented in RWS-210035, Anterix and SouthernLinc maintain and operate existing 2x3 MHz FDD networks in the USA in Band 26 and Band 8 – all of which have nationwide reach and global roaming capabilities. Our regulator, FCC, has allocated this spectrum in auctions and various rulings. We strongly advocate migration from our existing 3GPP networks to the next generation of technology – 5G NR. In Europe, we understand that there are 3 MHz FDD allocations for PPDR in band 28, as mentioned by Orange and GSM-R 900 MHz networks that need migration.

Question by T-Mobile USA: We are not targeting RedCap devices but are open to discussing commonalities in approach.

Question by Ericsson: We agree on limiting impact to the existing NR ecosystem. As part of a proposed SI/WI in Rel-18 we would want to consider what approach meets our needs and has the least impact. For example puncturing the first few RBs in the SSB helps us keep within 3 MHz CBW and retains the legacy PBCH and DMRS RE mapping.

Question by ZTE: Since we offer support to other bands and commercial roaming we do not want or require a new UE type that is only dedicated to this spectrum CBW. In order to minimize impact to the NR CORESET we want to utilize the same SCS. Ideally, we will introduce a Rel-18 SI/WI to investigate items such as PUSCH hopping issues and other possible considerations. For our particular use cases we want to initially focus on 3 MHz CBW. For future study we agree that we should consider URLLC and mMTC implementation in smaller CBW.

Question by Vivo: It is our current understanding that we do not need reduced capabilities in the UE. Since we offer access to other spectrum bands via roaming and carrier aggregation it does not seem to be possible or useful to use Redcap.

Question by OPPO: Our implementations are for private networks using LTE currently but we have multiple bands that we support. These networks offer roaming out to commercial networks. This includes most commercially available smartphones.

Question by Xiaomi: There are many system level KPIs, we can discuss offline if you have specific KPIs you are interested in. We are initially looking at non-RedCap devices.

Question by Samsung: For our utility grade networks we are not targeting LPWA devices initially. Our utility grade networks use the full function of mobility and capabilities like VoLTE – which are beyond "typical utility meters" used in LPWA smartgrid devices. We agree that the use cases are different between rail and utilities but the mechanism to migrate to a CBW less than 5 MHz remains the same. The majority of our devices are connected directly to grid power with backup – where size and power consumption are not a major concern. With our private networks we are looking at significant UL link budgets to ensure good coverage.

Question by Huawei: We are not targeting Redcap. Our goal is the have minimal impact on RAN1 If our spectrum allocation cannot reuse the 5 MHz BWP, then we may have to consider a new 3 MHz CBW for NR and this may have some RAN4 impact.

Questions by Vodafone: We agree that DSS impact/value for migration should be considered.

Questions by Mediatek: Please refer to https://docs.fcc.gov/public/attachments/DOC-354326A1.pdf The FCC has included Anterix's 900 MHz spectrum in its 5G FAST Plan, indicating the US government backs our spectrum as ideal for 5G. For railways, the European rail industry has decided to migrate GSM-R to NR in their FRMCS project.

4 – Qualcomm Incorporated

Considering multiple market requests and clear commercial plans, we support the study of narrowband NR in dedicated spectrum.

Regarding UE device type, it is non-RedCap. The study here is very different than eRedCap because of:

- Smaller BW than 5MHz from network side.
- No specific concern on power consumption, complexity. Specifically, a UE operating in <5MHz in this band may support a much larger bandwidth in a different band. The issue is in the network bandwidth, not on the UE bandwidth.
- No backward compatibility issues (e.g., no UEs with wider bandwidth) in dedicated spectrums

Regarding spec impact, we strive for reusing existing NR techniques with minimum changes.

From RAN1 perspective,

- SCS of 15kHz is sufficient for the FDD sub1GHz
- No change of PSS/SSS
- RB puncturing and power boosting can be used for the transmission in the limited CBW, such as PBCH, CORESET0.
- Legacy schemes, such as coverage enhancement and DSS, can be considered if needed in some scenarios. But over optimization should be avoided to control the workload.

From RAN4 perspective, the expected work includes channelization and potential changes in sync raster of dedicated spectrum.

5 – Nokia France

During the first round, several companies have recognised the market demand for the ability to deploy NR in spectrum allocations between 3 & 5 MHz. As well as FRMCS in Europe, this is relevant for PPDR in band 28 in Europe and the highlighted utility networks.

Several companies also ask about the relationship to RedCap, and the expected specification impacts.

We believe it is important to minimise the RAN1 impact, and therefore simple solutions such as puncturing are strongly preferred. For some deployments, such as 3MHz, a new channel bandwidth is expected to be needed in RAN4. Thus the expected impacts are rather different from reducing the max supported bandwidth of RedCap devices to 5 MHz, since the latter should not impact the fundamental L1 signals and channels like SSB and CORESET. Also, the kinds of terminal needed for the railway, utility network and public safety deployments are not subject to the same constraints as those that motivate RedCap: power consumption, cost, complexity and form factor are not issues for the devices we consider here. Thus, devices that support operation in these narrow spectrum allocations could also support wider bandwidths to operate as normal UEs on normal NR carriers.

Overall, we see here a substantial opportunity for NR ecosystem expansion, meeting the needs of important industries who are committed to using NR for the long-term.

6 – Huawei Tech.(UK) Co.. Ltd

To respond to ZTE:

ZTE:

4) For the smart grid use scenario where both URLLC and mMTC are concerned, we believe some physical layer enhancements (e.g. PRACH, DMRS, procedure) can be considered to meet such requirements.

Answer: These are interesting enhancements and might not need to be specific to <5 MHz dedicated band ~~UEs~~ and, if so, would be worth discussing under the general RedCap enhancements.

7.4 Network Slicing Enhancements

This section is targeted at identifying commonalities and interactions for Network Slicing Enhancements.

Feedback Form 19: Questions/Comments

1 – Huawei Tech.(UK) Co.. Ltd

In term of feature, we can distinguish the continuation of the rel-17 and new proposals. Should RAN focus first on completion and if time allow in term of TU provide new proposal?

2 – Ericsson LM

The proposed Network Splicing enhancement should be based on the current NR architecture.

The enhancements related to the slice remapping enhancement, the new requirements/use cases, etc., should first be studied and agreed by SA1/SA2.

3 – Nokia

There seems to be strong interest from operators to introduce further flexibility in network slice deployment and operations, e.g. in case of small service areas that could also be deployed for a limited time. It would be good to clarify the exact deployment scenarios of interest for Rel-18 to understand all the requirements for slicing enhancements.

4 – T-Mobile USA Inc.

T-Mobile would like to see R18 enable slice identification / selection available at the cell level. In R17 this was restricted to the Tracking Area which lacks granularity.

5 – ZTE Corporation

We see common interest among the proponents on continuation of the slice re-mapping work to support service continuity and the potential RAN impact of Rel-18 progress in other WG (SA1/SA2), which we are also interested in. Furthermore, we are interested in UE leverage different slice resource in MN and SN as well as some further enhancement on cell re-selection in addition to what we have in Rel-17.

As raised by some companies during the 2 rounds of email discussion, we are also wondering whether the homogeneous principle should also be followed in Rel-18?

For the Rel-18 requirements on slicing from SA1, we understand the Rel-17 RAN slicing enhancement would be helpful to some extent thus some analysis and evaluation should be performed to see if some further enhancement in RAN is needed in Rel-18.

6 – Spreadtrum Communications

Regarding R18 slicing enhancement, we have one question about the scope.

Q1: For the potential slice enhancement, some contributions (RWS-210082, 0230, 0349 and 0482) proposed to handle the RAN impact from SA1, including fast access to the slices, minimize service interruption time, and access to a slice via a relay node, etc. Due to some of RAN impact have been studied in R17 Slice, e.g. fast access to slices, should we first identify what scenarios that cannot be satisfied by R17 slice?

7 – LG Electronics UK

Considering use cases identified by SA1 and variable verticals in 5G system, we'd like to further investigate possible deployment scenarios and RAN solutions in Rel-18. We are also interested in the cases of slice configurations for small area and MR-DC cases. We think further analysis of possible RAN impacts for new use cases and requirements from RAN perspective would be beneficial. Coordination with SA is needed.

8 – Guangdong OPPO Mobile Telecom.

General question: which WG will be involved in?

General comment: this work should depend on the progress of R17 RAN slicing and outcome of SA1/SA2 new requirements.

- On minimization of service interruption, this seems like a RAN3 issue, so it depends on the progress in RAN3 in Rel-17.
- On new requirement from SA1 SI FS_EASNS, the delta part from Rel-17 should be clearly identified.
- Questions to [230] from LGE:

- Regarding “Restriction is based on frequency, geographical area, timely-manner, simultaneous usage of network slices”□ seems it is somehow covered in R-17 scope?
- Regarding “Support power saving mechanisms based on slice priority and/or disjoint network slices information”, the later one is out of slicing scope?

9 – Beijing Xiaomi Mobile Software

1. Do you think it is a valid scenario that one operator deploys multiple CUs serving the same DU with different capability in supporting slices?
2. Do you think it is necessary to support cell level granularity of slice deployment (instead of current TA level granularity)?
3. Do you think slice specific power saving (e.g. slice specific RRM/DRX) is needed?
4. Do you foresee any RAN impact of slice restriction (one slice can not be used simultaneously with another slices)?

10 – Beijing Xiaomi Mobile Software

General comments:

We are in line with companies’ interest on IoT area. And companies proposed the questions on different angles, we can put them into several categories:

1) Terminals coordination (RWS-210060, 0172,0251)

2) Power saving and cost reduce(0324,0453)

3) New QoS requirement(0294,0508):

4) enhanced coverage, SDT and others(0509, 0467)

We think it is necessary to decide in which SI/WI these topics should be discussed first in order to control the scope of each SI/WI considering some may have partly overlapped with Redcap, sidelink, and SDT enhancement. For the overlap parts, we think we can discuss them first in the specific WI (e.g., sidelink enhancement) to see whether some solutions can be reused for IoT devices as well.

Some specific questions for the contributions. Really appreciated if the source companies can help us clarify.

To RWS-210060, 0172:

We are interested in this terminals coordination case mentioned by personal IOT. Your paper is mainly about sharing the same content on multiple UE. We are wondering whether you are also interested in other multi-UE coordination cases, for instance, different content transmitted on multiple UEs cooperatively?

To 0294:

Does this involves some SA1 work considering the new Qos types?

To 0324:

For the ”Power Saving enhancements in RRC_Connected”, RRM relaxation and PDCCH skipping is now discussed in R17, do you want other enhancement?

To 0453:

1) For the ultra-simple hardware in downlink, it is the same as AZP-WUS?

2) For ”Minimized protocol stack”, do you want a new simplified protocol stack?

To 0508:

How to achieve the high-reliability of first transmission? Do you have some enhancements in mind?

11 – Beijing Xiaomi Mobile Software

Our comment #10 is for other topic, pls ignore it. Sorry for the mistake.

12 – CATT

In general, we think slicing enhancement should be continued in Rel-18.As to the bullet that should be considered in Rel-18,we agree with most companies that at least the Rel-17 leftover/low prioritized aspects such as service interruption due to slice not supported should be included. For the potential RAN impact brought by the new requirement in SA,we think we could observe the discussion in SA2 and see whether further work in RAN side is needed or not.

13 – KDDI Corporation

We are very supportive to have enhancements on this area. We summarized all the proposals as below to organize the next phase discussion.

1. Continuation from Rel-17

- Slice based reselection for MO (RAN2) (CMCC, ZTE)
- Enhancement to slice based cell reselection (e.g. Different RSRP/RSRQ thresholds) (ZTE)
- TA (Tracking area) aware cell reselection (RAN2) (KDDI)
- Slice re-mapping work (RAN3) (CMCC, Nokia, ZTE, KDDI)
- Network slicing on MR-DC/CA (CMCC, ZTE)

2. Potential RAN impacts from other WGs

- SA1 FS_EASNS (CMCC, ZTE)
- RAN Topology information awareness by AMF (SA2 mainly impacting RAN3) (Nokia)
- Secured RRC connection establishment (SA3) (Nokia)

3. Rel-18 new enhancement

- Slice prioritization/preference in case the UE is associated with multiple slices (Nokia)
- Support of network slices with small service area requirements (Nokia)
- Slice dedicated cell selection criterion S (KDDI)
- Slice aware mobility when usage of network slices is restricted (LG)
- Power saving mechanisms based on slice, RRM, DRX (LG)

14 – Samsung Electronics Co.

We need to understand how slice priority impacts on power saving mechanism i.e., DRX.

15 – Motorola Mobility UK Ltd.

We are open to R18 enhancements. However, in view of the many different areas of potential RAN slicing enhancements with impacts to different groups we suggest to focus further discussion in RAN on:

- Identify the enhancements which may be started directly with a WI or firstly with a SI
- For the enhancements which may require a study, clarify which group (e.g. SA2, RAN2, RAN3) may start with the study
- Prioritization of topics, e.g. whether R17 leftover issues have higher priority over the new areas of enhancements or vice versa; whether to prioritize enhancements which rely on the R17 enhancements etc.

16 – Sony Europe B.V.

A general comment/question about the timeframe regarding a slice being added or removed from a network and passing the slice related information down the network. Is an application provider requesting a slice assumed to be tied up for a long time (months) or is it more dynamic? This would then dictate the frequency of slice related parameters updated in the network.

17 – China Telecommunications

The Operator Customizable Network Sharing as proposed in RWS-210156 is about RAN sharing, and seems to be more applicable to be discussed in "Other" topics.

Feedback Form 20: Answers/Comments

1 – Samsung Electronics Co.

Comment to #1:

We think that RAN should first focus on completion of leftovers from R17.

2 – LG Electronics UK

Leftover and deprioritized topics in Rel-17 should be discussed in Rel-18, and we would suggest to discuss Rel-18 RAN slicing enhancements as well.

For Rel-18 enhancements, LG would suggest that:

- RAN2 and RAN3 start Rel-18 work from SI.
- During SI phase, RAN2 and RAN3 analyze/investigate RAN impacts and focused scenarios considering use cases identified by SA1 in Rel-18. Also, we would like to discuss deployment scenarios to support e.g., small area configurations, MR-DC configurations.

We are thinking RAN WGs should start study RAN impacts for new use cases identified rather than waiting for inputs from SA2, and provide inputs to SA1/SA2 if RAN level solutions are beneficial or non-homogeneous deployment scenarios needs to be reconsidered.

@Spreadtrum, OPPO

Among the lists of considerations in 0230, we would like to discuss RAN solutions using simultaneous usage restriction information. We see possible RAN impacts on this scenario.

Regarding frequency and area restrictions, further discussion would not be needed if only homogeneous deployment is possible. Regarding time restriction, we think upper layers could handle this, but we are open for discussion.

We agree that we should first identify what scenarios that cannot be satisfied by R17 slice. We need further analysis on scenarios.

@OPPO

We'd like to clarify your question. Does the later one mean "disjoint network slices information"? We think disjoint network slices information can be considered for RAN slicing solutions.

@Xiaomi, Samsung

If a particular slice is unavailable, that means the associated service and radio resources cannot be used. So, we would like to discuss power saving mechanisms based on slice availability.

@Sony

In our understanding, the available time related restriction could not be always controlled by frequency. In homogeneous deployment, we think upper layers can handle this restriction.

Thank you all for the questions and further clarification.

3 – ZTE Corporation

Answer to #1:

We understand a WI with a study phase for slicing would help.

The continuation of the Rel-17 work (e.g. slice remapping) can be included in WI scope directly as there has already been some analysis while the new proposals and the new Rel-18 requirements from SA1 can be evaluated and analyzed in the study phase to identify the extra work needs to be done in RAN in Rel-18.

Comment to #2:

The slice remapping has already been studied in Rel-17 so we understand normative work can be started in Rel-18.

For the new requirements, we agree some analysis is needed to identify if some extra work needs to be done in RAN in Rel-18.

Thus, we understand a WI with a study phase would help, with Rel-17 leftovers (e.g. slice remapping) included in the WI scope directly and a study phase for the new requirements or proposals.

Comment to #3 and #4:

We also see interest from operators to introduce further flexibility in slice deployment, e.g. in cell level instead of TA level.

As mentioned above, a WI with a study phase for slicing is suggested from our side, and the deployment of interest for Rel-18 can be clarified in the study phase to better understand the new requirements and evaluate the potential RAN impact.

Answer to #6:

We agree that some analysis on the new requirements is needed before we start the normative work in RAN. Thus a WI with a study phase for slicing is suggested from our side, with the continuation of the Rel-17 (e.g. slice remapping) included in the WI scope directly and a study phase to clarify and evaluate the new requirements.

Comment to #7:

We agree that further analysis of the RAN impact for new requirements and use cases is needed.

To cater for interest in continuation of Rel-17 work (e.g. slice remapping) and the new requirements and use cases, we suggest to have a WI with study phase for slicing, with continuation of Rel-17 work included in the WI scope directly and a study phase for the new requirements and use cases.

Answer to #8:

General: We understand RAN2 and RAN3 will be impacted considering the interest in continuation of the Rel-17 work (e.g. enhancement to slice based reselection and slice remapping). Also impact in RAN2 and RAN3 is foreseen according to the new requirements from SA1.

Minimization of service interruption: There has been SI for slice remapping to reduce the service interruption in Rel-17 but no normative work due the limited time, we understand the normative work can be started in Rel-18.

New requirement from SA1: We agree the requirements should be clarified and analyzed first to identify the delta part from rel-17.

Overall, to cater for interest in continuation of Rel-17 work (e.g. slice remapping) and the new requirements, we suggest to have a WI with study phase for slicing, with continuation of Rel-17 work included in the WI scope directly and a study phase for the new requirements.

Comment to #9:

Q2: We see interest from operators to introduce further flexibility in slice deployment, e.g. in cell level instead of TA level.

Q3: We understand the slice specific power saving related proposals come from SA1 new requirements and some clarification and analysis is needed to see whether some enhancement is needed in addition to the common power saving mechanism we have in Rel-16 and Rel-17.

Comment to #12:

Agree and we suggest to have a WI with a study phase for slicing, with continuation of Rel-17 work included in the WI scope directly and a study phase for the new requirements.

Comment to #13:

Thanks for the summary.

Among all the proposals, we understand we can identify the enhancements which can be started directly and those require a study.

A WI with a study phase is suggested from our side with some enhancements (e.g. continuation of Rel-17 work like slice remapping) included in the WI scope directly and study phase for the new requirements or enhancements.

Comment to #15:

Agree to identify the enhancements which can be started directly and those require a study. A WI with study phase is suggested from our side with the some enhancements (e.g. continuation of Rel-17 work like slice remapping) included in the WI scope directly and a study phase for the new requirements or enhancements.

7.5 Other IoT Enhancements

This section is targeted at identifying commonalities and interactions for Other IoT Enhancements.

Feedback Form 21: Questions/Comments

1 – Ericsson LM

It was proposed to introduce enhancements for PIN. We think that the main issues for PIN would be on application layers (which we assume anyway would need to be involved). And give that application layer solutions are needed for this we are unsure what exactly would need to be done in RAN, and if it is worth the additional complexity to introduce the suggested enhancements.

2 – Huawei Tech.(UK) Co.. Ltd

Passive IoT, and/or very lower power operation for IoT devices, as a distinct topic has been raised in a number of papers: RWS-210331, 0041, 0302, 0350, 0453, 0509. Passive IoT has a similar level of interest as some other topics which warrant their own discussion, such as RIS (section 5.5 of the eMBB discussion) and narrowband NR (section 7.3 in non-eMBB).

There is a market of use cases of extremely low power and cost, in the cost region of a barcode, e.g. $0.01,and the power consumption of energy harvesting and/or backscattering levels e.g. <0.1 mW, that cannot currently be addressed by any 3GPP technology even though they are currently in some cases dependent on human operation in line-of-sight to the item – a case where a small-area cellular solution would be particularly attractive. Assuming that other technologies will be ready to address this market in the years well before 6G would be commercialized, and very likely within the timeframe of 5G-Advanced, it would be valuable to have discussion on where in 3GPP to develop requirements for passive IoT in Rel-18, e.g. RAN SI, RAN1&4 SI, etc.

3 – ZTE Corporation

1) Our contribution RWS-2100467 is relevant to this sub-agenda item, in which we believe the transmission efficiency and/or certain URLLC requirement should be taken into account in addition to massive connections for the enhancement of NR-IoT. Enhancement on SDT (e.g. idle state, MT triggered) as well as some physical layer enhancements (e.g. PRACH, DMRS, procedure) can be considered to achieve such requirements. Please refer to our further input for SDT in ”5.6 others” under eMBB NWM thread.

2) Regarding personal IoT, we think SA2 should discuss the potential solutions, and to identify if there is an impact to RAN.

3) Regarding passive IoT, we think the urgency of the study in RAN can be further discussed, given that there is a similar proposal in SA1 to study the requirements of Wireless Power Sourcing enabled Communication Services (WPSCS).

4 – Spreadtrum Communications

We have one clarification on RWS-210294, regarding the new QoS type, as the QoS parameters are informed to RAN by CN, should the new QoS types be defined in SA first?

5 – Beijing Xiaomi Mobile Software

General comments:

We are in line with companies’ interest on IoT area. And companies proposed the questions on different angles, we can put them into several categories:

1) Terminals coordination (RWS-210060, 0172,0251)

2) Power saving and cost reduce(0324,0453)

3) New QoS requirement(0294,0508):

4) enhanced coverage, SDT and others(0509, 0467)

We think it is necessary to decide in which SI/WI these topics should be discussed first in order to control the scope of each SI/WI considering some may have partly overlapped with Redcap, sidelink, and SDT enhancement. For the overlap parts, we think we can discuss them first in the specific WI (e.g., sidelink enhancement) to see whether some solutions can be reused for IoT devices as well.

Some specific questions for the contributions. Really appreciated if the source companies can help us clarify.

To RWS-210060, 0172:

We are interested in this terminals coordination case mentioned by personal IOT. Your paper is mainly about sharing the same content on multiple UE. We are wondering whether you are also interested in other multi-UE coordination cases, for instance, different content transmitted on multiple UEs cooperatively?

To 0294:

Does this involves some SA1 work considering the new Qos types?

To 0324:

For the ”Power Saving enhancements in RRC_Connected”, RRM relaxation and PDCCH skipping is now discussed in R17, do you want other enhancement?

To 0453:

1) For the ultra-simple hardware in downlink, it is the same as AZP-WUS?

2) For ”Minimized protocol stack”, do you want a new simplified protocol stack?

To 0508:

How to achieve the high-reliability of first transmission? Do you have some enhancements in mind?

6 – vivo Communication Technology

On Personal IOT

In our PIOT contribution RWS-210172 , the three cases, can be categorized two operations between UEs, i.e., service switching and aggregation between UEs. And based on the contribution review, very similar functionalites are proposed in many contributions, as summarized below

For service swtiching across devices

a) Consumer use case: RWS-210172(vivo), RWS-210060(Spreadtrum), RWS-210345(CMCC), RWS-210422(interdigital, RWS-210479(ZTE)

b) Industrial use case: RWS-210346(CMCC), RWS-210454(Huawei), RWS-210229(LG)

For UE aggregation

RWS-210172(vivo), RWS-210355(CMCC), RWS-210451(Huawei), RWS-210479(ZTE), RWS-210422(interdigital), RWS-210192(FGI), RWS-210199(Rakuten)

Although the UE aggregation has been allocated to another email thread, but we observed the commonality with service switching use cases.

Reply to some comments above:

We agree that application layers have to be involved, i.e., use the same application in two separate UE

at same time (switching service for consumer case because two UE is in two device), or one application deliver the one service to separate UE at same time (Industry case and UE aggregation case because two UE is in one device). The drawback of such application layer solution could be

1) The app approach has a limitation that the involved devices have to install the same app. The 5G network involved solution however does not have such limitation.

2) App layer has no idea about the radio condition information, there operator cannot optimize the performance due to lack of related detail information. With RAN side solution NW can select appropriate UE and some other optimizations can also be performed based on the radio information.

3) The switching is in high layer which cannot guarantee the lossless or seamless, which is critical for some commercial use cases (e.g. gaming) and most of the indurstrail use cases.

For existing SA2 solutions, i.e., MPTCP, it is for redundant transmisison which is totally differrent service switching. And the delay of SA switching solution will be 100ms because UPF node is far from UE than gNB. However, it is better if delay of gaming switching can be lower than 50ms and backup case is for URLLC, Potential delay and interruption of service is lower than 10ms.

For UE aggregation case, it is for UL coverage and thoughput enhancements, the channel radio solution is well known by AS layer. RAN is suitable node to split different packet to different UEs in coverage limitation case.

Furthermore, we think that service switching for consumer and industry and aggregation between UEs can be considered together because RAN can select appropriate UE and some other optimizations can also be performed based on the radio information if gNB is as the anchor.

7 – vivo Communication Technology

On Passive IOT (0453)

we observed there might be some commonality with the almost-zero-power wake up signal as being proposed in email thread 5.1 UE power savings(eMBB), Tdoc #0168/0169. As one example, an OOK waveform in DL is likely required to enable the envelop detector with extremely low complexity and power, however, there could be some difference in the required data rate between wake-up signal and DL data transmission (in Passive IOT). Some joint consideration might be considered.

8 – Samsung Electronics Co.

Service discovery/negotiation/switching:

RAN have defined AS layer features specific for certain services. However if we see the objectives on slide 6, we wonder whether they are in scope of RAN and it is not clear what RAN should work in R18. For example device discovery procedure and service negotiation procedure, service sharing architecture look like items to be studied in SA group. Could you give some specific example of RAN feature?

UE coordination:

The listed scenarios from the contributions are interesting, however, it is unclear what is not supported by existing and ongoing standards to support the scenarios. We have some questions:

- How can the network identify whether two devices belong to the same user, and thus provide this coordinated TX and/or RX?

- Is there any measured result and specific KPIs to supported more in R18? For example, regarding power saving for multi UE coordination, could you clarify what is lack in existing and on-going (e.g., R17) UE power saving mechanisms and functional requirement in R18?

In general, we think that more analysis on functional requirements are needed e.g., what is lack in the existing and ongoing (R17) standards.

SDT enhancement: This can be discussed later after Rel-17 SDT is clearer.

9 – China Mobile Com. Corporation

Our contribution *RWS-210345 Motivation of study for Inter-UE Handover or Replication for Same Useris* relevant to this sub-agenda item as well. From our perspective, we see the following commonalities among the listed contribution in the table of the email discussion:

a. The intention is to require the network can enable the users to initiate, handover (transfer/ switch), or sometimes replicate communication streaming (e.g. video, speech, audio) between multiple devices of the same end-user for a variety of reasons, in order to make the inter-UE handover/replication more flexibility and improve radio resource efficiency via RAN-based solutions.

b. Study the control plane procedure design, including RRC connection management, paging mechanism and access control for initiating inter-UE handover and replication for the same end-user.

c. Study user plan functionalities that will support data forwarding/data replication of communication data amongst multiple devices of the same end-user, e.g. which layer to act as the anchor layer to perform the data forwarding/routing.

d. And we think the SA2 can be involved in the RAN study, but no need to wait for the ultimate result from SA.

10 – Lenovo (Beijing) Ltd

1) Some companies propose to enhance NBIoT on power saving. In fact, from Rel.15 to Rel.17 NBIoT and eMTC, power consumption is the main target for IoT evolution, we have achieved a lot on power saving. So we don't have much room to enhance it on the existing RAT scope and we need further investigate the necessity.

2) Some companies propose personal IoT with motivation on the extreme low power and cost. It seems to be one of the IoT evolution trends. However, to develop a new RAT on 5G, we need carefully study the use case (only for indoor scenarios? commercial target?), traffic model (frequency band?), design target (coverage, UE power level, etc).

11 – China Mobile Com. Corporation

We are interesting and supportive on the study of NR UAV features considering the trend of market demand. And from CMCC perspective, since some features and functionalities of UAV have been studied in LTE R15, for NR UAV, the features of UAV discussed in LTE R15 could be the baseline, then consider further enhancements, for example, mobility enhancements(e.g. CHO, group HO), measurement enhancements, UE reporting including location, height, speed, and reliability about flight path, etc.

Feedback Form 22: Answers/Comments

1 – Beijing Xiaomi Mobile Software

Thanks to Samsung for your good questions on multi-UE coordination.

A little bit clarification for the motivation. We foresee the new SA1 use cases/scenarios (e.g., multi-modality interactions [TR 22.847], federated machine learning[TR 22.874], etc) addressing coordinated parallel transmission imposes new requirements for 5G system on multi-UE coordination while the current 3GPP networks schedules or considers the QoS individually for a single UE device which may not capable to support this well.

We give an example in our paper on user plane procedure including coordinated scheduling to fulfil the traffic synchronization. This is helpful when the radio resource is undergoing a congestion (where this problem may not exist in wired or WIFI environments). If the radio resource management understand what is required at the application level, we can do things to make sure the application will receive all the

data flows in needs at the same time or within predefined delay which will lead to less waiting time in the Application.

I admit there are a lot ways of doing things. As people say App can do this. But it does not mean the network should not participated in it especially in the wireless network. The RAN can do this coordination to better support the service. And we are not considering what the best is for a single UE, we should look at what is the best way to have all those UEs working together. As a lack of 1 out of 3 multi-modality streams will cause the application server to drop the data received from the 2 acquired multi-modality streams and hence already consumed radio resources are wasted.

For your detailed questions:

1) How the network identify whether two devices belong to the same user: The application will give the network some assistance information about the UEs.

2) For the power saving enhancements, what in our mind is UEs in vicinity can share some processing. An example is UE's RRM measurement results can be reused by other UE to achieve RRM relaxations. Currently, we have not thought about how DRX/WUS/SDT works for a group of UEs. But we are open to discuss and welcome ideas from other companies.

3) Functional requirements: As the requirement is from SA1 (TR 22.847), we'll keep an eye on SA1 to see if there is more impact. And we are most welcomed to companies who are willing to join in.

2 – Spreadtrum Communications

Answers to #5 (Xiaomi)

In PIOT, we focus on the sharing scenario including the switch and duplicate cases. We are also interested in the collaborative case where the different contents are transmitted on different UEs. We think this case can be discussed in UE aggregation item, or maybe in this item.

Answers to #8 (Samsung)

In our thinking, some RAN related information is needed during the device discovery/negotiation for the target device selection/reselection. E.g. cell id, UAC result of target device in its cell. For the architecture, how to accomplish the lossless switching is also RAN related, e.g. via the status report and DL retransmission.

3 – Huawei Tech.(UK) Co.. Ltd

Replies on passive IoT discussion area:

vivo

Question: we observed there might be some commonality with the almost-zero-power wake up signal as being proposed in email thread 5.1 UE power savings(eMBB), Tdoc #0168/0169. As one example, an OOK waveform in DL is likely required to enable the envelop detector with extremely low complexity and power, however, there could be some difference in the required data rate between wake-up signal and DL data transmission (in Passive IOT). Some joint consideration might be considered.

Answer: Yes, it is possible there are similarities, as we mentioned during Tuesday's GTW. A difference is that in passive IoT, the received signal might not be used only for a wake-up receiver to alert the rest of a conventional UE, but also to power the UE as a whole e.g. via harvesting the received RF energy for backscattering transmission. In Rel-18, we assume a SI, and it is indeed possible that a suitable scope can be found which allows addressing the potential commonalities of waveform design, etc.

Xiaomi

Question 1) For the ultra-simple hardware in downlink, it is the same as AZP-WUS?

Answer: Envelope detection is a useful technique for passive IoT reception, as for almost-zero power operation in general. It would be necessary for RAN1 to evaluate various signal types before settling on the best for passive IoT. At this stage, we do not have a fixed assumption on the hardware basis.

Question 2) For "Minimized protocol stack", do you want a new simplified protocol stack?

Answer: Yes, because the cost and power consumption of passive IoT devices has to be extremely low, which is likely to need evaluation of what protocol stack has to be stored and processed in the UE.

4 – China Mobile Com. Corporation

In summary, there are mainly the following questions raised by companies:

· Q1: Is there the strong motivation to support this functionality within the 5G network, compared to application layer service continuity?"

· A1: This can enable the users to initiate, handover (transfer/ switch), or sometimes replicate communication streaming (e.g. video, speech, audio) between multiple devices from different vendors of the same end-user for a variety of reasons. And the drawback from application layer service continuity is the restriction of the different UEs should belong to a same vendor.

· Q2: Both CN based or RAN based solutions should be studied in SA first. CN based solution should be studied in SA. And for RAN based solution, since gNB is able to recognize the two UEs are associated, the UE association and identification issue should be also studied in SA first.

· A2: As you mentioned that for RAN based solution, since gNB is able to recognize the two UEs are associated, the UE association and identification issue can be addressed in RAN, consequently.

· Q3:Thanks for your contribution. we are interested in how the service continuity can be guaranteed. For DL data, the application layer solution seems work as well. For UL, Is it necessary to replicate the UL data in UE buffer to antoher device in your assumpation?

· A3: This can enable the users to initiate, handover (transfer/ switch), or sometimes replicate communication streaming (e.g. video, speech, audio) between multiple devices from different vendors of the same end-user for a variety of reasons. And the drawback from application layer service continuity is the restriction of the different UEs should belong to a same vendor. For UL, if no direct link between the UE, e.g. PC5, the service continuity is pursued in best effort manner.

5 – Sony Europe B.V.

#2 (Huawei). We agree with Huawei that energy harvesting and passive IoT is an area of interest. We think passive IoT should be considered in a study item. We would have to decide whether aspects like low power WUR were included in such a passive IoT SI or in a UE power saving SI.

#3 (ZTE). We think that passive IoT does not necessarily rely on wireless power sourcing (from the SA1 study). We can also consider devices that are powered by energy harvested from sources other than the incident RF wave.

6 – vivo Communication Technology

Reply to some comments above:

We agree that application layers have to be involved, i.e., use the same application in two separate UE

at same time (switching service for consumer case because two UE is in two device), or one application deliver the one service to separate UE at same time (Industry case and UE aggregation case because two UE is in one device). The drawback of such application layer solution could be

1) The app approach has a limitation that the involved devices have to install the same app. The 5G network involved solution however does not have such limitation.

2) App layer has no idea about the radio condition information, there operator cannot optimize the performance due to lack of related detail information. With RAN side solution NW can select appropriate UE and some other optimizations can also be performed based on the radio information.

3) The switching is in high layer which cannot guarantee the lossless or seamless, which is critical for some commercial use cases (e.g. gaming) and most of the indurstrail use cases.

For existing SA2 solutions, i.e., MPTCP, it is for redundant transmisison which is totally differrent service switching. And the delay of SA switching solution will be 100ms because UPF node is far from UE than gNB. However, it is better if delay of gaming switching can be lower than 50ms and backup case is for URLLC, Potential delay and interruption of service is lower than 10ms.

For UE aggregation case, it is for UL coverage and thoughput enhancements, the channel radio solution is well known by AS layer. RAN is suitable node to split different packet to different UEs in coverage limitation case.

Furthermore, we think that service switching for consumer and industry and aggregation between UEs can be considered together because RAN can select appropriate UE and some other optimizations can also be performed based on the radio information if gNB is as the anchor.

Answer to #8 (Samsung) about UE coordination:

We think how the Network know the group UE can be discussed.

About KPI for Power saving due to separate UL and DL, we can provide it later. The separate UL and DL is not collision with existing power saving mechanism.

7 – ZTE Corporation

We would like to further clarify our previous comment on the personal IoT. We said the potential solutions should be discussed in SA2 were mainly for the service switching part, because there may or may not be RAN impact. For UE aggregation, we are also supportive but it is not relevant here because it is allocated in another NWM thread.

8 – Fraunhofer IIS

#5 (Beijing Xiaomi Mobile Software)

We are aware of the discussions on PDCCH skipping, RLM/BFD and RRM relaxations in Rel-17. Although the details of the adopted solution are still open, we believe that further enhancements will be required to cope also with limited computational complexities which is not in the focus of the power saving discussions.

More adaptable PDCCH monitoring schemes can help to find a good tradeoff between the traffic requirements and the limited computational capabilities of a device. Also, it is not clear how far these features will go in terms of power saving (more conservative changes or more aggressively reducing power consumption). The current discussions on RLM/BFD relaxation and RRM relaxation point to more conservative approaches. Further power saving gains should be possible if the features are further enhanced on Release

18. For some specific use cases/devices, such as wearables, we may need to go the last mile in terms of power saving and also consider RRM relaxation in connected mode.

Reply to Sony (answer #5 above)

We are also interested in energy harvesting, which might not need a study item before working on the topic, e.g. in RedCap or eMTC. Passive IoT might need a study item phase. The low-power WUR is not necessarily connected to Passive IoT and should be in Power Saving (WI?). We also agree to not limit passive IoT to wireless power sourcing but more to energy harvesting including other power sources as well.

9 – Guangdong OPPO Mobile Telecom.

As mentioned by Huawei, IOT with outside power sourcing was raised for discussion. We would like to make the scope more clear. In our contribution 0041, the consideration more for the requirement side. Thus, it seems too earlier to draw conclusion that they share the common parts with wake up signal for UE power saving.

7.6 HAPS

This section is targeted at identifying commonalities and interactions for HAPS.

Feedback Form 23: Questions/Comments

1 – SoftBank Corp.

Deployment scenarios for NTN were discussed in Rel-17 SI, but HAPS specific scenarios were not intensively discussed there. We would therefore propose to start from study phase led by RAN1 to identify the specific issues for HAPS. The potential areas for the study are, e.g.

- development of deployment scenarios including evaluation assumptions
  - determination of aircraft & BS type (e.g. output power, antenna/beam pattern)
  - interaction with TN including spectrum aspect (i.e. same or different spectrum)
  - regenerative payload is the baseline for HAPS
  - direct communication to normal UEs (handheld UEs) is the baseline for HAPS
- Identification of the problems under the developed scenarios, e.g.
  - Interference management between HAPS and TN
  - Necessity and benefit of defining interface for inter-HAPS link and feeder link

2 – Deutsche Telekom AG

We agree with Softbank that we better seperate HAPS from NTN (Sat). This combination of the two topics lead to confusion already in the past and both serve different use cases and utilise different assets. Obviously this work targets using normal (incl. legacy) devices for communication / service via HAPS.

The work shall focus on the essential parts missing until now, but do not extend to ”nice-to-have features” proposed in some contributions. Such a system must be operable under commercial conciderations.

3 – ZTE Corporation

For HAPS, comparing to the NTN discussion in both R17 and R18, there is clear need to investigate the co-channel interference issue. For this part, study will be needed with well-defined scenarios and assumption.

W.r.t other enhancement, justification on the needs and difference between the discussion in NTN and HAPS is needed to solidify the scope.

4 – Apple GmbH

HAPS in general has high amount of interference issues that RAN4 needs to consider. Also, as part of NTN in R17, there is not many HAPS specific design we have so far. Are there any non RAN4 issues that are specific to HAPS that cannot be achieved by procedures already present in RAN1/2/3 today?

5 – Beijing Xiaomi Mobile Software

The design for HAPS is within the Rel-17 NTN WI scope. However, no dedicated HAPS-specific design is specified in Rel-17. It is also suggested to work on the HAPS-specific design in Rel-18.

6 – DOCOMO Communications Lab.

Considering current situation of Rel-17 NTN, separate discussion between satellite and HAPS would be better so that HAPS can be discussed and specified sufficiently. Meanwhile, as commented in NTN part, many aspects are same between satellite and HAPS, thereby how to mange them should carefully be considered. For example, regenerative type could be included in Rel-18 NTN (satellite). One possible way might be that HAPS SI studies whether current NTN is sufficient for HAPS or not, as commented by Softbank.

7 – Lenovo Mobile Com. Technology

For HAPS, we think rely-based architecture could be a promising way-forward that proposed in RWS-210270. We also proposed similar done-based relay use cases in RWS-210255 and we think this can be studied further. Whether select IAB based relay or sidelink based relay could be studied further.

8 – Samsung Electronics Co.

We think that HAPS is part of Rel-17 NR NTN specification works except spectrum usage will be discussed in next RAN4 meeting. Also, since Rel-17 NR NTN is worst case in terms of link quality for service link (i.e., NR NTN UEs suffer from longer distance, longer latency and higher Doppler shift than HAPS), we think solutions identified for Rel-17 NR NTN can be reused for HAPS. So, question is which aspects need to be further enhanced for Rel-18 HAPS on top of Rel-17 NR-NTN

9 – China Unicom

We share the same view with most companies that it is needed to have a separate SI/WI for HAPS in Rel-18.

Based on the potential scope of HAPS provided by Softbank, we would like to share some new issues to be considered for HAPS topic.

1. The HAPS gNB may be located on airship or airplane, and the payloads of airship and airplane are rather different.

2. Study the mobility issue caused by the movement in stratosphere for the handover and identification of new neighbor cells. Considering the instability of HAPS gNB, this may cause potential beam failure, etc, and related mesurement issue.

4. Study to support the relay-based architecture HAPS.

It is proposed the additional scope on HAPS can be considered as following:

1. Study the deployment scenarios including co-channel and adjacent channel scenarios, and system-level performance evaluation can by leaded by RAN 1.

2. Study the technical requirements of HAPS gNB can be leaded by RAN 4.

3. The mobility issue if support HAPS, related with RAN2 and RAN3.

10 – Ericsson LM

It seems so far most proposals on HAPS, including on architecture and possible mobility enhancements, have a lot in common with the corresponding NTN areas. We also see considerable benefit in a common approach, which would also be more efficient. In particular, also for HAPS we would like to prioritize the regenerative option, considering that we don't see a lot of justification for e.g. a relay-like option for HAPS in terms of QoS management (it would be more complex) or reliability (which typically decreases with more hops).

Feedback Form 24: Answers/Comments

7.7 Others

This section is targeted at identifying commonalities and interactions for other topics submitted to non-eMBB evolution which are not categorized in any topic above.

Feedback Form 25: Questions/Comments

1 – NTT DOCOMO INC.

We have a question to RWS-210288 (*UPTEC: Ultra-precision time engineered communications* from Fujitsu):

Regarding your proposal to specify PDCP distribution to always select best leg for real-time timeliness delivery, we are supportive on it, do you assume both UL and DL PDCP distribution enhancement?

2 – Guangdong OPPO Mobile Telecom.

-

RWS-210061 (Spreadtrum – multi-modality services), Question: It seems many of the use cases studied in SA1 are related to VR audio and video. Could this work be done as part of XR in R18?

-

RWS-210229 (LGE – inter-UE duplication avoidance), Comment: From network capacity / resource efficiency perspective, transmission of the same message/information for the same event / problem from multiple UEs to the network is not ideal and should be minimized. On the other hand, from service level and use case application perspective, it may still be necessary to confirm the same event has been observed and reported from different UEs to avoid false reporting, collecting statistics and possible tracing the fault. In many case, these information/message reporting is done at the application layer, which the network has no control over. Without a specific solution or basic framework, it is hard to envision what can be studied in 3GPP.

-

RWS-210346 (CMCC – multiple UE backup), Question: Forwarding message data over multiple links to the network for service continuity seems aligned with the target use case by multi-path relay feature which is currently under consideration of SL relay work for R18. Is it one possible solution alternative for this issue?

-

RWS-210454 (HW – UE reliability), Comment/question: This paper propose the same / similar idea as RWS-210346. As commented, is multi-path relay one possible solution alternative for this issue?

3 – Beijing Xiaomi Mobile Software

After checked the docs, we can put them into several categories:

1) terminals coordination, UEs backup(RWS-210061, 229, 346,454, 345)

2)NPN(154, 277)

3)new QoS requirement(288):

4) enhanced URLLC, positioning, sidelink and others(350, 360)

We noticed that people are interested in terminals coordination cases, no matter they are proposed for backup or for the new requirement(061,288). So we think it is valuable to study the terminals coordination and we see new use cases/scenarios (e.g., multi-modality interactions, backup , etc) addressing imposes new requirements for 5G system on multi-UE coordination.

For the overlap parts, we think we can discuss them first in the specific WI (e.g., sidelink enhancement) to see whether some solutions can be reused.

4 – China Telecommunications

Some companies have showed interest in NPN enhancement (154). The detail scopes of the work need be further discussed, some works are pending on SA2 study result.

5 – LG Electronics Inc.

Terminal coordination : We also see there are certain interest in terminals coordination as indicated by Xiaomi. There are real use cases in industrial area as well as personal entertainment area and we think It would be worth while studying how 3GPP can support multiple UE operation.

Response to OPPO : If we count on only the application layer to detect the same information/message, it is inevitable to consume more radio resources. Given that the uplink capacity is limited and the size of uplink data would become larger thanks to the improved image/video processing, it would be desirable to look into the uplink resource efficiency when multiple UEs are involved in the same mission. Of course it is true that reporting from multiple UEs are beneficial to avoid false reporting and to acquire some statistics,

but the current back-up mechanism seems not so flexible and the risk of false reporting is decreased only with large consumption of uplink resources.

6 – HuaWei Technologies Co.

Regarding UE reliability/backup, we see some interest from companies like 0454, 0344, 0346, 0229 and we think this aspect is worth consideration for enhancing the RAN performance. Thus we think this can be further discussed.

Feedback Form 26: Answers/Comments

1 – Fujitsu Limited

Answer to #1

Yes. Both UL and DL will be the scope of the proposal for PDCP distribution enhancement. As for the UL, during 2nd round email discussion, we got one comment from Nokia if there is a case where UE needs to switch the current leg to another leg by itself. We think such a case, where gNB is difficult to be aware about UL path degradation, can exist.

Comment to #3

Yes, our intention of RWS-210288 is considered to be new QoS. Some companies (e.g. RWS-210251 for multi-modality services, RWS-210428 for XR) are also proposing to study synchronized transmission of multiple data streams. So we are ok to consider RWS-210288 to be categorized as new QoS.

2 – Spreadtrum Communications

Answer to #2 (OPPO)

We think VR audio and video is only one use case of multi-modality. There are many differences between multi-modality and XR, E.g. the multiple UEs scenario in multi-modality also needs to be considered compared with XR.

Perhaps some issues can be discussed jointly while it should depend on the final scope of the item.