RAN93e-R18Prep-07 - RedCap evolution - Version 0.0.7
RAN

3GPP TSG RAN#93e **RP-212221**

Electronic Meeting, September 13 - 17, 2021

Agenda Item: 9.0.1

Source: Ericsson

Title: Moderator's summary for discussion [RAN93e-R18Prep-07] RedCap evolution

Document for: Information & Decision

1 Introduction

This discussion covers topic #7 "**RedCap evolution**" from the summary of the RAN Rel-18 Workshop [RP-210659]:

7. RedCap evolution (excluding positioning), with the following example areas:

- **New use cases and new UE bandwidths (5MHz?)**
- **Power saving enhancements**

Deadlines and NWM organization are based on the guidelines provided by the RAN Chair in [RP-211639] and [RWS-210659].

The aim is to converge on a set of areas with a reasonable scope as a "high-level description" – where "high-level description" herein is not a "draft SID/WID" but is something like a single slide with a set of bullets. In other words, it can be viewed as a skeleton of the possible objectives with some high-level notes.

Please avoid any input like "We support / we do not support" without giving additional justification and motivation as this is no "number counting" driven discussion. Instead justify your view with strong technical arguments and/or tangible commercial interests (near & longer terms).

2 Initial Round

Please provide your comments of the initial round in the below feedback forms. The initial round takes place from Mon. 08:00h UTC to Tue. 12:00h UTC.

2.1 General high-level views

Feedback Form 1: eRedCap - General high-level views

1 – vivo Communication Technology

Based on the outcome of Rel-17 RedCap WI, we expect a work item in Rel-18 for further enhancement of cost and power effciency for RedCap devices.

Some additional enahncements can be specified for device complexity/cost reduction in Rel-18 eRedCap, and many of them also bring power saivng benefits as well. Furthermore, RedCap specific power saving features can also be considered, e.g. further RRM relaxation.

According to the RAN Rel-18 WS discussison, generic UE power saving improvments that are potentially applicable to all device types can be studied seperately in Rel-18 UE power saving item, for example the ultra-low power wake-up receiver.

2 – Ericsson LM

Our high-level views on RedCap evolution in Rel-18 are:

- Rel-17 RedCap can already provide substantial UE cost/complexity reduction (65%-70% cost reduction).
- There might not be much room for further significant cost/complexity reduction without causing significant impacts on specification and backward compatibility issues.
  - <10% cost reduction compared to Rel-17 RedCap from further BW reduction and <5% cost reduction difference when compared to the Rel-15 reference device, RWS-210313 (pages 10-11)
- For Rel-18, it is preferred that RAN WGs focus on further energy efficiency improvements which can support the envisioned use cases more efficiently and expand the addressable use cases including, e.g., devices operating with harvested energy from environments.
- For use case with low data rate requirements, Rel-17 RedCap together with some limitation of peak data rate through scaling factor or related condition can be considered (ongoing discussion in Rel-17 RedCap in RAN1/2).

3 – InterDigital Communications

Although Rel-17 RedCap has introduced some important cost reduction features, its scope has been somewhat limited. We think RedCap can evolve to further reduce cost/complexity and expand addressable market. Power saving schemes that apply to all device types can be treated in a separate WI.

4 – Futurewei Technologies

FUTUREWEI Rel-17 is still in progress, but it is expected that Rel-17 RedCap UEs should be able to be very similar to non-RedCap UEs in terms of feature support if desired, other than the prohibited ones such as > 2 MIMO layers, CA/DC, ... This means that we should not need lots of follow-on work items for e.g., unlicensed RedCap, RedCap that support SL, etc. We should be careful when considering Rel-18 work that breaks this paradigm as it may create lots of future work in order to make hundreds of FGs ”compatible” with Rel-18 RedCap.

5 – Samsung Electronics Co.

eRedCap should focus on the improvements on the system efficiency, UE power saving, coverage recovery, without/with limited increasing the complexity/cost. Evolution of RedCap shall not overlap with LPWA (NB-IOT/eMTC) market. In addition, eRedCap shall not fragment NR-IoT market.

6 – Xiaomi Communications

Xiaomi

- During Release 17, basic framework and functinalities are established for RedCap. In Release 18, eRedCap should aim to expand more use cases and applications to enrich the market. For example, eRedCap should be able to support sidelink, unlisenced band, positioning , MBS and so on.
- Since RedCap is sensitive to power saving, further enhancment on the power saving can be considered as well. In addition, some RedCap-specific power saving solution can be considered
- In Rel-17, it has been identified that there is certain coverage gap between RedCap and non-RedCap. In Rel-18, coverage recovery for RedCap can be considered to elimate this coverage gap.

7 – Intel Corporation (UK) Ltd

We see evolution of Rel-17 RedCap with further cost/complexity/power consumption reduction commensurate to target data rates that are considerably lower compared to typical achievable peak rates for Rel-17 RedCap, primarily to enable migration of Cat1, Cat1bis, and eventually Cat M to NR.

Towards this, specifying a new UE BW, of around 5 MHz, is proposed.

While offering potential reduction in device cost/complexity and power consumption compared to "eMBB" or "URLLC/IIoT" UEs, Rel-17 NR RedCap offers a considerable over-design in terms of device cost/complexity or power consumption for IoT use cases demanding peak rates of a few Mbps (e.g., 1 20 Mbps). Such use-cases include wireless sensors, low-end wearables, basic (SD) video surveillance, asset trackers (with mobility support), IoT use-cases with human-machine interfaces involving voice (VoIP), etc.

Although the cost/complexity reduction estimates from BW reduction to 5MHz (and associated cost/complexity reduction features) may not appear significant at a first glance when using the framework of TR 38.875, at the low-cost segment, a **20 25% reduction in cost/complexity compared to Rel-17 solution** becomes rather relevant. Examples of "low-end IoT" use-cases like those cited above can be expected to primarily drive the device volume for NR IoT. Thus, the apparent negative of "market fragmentation" (by introducing new UE BW) can be offset by a more appropriate design for the bulk of IoT devices, if an overdesigned solution, amounting to about 20 25% additional cost/complexity, can be avoided.

In this regard, using lower peak rate scaling factors, that mostly help reduce cost related to L2 buffer requirements without helping with cost/complexity/power reduction at lower layers, would be a "hack" to artificially gate the achievable data rates without being able to meaningfully realize the potential cost/complexity/power consumption reduction. Similarly, mandating the UE to operate at 20 MHz for idle mode and allow for BW reduction in connected mode for data, negates the UE cost/complexity reduction from BW reduction, and thus, rather limited in potential benefits.

8 – China Mobile Com. Corporation

We are open on further complexity reduction, power saving and network efficiency improvement for RedCap devices. However, the R18 design of RedCap should be compatible to R17, large upgrade of network to support R18 needs to be avoided.

9 – Facebook

Rel. 18 RedCap Evolution, the enhancements to support high end wearables, such as smart watches, smart glasses, etc should be prioritized due to the compact form factors with increasing diverse applications and data consumption, due to e.g. voice communications, image/video messaging and social sharing. Hence, we think that the support of wider bandwidth such as 40Mhz is crucial for Rel. 18. Moever as mentioned in SA4 SI 26.669 due to the increasing popularity of video-sharing-centric applications (Four of the top

20 applications on the upstream are messaging apps), UL enhancement for RedCap should be considered for Rel. 18.

10 – ZTE Corporation

Our high-level views can be summarized as following:

1) Considering the peak data rate requirement for the industrial sensors and economic surveillance video is low, further cost/complexity reduction can be considered. Detailed techs for cost/complexity reduction can be selected after evaluation in the Rel-18 stage.

2) The duplicated discussion should be avoided for RedCap specific power saving and UE power saving.

3) Other potential enhancement can be considered, e.g., multicast support.

11 – QUALCOMM JAPAN LLC.

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[Qualcomm]
The platform of NR RedCap devices should be enhanced with additional
   features and also evolved towards lower tiers in such a way to
   gradually expand its addressable market, while leveraging the
   initial designs introduced in NR R17.
NR R18 eRedCap devices mainly target low-tier sensors and wearables,
   whose capabilities are between those specified for NR R17 RedCap
   devices and LTE LPWA devices.
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12 – China Telecommunications

China Telecom

With the development of RedCap market, we are expected to see RedCap evolution with better performance and lower cost. RedCap evolution in Rel-18 should ensure coexistence with non-RedCap UEs and Rel-17 RedCap UEs. It is not expected market fragmentation and large impact on current network.

In addition, it should define Rel-18 eRedCap UE type clearly. And specify the difference between Rel-17 RedCap or other LTE eMTC/NB-IoT without ambiguity.

The overlapping with other WIs should be taken into consideration when study Rel-18 eRedCap, like power saving, coverage, positioning, etc. If time needed, it would be better to have both SI and WI during Rel-18 eRedCap.

13 – TELECOM ITALIA S.p.A.

We fully support the statement from Softbank

Generally, most of the enhancements in the 2nd release or later were not commercialized in the past. Addition of enhancement technologies should be carefully investigated.

3GPP should wait for RedCap Rel 17 to get some market traction before pushing for enhancements with uncertain needs and that could further fragment the market and increase costs. **We do not see at this stage the need for a Rel 18 activity**.

If something must be done, the overall scenario (power consumption, network impacts, etc.) shall be considered. It is not acceptable to re-open the discussion on the maximum channelization and all the other compromises agreed in Rel 17.

14 – Spreadtrum Communications

From SPRD's view, the top goal of Rel-18 RedCap is to further enlarge vertical (including industry) market, thus investigating the requirement of vertical market (e.g., new use cases, etc.) and their pain points (e.g., cost, etc.) should be the first step to catalyze and construct Rel-18 RedCap. Also taking past experience into account, backward compatibility and forward compatibility should be guaranteed.

15 – TELENOR ASA

Telenor Group fully supports this statement from TIM: "If something must be done, the overall scenario (power consumption, network impacts, etc.) shall be considered. It is not acceptable to re-open the discussion on the maximum channelization and all the other compromises agreed in Rel 17."

16 – SHARP Corporation

Main objective of Rel-18 eRedCap devices should be more power efficiency. Regarding complexity/cost reduction, it can be considered as long as it can avoid fundamental impact from compatibility view.

17 – NTT DOCOMO INC.

RedCap evolution is necessary for further extending NR-IoT market, especially to low-end use cases such as smart meters, low-end video surveillance, low-end wearables, etc. In addition, since NR UE capability framework has quite high degrees of freedom to support a variety of use cases, specifying low-end NR platform, which does not overlap with LTE eMTC/NB-IoT, is quite useful to further extending NR-IoT market not covered by LTE Cat1 UEs. To this end, we think followings can be considered as key directions:

- Further UE complexity reduction
- Further power saving
- Minimum impact on current NW

18 – LG Electronics Inc.

Rel-17 RedCap WI has focused on high-end use case scenarios (e.g., low-/high-end smart watches, high-resolution surveillance camera) and supports the high-end and low-end use case scenarios by a single UE type.

In Rel-18 RedCap, we would like to shift the focus on the low-end use case scenarios (industrial wireless sensors, low-end wearables, etc.) providing further reduced cost/complexity and extended battery lifetime. These low-end devices are supposed to be larger in volume and more sensitive to the cost/complexity than the Rel-17 RedCap UEs.

19 – VODAFONE Group Plc

The market development and global rollout of of NB-IoT have shown how difficult it is to replace 2G as an IoT technology. Hence we expect it to be very challenging - and require a high degree of industry focus - for RedCap to replace LTE as a 'mid-tier' IoT technology.

So, at this point in time, 3GPP needs to decide whether:

a) to focus on a suite of different RedCap variants that would enable a variety of niche, low volume, high-end NR products and leave mid-tier IoT traffic using LTE, or,

b) to focus on the economies of scale needed to give RedCap a chance to replace LTE in the mid-tier IoT market space.

If 3GPP decides to pursue the development of the 5MHz variant then this leads to path 'a', above.

Note that as many "low band" (coverage band) NR/LTE frequency allocations of operators are greater than 5 MHz but less than/equal to 20 MHz, a 5MHz RedCap device may run into compatibility problems with non-upgraded networks (while the R17, 20 MHz RedCap device would be OK).

20 – FirstNet

It is generally understood that the generic UE power saving techniques/ improvements are equally applicable to most RedCap devices. With this in view, R18 should extend the RedCap feature support to close the gap between RedCap and non-RedCap devices to the extent possible.

21 – Lenovo (Beijing) Ltd

From our perspective, we think Rel.18 RedCap should study techniques to achieve further cost/complexity breakdown and lower power consumption compared with those for Rel.17 RedCap UEs. There is also potential to extend the RedCap scope to support e.g., ultra-low complexity devices. Besides, Rel.17 leftovers should be studied, if any.

22 – Huawei Tech.(UK) Co.. Ltd

We believe RedCap evolution in R18 should continue, focusing on UE complexity/cost reduction to expand NR's IoT support into rapidly growing lower-end market which can fill the gap between LPWA (approx. 1 Mbps) and R17 RedCap (approx. 100 Mbps). A new UE with lower complexity, focusing on bandwidth reduction to 5 MHz, is necessary to enable lower-end NR-IoT market and facilitate eventual migration of LTE-based cellular IoT solutions to NR (except LPWA).

23 – MediaTek Inc.

On cost reduction: While Rel-17 has introduced several complexity reduction features for RedCap, there is some further scope for cost savings. However economies of scale needs to be an equally important consideration, when looking at new complexity reduction techniques.

On power consumption: There are further opportunities to reduce device power consumption that can be considered in this release, such as wake-up enhancements. However, we must be prudent when defining the scope of this work, i.e. differentiate between what can be reasonably completed in Rel-18 (as part of a WI) and what needs further study (as part of a SI)

24 – Fraunhofer IIS

Fraunhofer

We still see RedCap primarily in use cases in the industrial/professional environment rather than in the consumer market. In our view, RAN WGs should specifically focus on work that is supporting the following use-cases, where we see market potential:

1. Monitoring/process control
2. Wearables/human machine/augmented reality interaction
3. New market opportunities (satellite, special frequency allocations)

We see a lot of market potential in industrial (non-latency-critical) use-cases that are in between URLLC and mMTC. Particularly for RedCap devices that are capable of enabling these use-cases with a long battery lifetime where the processing is outsourced to an external server.

25 – Everactive

26 – NOVAMINT

We agree with the comment from Vodafone that we need to decide where 3GPP needs/wants to go regarding the market(s) to be addressed by RedCap and we agree as well with Fraunhofer that we still see RedCap primarily in use cases in the industrial/professional environment rather than in the consumer market.

We believe there is a high value for Redcap to address in particular use cases for which LPWAN technologies (NB-IoT/eMTC) are not sufficient (critical iot) and for which purely Broadband devices are way too expensive and too complex for market adoption. We believe we will see such use cases coming out of the energy/smart grid sector - details under definition as currently are worked out in SA1 with 5G SEI

2.2 New use cases and new UE bandwidths (5MHz?)

Feedback Form 2: New use cases and new UE bandwidths

1 – Nokia France

We see further cost and complexity reduction being the top priority for RedCap evolution.

Considering the inputs to the Rel-18 workshop, we would propse to specify the following:

One very low complexity RedCap device type for FR1 with peak rates comparable to LTE Cat1bis UE (10 Mbps DL, 5 Mbps UL)

- Maximum UE bandwidth 5 MHz (both during and after initial access)
- Also consider reduced number of HARQ processes, reduced peak data rates, relaxed processing times, etc.

2 – vivo Communication Technology

We propose to consider following aspects for further UE complexity and cost reduction

1. Further UE BW reduction to 5 or 10MHz
2. UE processing time relaxation
3. Reduced number of HARQ processes
4. Lower UE power class (14dBm and 20dBm)

3 – Guangdong OPPO Mobile Telecom.

OPPO

The Rel-17 RedCap introduce 1 more BW for FR1/FR2. It help to provision mid-end devices. As the NR is deployed more in the field, we see need of different level of Devices. Then we see the lower end one could be 5MHz. 40MHz should also be supported, epecially for 1RX case, to provide similar capability as cat 4 of LTE(current commercial wearable devices).

We consider 10 MHz, in addition to above 2.

With minimum impact, we consider relaxed processing times and Less number of HARQ processes.

4 – Ericsson LM

The following use cases should be addressed:

- Support new use cases related to new power consumption requirements
  - See 2.3 Power saving enhancements below.
- Support for limited max. data rate for new use cases with low data rate requirements (2nd priority depending on the discussion in Rel-17)
  - A backwards-compatible solution is strongly preferred, e.g., using a relaxed peak rate scaling factor in connected mode while maintaining Rel-17 RedCap UE behavior in idle mode and during initial access (i.e., avoid introducing non-backwards compatible SSB, CORESET#0, etc.)
  - New smaller UE bandwidths (in the RF and/or BB parts of the UE) should only be considered if they can be motivated by substantial cost reduction, which currently does not seem to be the case (<10% cost reduction compared to Rel-17 RedCap from further BW reduction and <5% cost reduction difference when compared to the Rel-15 reference device, RWS-210313, pages 10-11). Unnecessary market fragmentation should be avoided.
    - only BB BW reduction for data channels may be considered, if needed, e.g., through relaxed peak rate scaling factor

5 – InterDigital Communications

As of new use cases, we think lower data rate and applications that need further reduced power and extended battery life are necessary. For further cost reduction, lower BW (e.g., 5 MHz) should be supported. In addition, reduced UE processing capability, CSI and beam management simplifications can be considered.

6 – Futurewei Technologies

FUTUREWEI We have some concerns on the proposal for 5MHz UE bandwidth, mainly that when using the agreed methodology, the gains appear to be small while the amount of work may be large. For Rel-17 RedCap, the bandwidths were chosen to be able to minimize impacts, but we are still having a difficult time making progress. In particular, the scenarios of interest need to be clarified in terms of co-existence with other UEs (including non-RedCap and Rel-17 RedCap) and features (including unlicensed, ...).

7 – SoftBank Corp.

Generally, most of the enhancements in the 2nd release or later we not commercialized in the past. Addition of enhancement technologies should be carefully investigated.

As for support of 5MHz, while UE cost is important for RedCap use cases, network cost is equally important when we commercialize a new functionality. We want to take a look at the detailed system impact caused by the introduction of 5MHz BW before agreeing the WI scope.

8 – Verizon UK Ltd

As we commented in the WS email NWM disucssion, we can be supportive of 5MHz BW if true compatibility is guaranteed. By true compatibility, we mean competibility on both sides - device and NW side. Rel-18 RedCap UE should be able to access a non-upgraded Rel-17 RedCap cell. Given the expected cost saving, which has yet proven to be first order (e.g., not chosen in R17), If the 5-MHz UE is not be able to access a Rel-17 RedCap cell, we see a clear risk for unnecessary increases in our CAPEX , our IODT costs and our OPEX, in addition to market fragmentation, and an overall confused market message which may put the takeoff of the (Rel-17/18) RedCap ecosystem in jeopardy. We have serious concern of the feature if true compatibility can not be guaranteed. We will be glad to support with true compatibility.

9 – Samsung Electronics Co.

Although some use cases might not require such high data rate of Rel-17 RedCap UEs (20/60Mpbs for UL/DL), the additional cost saving is very limited (e.g., 1 3% additional cost saving). In addition, the specification impact is large(e.g, coverage recovery, PDCCH blocking, UL resource fragmentation, etc), as well as the potential coexistence issue with non-RedCap and Rel-17 RedCap and also potential impacts on Rel-17 NW. On the other hand, Rel-17 RedCap UEs can be used to cover the use cases that require lower bitrate. Without fragmentation of the market, the actually cost of the chipset might be even lower with large amount.

10 – Xiaomi Communications

Xiaomi

- Views on the further cost reduction:
  - New cost reduction solutions can be studied for RedCap. But solutions which were fully studied and identified with small gain e.g., relaxed processing timing, smaller TBS should not be touched again.
  - As for the BW reduction, we prefer NOT to impact the SSB design.
- Views on the new use case:
  - **positioning in Redcap**: positioning and tracking are important in many IoT applications, such as children tracking via wearables and asset tracking via industrial sensors. However, the narrow UE bandwidth poses challenges for the positioning accuracy when using 3GPP positioning functionalities defined for normal UEs. In this case the study on the positioning accuracy is needed. In addition, due to the small factor, the battery capacity is limited for RedCap devices. In this case more power-efficient solutions are more desirable.
  - **sidelink RedCap** : Supporting sidlink interface on Redcap could enable the interaction between RedCap wearables and smart phone or the interaction between the industrial sensor and the control center directly. In addition, the sidelink relay function could enable the smart phone to relay the data of RedCap wearable to network for power saving and coverage extension. However, when importing RedCap into the sidelink system. Solutions to guarantee good coexistence between UEs with different capabilities should be specified.
  - **unlicensed Redcap** : In the industrial scenario, utilizing unlicensed band is usual. Industrial sensor is one important use case for RedCap and they work on the unlicensed band should be considered as well. However, due to the limited UE bandwidth, the monitored narrow frequency resource would be easily blocked, which would impose negative impact on the channel access and data transmission. Thus how to support RedCap to work on the unlicensed bands should be carefully studied.
  - **MBS for RedCap** : According to TR 23.757, enabling general MBS service over 5GS could support general multicast and broadcast communication services, e.g. transparent IPv4/IPv6 multicast delivery, IPTV, software delivery over wireless, group communications and IoT applications, V2X applications, public safety. For Redcap, in the case of industrial sensor or camera, the MBS is very efficient for the software update. In case of wearable, receiving important public safety message should be considered. Considering these aspects, MBS feature should be supported by RedCap. However, currently MBS is under design and it seems some restriction from RedCap is not taken into account. So we suggest to consider it in Rel-18

11 – China Mobile Com. Corporation

For low data rate use cases, we should first examine how to satisfy them with an efficient way based on current R17 framework. Further reduce UE bandwidth to 10M/5MHz will have some backward compatibility issues. Firstly, if 5MHz is introduced, most of CORESET#0 configuration in Table 13-1 Table 13-6 in FR1 cannot be supported due to larger bandwidth, therefore, the initial access procedure needs redesign. Secondly, keep coexistence with legacy non-RedCap or R17 RedCap devices is also an important thing, signals or channels such a SSB, CORESET□SIB, paging may not be shared by different devices types, the overhead will increase for network.

Therefore, the cost/complexity benefit and feasibility of further reduce 20MHz to 5MHz needs to be carefully examined and justified.

12 – Facebook

The support of wearables, such as smart watches, should be one of the top priorities for Rel. 18 RedCap evolution. Due to the increasing popularity of mobile consumers sharing video, UL enhancement, including the support of wider bandwidth (i.e. 40MHz) should be included in Rel. 18.

13 – Intel Corporation (UK) Ltd

As introduced in the "general high-level views" section, the following high-level objectives on new use-cases and UE BW should be included for a possible Rel-18 WI on RedCap enhancements to enable meaningful migration of the bulk of IoT use-cases, currently served by Cat 1 or Cat1bis to NR:

- **A new class of RedCap NR devices with lower device cost/complexity and power consumption compared to Rel-17 NR, targeting data rates [1 20] Mbps**
  - BW reduced from 20 MHz à preferably no smaller than 5 MHz (Cat M2 UEs)
  - Limited to FR1 bands only, and at least with 15 kHz SCS
  - Further complexity reduction on features/PHY procedures, e.g., UE processing time relaxations for shared channels and CSI feedback, reduced # of HARQ processes, reduced peak rates/limited TBS, etc.
  - Means of coverage and spectral efficiency recovery (mainly in DL) as justified

Further details on coexistence, exact requirements, and constraints can be discussed as part of the next steps.

14 – QUALCOMM JAPAN LLC.

Qualcomm

In our view, the following aspects should be studied for R18 eRedCap UE type:

1. Further UE BW reduction down to 5 MHz in FR1
2. UE processing time relaxation (e.g. N1, N2, Z, Z')
3. Reduced number of HARQ processes for PDSCH/PUSCH
4. Lower UE power class (e.g. PC4)
5. Power saving enhancements
6. Co-existence with other UE types specified in NR R15/16/17
7. Upper layer enhancements (e.g. access control, SDT enhancements, mobility, paging, initial access)

15 – ZTE Corporation

For the industrial sensors and economic surveillance video scenarios, lower data rate, less complexity and extended battery life are expected. So, the following can be considered to be specified:

– reduce the maximum UE bandwidth to 5 MHz

– reduce the HARQ buffer/HARQ process number

– reduce the modulation order

16 – Apple Poland Sp. z.o.o.

Apple

The following use cases should be targeted:

- Reduced maximum UE bandwidth to 5MHz.
- UE processing time relaxation
- Lower UE power class.

17 – China Telecommunications

China Telecom

More interesting new use cases should be studied and identified in Rel-18 to enlarge RedCap market. The performance and cost of network and UE are equally important. It should be prudential to find balance between data rate and cost to achieve requirements of Rel-18 use cases. We are expected minimum impact on current network via reusing existing operations or backwards-compatible solutions. No matter larger or smaller maximum BW, the key point is to find the matched use cases and expand the market. We are open to study new UE bandwidth, like 5MHz for FR1 (low-end) or 40MHz for FR1 (high-end), but more discussions are needed before starting Rel-18 eRedCap WI.

18 – Spreadtrum Communications

New use cases:

In Release 18, RedCap should strive to expand the new use cases or applications to enrich the market. Considering the industrial transformation and digitalization, the potential market size in vertical will be very large in near future. Therefore, we need to focus on vertical related scenarios, e.g. Industrial controller, smart grid, patrol robot, etc. The detailed KPIs can be FFS.

New UE bandwidths

From our perspective, the motivation of new UE bandwidths is to reduce the supported peak data rate of RedCap for some scenarios, then reduce the required memory size, hence cost/complexity of the UE.

The L2 buffer size reduction is under discussion in Rel.17, if the related mechanism is specified in Rel.17 to achieve memory size reduction, based on the principle of backward compatibility, the same mechanism can be extended to Rel.18. Instead, as R17 RedCap is overdesigned for sensors and video surveillance, further BW reduction (e.g. reduce to 5MHz) needs to be supported.

19 – CATT

Rel-17 RedCap UE maximum channel bandwidth of 20MHz in FR1 is a good trade-off between UE complexity reduction and backward compatibility. Supporting an even smaller UE channel bandwidth e.g. 5 MHz cannot bring significant further complexity reduction as analyzed in RWS-210409. On the contrary,

it scarifies the economy of scale due to market fragmentation and introduces backward compatibility issues. If the maximum UE BW is reduced to 10 MHz, about half of the SSB/CORESET#0 configurations cannot be used. And if the maximum UE BW is reduced to 5 MHz, less than 10% of the SSB/CORESET#0 configurations can be used. The following new designs/features are likely to be needed to support 5MHz RedCap UE:

- New synchronization signal/PBCH design (30kHz SCS)
- New CORESET#0 design (30kHz SCS)
- New BWP framework to overcome the lack of frequency diversity
- Coexistence between 5MHz UE, normal UE and Rel-17 RedCap UE, including:
  - o System information transmission, initial DL/UL BWP sharing/offloading, paging, etc.
  - o Early identification of 5MHz UE during RACH, in addition to Rel-17 RedCap UE
  - o Cell barring/access for 5MHz UE, in addition to Rel-17 RedCap UE
  - o New type definition of 5MHz UE

It is also doubtful whether the L1 capabilities for NR normal UE can be reused by 5 MHz UE by default. Some RS are based on the assumption that the configurable RS bandwidth is no smaller than 24 PRBs. Hence, term-by-term checking may be required. For the capabilities that cannot be directly reused, it should be determined whether further work/modification/optimization is involved in Rel-18.

In addition, in Rel-17, heated debate on the number of RedCap UE type(s) happened not only in RAN1/2 but also in RANP. At last, the group reluctantly agreed that only one RedCap UE type was defined, for the sake of ecosystem and economic of scale. Nevertheless, if a 5/10 MHz RedCap UE bandwidth is introduced, a brand new UE type will also be certainly defined. It is suspected that this is a worthy direction, and whether the group can bear the burden of maintenance/evolution of 3 kinds of UE types in the future.

20 – TELEFONICA S.A.

UE bandwidth reduction (i.e. 10MHz, 5MHz) backward compatibility issues should be carefully analysed. The impact on performance and cost reduction from NW and UE perspective needs to be further studied (SI) before starting a Rel-18 RedCap WI. A Rel-17 RedCap backward compatible solution with minimum or no impact in operators‘ CAPEX /OPEX is expected.

21 – SHARP Corporation

New use case: At least Rel-17 RedCap use cases with more power efficiency are desirable as Rel-18 RedCap devices. it can be lower data rate than Rel-17 devices.

New UE BW: we are supportive to consider 10MHz. Regarding 5MHz, it may require lots of works on system design and it should be carefully discussed.

22 – NTT DOCOMO INC.

We support a low-end eRedCap UE type with maximum 5MHz BW / 10 Mbps DL data rate for FR1 to obtain further cost reduction while avoiding overlap with LTE eMTC/NB-IoT. Rel-15 SSB can be reused for 5MHz UE BW at least 15 kHz SCS and we are open to further discuss the applicability of 30 kHz SCS. In addition, we are generally supportive for the features which provide the low-end NR platform and have reasonable tradeoff between cost reduction gain and specification/NW impact, as long as the low-end NR platform does not overlap with LTE eMTC/NB-IoT, to further extending NR-IoT market. In that sense,

- UE processing time relaxation (data, CSI) can be considered for further cost reduction as it would provide around 6% and 5% cost reduction gain, respectively, according to TR38.875.

- Reduced number of HARQ processes was discussed in Rel-17 RedCap SI but no observation was captured in TR38.875. As mentioned in R1-2009393, some companies observed 3 9% cost saving gain by reduced number of HARQ processes and thus, we are open to further study this point.

23 – LG Electronics Inc.

RedCap-specific target use cases are summarized in Rel-17 SID/WID among which Rel-18 RedCap targets the low-end use case scenarios (wireless sensors, low-end wearables, etc.).

The new bandwidths being considered are 5MHz and 10MHz. We expect the peak bit rate for the low-end use case scenarios to be no more than 10Mbps for DL (comparable to LTE Cat1bis) in which case more than 5MHz bandwidth may be not essential during and after initial access. Furthermore, for these low-end devices, cost/complexity is more important than providing some margin for the peak bit rate. Therefore, we prefer the new max UE bandwidth for Rel-18 RedCap to be 5MHz during and after initial access.

24 – Telstra Corporation Limited

Rel-18 eRedCap UE bandwidth reduction to 5MHz should be avoided to ensure backward compatibility with Rel-17 Redcap and to maintain market segment differentiation with eMTC as there is already industry confusion in this space.

25 – VODAFONE Group Plc

We believe that Rel 18 should focus on features that enable the successful growth of the market for R17 RedCap devices, e.g. positioning and battery life improvements.

26 – Lenovo (Beijing) Ltd

We support further cost/complexity breakdown specific for RedCap devices like industrial sensors, economic videos, etc., which require much lower reference bit rate even less than 5Mbps. New UE bandwidth down to 5MHz is a good candidate for cost reduction (and also power saving).

27 – Huawei Tech.(UK) Co.. Ltd

Mid-tier IoT (1-10Mbps) has rich use cases such as elevator cameras (480p etc.), low-end wearables, cellular push-to-talk, IoT gateway/data transfer unit, smart POS/self-service cashier, smart speaker, vending machines, cloud tele-operation, industrial sensors, etc. The market is growing quickly in recent years and the near future. The Rel-17 REDCAP UE has capabilities/cost far higher than LTE UE which is current main choice of mid-tier IoT use cases.

NR's flexible framework can support different bandwidths from Rel-15 onwards. NR has a very flexible air interface with a forward-compatible design, and already supports a wide range of channel bandwidths down to 5MHz. We would propose NR to support new UE bandwidth of maximum 5 MHz in R18 to further reduce cost/complexity. Other complexity reductions may also be considered, but they are expected to offer smaller cost savings.

We also see observations from many companies during Rel-18 workshop that 5 MHz UE bandwidth can bring meaningful gains for such a cost-sensitive lower-end market, and be distinguished from LTE UEs.

28 – MediaTek Inc.

With regards to cost reduction, we see the **introduction of PA-less operation** as a simple enhancement for Rel-18.

Reduction in operational BW for RedCap comes with a corresponding set of issues, i.e.

- cost benefits may be offset by a loss in economies of scale
- compatibility of these UEs with Rel-17 RedCap deployments

We therefore need to carefully evaluate the cost reduction benefits associated with reduced BW, as well as the scale of potential use-cases that justify this reduction, to determine whether this is a meaningful direction to explore for cost reduction in Rel-18.

29 – Philips International B.V.

Some new cases we have identified are related to applications that require an extended battery life.

As for the UE bandwidths, we think that RAN should further decrease the complexity and cost of RedCap devices by reducing the bandwidth to 5MHz.

30 – Sony Europe B.V.

We do not see the need to support smaller bandwidths than the Rel-17 minimum of 20MHz, given the specification impacts and limited benefits, as discussed in the rel-18 workshop.

31 – Fraunhofer IIS

Fraunhofer

Lower UE bandwidth of 5 MHz makes sense for us - this enables new RedCap use-cases where less bandwidth than 20 MHz is available, for example RedCap for train control systems and/or NTN deployments.

New RedCap features should extend RedCap to use cases with lower requirements than Rel-17 RedCap WI definition but above LPWAN.

32 – CEWiT

We support impact of further reduced bandwidth in Red cap devices.

Study of new use cases:

1. Positioning using Red Cap UEs
2. Sidelink transmission using Red Cap UEs

33 – Panasonic Corporation

From our perspective, UE bandwidth reduction less than Rel.17 are not attractive from the backward compatibility perspective as the network cost to mandated transmission of additional SSBs and so on. The fast retuning, which discussed in Rel.17 RedCap, should be supported in Rel.18 for better co-existence with non-RedCap UEs.

34 – Everactive

2.3 Power saving enhancements

Feedback Form 3: Power saving enhancements

1 – Nokia France

Reduced power consumption is the second priority area for RedCap evolution in Rel-18.

We would propose specifying the following:

- A lower power class
- More power-efficient wake-up procedures
- Extended DRX for RRC_INACTIVE with eDRX cycles up to 10485.76 s (if not completed in Rel-17)
- More power-efficient beam management, e.g. simplified beam management procedures, beam failure detection and recovery optimization for stationary and low-mobility devices
- Reduced-bandwidth monitoring and measurements within a portion of a bandwidth part
- SDT for RedCap devices, starting with checking Rel-17 SDT for compatibility with RedCap, and then including:

a) MT SDT

b) Improved PDCCH monitoring reduction during SDT [RAN2] (at least for subsequent UL/DL transmissions and with UE context fetch. (Limited or no RAN1 impact: Reuse existing Rel-17 power saving PDCCH monitoring schemes, focus on signalling to enable use of existing schemes by UEs in RRC_INACTIVE for SDT))

c) Failure handling for subsequent UL/DL transmissions.

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2 – vivo Communication Technology

It is expected that following UE complexity and cost reduction features can also bring UE power efficiency improvements,

1. Further UE BW reduction to 5 or 10MHz
2. UE processing time relaxation
3. Reduced number of HARQ processes
4. Lower UE power class (14dBm and 20dBm)

In addition, we propose the following RedCap specific power saving features

1. Further RRM measurement relaxation, e.g. serving cell RRM relax
2. We are open to consider SDT enhancement for power efficiency improvement as well, e.g. MT SDT

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3 – Guangdong OPPO Mobile Telecom.

OPPO We see the above complexity reduction leds to power saving.

The power saving feature is important to RedCap UE. Some of the general power saving feature can be supported by RedCap UE. It could be in an dedicated WI.

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4 – Ericsson LM

Power saving enhancements should have highest priority in RedCap Rel-18, including:

- Support new use cases enabled by the power saving/energy efficiency enhancements, e.g.,
  - Industrial sensor use cases where replacing battery is prohibitively difficult or undesirable
    - Example: large number of sensors deployed for safety monitoring or fault detection in smart factories, infrastructures, or environments

- Wearable use cases where patients do not need to replace battery themselves (battery lasts between office visits)
- Use cases involving devices capable of harvesting ambient energy for operation (vibrations, heat, light, …)

- Support for low power wake-up receiver(WUR) / wake-up signal(WUS)
  - Identify suitable sensitivity/power consumption tradeoff for the low power WUR

Study and specify suitable new wake-up signal for low power WUR

- Support for devices operating on harvested energy from environments
  - L2/L3 protocol optimizations to consider potential variations of amount of harvested energy and traffic, e.g., extension of UE assistance information
- Support for lower UE power class

Specify suitable power level considering UL coverage impact

- Other power saving enhancements

Specify cross-slot scheduling for paging (for long DRX use cases), any left-over on eDRX in inactive (longer than 10s) from Rel-17, and potentially MICO in inactive mode

5 – InterDigital Communications

Further power saving enhancement should be studied, however, some of the applicable schemes can be treated under a separate WI. More power efficient wake-up techniques including low power wake-up radio, energy efficiency enhancements (including energy harvesting), low UE power class can be studied. We are also open to study SDT enhancement. CSI and beam management simplifications can provide additional power saving.

6 – Futurewei Technologies

FUTUREWEI We have some concerns on including RedCap-specific power savings in Rel-18. Power saving was not among the Rel-17 RedCap WID objectives due to the limited benefits observed in the Rel-17 studies, so moving those same techniques to Rel-18 may not be worthwhile. In fact, RedCap UEs can benefit from the features identified in Rel-17 power savings WID. So for Rel-18, scenarios for power savings reduction specific to RedCap UEs need to be clarified. Some potential power saving topics being discussed for Rel-18, such as wake-up receivers, may be applicable to all UEs, not just RedCap UEs.

7 – Samsung Electronics Co.

As in Rel-17, power saving enhancement for RedCap shall focus on RedCap-specific techniques. If the solution/techniques can be general applied to eMBB UE, we suggest to discuss in others agenda, e.g., ZP-WUS. In addition, as the second/low priority issue, eDRX cycle for RRC_INACTIVE can be extended to 10485.76s, if not completed in Rel-17.

8 – Xiaomi Communications

Two directions can be considered for power saving in RedCap.

- Direction #1: Reuse the existing power saving solutions for RedCap and identify if there is any problem specific for RedCap. The existing power saving solution could include the power-saving PDCCH, TRS/PEI and SDT, etc

- Direction #2: Come up some RedCap-specific power saving solutions considering the unique feature of the traffic or the application scenario. For example, multi-TB scheduling

9 – China Mobile Com. Corporation

Power saving is important for RedCap use cases, and schemes specific to RedCap use cases can be studied in R18 RedCap. For example, further enhancement for static industry scenarios, such as serving cell RRM relax, beam management simplification, eDRX left over, etc.

Other common power saving solutions such as low power WUS or PDCCH monitoring reduction can be considered in power saving WI.

10 – Intel Corporation (UK) Ltd

On UE power savings, the reduced UE BW and other associated cost/complexity reduction features would already contribute to a significant extent to realize further UE power savings beyond Rel-17.

In addition, support of lower UE power classes can be considered.

Further, enhancements in view of low/no mobility use-cases, could be further explored. These could include, but not limited to, relaxations to serving cell measurements and reporting, or separate ultra-low power WUR (study phase may be necessary to establish feasibility and justify the gains). At this point, the potential benefits from separate WUR in cellular settings remain to be established.

On passive IoT and energy harvesting based operations, while we are interested in exploring such technologies, they go beyond the scope of RedCap evolution. In context of RedCap, the practical applicability/feasibility considering target use-cases, data rates, and cost/complexity, remain unclear. Thus, any studies on passive IoT and/or energy harvesting based operations should be considered separate from RedCap evolution.

11 – ZTE Corporation

Some power saving techs in Rel-17 stage can be considered in Rel-18 as following.

– Compact DCI

– PDCCH candidates reduction

However, SDT is kind of general tech for different type of devices, and related issues are more appropriate to be discussed in other agenda item.

Additionally, considering there exists the indoor coverage scenarios, the lower power class UE also can be considered for RedCap. In this case, it is not hoped that the coverage enhancement for lower power class UE is also considered in Rel-18.

12 – Apple Poland Sp. z.o.o.

Apple

In general, further reducing BW for Redcap would bring power saving benefit as analyzed in Rel-17 Redcap study item e.g., due to smaller TBS. In addition, UE processing time relaxation including both N1/N2 and CSI processing relaxation should be targeted, which is suitable for non-delay-sensitive application or device type.

On SDT support for Redcap, we are supportive to include it into Rel-18 Redcap enhancement if it would not be supported by Redcap in Rel-17 WI. It should depend on the Rel-17 UE features discussion for Redcap.

13 – China Telecommunications

China Telecom

The power saving feature is important to RedCap UEs especially considering the limited form factor. We see the necessity to identify RedCap-specified power saving solutions to avoid overlapping with power saving WI. Some complexity reduction features would bring benefits for power saving to a certain extent.

14 – Spreadtrum Communications

Power saving is very important for vertical RedCap UEs, especially for those scenarios without power supply, RedCap-specific power saving techniques can be considered (e.g., Lower RedCap power class, UE processing time relaxation, RRM relaxation, SDT enhancement, etc.)

15 – CATT

In general, we think power saving enhancements is an important aspect to be considered for Rel-18 RedCap enhancements. The following potential enhancements can be considered in Rel-18:

- Enhancements based on Rel-17
  - Lower power class
  - Rel-17 leftovers, DRX/eDRX/PSM enhancement, if any
- New wake-up mechanisms, including:
  - Wake-up signal design (potential support of low power wake-up radio)
  - Related L2 protocol enhancements

16 – SHARP Corporation

Following can be considered for power saving

- BW reduction

- A lower power class

- RRM relaxation for serving cell can be introduced to reduce the power consumption of stationary RedCap devices

- Simplified beam management for stationary RedCap devices

It is noted that duplication of work with power saving agenda should be avoided.

17 – VODAFONE Group Plc

Long battery life is a very important feature for a significant proportion of IoT devices, hence we are interested in power saving improvements for RedCap devices in Idle/Inactive.

Note that while many - but NOT all - IoT devices are stationary for a large part of their lives, it is often critical to know when a stationary device starts to move! (e.g. bicycle has been stolen).

The system aspects of features such as ”wake up signals” and ”MT Small Data” need to be considered carefully to ensure that they do not have a negative impact on the battery life of other devices.

The extended DRX >10.24 second for RRC Inactive is a task that RAN should ask SA to complete in Rel 18.

18 – NTT DOCOMO INC.

Further power saving enhancement for RedCap UE is important.

RedCap UE is being specified in Rel-17, and RedCap-specific power saving techniques can be considered based on the Rel-17 outcome. For example, wake-up/paging enhancements considering eDRX cycle.

Also, the study on low power wake-up receiver can be considered in RedCap WI or separated SI.

19 – LG Electronics Inc.

Power saving enhancements should be included in the scope of Rel-18 RedCap.

The left-overs from Rel-17 RedCap WI (if any) should be included in Rel-18 RedCap. Left-overs from Rel-17 NR_PS WI can also be included if they are relevant to RedCap and if there is no dedicated WI for NR PS.

Regarding SDT, we think SDT is different feature than REDCAP. The SDT targets not only for power saving but also for latency and overhead reduction. Thus, we propose to make the SDT a separate item, led-by RAN2.

20 – Telstra Corporation Limited

Additional UE power saving techniques should be a focus given the general nature of predicted RedCap use cases, eg wearables, tracking, etc. However these enhancements need to balanced against any impact on network system efficiency and/or coverage.

21 – Lenovo (Beijing) Ltd

We support to study power saving techniques including

1) lower UE power class
2) narrower BWP
3) more efficient wake-up signal
4) further PDCCH monitoring reduction.

22 – Huawei Tech.(UK) Co.. Ltd

By the end of Rel-17, NR already supports many features to enhance UE power saving for both RRC connected mode and idle mode. Assuming RedCap will support all of those features and taking wearables as an example, we observe that the power consumption and battery life for RedCap is mainly limited by stand-by deep sleep and reception, under IoT traffic.

RedCap should thus support UE power saving enhancements which can significantly reduce standby deep sleep and Rx power consumption in R18. Whether those enhancements are specified in a RedCap WID (if they are RedCap-specific) or another WID, they should support use by RedCap UEs.

23 – MediaTek Inc.

We see the following directions as useful for power savings in RedCap:

- Necessary restrictions/changes to **Rel-16 and Rel-17 wake-up signalling to enable use of a non-coherent sequence-matching receiver** in the UE (e.g. R1-2107519, Section 3)
- **Serving-cell measurement relaxations**

We suggest reusing the existing wake-up framework to have a reasonable work scope that can be completed in Rel-18's timeframe. The enhancements should enable wake-up processing to be robust enough to sustain larger residual CFO, to accommodate serving cell measurement relaxations.

24 – Philips International B.V.

RedCap devices as defined in Rel-17 are not necessarily very low power specially for wearable devices with constrained batteries. These devices should last at least 2 to 4 weeks on battery. Some power saving enhancements can be:

- **Lower UE power classes**
- **WUS**
- **SDT, EDT**
- **5MHz bandwidth**
- **LP-WUS (Low Power Wake Up Signals)**

These power saving enhancements may be applicable to all devices, not just RedCap, and hence, treated in a generic power saving WI.

Furthermore, considering the shorter distances at which PC5 operates, we think that the **support of Sidelink relays** can bring extra energy savings. Our understanding is that the on-going Rel-17 Relay discussions do not prevent RedCap devices to announce its capabilities for Sidelink operation. Having said that, we would like to ensure that RedCap devices can benefit from the Sidelink Relays, including support for acting as Relay device, support for power saving, half-duplex etc. Whether this is treated in Sidelink Relay WI or RedCap WI is to be decided.

25 – Sony Europe B.V.

Our comments are similar to those in Prep-14. These comments relate to Redcap UEs.

Low power wake up radio

We are supportive of studying low-power wake-up radios/receivers to further reduce UE's power consumption. We also think Mobility and RRM measurement is an important aspect that needs to be considered when designing low-power wake-up signalling. Wake-up radio is beneficial for use-cases where the traffic is relatively low, but the device needs to be reachable by the network quite often. Whether low-power wake-up radio is only to be studied for RedCap or as generic UE features depends on the use-case and FFS.

Objectives

Objective I:

- Study and evaluate low-power wake-up receiver architecture and design trade-offs such as sensitivity, data-rate, bandwidth vs. power consumption
- how to compensate for performance/sensitivity loss, if any

Objective II:

- Study and evaluate wake-up signal designs to enable ultra-low power reception
- How to do the multiplexing of wake-up signal and other transmission types signaling, if in-band transmission is selected

Objective III: Study and evaluate mobility aspects, whether to support only stationary devices or adapt the protocol to also support measurement for ultra-low power wake-up receivers

Objective IV: Procedures to adjust/adapt/extend the current protocol to support ultra-low power wake-up receivers

Support for devices operating on harvested energy

Devices can operate with small batteries or capacitors if they operate on harvested energy. Use of ambient harvested energy is more realistic than operating on energy harvested from the incident RF energy. The issue with operating on ambient harvested energy is that signalling exchanges may be interrupted when the UE runs out of harvested energy and can only restart when the UE has harvested sufficient energy. Hence there need to be protocol enhancements to support operation on intermittently available harvested energy.

Objective

- Protocol enhancements for the support of operation on intermittently available ambient harvested energy.

26 – Fraunhofer IIS

Fraunhofer

A dedicated low-power wakeup-signal would enable to further reduces power consumption of RedCap devices. This is particularly interesting for energy harvesting (EH) powered devices where a fully EH-mode might not be sufficient to operate the device but can maintain a specific WUS receiver without draining the main battery.

Like other companies already mentioned, we also see potential in RRM relaxation for serving cell measurements. This can be discussed for RRC_IDLE/INACTIVE and RRC_CONNECTED based on the outcome of the Power Saving WI discussions in Rel-17.

A lower power class for RedCap UEs can also increase the battery lifetime, especially for local deployments, i.e. campus networks where coverage is less an issue.

27 – Panasonic Corporation

Although we think power saving is quite important, our thinking is power saving feature specified in Rel.16/17 can be well applicable to RedCap UEs. Therefore, we don't see specific topic for now.

28 – Everactive

2.4 Other proposals

Feedback Form 4: eRedCap - Other proposals

1 – Ericsson LM

We are open to discussing other enhancements related to improving system performance

2 – InterDigital Communications

We are open to discussing other relevant enhancements.

3 – Samsung Electronics Co.

For efficiency improvement, the following can be considered:

- Fast BWP switching
- CSI enhancement
- Wider BW FH
- Traffic offloading for initial access (depends on Rel-17)
- PDCCH overhead reduction

For coverage recovery, the following can be considered:

- PDCCH Rep/CORESET combination/larger AL, etc, especially for CSS
- PDSCH Rep for Msg 2/4

4 – China Mobile Com. Corporation

Solutions that can further improve system efficiency can be considered, take the industry use cases as an example, similar traffic characteristic for sensors, and similar channel quality among the devices can enable multi-user scheduling, to reduce PDCCH overhead.

5 – ZTE Corporation

For some wearables, the video service in the future is foreseen. For the surveillance video and industrial sensors, software update is also needed. Therefore, multicast service can be considered in Rel-18.

However, due to the limitation of RedCap UE bandwidth, if multicast and unicast are still transmitted under the one BWP similar with Rel-17 NR device, the peak rate of unicast and multicast for RedCap UE will be limited. If a multi-cast session is shared for RedCap and non-RedCap, the peak data rate and transmission efficiency for non-RedCap would be restricted. Therefore, study on how to effectively support multicast IoT applications for RedCap should be considered in R18 RedCap.

6 – QUALCOMM JAPAN LLC.

Qualcomm

In our view, narrow-band positioning and SL should be supported by R18 eRedCap devices as well. However, we are open to study/specify positioning and SL enhancements applicable to eRedCap devices in R18 WIs dedicated to FePos and SL.

7 – China Telecommunications

China Telecom

We are open to discuss other topics related to eRedCap in Rel-18.

8 – Spreadtrum Communications

Other enhancements that benefit to RedCap operation and vertical market extension can also be considered, e.g., coexistence, mobility enhancement, access to unlicensed band and/or NTN, etc.

9 – NTT DOCOMO INC. - Similar to Rel-17 RedCap UEs, early indication of Rel-18 eRedCap UEs with maximum 5MHz BW is necessary for proper scheduling during initial access. - Due to lower frequency diversity gain caused by narrower UE BW, coverage recovery may be necessary for same coverage as non-RedCap UEs and Rel-17 RedCap UEs. - Support high UE density based on Rel-17 RedCap outcome, e.g. solutions to avoid initial BWP congestion and to reduce PDCCH blocking rate. - Potential SA/CT impact is foreseen if eRedCap UE specific access control, e.g., UAC is introduced.
10 – VODAFONE Group Plc For other proposals, Rel-18 RedCap should focus on coverage recovery techniques and also ensuring the coexistence between non-RedCap UEs and legacy Rel-17 RedCap UEs
11 – Huawei Tech.(UK) Co.. Ltd We assume that Rel-17 leftovers, if any, will also need to be considered before WI approval, and a placeholder can be included in early drafts of the WID.
12 – Fraunhofer IIS Fraunhofer Positioning for RedCap devices should be discussed in the Positioning WI.

2.5 Moderator Summary of the Initial Round and recommendation for further discussion

2.5.1 General comments

Companies stated their views on the general direction of RedCap. Most companies agreed that further UE complexity/cost reduction and reduced UE energy consumption will open up for new use cases. These two areas were then discussed in more detail in the next 2 sections. However, a few companies expressed the view that no evolution was needed in Rel-18.

Many comments highlighted the relation of Rel-18 eRedCap to other IOT tracks (Rel-17 RedCap, LTE, LTE-M, NB-IOT) and the need to consider eco system aspects, especially the need to avoid market fragmentation.

The relation of RedCap to other independent features was raised, e.g. positioning, sidelink, unlicensed, broadcast. The common desire is that those features should work also on a RedCap device. For some features, nothing seems to be needed, e.g. SL, unlicensed. For others, enhancements are part of a separate discussion thread, e.g. positioning. For yet other features, it might be worthwhile to check if anything was needed to enable them, e.g. broadcast. **As moderator, I would propose to discuss this further in the Intermediate Round.**

2.5.2 New use cases and UE bandwidth

Most companies supported that Rel-18 should further reduce the UE cost/complexity. But there was no common view whether the UE RF bandwidth should be further reduced, i.e. to 5MHz, or not. The argument in favour is the expected UE cost saving and the argument against is the lack of compatibility to Rel-17 RedCap and the corresponding fragmentation.

As there was strong opposition to a 5MHz UE bandwidth from 15 companies, a fast and time-saving solution would be not to proceed with the proposal now and come back when more companies are convinced.

But as there was support for a 5MHz UE bandwidth from 17 companies, one could discuss a Study Item (or study phase), where the pros and cons of a reduced RF bandwidth are assessed, and a common solution is targeted. **As moderator, I would propose to discuss this potential study further in the Intermediate Round.**

A group of other proposals to further reduce the UE complexity got good support, i.e. reduced peak data rate, reduced number of HARQ processes, relaxed UE processing time. **As moderator, I would propose to discuss these proposals further in the Intermediate Round.**

A group of other proposals were only mentioned seldomly, e.g. CSI and beam mgmt, reduced modulation order, 40MHz UE bandwidth, coexistence, upper layer enh. **Unless there is more support, the moderator would propose not to discuss those further in the Intermediate Round.**

2.5.3 Power saving

There was strong support that Rel-18 should further reduce the UE energy consumption. However, a few companies highlighted that the generic UE power saving enhancements of Rel-16 and Rel-17 would be sufficient. In general, the relation of RedCap-specific vs. general UE power saving techniques was highlighted. It was also highlighted that some of the proposals on UE complexity reduction would have a positive effect on the power consumption.

The most famous proposal was about a low-energy wake-up radio. Many companies supported that proposal but there were split views whether it should be done as part of a RedCap WI/SI or whether it should be done in a separate item, e.g. UE power saving. **As moderator, I would propose to park the discussion on where to do the work and instead continue to discuss what should be done exactly. In a second step, e.g., at the Sep plenary, we can come back to the work structure.**

A group of proposals to further reduce energy consumption got good support, i.e. lower UE power class, eDRX, RRM relaxations, energy harvesting. **As moderator, I would propose to discuss these proposals further in the Intermediate Round.**

Small data transmission was also proposed by quite some companies but it was acknowledged that it is rather independent of RedCap and discussed in another thread (14.6).

A group of other proposals were only mentioned seldomly, e.g. cross-slot paging, PDCCH reduction, narrower BWP. **Unless there is more support, the moderator would propose not to discuss those further in the Intermediate Round.**

2.5.4 Others

A few companies expressed their interest to study enhancements to improve system performance. Another proposal by multiple companies was to look into coverage recovery. More proposals were only brought up by single companies. **Unless there is more support, the moderator would propose not to discuss those further in the Intermediate Round.**

Like in the first "General" part, the relation of RedCap to other independent features was raised, e.g. positioning, sidelink, unlicensed, broadcast, see above.

2.5.5 Proposed way forward

Let's discuss the following structure during the Intermediate Round:

RedCap evolution

- **Main goal: further embrace new use cases, especially requiring low-cost devices and low energy consumption**
- **Power saving/energy efficiency enhancements**
  - **Support for low power WUR/WUS [could potentially be part of a separate SI/WI]**
  - **Support for lower UE power class**
  - **Other power saving enhancements**
    - **Enhanced DRX**
    - **RRM relaxation**
    - **Enhanced support for devices operating on harvested energy**
- **Complexity reduction**
  - **Study further reduced UE bandwidth**
    - **Especially considering the expected savings and the compatibility with Rel-17**
  - **Reduced UE peak data rates**
  - **Other complexity reduction techniques**
    - **Reduced number of HARQ processes**
    - **Relaxed UE processing times**
- **Relation of RedCap to other independent features, e.g. broadcast**

3 Intermediate Round

Please provide your comments of the Intermediate Round in the below feedback forms. Deadline of the Intermediate Round is Wed. 12:00h UTC.

3.1 General comments

Feedback Form 5: General comments

1 – Futurewei Technologies

FUTUREWEI

Based on the comments in the first round, many companies have stronger interests in power savings than with aspects of complexity reduction. This is not surprising because the Rel-17 study identified the primary drivers of complexity, and they are being addressed in the Rel-17 WID. As anticipated by the Rel-17 study, the identified potential targets for power savings are not specific to RedCap UEs. Thus, it may be reasonable to conclude that if a Rel-18 WI for RedCap were pursued, it should be small in scope.

2 – vivo Communication Technology

On broadcast support for RedCap, it is not very clear to us what exactly is missing from Rel-17 thus require specification work in Rel-18. Some detailed justification would be necessary.

3 – Facebook

We would like to reiterate some comments we made in the first round. It was agreed that RedCap should not overlap with the space currently targeted eMTC/NB-IoT. We think the justification on not having RedCap targeting similar use cases remain valid. While at the same time, there is an emerging need for the better support of wearables, particularly, the high end wearables, as mentioned by some other devices vendors. Somehow, we seem try to ignore the need. In additonal to the increasing popularity and varieties, wearables by itself creates lots of technical problem that 3GPP should help solving such as compact formfactors (e.g. smart watches, smart glassses, all day wearables, and small battery size.. On the other hand conversation-al/multimedia traffic continues to grow with increasing popularity of sharing multimedia causing growth in both downstream and upstream traffic as well. As we see the need to enhance the RedCap to support high end wearable use cases, such as more flexible bandwidht such as 40 Mhz, optional support of CA..at a slightly expense of complexity to feasiliate the increassing variety of of use cases and applications.

4 – QUALCOMM JAPAN LLC.

- We agree with moderator's proposal in Section 2.5.5 in general. Besides, we think Type-B HD-FDD can be further studied for R18 eRedCap devices, together with other UE complexity reduction features.
- For new use cases of R18 eRedCap devices, we are also interested in high-density deployment of low-power sensors (e.g. smart cities, automated factories). Efficient support of this new use case would require further enhancements in upper layer, such as beam-specific RACH procedures, contention-based CG-SDT and etc.
- To support eRedCap UE with further reduced BW, we think co-existence among different UE types (NR R15/R16/17 non-RedCap UE, R17 RedCap UE) needs to be ensured. Besides, the upper layer enhancements such as access control, early indication of UE type/capability, paging and mobility enhancements can be further studied.

5 – InterDigital Communications

We agree with the general direction of the moderator's proposal.

6 – Xiaomi Communications

Xiaomi

Since there may be a separate SI/WI for the low power WUR/WUS the relationship between RedCap and the low power WUR/WUS should be clarified and coordination should be performed to avoid duplicate discussion.

7 – Apple Poland Sp. z.o.o.

Apple

We are supportive the moderator's proposal except the last bullet on broadcast. It is unclear what exact enhancement it targets for, especially it seems assumed to be not supported by Rel-17 Redcap.

8 – NTT DOCOMO INC.

We are fine with the overall structure of the way forward.

9 – TELECOM ITALIA S.p.A.

Support Futurwei statement. Most of the topics seems to fall under other activities and we don't see the need to have a specific Work Item in Rel 18

10 – Lenovo (Beijing) Ltd

We are in general fine with moderator's way forward. From the main goal of embracing new use cases of low cost and low energy UEs, one aspect for study is identification of such UEs and access control of the UEs.

We support further power saving and reduced cost/complexity RedCap UEs in Rel.18. Further reduced BW, low power WUR/WUS and low UE power class are preferred. Some of the techniques in the way forward, such as relaxed processing time, were discussed in Rel.17 and repeated discussed should be avoided.

We in general Not prefer to discuss RedCap with other independent features in RedCap WI.

11 – Spreadtrum Communications

From our understanding, the total IoT market will be enlarged by Rel.17/18 RedCap than fragmentation. In addition, different capabilities (e.g. MIMO/Modulation/BW, etc.) can match different requirements of different use cases, which is helpful to achieve a better balance between costs and all vertical requirements.

12 – Guangdong OPPO Mobile Telecom.

OPPO

We agree with main proposal of moderator about the narrower bandwith and the relaxed processing complexity.

However, we see the need of considering the 40MHz UE bandwidth for RedCap UE. Alough with less supportor, it have very little specification impact to the exsiting RedCap. Since we supported 20MHz in Rel-17. 40MHz UE can reuse all the scheme and there is not compatability issue. The only specification impact may be NW should know that capability and RF requirements. The market value is it can truely offer the capability similar as LTE wearable, e.g. cat 4. We still propose to consider that.

13 – LG Electronics Inc.

Okay with the general direction and the main goal formulated by the FL.

In Rel-18 RedCap, the main focus should be on the low-end use case scenarios (industrial wireless sensors, low-end wearables, etc.) where devices are larger in volume and more sensitive to the cost/complexity and power consumption than the Rel-17 RedCap UEs.

14 – ZTE Corporation

We are generally fine with the objectives of RedCap in Rel-18, including three parts, complexity/cost reduction, power saving and Functional enhancements. Also, we should try to avoid the duplicated discussion with other agenda items. For example, unlicensed spectrum, sidelink, harvested energy for RedCap can be discussed in the separate agenda item.

15 – China Mobile Com. Corporation

It is desirable to expand RedCap use cases and construct a rich ecosystem. However, without additional coverage extension for RedCap, it is unlikely to replace LTE-M or NB. So the intention of RedCap is to meet higher requirement than LPWA, and at the same time reduce UE complexity and cost. Redesign a new system without compatibility with legacy NR system should be avoided.

16 – SHARP Corporation

We are fine with the direction of the moderator's way forward in general.

17 – Panasonic Corporation

We agree to study the feasibility of positioning, sidelink, unlicensed and broadcast.

18 – Huawei Tech.(UK) Co.. Ltd

There are some comments during the initial round on network impact for 5 MHz UE and the moderator uses this to propose only to study the feature. We don't think the statement of "As there was strong opposition to a 5MHz UE bandwidth from 15 companies" in the summary can be read from all the 34 replies in section 2.2. Rather, a number of them are applying a constraint to the design, and this would be a better way to reflect those points in a WID. See our specific comment below.

19 – Samsung Electronics Polska

The use cases for Rel-17 RedCap covered a quite wide range of data rate, e.g., less than 2Mbps, till up to 50Mbps/150Mbps. Several companies proposed to support the use case with a bit rate of 1Mbps. We think this can be covered by Rel-17 RedCap since the target bitrate is in a similar level. Use cases and requirements for low tier RedCap should be better study and clarified.

In addition, we suggest to also consider/discuss on the potential leftovers of Rel-17, e.g., RF retuning, fast BWP switching, [multi-] initial BWP operation, CSI enhancement etc.

20 – Ericsson LM

We support the main goal of further embracing new use cases, with low-cost devices requiring low energy consumption. Our first priority for Rel-18 eRedCap is power saving/energy efficiency enhancements.

21 – vivo Communication Technology

In additionl to complexity reduction and redcap specific power savings, we are also interested in SL support for Redcap devices.

22 – Nokia France

The Moderator's summary seems well focused on power saving and complexity reduction.

Regarding "other independent features", we agree with Apple that the bullet and justification is unclear, and we suggest to delete it.

3.2 Power saving/energy efficiency enhancements

Feedback Form 6: Comments to Power saving/energy efficiency enhancements

1 – SoftBank Corp.

Thanks moderator for the nice summary. Here is our comments

- For low power WUR/WUS, the difference between Rel-17 PEI should be clarified. Otherwise, it is not easy to understand the difference, and introduction of two similar & exclusive functionalities is not desired.
- We think lower UE power class needs careful assessment, especially from network impact point of view. In addition, necessity of coverage recovery (including reuse of Rel-17 CovEnh and/or something new) is not clear from this description.

2 – Futurewei Technologies

FUTUREWEI

Many companies expressed interest in additional power classes for RedCap UEs. Since UL coverage is a limiting factor for RedCap UEs, the techniques considered in the Rel-17 WID for UL coverage enhancement may then have to be used. It is unclear how much power savings can be achieved if a RedCap UE stays on longer and transmits more often.

As indicated by the moderator, supporting low power WUR / WUS, and even harvested energy may benefit for all UEs, not just RedCap UEs. If there is a SI/WI for WUR/WUS, it should not be limited in scope to RedCap UEs. A RedCap UE can then incorporate the feature, just like in Rel-17.

3 – QUALCOMM JAPAN LLC.

- Several companies mentioned SDT enhancements in the initial round. We are flexible as to whether SDT enhancements should be studied/specified under R18 eRedCap WI, or in a separate WI by itself, depending on how companies prefer to prioritize different topics in the R18 package.
- We are interested to study the performance and complexity/cost impacts of LP WUS/WUR and the potentials of energy harvesting. To get a comprehensive understanding for their benefits, careful analyis/evaluation needs to be done in R18 for eRedCap UEs. Besides, a comparison with other UE power saving solutions (NR R16/17/18) is necessary.

4 – InterDigital Communications

Low power wake-up radio is a promising technique and as mentioned can benefit all UE types. We support to study this; whether it will be under a separate SI/WI can be discussed at a later stage.

5 – Intel Corporation (UK) Ltd

Couple of comments on the proposed objectives on UE power savings enhancements:

1. The potential support of **ultra-low power WUR** requires a study on feasibility and applicability of the separate WUR in multi-cellular systems and mobility considerations. We understand the moderator has requested not to focus on target SI/WIs, but we would like to emphasize the need for a proper study before normative work can be considered. We cannot move to normative spec work on this without studying these. Although our original preference is to limit applicability of ultra-low power WUR to RedCap for no/low mobility use-cases, considering the overwhelming support for studies on ultra-low power WUR in [**RAN93e-R18Prep-14**], we would also be fine with a common study item to evaluate applicability and feasibility and design targets and potential solutions, that includes non-RedCap use-cases as well.

2. As indicated in the previous round, we are not comfortable to going directly to normative spec work for support of "**devices operating on harvested energy**". In our view, such devices would have very different target KPIs (data rate, latency, reliability requirements), power consumption, and cost sensitivity compared to the RedCap UEs considered so far in Rel-17 and being considered for Rel-18 (cf. "Complexity reduction" section). These details need to be studied carefully including identifying the design targets for devices operating on harvested energy. In this regard, if we are to consider support of UEs operating on harvested energy, it should be studied properly, e.g., as part of the "passive IoT" related discussions in [**RAN93e-R18Prep-15**].

6 – Xiaomi Communications

Xiaomi

For the low-power WUR/WUS and energy harvest, we should clarify the relationship with RedCap first. If it is not specific for RedCap, we think we'd better not to touch this proposal in RedCap to avoid duplicate discussion. If the majority think it is RedCap-specific, then we think a SI phase is needed to study the feasibility.

7 – vivo Communication Technology

About low-power wake-up receiver

As commented in this NWM thread and the other NWM thread [RAN93e-R18Prep-14], clear majority of companies prefer to have a separate study item for low-power wake-up receiver in Rel-18, rather than include it in the eRedCap WID. We appreciate if moderator can summarize such discussion status and report to RAN#93e.

The reason from majority companies to prefer a separate study item on low-power wake-up receiver could be summarized as below.

1) Different from Rel-16/17 UE power saving features, the low-power wake-up receiver is brand-new for NR thus comprehensive study is required to investigate the use cases, power saving gain, receiver structure and WUS signal design, etc. However, from companies input, most of the other eRedCap enhancement proposals can be specified directly, or with a quick study phase. Therefore, the level or maturity of the low-power wake-up receiver is much lower than other objectives, having a single work item to cover both is not appropriate.

2) From technical perspective, the low-power wake-up receiver can potentially be applicable to all UE types, it is not appropriate to restrict the study or design low-power wake-up receiver to RedCap devices with no good reasons. The study will be different depending on whether to restrict ourselves to RedCap only, e.g. the traffic model, power model and evaluation assumptions are quite different between RedCap and non-RedCap UEs, and the baseline power consumption are also different for the two UE types, thus the relative power saving gain provided by the low-power wake-up receiver can be quite different. Without a throughout study, it is not clear in which use cases we can observe better gains. Furthermore, we expect the low-power wake-up receiver, if specified, can be used to wake-up other radios in addition to NR, like eMTC, NB-IOT or sidelink in the future. From this perspective it is clear that separate study item is more appropriate.

3) Regarding the detailed study objectives, please refer to the latest proposal in [RAN93e-R18Prep-14], companies are welcome to make any comment or suggestions on the scope.

About other RedCap specific power saving features

We support the RRM relaxation as summarized by moderator, and fine to discuss enhanced eDRX with much longer cycle.

Regarding low power class, we think it is more related to cost/complexity reduction while can also offer power efficiency improvement. We also notice there is similar discussion in RAN4 email thread [RAN93e-R18Prep-17] as FR1 UE RF enhancement in Rel-18. As this work is clearly RAN4 centric, we wonder if it is more proper to include it in the RAN4 Rel-18 package.

Regarding energy harvesting, we think more discussion would be needed before agreeing to include it in a WI.

And we agree with the moderator observation that some complexity/cost reduction features can also bring power saving benefit, as following.

- Peak data rate reduction (RF or BB or both)
- Reduced number of HARQ processes
- Relaxed processing timeline (for data, CSI)

8 – Apple Poland Sp. z.o.o.

Apple

As commented in the initial round, our preference is to start from a study item to figure out the practical use cases (e.g. stationary or low mobility) that can really harvest the power saving benefit.

Regarding the 'harvest energy', some clarification would be helpful to understand the potential impacts on specification e.g., whether it is overlapped with the first two techniques i.e, RRM enhancement, enhanced DRX, or it would require fundamental changes on protocol design.

9 – NTT DOCOMO INC.

Thanks moderator for the nice summary.

- Regarding WUS enhancements, it should be clarified whether WUS enhancements considering Red-cap features, e.g. Extended DRX cycle, are included or not.
- Regarding RRM relaxation, RRM relaxation for low mobility has been already introduced in Rel-16, and we are not sure what the difference between new RRM relaxation scheme for Redcap and existing function is. It should be clarified.
- Regarding lower UE power class, we are fine only if corresponding coverage recovery techniques are specified.

10 – TELECOM ITALIA S.p.A.

The topics are of interest, but it can be included in the general UE power saving discussion

11 – Lenovo (Beijing) Ltd

We need to firstly discuss the application area of the low power WUR/WUS, e.g., whether it could be applied for all RedCap devices or even non-RedCap devices, or it targets for ultra-low complexity UEs that might be introduced in Rel.18 RedCap. Based on this, we can determine if it is in RedCap or a separate SI/WI.

12 – Guangdong OPPO Mobile Telecom.

OPPO

As we earlier discussed. We think the power saving features is very important to RedCap UE. We understand the intention here is to give conderation of PS aspects, not scoping a WID/SID.

13 – CATT

We are supportive of low power WUR/WUS and also agree that it needs to be discussed whether it is included in Rel-18 RedCap item or in a separate item for UE power saving.

For lower UE power class, our understanding is that it is used in the scenario when coverage is not an issue and no coverage enhancement is expected to compensate the coverage loss due to lower UE power class. We think it needs to be clarified in the proposal.

14 – RadiSys

We support studying low power wake up receiver as a seperate study item to cover all UEs. We agree to Moderator's summary and we also think that eDRX, further RRM Relaxation and UE's mobility profile identification are the key factors to be considered power saving enhancements.

15 – LG Electronics Inc.

Further clarification on the low power WUR/WUS is needed. We need to understand what should be done exactly first. Our initial assessment is that it has a huge impact on evaluation and specification work, and in this case we recommend the low power WUR/WUS to be discussed in a separate SI (e.g., Rel-18 SI on NR UE power saving).

The scope of the lower UE power class needs to be discussed. The introduction of lower UE power class involves network impact as it directly affects the UL coverage. Furthermore, existing coverage enhancement solutions may not be enough if the lower UE power class is meant to be supported in all deployment scenarios.

Enhanced DRX and RRM relaxation can be considered if there are left-overs from Rel-17 RedCap WI and further enhancements being identified. Other power saving enhancements should not be included in Rel-18 RedCap.

16 – ZTE Corporation

For serving cell measurement relaxation, it was excluded from Rel-17 because companies haven't identified effective serving cell RRM relaxation method without impacting IDLE/INACTIVE behaviour (e.g. Paging). moreover, the quality of serving cell measurement is used in "stationary criterion" evaluation. If serving cell measurement relaxation is applied, the transition from "relaxed mode" to "normal mode"

may be delayed and affects mobility performance. So, we do not see the necessity for serving cell RRM relaxation.

eDRX is still on the discussion in Rel-17. The justification of further eDRX in Rel-18 should be clarified, e.g., use case.

From our understanding, harvested energy requires a new PHY design and high layer design. We are confused how the RedCap UE can operate on harvested energy. Seems it is part of the "Other IoT" discussion and not the RedCap specific issue.

If low power WUR/WUS is taken as the separate SI/WI, PDCCH candidates reduction can also be considered for RedCap power saving.

17 – China Mobile Com. Corporation

Power saving is a important feature for RedCap device, so we are supportive of such enhancement. However, the influence of coverage performance should be carefully analyzed and satisfied when considering introduction of low power WUS and low power class.

18 – Panasonic Corporation

We also would like to understand the difference from Rel.16/17 function instead of generic power saving for RedCap UE.

Low-energy wake-up radio should not be specific to RedCap UEs.

19 – vivo Mobile Communication Co.

- [Reply to ZTE] Actually, serving cell RRM relaxation have been already specified in LTE in Rel-15/16. The scenario is mainly for stationary UEs, while the relaxation is configured by network but not based on criteria check. In this way, there is no need to evaluate "stationary criterion" based on the quality of serving cell measurement. For example, cells deployed as indoor scenario could configure such relaxation. Then, there is no problem for the transition from "relaxed mode" to "normal mode". We could apply the same mechanism in similar use case, as RedCap UEs also have some "true stationary" use case.
- Besides, regarding the power saving gain for serving cell measurement relaxation, it has been studies in Rel-17, significant power saving gain could be achieved based on evaluation, which could be found in the TR 38.875. If serving cell measurement relaxation is not supported for RedCap, there may be risk that RedCap UEs have worse market competition ability than NB-IoT/MTC in LTE, considering the power consumption.

20 – Huawei Tech.(UK) Co.. Ltd

- Support for low power WUR/WUS: It should be clearly described to allow judgement of what is the difference to existing WUR/WUS which 3GPP already specified in Rel-17 and previous, if it is part of this WI.
- Support for lower UE power class: First, we think it is more related to cost reduction rather than power saving, since a UE always can transmit lower power than its maximum power class. And there is coverage loss for such kind of UE. Overall we don't think it is urgent in Rel-18.
- Other power saving enhancements: eDRX is already in current Rel-17 scope thus we prefer to look at all Rel-17 leftovers together later. RRM relaxation was discussed during SI, and our understanding was that serving cell RRM relaxation is very controversial and not in the Rel-17 scope. We are still not in favor of RRM relaxation on serving cell in Rel-18.

- We believe harvested energy shall be discussed in other IoT enhancements thread and it is related to passive IoT.

21 – MediaTek Inc.

We are supportive on addressing low-power WUR/WUS as part of these discussions, but it would be good to have a better understanding on **what low-power WUR/WUS means in this context**. If this pertains to enhancements to Rel-16 and Rel-17 wakeup mechanisms, it could be done as part of a WI in Rel-18. However, if this is intended to be a completely new radio interface, this will require further evaluations which would be part of a SI for Rel-18. Regardless of the direction we take, we see LP-WUR as useful to all types of UEs and not just RedCap UEs.

On the topic of **energy harvesting**, we have a similar view as Intel, i.e. this would potentially **need further study** as opposed to being a WI objective for eRedCap. Given that energy harvesting is more relevant to Passive IoT type devices, it would be appropriate to have this discussion in the *RAN93e-R18Prep-15* thread.

22 – Philips International B.V.

We agree with the overall sentiment that low-power WUR/WUS as well as devices operating on harvested energy shall not be specific to RedCap and, therefore, can be treated in other WI/Sis such as UE power savings or Other IoT enhancement types

23 – VODAFONE Group Plc

Power Saving: As mentioned before the impact on the design of Wake Up Signals should be evaluated in terms of its impacts on the battery life of other devices. Also its similarities with the PEI being designed in Rel-17 currently and if there is any work that can be reused from those discussions. A study concerning all UEs may not be the most appropriate as the power saving in RedCap UEs is expected to be mostly during idle/inactive.

Energy harvesting/passive IoT should be separated into a separate study.

24 – Samsung Electronics Polska

We also think that the generic UE power saving enhancements of Rel-16 and Rel-17 would be sufficient in general, so the leftover from Rel-17 (i.e. to extend the eDRX for INACTIVE, if not agreed) can only be considered.

For low UE power class, the uplink coverage issues need to be further discussed, i.e., whether to compensate UL coverage loss due to lower UE power class. In addition, the use cases is not very clear but it will have negative the impact on the network, especially uplink coverage. We think the energy harvesting is not belong to RedCap WI, it should be discussed separately, and it may not be urgent to study in Rel-18.

There are some discussion on ZP or low power WUS in others. We suggest to avoid duplicated discussion in two threads.

25 – Ericsson LM

We support considering low power WUR/WUS in Rel-18 eRedCap as it matches well with the use cases of lower-end devices requiring low power consumption. In some latency-sensitive applications, long DRX may not be suitable, e.g., industrial actuators for emergency stop. Having a dedicated low power WUR with WUS can provide significant power saving gain. To maximize the power saving, we also see that cross-slot

scheduling for paging message should also be considered as a complementary enhancement to maximize the benefit of WUR.

Regarding whether this topic should be discussed in general and applicable to normal NR UEs as well, technology-wise, it may be argued that low power WUR can be useful in general. However, in our view, the gain for regular eMBB use cases may not be clear due to more frequent data activity and charging of MBB. We are open for the discussion on this.

To enable use cases with low power consumption and expand the addressable use cases of Rel-18 eRedCap, we support to include

- Support for lower UE power class, and
- Support for devices operating on harvested energy from the environment

As a continuation from Rel-17 discussion, some leftover topics on other power saving enhancements such as longer eDRX in RRC_INACTIVE (>10.24s) can be considered in Rel-18.

Regarding RRM relaxation, it has been specified in Rel-16 and also in Rel-17. It is not clear to us which use cases this is supposed to address and why existing functionality is not enough. In our view, it was not even well motivated in Rel-17 as the gain is not significant. Therefore, we don't see the need to specify any further RRM relaxation in Rel-18 unless strong motivation is brought up.

26 – Sony Europe B.V.

Low power WUR / WUS

We support study of the performance and complexity / cost impacts of low power WUR / WUS. Wake-up radio is beneficial for use-cases where the traffic is relatively low, but the device needs to be reachable by the network quite often. Whether low-power wake-up radio is only to be studied for RedCap or as generic UE features depends on the use-case and FFS. We hence think that low power WUR / WUS should be considered in a separate study item (as commented in Prep-14). The list of objectives that we think should be covered by a low power WUR / WUS study include:

Objective I:

· Study and evaluate low-power wake-up receiver architecture and design trade-offs such as sensitivity, data-rate, bandwidth vs. power consumption.

· how to compensate for performance/sensitivity loss, if any

Objective II:

- Study and evaluate wake-up signal designs to enable ultra-low power reception
- How to do the multiplexing of wake-up signal and other transmission types signaling, if in-band transmission is selected

Objective III:

- Study and evaluate mobility aspects, whether to support only stationary devices or adapt the protocol to also support measurement for ultra-low power wake-up receivers

Objective IV:

- Procedures to adjust/adapt/extend the current protocol to support ultra-low power wake-up receivers

Energy harvesting

Operation on ambient harvested energy is very interesting. The issue with operating on ambient harvested energy is that signalling exchanges may be interrupted when the UE runs out of harvested energy and can only restart when the UE has harvested sufficient energy. Hence there need to be protocol enhancements to support operation on intermittently available harvested energy.

Lower UE power class

Lower UE power class does not necessarily reduce the UE power consumption as the UE needs to be "ON" for longer to transmit data. Lower UE power class is mainly a complexity / cost issue. Lower UE power class will have impacts on coverage which may be undesirable.

27 – Fraunhofer IIS

Fraunhofer

Regarding a dedicated low-power WUS, we have the same view as Intel. This topic first requires a study of the feasibility and applicability of low-power WUS/WUR. Further, we see that the combination of low-power WUS/WUR and energy harvesting has a huge benefit for increasing the battey lifetime of low power UE devices.

28 – Nokia France

Overall the bullets are reasonable.

- We agree with Ericsson that if WUS is included, it fits best under e-RedCap. If it is included, then evaluation of the impact of WUS on network energy efficiency should also be included in order to understand the overall system impact rather than just transferring energy consumption from the UE to the network.
- "RRM relaxation" seems a bit unclear. It would be good to give some specific points, for example:
  - more power-efficient beam management, e.g. simplified beam management procedures, beam failure detection and recovery optimization for stationary and low-mobility devices.
  - reduced-bandwidth monitoring and measurements within a portion of a bandwidth part.
- "Enhanced support for devices operating on harvested energy" is a good motivation, but it is not really a technical objective. Fundamentally, devices operating on harvested energy need power saving enhancements. The type of energy source (harvested vs battery) is not going to appear in 3GPP RAN specifications. So the important point is to identify the specific power saving mechanisms, as in the bullets above. We therefore suggest to delete this bullet, without in any way meaning to deny its motivation.

29 – Spreadtrum Communications

We are positive to all the power saving/energy efficiency enhancements listed by moderator. As we commented in the last round, RedCap-specific power saving techniques can be considered in RedCap item, and we are open to discuss which features are RedCap specific.

3.3 Complexity reduction

Feedback Form 7: Comments to Complexity reduction

1 – SoftBank Corp.

Thanks for the summary.

- Regarding UE bandwidth reduction, our concern is not ”compatibility with Rel-17”, but ”whole impact to network side including coexistence with Rel-17 RedCap UE and non-RedCap UE”. With this, we are fine with the study phase.
- We are wondering if Reduced number of HARQ processes and Relaxed UE processing times are worthwhile considering as the 2nd release enhancements.

2 – Futurewei Technologies

FUTUREWEI

The motivation for further study of a reduced bandwidth is unclear given that nearly 50% of the companies have some concerns regarding a 5 MHz bandwidth. There is a good chance that the study will prove inconclusive.

As we mentioned, the 20 MHz channel bandwidth is proving to be challenging to get agreements for Rel-17. A smaller BW would introduce more issues especially during initial access. If there is an objective, a study for 5MHz BWP in the connected state to get power savings benefits with minimal (or no) spec changes could be considered.

The other items for complexity reduction (relaxed processing times, reduced number of HARQ processes, and reduced data rate) were studied in Rel-17 but were not included in the Rel-17 WID. If agreed for Rel-18, these items have a larger impact to RAN2.

3 – vivo Communication Technology

We think reduced UE BW is one solution for peak deta rate reduction, other solution would be to reduce the data rate in baseband only but not the RF side, in this sense the first two bullet under complexity reduction from moderator proposal are correlated. Suggest to merge the two bullet and have a study phase for the exact solution, and to our understanding both 10MHz and 5MHz are to be considred, not just 5MHz.

We support the reduced HARQ process number and relaxed processing timelin (for data and CSI), suggest to make paralell sub-bullets for these two rather than having them in ”other techniques” as it implies some priotiy.

4 – InterDigital Communications

We agree that further BW reduction can first have a study phase. In addition, complexity reduction in beam management and CSI can also be considered.

5 – QUALCOMM JAPAN LLC.

- In the Moderator’s summary for UE BW reduction, it mentioned “there was strong opposition to a 5MHz UE bandwidth from 15 companies.” In our view, it is not 100% correct. Some companies out of the “15 companies”, mostly operators, commented that they can be supportive of 5MHz BW, if sufficient backward compatibility is guaranteed and/or if cost benefits are sufficiently large.

- We believe that UE BW reduction down to 5MHz provides sufficient cost saving gains with relatively limited system/network impacts. However, if it is not agreeable at this stage, we are OK to have a short-term study phase to demonstrate/evaluate the benefits/impacts of BW reduction either in RAN plenary meeting of 12/2021, or in the early phase of WG-level WI in 2022.

- We think BW reduction should be applied to both RF and BB of eRedCap devices, to maximize the benefits of cost/complexity reduction. Therefore, the bullet of "reduced UE peak data rates" in Moderator's proposal (Section 2.5.5) should be discussed in parallel with max BW reduction in both RF and BB of a R18 eRedCap UE.

6 – Intel Corporation (UK) Ltd

1. On support of further reduced UE BW, we do not think a study phase is strictly necessary. The existing Rel-17 SI framework would anyway apply and RAN WGs can explore and evaluate the options to support further reduced BW UEs as part of normative work. However, we acknowledge that details of supporting reduced UE BWs may benefit from some studies. **In this regard, we can compromise to agreeing to support of further reduced UE BW to 5 MHz and having a study phase for the evaluation of available options to address coexistence with other UEs and backward compatibility.**

2. Without further UE BW reduction, the remaining cost/complexity features either (i) do not seem to provide meaningful gains, or (ii) would be a repetition of discussions from Rel-17. Thus, the following UE cost/complexity reduction schemes should only be considered subject to support of further reduced UE BW:

- Reduced UE peak data rates *(Note: decision on this depends on decision for Rel-17)*
- Reduced number of HARQ processes
- Relaxed UE processing times.

7 – Xiaomi Communications

The reduction of UE BW and HARQ process number would result in the peak data rate reduction accordingly. We prefer to remove the subbullet of "**Reduced UE peak data rates**".

8 – NTT DOCOMO INC.

- Regarding backward compatibility, we fail to understand why backward compatibility should be ensured for "reduced cost/complexity" devices from previous releases. Rel-17 RedCap UEs are being designed assuming 20 MHz BW, which is not backward compatible with 100 MHz BW mandatory for non-RedCap UEs, either. It is clear that the eRedCap UEs with maximum 5MHz BW cannot directly reuse the same initial access procedure with 20 MHz initial DL/UL BWPs being specified for Rel-17 RedCap UEs. On the other hand, since current SSB can be reused for 15KHz SCS, similar approach as Rel-17 RedCap can be applied to Rel-18 eRedCap, such as separate initial DL/UL BWPs and PUCCH FH enabling/disabling which are being discussed in Rel-17, and thus specification work can be minimized.
- Regarding market fragmentation, we believe it is quite important to provide the low-end NR platform, which does not overlap with LTE eMTC/NB-IoT, to further extending NR-IoT market since there is definitely a gap between Rel-17 RedCap and LTE eMTC/NB-IoT. Note that Rel-17 RedCap UEs with 20MHz BW, 1Rx, and maximum DL 64QAM can support up to around DL 75Mbps, which is too high to support up to DL 10Mbps use cases.

- Regarding other complexity reduction techniques such as reduced UE peak data rate, reduced number of HARQ processes, and relaxed UE processing time, we are supportive of these features as commented in the initial round.

9 – Lenovo (Beijing) Ltd

Given the diverse view, we are fine to have a study phase on further reduced BW for RedCap in Rel.18. The relaxed processing times, reduced peak data rate and some related aspects have been discussed or under discussion in Rel.17. Repeated discussion should be avoided in Rel.18.

10 – Spreadtrum Communications

For further reduced UE bandwidth

- **Cost savings:** The cost saving of further reduced UE bandwidth is mainly come from memory size reduction (different from RF and BB), since the supported peak data rate can be further reduced.

- **Compatibility**:
  SSB/CORESET0: In our understanding, when the BW is further reduced to 5MHz, the current SSB design/CORESET0 can be limited reused for 15Khz SCS. For 5MHz with 30KHz SCS, it can be FFS (e.g., by RF retuning).
  Backward: The fundamental features of first release of RedCap should be naturally extended to Rel.18, for example, cost/complexity reduction mechanisms, etc.
  Forward: For the potentially different dedicated spectrum used for different verticals, a unified design is preferred to guarantee forward compatibility, and suggested for carefully further study.

For reduced UE peak data rates, this bullet should be combined with the first bullet, as these two bullets are highly correlated.

11 – Guangdong OPPO Mobile Telecom.

OPPO

Their could be different views on 5MHz, seems it is not deem to be not compatible with the Rel-17 RedCap. This can be study. We are OK with the proposal on 5MHz.

As we also commented earlier, 40MHz have very little specification impact to the exsiting RedCap. 40MHz UE can reuse all the schemes for 20MHz and there is not compatability issue. The only specification impact may be NW should know that capability and RF requirements. The market value is it can truely offer the capability similar as LTE wearable, e.g. cat 4. We still propose to consider that.

12 – CATT

We are still not convinced to support further reduced UE bandwidth in Rel-18 given the limited benefit, market fragmentation, big specification impact and potential backward compatible issues. The proposal from moderator to have a study item/phase first could be one possible way forward. Moreover, it would be better to clarify the reduced UE bandwidth e.g. 5MHz to limit the scope of the study.

For reduced UE peak data rates, we think it may have some correlation with reduced UE bandwidth since reduced UE bandwidth itself would also reduce UE peak data rates. Therefore, we think reduced UE peak data rates can be discussed later after the completion of the study of further reduced UE bandwidth.

Both reduced number of HARQ processes and relaxed UE processing times were discussed in Rel-17 RedCap SI but were not agreed to be included in the WI. We should be more careful to agree those in Rel-18 in order to avoid repeating the same discussions we had before.

13 – RadiSys

We support study on BW reduction, reduced L2 and L3 process based on UE mobility profile and reduced DL data rate for complexity reduction

14 – LG Electronics Inc.

We recommend to include the reduced max UE bandwidth down to 5MHz in the scope of Rel-18 RedCap. Study phase may be needed. During the SI phase we can discuss how to minimize the impact on the network and ensure coexistence with Rel-17 RedCap UEs and non-RedCap UEs.

Reduced UE peak data rates can be mainly achieved by the reduced max UE bandwidth. Additional efforts to reduce the peak data rates are considered as minor optimizations, hence not recommended.

Other complexity reduction techniques are not recommended based on the observations in Rel-17 RedCap SI.

15 – ZTE Corporation

Besides the bandwidth, the modulation order relaxation and HARQ process number reduction can be a possible method to reduce the peak data rate. So it is suggested to view the HARQ process number and modulation order reduction as the sub-bullets of 'reduce the peak data rate'

Also, for the relaxed UE processing, the consensus is not achieved in Rel-17. therefore, this could be de-prioritized in Rel-18.

16 – China Mobile Com. Corporation

Considering the lack of compatibility with R17 RedCap and non-RedCap designs, the possible workload for redesign a new system, the coexistence problems, and the coverage loss due to less available CCE in CORESET, further reducing UE bandwidth is not persued.

Other complexity reduction solutions based on current framework summarized by the moderator can be discussed.

17 – Panasonic Corporation

We are ok to study phase. The impact to the network operation should be well discussed.

18 – MediaTek Inc.

We are open to studying the cost reduction aspects and means to ensure compatibility with Rel-17 RedCap UEs (as highlighted by several operators) as part of the work on reduced bandwidth.

With regards to reduced HARQ processes and relaxed UE processing time, these were discussed in Rel-17 and not pursued. We should avoid repeating earlier discussions here.

19 – Huawei Tech.(UK) Co.. Ltd

The cost benefits of bandwidth reduction are rather clear. Based on the comments, we do not think it is justified to have merely a study item on complexity reduction since the techniques are very well understood from the Rel-17 RedCap SI. We also do not think a study 'phase' is necessary, since the concerns from some operators represent a design constraint which can be reflected in normative WID text.

On, "Study further reduced UE bandwidth", in addition to being normative, the sub-bullet should be rewritten to link together BW reduction and peak data rate, since the latter results from the former, and thus does not require decoupled work.

For other complexity reduction techniques, they could be only considered in addition to further reduced UE bandwidth due to their smaller gains. And these should be also considered in network impact.

Revision to the moderator's proposal:

− Complexity reduction

○ ~~**Study f**~~**F**urther reduced UE bandwidth **of 5 MHz together with peak rate reduction, striving to minimize impact on the network**

~~**Especially considering the expected savings and the compatibility with Rel-17**~~

~~**Reduced UE peak data rates**~~

○ Other complexity reduction techniques **in addition, striving to minimize impact on the network:**

 Reduced number of HARQ processes

 Relaxed UE processing times

20 – Samsung Electronics Polska

For 5MHz BW for eRedCap:

The gain is about 3% depending on the techniques, when combining with existing cost reduction techniques, e.g., single Rx. This cost saving is not attractive to introduce another UE type to fragment the market and increasing the operating cost.

We agree on CATT's comment in initial round on the potential specification impact:

- New initial access channel design: SSB/CORESET #0 design for 30kHz SCS, or support 15kHz SCS SSB on the exsiting bands that only support 30kHz SCS => this means, in such bands(n77, n78, n79), double SSBs are needed.

- Coverage recovery: DL coverage is expected to be reduced about 6dB due to the reduced of DL BW. PDCCH, PDSCH for Msg 2/4 needs further enhancement to achieve similar coverage as NR and R-17 RedCap UE

- Coexistence between 5MHz UE, normal UE and Rel-17 RedCap UE

If the need of low bit rate can be justified, other techniques can be considered to limit the data rate (although we don't see the need yet), including: TBS reduction, reduced the # of HARQ, restrict L2 buffer.

21 – VODAFONE Group Plc

Will a study item change the opinions of the >30 companies involved? If not we should just decide in the next 3 months what to do on the 5MHz variant.

If we do study this, then the coexistence of Rel-18 RedCap UEs with non-RedCap UEs and the focus on economies of scale should be taken into consideration when discussing complexity reduction features.

22 – CEWiT

We support study on bandwidth reduction, reduced number of HARQ process and UE processing times

23 – Ericsson LM

We are open to enhancements which can support use cases with low data rate requirements in a backward-compatible manner. We note that one possibility of reducing UE peak data rate is already being considered in Rel-17, i.e., to limit UE's supported maximum data rate by lowering the *scalingFactor* value range, or a relaxation of a constraint on the product of the number of MIMO layers, modulation order, and scaling factor (vQf >= 4 condition). This discussion is ongoing in Rel-17 RAN1/RAN2. Our preference is to support this in Rel-17, if possible. Otherwise, a similar approach can be considered in Rel-18 in a backward compatible manner with respect to Rel-17 compatibility.

Regarding reduced BW, e.g., to 5 MHz in FR1, our estimate cost reduction based on the established cost evaluation methodology only showed small gain of <10% compared to Rel-17 RedCap UE which is even less than 5% cost reduction when compared to the Rel-15 reference NR UE. In our view the gain is too small to justify backward compatibility issues with Rel-17 RedCap cell as well as the large specification impacts considering that operation based on 30 kHz SCS in FR1 is important. In our view, this small additional potential cost reduction cannot motivate the resulting market fragmentation that would result from the introduction of a non-backwards-compatible 5-MHz UE. The 5-MHz UE will not be able to access a Rel-17 RedCap cell, and a cell supporting the 5-MHz UE may not necessarily support Rel-17 RedCap UEs either. We see a clear risk for unnecessary increases in R&D and IODT costs, market fragmentation, and an overall confused market message which may put the takeoff of the (Rel-17/18) RedCap ecosystem in jeopardy.

We are not supportive of any changes which are not backward compatible, e.g., any introduction of non-backward compatible SSB or CORESET #0 configurations. If further cost reduction from BW reduction is really needed, one possibility is to consider an option of reducing only baseband (BB) BW reduction for data channels, which can, e.g., be realized though a *scalingFactor* discussed earlier but may involve additional complexity reduction of some baseband components such as Post-FFT data buffering. This approach would incur minimal specification impact while providing similar level of gain as in the case of reducing both RF and BB BW (see e.g., RWS-210313, pages 10-11). According to our evaluations, for FDD a BW reduction only for BB of data channels would give 7% cost reduction (which can be compared with 9% for RF+BB BW reduction), and for TDD a BW reduction only for BB of data channels would give 5% cost reduction (which can be compared with 7% for RF+BB BW reduction). We are open to discuss this.

Regarding other UE complexity reduction techniques listed, we think a study would be needed to see if they are justified. In our view, we do not expect any significant cost/complexity reduction from reduced number of HARQ processes and relaxed UE processing time. These techniques have been extensively discussed and evaluated during the Rel-17 RedCap SI phase where it was concluded that the cost saving gain is not significant, and any potential power saving gain is also unclear. When judging the potential additional cost reduction from additional cost reduction techniques, it is important that the cost reduction is estimated with respect to the simplest Rel-17 RedCap UE, which is a 1-Rx UE. We suspect that any more optimistic cost reduction estimates than the ones we have presented here are with respect to some other reference than the simplest Rel-17 RedCap UE.

24 – Sony Europe B.V.

Bandwidth reduction has already been studied in Rel-17. Do we need to study it again in Rel-18? It was concluded in Rel-18 that there was reduced benefit in supporting bandwidths less than 5MHz and significant specification changes.

We understand that the other complexity reduction techniques identified in the moderator summary will not significantly reduce cost / complexity.

Type-B HD-FDD support is of interest for complexity reduction. We also think that Rel-18 should better support multiplexing between redcap UEs and URLLC devices. This use case is important for IWSN devices. It should be possible to cancel an UL transmission from a redcap devices when pre-empted by a transmission from a URLLC device.

25 – Nokia France

We suggest adding "Study further reduced UE bandwidth to 5MHz". (If there is to be a new bandwidth, there is widespread agreement that it needs to deliver worthwhile complexity reduction, so then we should focus on the most promising case, i.e. 5MHz; there is no point to discuss further 10MHz.)

3.4 Relation of RedCap to other independent features

Feedback Form 8: Comments to the Relation of RedCap to other independent features

1 – Futurewei Technologies

FUTUREWEI

With a 20 MHz RedCap UE, many Rel-16 / Rel-17 features can be supported directly in Rel-17 (pending the features discussion). If certain features (e.g., MBS) require some small compatibility updates, these could be supported under a small objective in the WI to address operation of that feature within the RedCap UE framework. (Similar handling to URLLC & NRU compatibility in Rel-17.)

2 – vivo Communication Technology

On broadcast support for RedCap, it is not very clear to us what exactly is missing from Rel-17 thus require specification work in Rel-18. Some detailed justification would be necessary.

3 – Intel Corporation (UK) Ltd

Our views on relation of RedCap to other features are summarized below:

1. Broadcast: No need to optimize for RedCap – support depends on decision as part of UE features discussions for RedCap in Rel-17.

a. To the comments indicating restrictions to scheduling for non-RedCap UEs if they share CFR with RedCap UEs, MBS sessions are defined/grouped based on services, and in this case, if the QoS requirements for a service can be satisfied for RedCap UEs (e.g., with limited BW or # of Rx antennas), the same should work perfectly fine for non-RedCap UEs. Thus, necessity to optimize @ PHY separately for RedCap and non-RedCap UEs **for a common MBS service/session** would need further justification.

2. Positioning: Separate considerations are needed in consideration of BW limitations for RedCap and ways to address the performance gap between RedCap and non-RedCap UEs in terms of positioning accuracy. However, this may be better handled as part of enhancements to positioning in NR and not as part of RedCap enhancements

3. Sidelink: This depends on decision for Rel-17. Some specific enhancements may be necessary especially if further reduced UE BW is introduced.

4. Unlicensed: This depends on decision for Rel-17. Some specific enhancements may be necessary especially if further reduced UE BW is introduced.

4 – Xiaomi Communications

Xiaomi

We think the discussion is necessary. Besides the broadcast, we think there is also some problem for the support of sidelink and unlicensed band. For example, in current sidelink, all UE will share one sidelink BWP, if RedCap is imported into the sidelink system, there will be significant restriction on the sidelink BWP configuration. And for the unlicensed band, due to the limited UE bandwidth, there will be some problem for the channel access.

As for how to handle these features, we prefer to check it in RedCap. And whether to discuss in Rel-17 UE feature or Rel-18, considering the tight schedule for Rel-17, we think at least the features which needs further enhancement should be discussed in Rel-18.

5 – NTT DOCOMO INC.

It would be necessary to clarify what additional specification work is expected for these features from proponents.

6 – Lenovo (Beijing) Ltd

We prefer that the discussion of RedCap with other independent features, if necessary, should Not be in RedCap WI. It is also noted that RedCap capabilities are expected to be discussed in Rel.17 and which features a Rel.17 RedCap UE might support will be determined. The Rel.18 discussions in this area might be dependent on Rel.17 determinations.

7 – RadiSys

We think analysis need to be taken up in R18 for RedCap UE in Unlicensed band and broadcast feature.

8 – ZTE Corporation

Because current multicast transmission and scheduling in NR does not consider the bandwidth limitation of RedCap, the RedCap UEs may be unable to receive the PDCCH/PDSCH with larger bandwidth, if the RedCap UE reuse the NR Rel-17 multicast scheme. Therefore, RedCap specific configuration for multicast and RedCap specific multicast service identification should be specified in Rel-18.

Additionally, it seems impossible to specify related aspects for RedCap UE in Rel-17 due to the limited TUs left.

9 – China Mobile Com. Corporation

Power saving, coverage enhancement features have been discussed as necessary for RedCap in R17. And RedCap positioning comes from application requirement is discussed in RAN93e-R18Prep-10. For other features support, the involved spec work besides R17 feature discussion needs clarification.

10 – MediaTek Inc.

In general, we support the use of RedCap with other independent features developed for NR such as broadcast, sidelink, NR-U, positioning and so on. If these features require minor updates to ensure compatibility with RedCap, we support investigating these further.

11 – Huawei Tech.(UK) Co.. Ltd We think in general other independent features could be handled as UE features for RedCap. Potential RedCap specific issues might need to be discussed in RedCap e.g. coexistence, limitation due to low UE capability etc.
12 – Philips International B.V. We think that supporting Sidelink relay can further reduce the energy consumption as well as increasing the reliability of the communications for those RedCap devices under poor coverage
13 – Samsung Electronics Polska We suppose in general, features specified in Rel-16/Rel-17 can be optionally supported by RedCap as well. If some necessary changes are identified for some feature, e.g., MBS, we are open to have an SI phase to discuss the necessary change for such feature. However, justification should be discussed firstly.
14 – VODAFONE Group Plc Broadcast and sidelink don't seem to be of interest to us for RedCap. Positioning for indoor use cases is useful (as in outdoor the RedCap UE may use GNSS capabilities). We assume that this is in the positioning topic
15 – Ericsson LM For any other feature to be combined with RedCap, then the combination should be supported also for Rel-17 RedCap UEs
16 – Nokia France To us, this bullet and its justification are unclear, and we suggest to delete it.

3.5 Others

Feedback Form 9: Others comments

1 – Spreadtrum Communications For coverage recovery, we share with several companies' opinion that this issue should be considered in Rel.18.
2 – Huawei Tech.(UK) Co.. Ltd As commented in initial round, we think a separate bullet should be added to proposed way forward as a placeholder: Rel-17 leftovers, if any
3 – Nokia France We do not see the value of mentioning unknown leftovers.

3.6 Moderator Summary of the Intermediate Round and recommendation for further discussion

The comments of the Intermediate Round mainly circled around the following aspects:

- It was commented that the potential study on WUS/WUR should be further clarified, especially regarding procedural aspects, requirements and potential technical objectives. Hence, I added a few clarifying notes. And in order to have a more technical discussion in the Final Round, I took Sony's proposals as baseline. (It was the only one.)
- It was commented that eDRX should only be a Rel-18 objective if not completed in Rel-17
- It was commented that RRM relaxations have been discussed and introduced in R17.
- Energy harvesting was discussed. It was commented that, in the context of collecting energy from a radio transmission and redirecting it (like RFID or passive IOT), it does belong to a separate thread. Others actually proposed protocol enhancements for resilience against signalling exchange interruptions when the UE runs out of harvested energy from the environment, e.g. solar power, motion energy, heat, etc.
- It was commented that the potential study on 5MHz UE bandwidth should be further clarified, especially regarding potential network impact, coexistence, and the alternative solution of UE data rate reduction.
- It was commented that coverage should be considered when discussing lower UE power classes
- It was commented that HARQ processes and UE processing times have been discussed in Rel-17 and that such discussions should not be repeated.
- The relation to other independent items was of interest but no concrete gap could be identified.

Based on the above, I adapted the RedCap description as below. So let's discuss it further during the Final Round:

RedCap evolution

- **Main goal: further embrace new use cases, especially requiring low-cost devices and low energy consumption**
- **Study low-power wake-up receiver / wake-up signal (WUR/WUS)**
  - ***Editorial notes:***
    - ***TBD whether the study is part of RedCap or of a separate SI***
    - ***TBD in which email thread the discussions should continue***
  - ***Technical notes:***
    - ***Solutions should be applicable to RedCap UEs and also to NR UEs in general***
    - ***Solutions should give justifiable gains compared to the Rel-16/17 UE power saving enhancements***
    - ***Consider potential impact on other UE's power consumption***
  - **Objectives**:
    - **Study and evaluate low-power wake-up receiver architectures and design trade-offs**
    - **Study and evaluate wake-up signal designs**
    - **Study and evaluate mobility aspects**
    - **Study and evaluate procedures to adjust/adapt/extend the current protocol to support**
- **Power saving/energy efficiency enhancements**
  - **Enhanced DRX in RRC_INACTIVE (>10.24s) (*if not completed in R17*)**
  - **Protocol enhancements to support operation on intermittently available energy harvested from the environment**
- **Complexity reduction**
  - **Study further reduced UE bandwidth of 5MHz, especially considering**
    - **expected UE savings**
    - **network impact, especially the compatibility with Rel-17 and coexistence of RedCap and non-RedCap UEs**
    - **alternative solutions of reducing the UE peak data rates**
  - **Support for lower UE power class**
    - **Considering NW impact, e.g. on coverage**

4 Final Round

Please provide your comments of the Final Round in the below feedback forms. Deadline is Thu. 12:00h UTC.

4.1 Study low-power wake-up receiver / wake-up signal

Feedback Form 10: Comments on the Study low-power wake-up receiver / wake-up signal

1 – Everactive

2 – Sierra Wireless

Support the study and currently outlined objectives in principle.

Some more specificity WRT to what should (at least) be evaluated (e.g. KPIs) would be useful (e.g. power, cost, specification impact).

Since a WUR is an implementation of a low power receiver, the WUR will of course never get specified thus we should be careful when studying architectures and try to de-scope it if possible:

Study and evaluate low-power wake-up receiver architectures ~~and design trade-offs~~

We feel the focus of the study should on these bullets (with suggested changes)

Study and evaluate wake-up signal designs to support wake-up receivers

Study and evaluate protocol changes to support wake-up receivers ~~procedures to adjust/adapt/extend the current protocol to support~~

3 – Futurewei Technologies

We can agree to study WUR/WUS. Since this solution may be applicable to more than just RedCap UEs, we recommend having a dedicated email discussion on WUR/WUS going forward. (i.e., not in RedCap [RAN93e-R18Prep-07] nor in Additional set 1 [RAN93e-R18Prep-14]).

The notes and objectives should just be seen as a moderator's suggested starting point for discussion. Note that in the last bullet, the rest of sentence is missing after "...to support".

4 – Verizon UK Ltd

Support study WUR/WUS. It is important that the solution is applicable to NR UE in general. In addiion to 1) benefiting general public; 2) just look at the RedCap situation as of today, the "saving" techniques need a bigger ecosytem to really save - delta^2 is too small for fast adoption of these "saving" techniques.

5 – Apple Poland Sp. z.o.o.

Apple

We support to study low-power WUR/WUS in general and the starting point should target for all types of devices and not limited to Redcap only.

Regarding 'Technical note', we think Redcap devices should be targeted for, same as other types of devices. On the other hand, it seems premature to put conditions that 'solution should be applicable to Redcap UEs' as it should be part of study, pros/cons analysis and evaluation.

6 – QUALCOMM JAPAN LLC.

We support the study of LP WUR/WUS in R18 for eRedCap devices. Instead of going directly to the normative spec work, a study phase is required to identify the use cases, performance, complexity and compatibility with other UE power saving solutions specified in NR R16/17.

7 – vivo Communication Technology

A a new technical area, study of ULP WUR/WUS should target general use cases as much as possible. It is not proper to only address the demand of IOT use case while ignoring the general requirement of UE power saving from all the device vendors.

There are many differences among different use cases/device types, including traffic characteritics, power model, etc. Therefore, the study should be carried out by a standalone SI so that the benefit/feasibility for different use cases can be fully investigated.

8 – Intel Corporation (UK) Ltd

We are mostly fine with the characterization and support the idea of studying low-power WUR/WUS, except that we do not know yet whether solutions for low-power WUR/WUS should automatically apply to RedCap and non-RedCap UEs.

We are fine to investigate into the applicability as part of the WG studies and in this regard, include both RedCap and non-RedCap UEs, but not commit to applicability of same solutions to RedCap and non-RedCap UEs. Thus, we would suggest revising the bullet as:

Technical notes:

~~Solutions should be applicable to~~ Applicability of solutions to both RedCap ~~UEs~~ and ~~also to NR~~ non-RedCap UEs ~~in general~~ to be evaluated as part of the study

In addition, we would like to note that it would be necessary to consolidate/resolve (as applicable) the parallel discussions/decisions on this topic here and in *[RAN93e-R18Prep-15]*.

9 – TELECOM ITALIA S.p.A.

Concerns with the current overall proposal: the activity is a Study with uncertain outcome ; most of the topics fall under other discussion (e.g. UE power enhancements).

We reiterate the fact that there seems no need to open a dedicated Study Item in Rel 18

10 – Guangdong OPPO Mobile Telecom.

We can study the WUS and the related WUS for even lower power consumption. Not sure why the new WUS and receiver has to consider impact on other UE's power consumption. Would be good to have more elaboration.

11 – ZTE Corporation

LP wake-up receiver is a generic tech used for different kinds of UEs. SI stage is needed to evaluate complexity/cost, the performance, and spec impacts.

12 – Spreadtrum Communications

We are fine with the objectives listed by moderator. In order to avoid duplicate discussion on this feature, we should decide whether to discuss it in RedCap item or separate item as early as possible.

13 – Nokia France

We agree with the moderator's proposal that if RAN does decide to include this item as part of Rel-18, it should start with a study. The objectives should additionally include the following:

- Assess the potential benefits of WUR/WUS, and suitable use cases (e.g. over how much of the cell area it is useful)
- Assess the potential impact of WUR/WUS on network power consumption

14 – NTT DOCOMO INC.

We support moderator proposal.

15 – LG Electronics Inc.

We agree with the Moderators view summarized under technical notes.

In addition, we would like to add "consider coexistence with Rel-17 RedCap and non-RedCap UEs (e.g., efficient multiplexing with existing NR channels and signals)".

In our opinion, the low-power wake-up receiver should be discussed in a separate SI. We have designed the RedCap in Rel-17 under the framework of NR UEs. Thus, we see no risk of studying the low-power wake-up signal and the corresponding receiver targeted for both RedCap and non-RedCap UEs.

Regarding the objectives, what it means by the "design trade-offs" is not clear as it is. Without further clarification, we recommend to remove it.

We also would like to clarify that the scope of the wake-up signal is not intended for the enhancements on the Rel-17 PEI.

16 – Lenovo (Beijing) Ltd

From this tech note "Solutions should be applicable to RedCap UEs and also to NR UEs in general", it seems not appropriate to have WUR/WUS in Rel.18 RedCap WI. It might better to put it in UE power saving, if UE power saving is in Rel.18 scope. On the other hand, we are open if WUR/WUS is designed for all type of UEs, or just for some certain UEs with e.g., the need of ultra-low power consumption.

17 – CATT

We support to study low-power WUR/WUS in Rel-18 and we can further discuss whether it is included in RedCap or a separate SI. However, 3GPP will not specify a 'wake-up receiver' anyway. We suggest focusing on 'evaluating the power reduction' brought by WUS/WUR, and avoid involving architecture discussions in the scope.

18 – RadiSys

We support study of WUR and WUS in Rel18. We prefer it as a seperate SI applicable to all devices and not just RedCap.

19 – InterDigital Communications

We support the proposal and think we should start with a study item. Whether it should be treated in a separate SI or under RedCap should be decided soon.

20 – Samsung Electronics Polska

There is a parallel discussion in email thread [RAN93e-R18Prep-14] on LP-WUR. We'd like to clarify what is the relationship with the discussion there. We prefer a separate SI for LP WUR, considering it has never been evaluated in 3GPP. For LP WUR, we'd like to clarify if it's for paging, similar as sequence based WUS for eMTC/NB-IoT. We are generally open to sequence based WUS for paging. But similar issue is under discussion in Rel-17 PS AI on paging enhancements, and RAN1 failed to do down-selection

between PDCCH based signaling and SSS-based singling in RAN1#106-e. So, we'd like to wait for the outcome of Rel-17 design if there is overlapping on the functionality between Rel-17 PEI and LP WUS.

For this low power wake-up receiver, we concern about the tradeoff between power saving gain and coverage loss. In order to achieve such low power consumption, some of component such as PA needs to be removed and it will result in coverage loss. Therefore, we'd like to also add one objectives on the top, as:

 Evaluation methodology, including new power models, for evaluating power saving gain and coverage loss

21 – Panasonic Corporation

Wake up signal would be one of the possibilities but the power consumption in poor SINR is more dominant by the measurements/mobility. Therefore, we don't want to limit the target is only wake up signal before the study conclusion of ultra-low power UE receiver. Our preference is to have separate study item not limited to RedCap UEs.

22 – Philips International B.V.

We agree with the moderator that a SI is needed on this topic. We also agree with Intel in that one of the objectives of the SI can be to identify the applicability of low-power WUR/WUS, instead of discussing now (too early) whether it is applicable to just RedCap or also non-RedCap UEs.

We agree again with Intel that some consolidation is needed with eRedCap (RAN93e-R18Prep-07).

23 – Ericsson LM

Regarding low-power WUR/WUS, we would like to see a strong emphasis on RedCap use cases. In particular, the solution should enable an ultra-low power consumption WUR that enables devices to operate on harvested ambient energy, e.g., vibrational energy, photovoltaic energy, thermal-electric generated energy, etc. If the WUR/WUS discussion is moved to another thread, our concern is that the work might not focus on RedCap use cases, and as a result, the solution might not be good enough for RedCap use cases. Our view is that it is the best to keep WUR/WUS in RedCap and make sure the solutions are suitable for RedCap use cases, e.g., for enabling devices to operate on harvested ambient energy. We believe if the solutions are good enough for RedCap use cases, they can also be considered for non-RedCap use cases.

We suggest revising the 1st bullet under "Technical notes" as

- Solutions should enable ultra-low power consumption WUR required by RedCap use cases that benefit from allowing devices to possibly operate on harvested energy. The specified solutions shall be applicable also to NR UEs in general.

24 – VODAFONE Group Plc

The impact on the design of WUS/WUR should be evaluated for all UEs as it may impact the battery lifetime of other devices. Some clarification on the difference between the Rel-17 PEI and its overlapping functionalities need to be considered

25 – MediaTek Inc.

We support a Rel-18 study as proposed by the rapporteur. This study should take the existing Rel-16/17 power saving solutions into account, and should be applicable to all UE types (not just RedCap).

26 – China Mobile Com. Corporation

We are generally fine to study low-power wake-up receiver / wake-up signal, and agree with above comments that the study may include applicability to different UE types.

And the objects should also include potential impact on network, for example, network power consumption, as Nokia comments, and coverage impact, since the low-power wake-up receiver may work on reduced sensitivity.

Objectives:

- Study and evaluate low-power wake-up receiver architectures and design trade-offs
- Study and evaluate wake-up signal designs
- Study and evaluate mobility aspects
- Study and evaluate procedures to adjust/adapt/extend the current protocol to support
- **Study on potential network impact, e.g. network power consumption, coverage.**

27 – Huawei Tech.(UK) Co.. Ltd

If this is part of RedCap SI/WI, the moderator's proposal may be OK in general except the followings:

- For the "technical notes": the first bullet may have a problem to RedCap UEs, since RedCap has different use cases and lower capabilities than NR normal UEs. Thus we suggest to focus on the usage of RedCap. There should also be one more bullet added to consider potential impacts, as it is important to consider the network side, coexistence with existing transmission, and system performance.
- For objectives, we suggest to add one objective to reflect the above.

○ Technical notes:

 Solutions should be applicable to RedCap UEs whatever where the study take place ~~**and also to NR UEs in general**~~

 Solutions should give justifiable gains compared to the Rel-16/17 UE power saving enhancements

 Consider potential impact on other UE's power consumption

Consider potential impacts on the network, coexistence with existing transmission and system performance

○ Objectives:

 Study and evaluate low-power wake-up receiver architectures and design trade-offs

 Study and evaluate wake-up signal designs

 Study and evaluate mobility aspects

 Study and evaluate procedures to adjust/adapt/extend the current protocol to support

 Study and evaluate potential impacts on the network, coexistence with existing transmission and system performance

28 – Fraunhofer IIS

Rel18 study for WUS/WUR should prioritize IoT use cases and can be expanded for further use cases at a second stage. The study should focus on IoT KPIs, battery lifetime, ultra-low-complexity and ultra-low-power receivers.

29 – ROBERT BOSCH GmbH

We support the moderator proposal. However, we anted to add: ” study the impact on sidelink operation with eRedCap”.

30 – Sony Europe B.V.

Study low-power wake-up receiver / wake-up signal (WUR/WUS)

There are two on-going threads of discussion, here and in Prep14/UE power saving. These two threads should be merged. Note that in the last bullet in WUS objectives is unfinished, the rest of the sentence after ”...to support” is missing.

4.2 Power saving/energy efficiency enhancements

Feedback Form 11: Comments on Power saving/energy efficiency enhancements

1 – Everactive

2 – Sierra Wireless

Support e-DRX enhancement objective.

WRT energy harvesting device:

This objective is too vague to even be considered for a study. The only specificity I see so far would be something like:

- Study protocol changes design to support devices with very short battery life (e.g. seconds)

3 – Futurewei Technologies

We are ok with energy harvesting. We think protocol enhancements for energy harvesting are necessary regardless of whether the UE is a RedCap UE.

4 – Apple Poland Sp. z.o.o.

Apple

We still think more clarification is needed for ’energy harvesting’ to make the use case or the potential scope more clear, which is helpful to determine whether it should be part of Rel-18 Redcap enhancement or part of other WIs or even a study item.

We support enhanced DRX if it would not be part of Rel-17.

5 – QUALCOMM JAPAN LLC.

Before discussing the protocol enhancement for energy harvesting, a study phase is needed to identify the use cases that can benefit from energy harvesting. Without a concrete model for energy harvesting, it is unclear to us how to analyze/quantify its impacts on UE and network, let alone which protocols need to be ”enhanced” for R18 eRedCap UE.

Compared to energy harvesting, the following techniques can bring more substantial gains to UE power saving with less spec impacts, less implementation complexity and reduced cost:

- Reduced number of HARQ processes
- Relaxed UE processing time
- Type-B HD-FDD

Therefore, the objectives of power saving/energy efficiency enhancements for R18 eRedCap devices should include/prioritize the following techniques:

- eDRX enhancement
- SDT enhancement
- relaxed UE processing time (N1, N2, Z, Z')
- reduced max number of HARQ processes
- Type-B HD-FDD

6 – vivo Communication Technology

RRM relaxation

Regarding the moderator's statement "It was commented that RRM relaxations have been discussed and introduced in R17.", it is true that RRM relaxation was specifeid in Rel-16/17. However, the serving cell RRM relaxation is still missing. For stationary redcap devices performing only intra-frequency measurement, the measurment power cannot be really saved if only neigbor cell RRM measurement is relaxed but not the serving cell. eDRX can achieve the effect of serving cell RRM relaxation but it is not applicable to some latency senstive services. Therefore normal DRX with serving cell RRM relaxaitoni is a good technique to reduce the UE power in IDLE/INACTIVE state. Serving cell RRM relaxation has been specified in LTE, if not supported in NR, we doubt if NR redcap can be competitive from power consumption perspective compared to LTE UE.

7 – vivo Communication Technology

And we also agree with Qualcomm that following features are beneficial from both compexity and power perspective, thus should be kept on the table for further discussion.

- Reduced number of HARQ processes
- Relaxed UE processing time (for CSI and data)
- SDT enhancement

8 – Intel Corporation (UK) Ltd

We still cannot accept the bullet on energy harvesting.

The use-case and practical feasibility for supporting cellular devices, supporting wide BWs (e.g., 20 MHz that we have today) and peak rates of 50+ Mbps, running on harvested energy, remains to be established. We are not convinced that just adjustments to protocol layers to allow for frequent interruptions to the link between gNB and UE is sufficient for practical support of devices running on harvested energy.

Towards this, a detailed study, starting from identification of technical requirements and feasibility of means to achieve them, would be necessary.

Also, perhaps the bullet on lower UE power class should be moved back to under power saving/energy efficiency enhancements?

9 – TELECOM ITALIA S.p.A.

Concerns with the current overall proposal: the activity is a Study with uncertain outcome ; most of the topics fall under other discussion (e.g. UE power enhancements).

We reiterate the fact that there seems no need to open a dedicated Study Item in Rel 18

10 – Guangdong OPPO Mobile Telecom.

The clarification of the energy harvesting here is needed. But the Power Harvesting has limited meaning. E.g. we are not defining how RedCap UE can harvest the power from environment. How to get the energy should be out of the 3GPP study. It seems the bullet may give different message that we going to study the power harvesting scheme. We would instead to state:"Protocol nhancements to support operation with energy availible intermittently from the environment. The time interval and scale of energe avaibility is to be defined in evalution"

We are also fine for way of description by sirrawireless

11 – ZTE Corporation

The justification of further eDRX in Rel-18 is not clear. For example, why should we introduce Enhanced DRX in RRC_INACTIVE (>10.24s) in Rel-18, if not introduced in Rel-17 and what is the new use case here.

Also, the specification work for supporting operation on intermittently available energy harvested from the environment is not clear. We need more discussion.

12 – Spreadtrum Communications

We also noticed that harvested energy is under discussion in passive IOT, similar views with the previous one, in order to avoid duplicate discussion on this feature, we should decide whether to discuss it in RedCap item or other item as early as possible.

In addition, we propose to add serving cell RRM relaxation to power saving enhancement, as RRM relaxation on serving cell have been introduced in LTE for NB-IoT/MTC, especially for stationary use case. We think RedCap UEs have similar use case. Meanwhile, it has been evaluated during study item for Rel-17 RedCap. Power saving gain with less system impact could be achieved at least for stationary scenario. We think we could further consider it in Rel-18 eRedCap.

13 – Nokia France

The eDRX bullet is OK.

Regarding the energy harvesting bullet, we fully agree with the comment from Sierra Wireless. Certainly it should not be more than a study at first, and the specific characteristics of energy harvesting that the study is supposed to look into would need to be clarified.

14 – Nokia France

Given the strong support from many companies for 5MHz BW, we do not see why this should be only a study. At least, it should be "study and specify...".

Many companies have also supported reduced number of HARQ processes and relaxed UE processing time. The fact that these were not included in Rel-17 does not mean they should not be adopted in Rel-18. We support to include them.

15 – Nokia France

(sorry, the above comment should be in the next section, my sincere apologies for the error)

16 – NTT DOCOMO INC.

We support moderator proposal.

17 – LG Electronics Inc.

We are okay with the first bullet.

But for the second bullet, the energy harvesting should be discussed in a separate SI preferably together with the low power wake-up radio. The related protocol enhancements can be discussed later once there is a progress during the study.

18 – Lenovo (Beijing) Ltd

Our understanding is that it is more suitable to put low UE power class under power saving, than under complexity reduction.

It is not clear for "Protocol enhancements to support operation on intermittently available energy harvested from the environment", there should be at least some examples on what the potential protocol enhancements are expected.

We are in general open to study other power saving techniques if there are noticeable gains and not covered in Rel.17.

19 – CATT

For protocol enhancements to support operation on intermittently available energy harvested from the environment, first of all, we cannot directly specify the protocol support. There should be a study item or a study phase if agreed. In addition, the current scope is not clear what exactly to be studied and further discussion is needed.

20 – RadiSys

We think green energy harvesting is device specific and might not have specification impacts. We support 5MHz BW, eDRX enhancement, reduced L3 and L2 capabilities and SDT enhancements for Power/energy saving.

21 – Samsung Electronics Polska

For energy harvesting, this is premature for WI or even a SI phase. We don't have clear view on the basic requirements, assumptions of energy harvesting, as well as the impact to the network.
We should focus the discussion on the enhancement for RedCap UE, other than extending the discussion too broad to other topics. The energy harvesting should be discussed separately.

22 – InterDigital Communications

We also agree to various other companies that energy harvesting should first start with a study phase and the objective should be more clear.

23 – Ericsson LM

We support both Enhanced DRX in RRC_INACTIVE (>10.24s) (if not completed in R17) and protocol enhancements to support operation on intermittently available energy harvested from the environment.

Regarding the protocol enhancements to support operation on intermittently available energy harvested from the environment, we support to have a study phase to identify relevant use cases and protocol aspects which need enhancements. It should also be clarified that how the devices harvest and store energy is outside the scope of 3GPP. That is, this is mainly about enhancing the communication protocol to make it possible for devices operating on intermittently available energy harvested from the environment to connect to 3GPP network.

24 – VODAFONE Group Plc

eDRX enhancements should be included in Rel-18 if not completed in Rel-17. Other enhancements such as duplex operation with HD-FDD type B (with the same reasoning employed in type A to reutilize most of Rel-15/16 collision handling), reduced number of HARQ processes and processing time can be further evaluated too. Energy harvesting should be a separate study.

25 – MediaTek Inc.

Agree on the need for **eDRX extension beyond 10.24s in Inactive state** in case it not completed in Rel-17. This would be especially **useful for RedCap UEs when combined with SDT in Inactive state**, given that RedCap traffic is largely expected to be small and intermittent.

The justification for energy harvesting in the context of RedCap (i.e. a mid-tier device) is not clear. If it is alternatively meant to be for Passive IoT type devices, this discussion should take place in the *RAN93e-R18Prep-15* thread. Regardless of where this discussion takes place, the topic needs further clarification which would warrant a study before we start any work on this topic.

26 – China Mobile Com. Corporation

We are open for power saving/energy efficiency enhancements. The energy harvesting needs to be started with a study item, since it is not clear of spec aspects.

27 – Huawei Tech.(UK) Co.. Ltd

eDRX is already in current Rel-17 scope, some companies also propose other aspects which under R17 discussion as well, thus we prefer to look at all Rel-17 leftovers together later.

We share similar view with other companies that harvested energy shall be discussed in other IoT enhancements thread and further we believe it is related to passive IoT.

In short, there is no need to have objectives here, instead can add one top-level bullet (at same level as lp-WUR/WUS and complexity reduction) to reflect Rel-17 leftovers as a place holder:

~~**Power saving/energy efficiency enhancements**~~

~~**Enhanced DRX in RRC_INACTIVE (>10.24s) (if not completed in R17)**~~

~~**Protocol enhancements to support operation on intermittently available energy harvested from the environment**~~

Rel-17 leftovers, if any

28 – Fraunhofer IIS

Fraunhofer
We see a need to further define the use case and requirements for a Passive IoT study and are unclear about the feasibility at this point in time. We agree with Everactive to focus on improvements for active energy harvesting devices regarding protocol and signaling optimizations and would like to express our support for this topic.

29 – Sony Europe B.V.

Power saving/energy efficiency enhancements

We are supportive of protocol enhancements for UEs operating on intermittently available energy harvested from the environment

4.3 Complexity reduction

Feedback Form 12: Comments on Complexity reduction

1 – Everactive

2 – Sierra Wireless

5MHz bandwidth:

Why do we need to re-study UE savings for this. What has changed since Rel17?

I don't think reduction of UE peak rates should be under the 5MHz study. This bullet should be promoted.

Lower Power class:

We do not support this objective if it includes any coverage enhancement studies or normative work. We are still working on this for rel 17 so I don't see how anything is different from Rel 17. If the normative changes are limited to RAN4 specifications, this would be acceptable. However, given the UL coverage issues caused by low power UEs and the lack of commercial success, we do not strongly support this objective in any form.

3 – Futurewei Technologies

For complexity reduction study, we are ok to discuss further but still hesitant. For the expected UE savings, we should reuse the RedCap SI methodology as a starting point. As part of the study, we should also include the impact to devices in addition to the network.

4 – Verizon UK Ltd

5MHz BW:

We are ok with a study as the moderator proposed but want to reiterate, when the ecosystem is small, further fragmentation to cost down part of the system, usually results in higher overall cost and further delay the takeoff of the ecosystem. Past lessons have shown, cost/saving deeply depends on volume, probably more than many other factors.

5 – Xiaomi Communications

We are open to discuss the 5MHz. The study of the UE saving can be carried out based on the R17 evaluation methodology. If there is a pre-study phase, we should keep it short.

6 – QUALCOMM JAPAN LLC.

The low-tier devices are more sensitive to cost/complexity reduction, and the NR R15/16 eMBB UE is no longer an appropriate baseline for R18 eRedCap UE. The conclusions made for R17 RedCap UE not necessarily hold for R18 eRedCap UE, whose max BW is 1/20 of the reference UE adopted by R17 RedCap SI.

In general, we prefer moderator's proposals in Section 2.5.5. Similar to lower UE power class, "reduced number of HARQ processes" and "relaxed UE processing time" **are synergic to power saving of eRedCap devices**, which have gained majority support in the first and intermediate rounds and should be kept for further discussion.

Therefore, we propose to study the following complexity reduction techniques for R18 eRedCap UE:

- further UE BW reduction down to 5 MHz in both RF and BB
- reduced max number of HARQ processes (starting with 8)
- relaxed UE processing timeline
- Type-B HD-FDD
- lower UE power class (starting with PC5)

7 – vivo Communication Technology

From TR38.875 study, it was observed that 5 6% cost saving by relaxed UE processing time (double N1/N2) compared to Rel-15 reference UE. Such cost saving gain is expected to be added on top of further BW reduction, if supported in Rel-18. And since the refernce UE is now the Rel-17 RedCap with 20MHz and 1Rx, the relative gain over Rel-17 RedCap is expected to be larger compared to the number in TR38.875.

Furthermore, more cost saving can be achieved if CSI processing timeline is relaxed in addition to N1/N2.

And we agree with serveral companies that reduced number of HARQ processes can also reduce the UE cost.

Type B HD-FDD is also worthwhile investigation for very low cost devices.

Therefore, we agree with QC to include the following objectives

- further UE BW reduction down to 5 MHz in both RF and BB
- reduced max number of HARQ processes (starting with 8)
- relaxed UE processing timeline
- Type-B HD-FDD
- lower UE power class (starting with PC5)

8 – Intel Corporation (UK) Ltd

We still think we can go with objective for normative work on 5MHz support. We can define the objective for normative spec work to introduce 5 MHz UEs (as commented by others, the feasibility at least for certain configurations is clear), while exact means to ensure coexistence with other UEs can be studied further as part of the WI objective. Also, the cost/complexity reduction features discussed in previous rounds should

be considered for meaningful overall cost/complexity reduction. As commented in the first round, for such lower-end devices, a 20 20% reduction compared to Rel-17 RedCap can be a significant impact (we agree with Qualcomm that the reference should not be Rel-15/16 eMBB UE).

Thus, we would propose the following updated objectives:

- **Further reduced UE bandwidth of 5 MHz**
  - **Study and specify means to support further reduced max UE BW of 5 MHz with minimal impact to network.**
  - **Further complexity reduction schemes for UEs with 5 MHz BW:**
    - **Reduced peak data rates**
    - **Relaxed UE processing times**
    - **Reduced number of HARQ processes**

In addition to the above, we are open to consideration of Type B HD-FDD for 5 MHz UEs.

Support of lower UE power class should perhaps be moved back to under "Power saving/energy efficiency enhancements" as the primary benefit is in terms of power savings over complexity reduction, even when considering support of integrated PA implementations.

9 – TELECOM ITALIA S.p.A.

Concerns with the current overall proposal: the activity is a Study with uncertain outcome ; most of the topics fall under other discussion (e.g. UE power enhancements).

We reiterate the fact that there seems no need to open a dedicated Study Item in Rel 18

10 – Guangdong OPPO Mobile Telecom.

The 5MHz BW apparantly have signficiant compelxity reduction could be more than 20%. The UE vendor have good reason to support that. Thus we also suggest to support 5MHz, and just study how to support it. This should reflect most of companies' views.

We do not support to have the coverage recovery for the lower power class case. Note, the coverage recovery is not specified in Rel-17. Study coverage gain is not needed.

11 – ZTE Corporation

We are generally fine with the complexity reduction related description. For the lower UE power class, we are OK to consider that for RedCap. However, it is not hoped that the coverage enhancement for lower power class UE is also considered in Rel-18.

12 – Spreadtrum Communications

For 4.3 complexity reduction, firstly it should be **cost**/complexity reduction to correctly reflect the discussion.

Secondly we want to echo Ericsson observation on "*can support use cases with low data rate requirements in a backward-compatible manner.*" "*one possibility of reducing UE peak data rate is already being considered in Rel-17, i.e., to limit UE's supported maximum data rate by lowering the scalingFactor value range, or a relaxation of a constraint on the product of the number of MIMO layers, modulation order, and scaling factor (vQf >= 4 condition).*". In addition, based on our observation, in Rel-17, if adopting the mechanism (*lowering the scalingFactor value range, or a relaxation of a constraint*), the simplest way is to consider potential

Rel-18 use cases in an Forward Compatibility way in Rel-17. In Rel-18, this mechanism will be naturally supported in an Backward Compatibility way.

Lastly, we made some revision on the moderator's proposal based on the current situation:

- Cost/Complexity reduction

o Study further reduced UE bandwidth of 5MHz, **together or comparing with Rel.17 solutions of reducing the UE peak data rates,** especially considering

- expected UE savings
- network impact, especially the compatibility with Rel-17 and coexistence of RedCap and non-RedCap UEs
- ~~alternative solutions of reducing the UE peak data rates~~

o Support for lower UE power class **(comment: suggest to move this bullet to " Power saving/energy efficiency enhancements ")**

- Considering NW impact, e.g. on coverage

13 – Nokia France

Given the strong support from many companies for 5MHz BW, we do not see why this should be only a study. At the very least, it should be "study and specify...".

Many companies have also supported reduced number of HARQ processes and relaxed UE processing time. The fact that these were not included in Rel-17 does not mean they should not be adopted in Rel-18. We support to include them.

14 – NTT DOCOMO INC.

- Regarding the compatibility with Rel-17 for further reduced UE bandwidth of 5MHz, as commented in the intermediate round, we don't think it is necessary for "reduced cost/complexity" devices from previous releases. Again, even for Rel-17 RedCap UEs, they are not backward compatible with 100 MHz BW mandatory for non-RedCap UEs as Rel-17 RedCap UE-specific initial access procedure is being specified in RAN1. According to Rel-17 RedCap WID, SSB has to be reused but others do not (it only says "L1 changes minimized"). We agree with moderator proposal that coexistence with both non-RedCap UEs and Rel-17 RedCap UEs should be ensured, but it is not equivalent to ensuring compatibility with Rel-17. It is fair to say "Rel-15 SSB bandwidth is reused and L1 changes minimized" as Rel-17 RedCap WID.
- Regarding other complexity reduction techniques such as reduced number of HARQ processes and relaxed UE processing times, they were not adopted to Rel-17 RedCap UEs because of "relatively" smaller cost reduction gain compared to other adopted complexity reduction techniques, and Rel-17 RedCap does not target low-end use cases. For Rel-18, as recommended in the moderator proposal, the main goal is to further embrace new use cases, especially requiring low-cost devices (and low energy consumption). In that sense, any complexity reduction techniques which are beneficial for low-end use cases should be supported as long as the cost reduction gain is justified with reasonable NW impact. Therefore, we think at least they should be kept for further discussion.

15 – LG Electronics Inc.

We are generally okay with Moderator's description on the complexity reduction.

For details, we think the expected UE savings are intended mainly for cost/complexity, so adding "in terms of cost/complexity" at the end would be recommended for clarification.

We also think the compatibility and coexistence should be emphasized not only for complexity reduction but also for all other topics. So, we recommend to elevate the bullet accordingly.

We are not supportive of the lower UE power class if it opens up the needs for UL coverage enhancement again in Rel-18 RedCap.

16 – Lenovo (Beijing) Ltd

We are supportive of 5MHz RedCap UE BW. We don't think the sub-bullet "alternative solutions of reducing the UE peak data rates" is necessary here. The reduced peak data rate not from reduced UE BW might depend on Rel.17 outcome. It could be FFS.

17 – CATT

Although we do not think support 5MHz maximum UE bandwidth is justified, we can live with a study in Rel-18 on further reduced maximum UE bandwidth of 5MHz. We share the similar view with Sierre Wireless that the bullet of reduction of UE peak data rate should be promoted if agreed.

For lower UE power class, it should be applied to UEs when the coverage is not an issue with lower UE power class. It should not impact the current network deployment and no coverage enhancement should be involved.

18 – RadiSys

We support 5MHz BW for RedCap UE. Also we prefer 5MHz BW solution to be backward compatible.

19 – Samsung Electronics Polska

We don't see clear use cases comparing with Rel-17 RedCap for this low bit rate support. We spent a lot of time to study and conclude the BW for FR 1 for RedCap UE is 20MHz, without opening to other bandwidth, to avoid fragmentation of the market. We don't see the point to re-open the study on the bandwidth for RedCap UE will lead to a different outcome. Again, we don't see the need to study 5MHz BW for eRedCap.

20 – InterDigital Communications

We are generally ok with the proposal.

21 – Ericsson LM

We support having a study phase where a tradeoff between expected cost/complexity reduction, specification impacts, and network impacts especially the compatibility with Rel-17 and coexistence of RedCap and non-RedCap UEs are considered. The study should also include possible BW reduction options such as both RF and BB BW or only BB BW for data channels where the tradeoffs are analyzed.

Regarding lower UE power class, we support introducing lower UE power class where coverage impact may be considered. The coverage aspect can be taken into account when identifying a suitable level of lower UE transmit power. Existing coverage enhancement techniques in Rel-15/16/17 and even UL-cell edge data

rate reduction can be considered. With this, we do not expect that there is a need for any new coverage enhancement techniques.

22 – VODAFONE Group Plc

If we study 5MHz, then it needs to be clear that the results of the study need to be debated before any decision to specify it is made.

23 – MediaTek Inc.

We support the rapporteur's proposal here on a further study on BW reductions. This study should evaluate the potential UE cost savings, taking all considerations from the past into account (including whether the cost savings are significant enough to overcome the increase in cost due to a loss of economies of scale). It is also good to consider alternative solutions, as suggested by the rapporteur, to reduce UE peak data rate as part of this study.

24 – China Mobile Com. Corporation

We can not agree to study further reduced UE bandwidth of 5MHz/10MHz. As Verizon states, redesigning a new narrow band system to serve low data rate leads to market fragmentation and not always contribute to low cost, but there is no doubt that it will involve large scale network upgrade and large effort for coexistence management. This should be avoided especially when currently RedCap design can already serve such low end services. We can further reduce UE complexity based on backward compatibility.

25 – CEWiT

We agree with the moderator

26 – Huawei Tech.(UK) Co.. Ltd

On UE bandwidth reduction, the first two sub-bullets are OK as a representation of the constraints on the design. However, the insistence on casting this as a study phase without any normative work to make use of the study is not suitable. It seems the best next-step for RAN is to start from the bullets in the latest moderator summary, and to discuss whether/how to have a study phase, how to link it to normative work, or whether we can simply go directly to normative work. This may necessitate further constraints, etc. or a timeline of work.

We don't see much need for the lower UE power class. It is just part of "alternative solutions", which needs more explanation of what techniques are included. The "alternative solutions" are not part of bandwidth reduction by definition of being alternative, so should be their own bullet (or removed, as not providing such large gains as BW reduction).

27 – Telstra Corporation Limited

We support Verizon & China Mobile comments on the impact of introducing reduced BW support. We should aim to minimise fragmentation and maintain market segment differentiation with eMTC as there is already industry confusion in this space

28 – Sony Europe B.V.

As commented by other companies, we do not see a significant motivation for this work. We also do not see what has changed since Rel17 when these complexity reduction techniques were also considered.

4.4 Others

Feedback Form 13: Other comments

1 – Facebook As we mentioned, concurred some companies that there are strong use cases for 40Mhz with minimum spec impact. The feature in critical for the high end wearables and should be addressed by 3GPP. As this marks the first week for official email discussion we would like this to be captured for further discussion.
2 – QUALCOMM JAPAN LLC. We support the study on low-cost and low-power devices, as they would open up opportunities for new use cases beyond those studied in R17 RedCap. Examples of such potential new use cases may include smart city/utility applications, etc. One salient characteristic of those applications is high-density deployment, which can have considerable impacts on procedures such as access control and RACH. We think it is worthwhile to study them in R18, to ensure eRedCap UEs can capture the new market opportunities enabled by their lower cost and lower power consumptions.
3 – vivo Communication Technology There is onging Rel-17 discussion on the BWP offloading for IDLE/INACTIVE and CONNECTED mode RedCap UEs, and it is very controvertial on whether and how to ensure the SSB availabilty in the UE active BWP (either seperate initial BWP or RRC configure BWP). If unfortunately this cannot be concluded in Rel-17, we think further discussion in Rel-18 should also be allowed.
4 – Spreadtrum Communications Since the reduced BW will lead to lower frequency diversity gain, then impact the coverage, therefore, coverage recovery should be also considered in Rel.18.
5 – Lenovo (Beijing) Ltd We prefer to add one bullet for upper layer study, it could be “study upper layer impacts for the potential new use cases”, and add companies’ interested topics (e.g., access control, etc) as examples.
6 – Samsung Electronics Polska Some leftover from Re-17 can be considered to carry on. And some enhancement to better support 20MHz RedCap should have high priority than introducing a new UE type. We think it is important for efficiency/capacity improvement for existing Redcap UE type, e.g., Fast BWP switching, CSI enhancement, Wider BW FH, Traffic offloading for initial access (depends on Rel-17), PDCCH overhead reduction. In addition, coverage recovery was not in the scope of R17 due to TU limitation. However, coverage is quite important. We suggest to include DL coverage recovery in Rl-18 scope as well.

4.5 Moderator summary of the Final Round

The comments of the Final Round mainly touched upon the following aspects:

The applicability of WUS/WUR was discussed. The common desire was that a specified solution should be usable by all types of UEs but not limited to RedCap UEs. It was also clarified that the prime targeted use case

for this study should be RedCap, i.e., low-end IoT use cases. Studies and normative work on low-power receivers targeting eMBB, i.e., smart phone use cases, have been conducted in Rel-16 and Rel-17. Clarification on the relation of the WUS/WUR study to previous work on UE Power Saving was requested. According to the moderators understanding, previous RAN work was based on existing NR signals, whereas this SI is supposed to also look into potentially new signals.

It was commented that the bullet on protocol enhancements for intermittent transmissions requires more clarity and should therefore be studied first.

The reduction of the UE bandwidth down to 5MHz was controversially discussed. The was quite some support but also quite some opposition. As rapporteur, I would continue to propose a study to further discuss pros and cons of the proposal.

Other technical enhancements were re-proposed but also got quite some opposition in earlier rounds, i.e., Reduced number of HARQ processes, Relaxed UE processing time, Type-B HD-FDD, serving cell RRM relaxation, and Rel-17 leftovers.

There was a re-occurring proposal to add a 40MHz RedCap device type, which is clearly controversial.

Based on the above, the RedCap description is adapted as below:

7. RedCap evolution

- **Main goal: further embrace new use cases, especially requiring low-cost devices and low energy consumption**
- **Study low power wake-up receiver / wake-up signal (WUR/WUS)**
  - ***The study should target ultra-low power WUS/WUR required by RedCap use cases. The specified solutions shall not be limited to RedCap UEs only.***
  - ***As opposed to the work on UE power savings in previous releases, this study will not require existing signals to be used as WUS. Solutions should give justifiable gains compared to the existing Rel-16/17 UE power saving enhancements.***
  - **Objectives:**
    - **Study use cases, evaluation methodology & KPIs, and compatibility with other UE power saving solutions**
    - **Study and evaluate low-power wake-up receiver architectures**
    - **Study and evaluate wake-up signal designs to support wake-up receivers**
    - **Study and evaluate protocol changes needed to support wake-up receivers**
    - **Study potential system impact, such as network and other UE's power consumption, coexistence with R17 RedCap and non-RedCap UEs, network coverage**
- **Power saving/energy efficiency enhancements**
  - **Enhanced DRX in RRC_INACTIVE (>10.24s) (*if not completed in R17*)**
  - **Identify use cases and study corresponding protocol enhancements to support operation on intermittently available energy harvested from the environment**
    - **Note that how the devices harvest and store energy is outside the scope of 3GPP**
- **Complexity/cost reduction**

- **Study further reduced UE bandwidth of 5MHz, especially considering**
  - **expected UE complexity/cost reduction based on Rel-17 evaluation methodology**
  - **network impact, compatibility with Rel-17, coexistence of RedCap and non-RedCap UEs, UE impact, specification impact**
  - **other solutions for reducing the UE peak data rates**
- **Support for lower UE power class**
  - **Considering NW impact, e.g. coverage aspects**

Moderator's notes:

- *TBD whether the WUR/WUS study is part of RedCap or of a separate SI*
- *TBD in which email thread the WUR/WUS discussions should continue*