

[RAN94e-R18Prep-11] Enhancements for XR - Version 0.0.6
RAN

3GPP TSG RAN#94e RP-212671

Electronic Meeting, December 06 - 17, 2021

Source: Moderator of XR Enhancements (Nokia)

Title: Moderator's Summary on "[RAN94e-R18Prep-11] Enhancements for XR"

Document for: Information

1 Initial round - now closed.

The previous email discussion identified the following 4 areas of interest to be considered further:

1. KPI and QoS

- 1a. Study and potentially specify RAN support for enhanced granularity for QoS;
- 1b. Study and potentially specify RAN support for ADU-based QoS;
- 1c. Study and potentially specify RAN support for XR-specific QoS parameters;
- 1d. Study and potentially specify synchronization of QoS flow handling belonging to the same XR service association and corresponding DRB control (in coordination with SA2).

2. Application awareness

- 2a. Identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc. that was concluded from KPI and QoS
- 2b. Application layer information (e.g. frame rate, delay, packet importance, etc.) to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc; One potential mechanism for this is to introduce UE assistance information;

3. Power Consumption

- 3a. Potential XR-specific power saving techniques: XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter, XR-specific multi-flow aspects. Enhancements to PDCCH monitoring and WUS can also be considered.

4. Capacity

- 4a. Potential capacity enhancement techniques: XR-specific resource allocation and scheduling enhancement, SPS and CG enhancements including dynamic SPS/CG parameter update, multi-TB SPS/CG, HARQ-ACK enhancement etc... to address XR-specific non-integer periodicity and jitter

Goals of the email discussion

1.1 Further consolidation and finetuning of 1 and 2

Please provide your views how best to further consolidate, finetune and structure objectives in the area of KPI, QoS and Application Awareness. Please provide your views in light of the expectation the RAN work on these aspects will be led by RAN2, and will heavily depend on outcome from SA2 and SA4.

Please also provide your views how best to structure work in terms of study item and work item on these aspects.

Feedback Form 1: KPI, QoS, Application Awareness

1 – TELECOM ITALIA S.p.A.

Application awareness is an important aspect to optimise performance

2 – vivo Mobile Communication Co.

General comment:

Since R17 XR SI mainly focused on evaluation, we suggest enhancements for XR in Rel-18 could be started with a study, and followed by a WI.

For the objectives of KPI and QoS enhancements for XR, we propose to modify the scope as follows:

- 1. Study and specify KPI and QoS enhancements for XR (RAN2, SA2)
 - o 1a. Study and potentially specify RAN support for media units level QoS, e.g., enhanced granularity for QoS, ADU-based QoS, XR-specific QoS parameters.
 - o 1b. Study and potentially specify RAN support for synchronization of intra/inter QoS flows handling belonging to the same XR service association and corresponding DRB control.
 - o Note: coordinate with SA2 is needed.

The reasons for above changes are as follows:

- The enhancement areas for the original sub-bullets 1a, 1b and 1c are similar. So we suggest to group them together as one objective for study. The description of ‘media units level’ is aligned with the terminology in SA.
- For synchronization among multi-flows, both intra and inter QoS flows synchronization can be considered in sub-bullet 1d.
- All the sub-bullets for KPI and QoS enhancements need to be coordinated with SA2.

For the objectives of application awareness transmission for XR, we propose to modify the scope as follows:

- 2. Identify, study and specify application awareness transmission for XR
 - o 2a. Identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g., media units level QoS, the QoS flow association etc. that was concluded from KPI and QoS. (RAN2)

- 2b. Identify application layer information from CN/application layer (e.g., frame rate, periodicity, delay, packet importance, frame boundary etc.) to aid XR-specific handling. (RAN2)
 - Note: coordinate with SA2 is needed.
- 2c. Introduce UE assistance information (e.g., special pose/control information, periodicity, synchronization, media units level buffer status, etc) to aid XR-specific handling. (RAN2)
- 2d. Study and specific XR-specific handling (e.g., scheduling, radio bearer handling, etc). (RAN2)
- 2e. Study and specific interaction between RAN and CN/application layer to aid application layer adjustment. (RAN2)

The reasons for above changes are as follows:

- Generally, we are fine with the original 2a, only a minor modification corresponding to KPI and QoS enhancement is proposed.
- More specifically, the original 2b can be split into 3 study areas. The 1st study area is to identify additional application layer information from CN/application layer. The 2nd study area is to introduce UE assistant information, e.g., special pose/control information (which can assist gNB for UL scheduling and channel measurement), media units level buffer status, etc. The 3rd study area is XR-specific handling, including not only gNB side scheduling and radio bearer handling, but also UE side radio bearer handling (e.g., UL packet dropping).
- In addition, interaction between RAN and CN/application layer is also beneficial for XR traffic. Some user experience-oriented information can also be delivered from RAN side to application server for application layer adjustment/adaptation.

3 – Nokia Corporation

RAN2 to consider possible actions for traffic handling based on the possible additional parameters from SA2 and SA4, and possible specification impacts. The identified areas look reasonable (1a,1b,1c & 1d). 2 looks sort of partly repetitive compared to 1 and could be consolidated to a single QoS/Applications awareness item

4 – Ericsson LM

Our proposal is to remove Item 1 (KPI and QoS) which is mainly in SA2 scope and prioritizing Item 2 (Application awareness) with a focus on the identification of application information useful to RAN, i.e. **not** restricting to certain particular aspects as listed (i.e. we should not have: "e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc.").

The reason is that we do not see any clear and strong motivation to change RAN for all potential changes in SA2, e.g., enhanced granularity for QoS, ADU-based QoS, XR specific QoS parameters, synchronization of QoS flow and KPI and QoS is also out of RAN scope. At the same time, it is our understanding that SA2 currently discusses a similar proposal for Rel-18 so that it is too early that RAN concludes the needs of KPI and QoS enhancements. Since SA2 is taking ownership of this, we should not do the same work as SA2 in parallel.

In item 2, Item 2b is very similar to Item 2a with respect to the identification of useful information to potential RAN features. At the same time, item 2 also should include a step to motivate the needs of particular application information by studying RAN features requiring those. When it comes to the "feasibility" of application awareness, RAN2 should not study the feasibility of getting the application information. This

is something SA2/SA4 should conclude. RAN WGs should simply determine what is useful and leave the feasibility analysis to SA groups.

Considering these, we would like to propose removing Item 1 at a given ongoing SA2 discussion and modifying Item 2 as below.

- Removing Item 1
- Modifying Item 2 with the following objective:
 - o Identify the XR traffic characteristics and application layer attributes which could be beneficial to RAN features and study the RAN features which could benefit from receiving the identified characteristics and attributes.
 - o Note that the feasibility of accessing and delivering application information to RAN should be concluded in SA2 and SA4 based on RAN input during a study item phase.

Once the study item identified useful information and RAN features to justify the information, the work item should standardize signalling between RAN and Core or UE report.

5 – Samsung Research America

Both identified areas, 1. KPI & QoS and 2. Application awareness are sufficiently scoped. 1a enhanced granularity for QoS, 1b, ADU-based QoS, 1c XR-specific QoS parameters, 1d sync of QoS flow handling / DRB control, 2a impacts from 1a-1d on gNB, 2b app layer / UE assistance capture the main improvements for further work reasonably. We support these.

There may be some redundancy between 2a and 2b and between 2a and 1a-1d. Both 2a and 2b aim to identify useful XR/CG app layer info to help RAN schedule better. Implementation can only occur in the gNB, so we see 2. Application Awareness mostly as an area where network-side information is propagated and made available at the gNB and/or UE-side app layer info is signaled to the gNB as non-committal assistance data. 2a would mostly depend on conclusions reached for 1a-1d. 2b requires separate consideration. 2b should be re-worded to have a real measurable goal and SI objective, “Identify the XR traffic and app layer service attributes which can improve RAN performance...” The SI phase should first quantify if benefits are to be had from UE assistance signaling.

Our biggest concern is that 1a-1d are in scope of SA2/SA4, i.e., not in RAN scope. If SA groups conclude that any of 1a-1d has benefits and specification changes are required, then RAN2 work will be necessary, but it should not be up to RAN to conduct the feasibility and impact analysis for these XR enhancements features. We propose to remove area 1 from the scope of the R18 SI+WI in RAN. We should budget enough time in the later WI phase to specify support for the KPI and QoS enhancements from area 1 in RAN2 after the R18 SA2/4 study concludes.

6 – HuaWei Technologies Co.

Regarding KPI and QoS, the concepts of enhanced granularity for QoS, frame-level QoS, and ADU-based QoS are examples to realize QoS enhancements, in SA2 it used a unified term as, media unit granularity QoS (S2-2106810), where a media unit consists of PDUs that have the same QoS requirements. Perhaps we can use consistent term to align with SA2 discussion and thus objective 1a, 1b, 1c can be merged into one. We also propose some rewording of bullet 1d as in our understanding, this is mainly to discuss the potential association of QoS flows belonging to the same XR service, the original wording is a bit unclear.

Regarding application awareness, we understand 2a is the consequence to support objective 1, and thus it is fine to keep it as is. Objective 2b is mainly targeting on how to utilize/deliver such parameters from 2a, it is fine to keep it as is, or we can merge them into one objective. Perhaps we don't need to mention any specific solution like UE assistance information, as always different solutions are not excluded when formulating the scope.

In general we see coordination is needed for all the bullets for QoS and application awareness, thus we think coordination with SA2 can be a generic statement. Such work needs joint efforts from RAN2 and SA2, and we don't think one WG only can decide purely on these aspects as we assume the mechanism is E2E.

We also would like to note that the work on QoS and application awareness have impact on capacity. For example, the identified enhanced QoS information (e.g. the media unit granularity QoS, XR specific QoS, etc.) and application layer information (e.g. frame rate, delay, packet importance, etc.) is useful for XR-specific handling, e.g. scheduling optimization, to enhance the XR capacity. Therefore we think this should be taken into account when evaluating the capacity enhancements.

According to the above discussion, we suggest the following refinements: ;

1. KPI and QoS

1a. Study and potentially specify RAN support for enhanced granularity for QoS, to support media unit granularity of QoS (e.g. video frame, Application data Unit) and XR-specific parameters;

1b. Study and potentially specify association of QoS flow handling belonging to the same XR service and corresponding DRB control (in coordination with SA2).

2. Application awareness

2a. Identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc. that was concluded from KPI and QoS

2b. Application layer information (e.g. frame rate, delay, packet importance, etc.) to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc;

NOTE: both objective 1 and 2 requires coordination with SA2/SA4

NOTE: objective 1 and 2 mechanisms should also be taken into account in capacity enhancements and corresponding evaluation.

7 – Asia Pacific Telecom co. Ltd

- 1a, 1b, 1c can be combined into one bullet, and to study whether each item is needed in SA2.
- For 2b, we think "One potential mechanism for this is to introduce UE assistance information" can be removed. How to provide the application layer information can be studied in WI phase.

8 – LG Electronics Inc.

We think traffic awareness is the essential feature of XR item.

But, item 1 can be removed as it is under the regime of SA2.

In item 2, we think the last sentence (i.e. UE assistance information) in 2b can be removed, which can be discussed in WI phase.

9 – DOCOMO Communications Lab.

Item 1 (KPI and QoS) can be removed since we think it is out-of-scope of RAN but in-scope of SA2 and SA4.

Regarding Item 2, it seems fine. It will be led by RAN2, closely related to SA2 and SA4.

10 – Spreadtrum Communications

We think the scope of 1b is covered by the scope of 1c.

11 – China Mobile Com. Corporation

Agree that some sort of merging is needed regarding two areas.

Generally share the view that a Study Item on KPI and QoS could be carried out followed by a Work Item in R18.

12 – Motorola Mobility España SA

1. KPI & QoS: we think the scope is reasonable. RAN2 can study all items 1a-1d from RAN point of view with tight coordination with SA2. The definition of ‘ADU’ should be clarified, what is the difference with Group of Picture /frames.

2. Application awareness: In general, we are fine with the scope. Anyway, the RAN needs to be aware of XR application layer information either by UE reporting or by CN indication, and the application layer information could be frame, ADU and importance of packets related information.

13 – MediaTek Inc.

1 and 2 are certainly valid items - however we would like to fully echo (and support) the comments above from **Ericsson**.

1: Remove. SA2 is planning work on these very issues right now, and this ought to be studied and conclude in SA2 first. We can reassess thereafter whether and which RAN2 work is needed.

2. Rephrase as suggested by Ericsson.

14 – Fujitsu Limited

(1) KPI and QoS

The proposals look good shape. On the KPI and QoS, 1a – 1c also needs consultation/coordination with SA2 and SA4. This point is good to be clarified.

(2) Application awareness

We also think that it is too detail to mention “One potential mechanism for this is to introduce UE assistance information”.

15 – Guangdong OPPO Mobile Telecom.

Similar as many companies’ view, enhancement for XR in R18 should be started with a study and followed by WI.

For the objectives of Identified areas in KPI &QoS and application awareness, they are very sufficient. And even there is some redundancy among bullets, e.g. 1a,1b,1c and 2a. Some bullets, e.g. 1 and 2a, overlap with potential study item in SA2. So, we prefer to remove the same work as SA2 in parallel. RAN could study and identify the XR traffic characteristics and application layer attributes beneficial for RAN performance.

16 – NEC Corporation

We think the KPI and QoS are out of RAN scope and RAN may wait for the progress in SA2 first. We propose to merge item 1 and 2 as follows:

1. Identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB/UE to be aware of, e.g., XR specific QoS information, frame rate, DL/UL PDB, periodicity, jitter, etc.
2. Study and potentially specify RAN support/utilization of these characteristics, attributes and information identified in 1, and study and potentially specify RAN support/utilization of enhanced QoS information in coordination with SA2 work, e.g., PDB-aware scheduling, packet dropping based on PDB and/or priority, traffic alignment/staggering among UEs, etc.

17 – Sony Europe B.V.

1. KPI and QoS

The proposed area looks ok, but is very much dependent on SA2/SA4 work and input. The KPI and QoS parameters should consider UE power, Capacity, Latency, and heavy uplink traffic.

Though not clear what is the scope for RAN2, since this is basically the result of SA2/SA4 input that may become visible to RAN2/RAN3 under Application awareness objective.

2. Application awareness

Identify application traffic characteristics for the RAN network to optimize resource

planning and scheduling, e.g. for demanding use cases like XR. Aspects like PDU vs DRB mapping, QCI/5QI, priority handling, GBR aspects and excessive TCP ACK handling should be considered.

Some sort of UE feedback/assistance information would be needed for the gNB to understand the traffic flow.

18 – China Unicom

We agree that objective 1a, 1b, 1c can be merged into one.

19 – Philips International B.V.

For items 1 and 2 we like the proposed formulation by Vivo.

20 – Beijing Xiaomi Mobile Software

- We suggest to remove item 1a-1d as it is mainly SA2/SA4 work scope.
- We are generally fine with the scope of application awareness but we think it would be premature to introduce UE assistant information.

21 – Futurewei Technologies

Item 1 (KPI and QoS) can be removed, as it is more appropriate to study them from a systematic view, and SA WGs (SA1/SA2/SA4) are better suited to take the task.

Item 2 (application awareness) should not assume a particular or a limited set of media codecs or particular ways of XR rendering mechanisms. TR 26.998 & TR 26.928 approach AR/XR devices/applications with a generic functional architecture, which cover different media codecs and rendering mechanisms for XR experience involving a range of different schemes for audio-visual integration, position tracking, and logical and spatial representation in multisensorial scene management. Making application awareness superficially tailored only to some specific (existing) XR application (or just some media codecs) would not bring meaningful enhancement in real deployment. It would unnecessarily impose limitation on the development of XR devices/applications. And it would not afford RAN an opportunity to stay relevant as new XR devices/applications emerge or existing XR devices/applications evolve.

RAN enhancement for XR should not deviate from 5G QoS model and framework. While it can provide support to SA WGs' efforts on enhancing KPI/QoS for XR application, the focus should be on RAN support, by enhancement of AS protocols and procedures, of high throughput low latency application traffic for XR.

Hence, the following objectives may be considered:

- 1) Study and identify traffic characteristics which could be beneficial for RAN to provide XR application with high throughput low latency support, and provide input to SA WGs for potential enhancement of 5G QoS model and framework for XR.
- 2) Study and identify RAN enhancement, in AS protocols and procedures, to provide XR application with high throughput low latency support based on 5G QoS model.

22 – ZTE Corporation

Support item 1a and 1b. Differentiated QoS granularity can be advantageous on identifying packets/stream-s/traffic with different requirements and assistive scheduling. To address this, an effective way for identifying data with different requirements is to design dedicated 5QI, depending on SA progress.

For item 2b, to enable application aware XR transmission, gNB needs to be aware of sub-stream level application information including e.g., priority, PDB/PER related information, then preemption/prioritizing scheduling scheme is capable of improving the system capacity and radio resource utilization as discussed in RAN1#106b-e for the capacity TR.

Moreover, UE assistance information e.g. UE data volume, UE orientation information and UE traffic type, known by scheduler has benefit on both DL and UL transmission.

23 – VODAFONE Group Plc

We support the need for work on 1, 2 and 4. If the objectives for 1 are removed because of SA2 discussions, then they should be replaced by a clear statement that RAN is expecting that SA2 does do the work - otherwise the "too large" SA2 SID can be cut to size by removing the RAN parts!!!

We remain of the view that the techniques listed for 3, UE power saving, are irrelevant for power saving in an XR device as an active XR device will be consuming much more power elsewhere!

24 – CATT

For KPI and QoS parameters, RAN had defined the Uu interface parameters, such as BLER and packet delay budget (PDB) based on SA4/SA2 end-to-end QoS parameters for XR traffic during XR study item. However, any end-to-end QoS parameters and enhancement for XR service should not be part of XR work in RAN. RAN should continue to work based on Uu link QoS parameters and KPI defined in XR study item.

For application awareness, it is essential for gNB to get XR traffic characteristics and application layer attributes in order to support any NR enhancement for XR service. The XR work item in RAN could focus on the method in obtaining XR traffic characteristics and application attributes from XR server through CORE network or UE feedback during the service request and radio bearer establishment.

For UE power saving and system capacity enhancement for supporting XR, we should be specified based on the evaluation results of proposed techniques during XR study.

25 – Facebook

We are fine with the proposed 4 bullets. For KPI and QoS, we agree that it's mainly SA2/SA4's responsibility. RAN can focus on how to improve the support for the KPI/QoS defined in SA2/SA4, including the support of multi-flow traffic as well as more granular support of the KPI and QoS due to the diversity of XR application and heavily related to video communications.

We think application aware RAN is an important scope for the WI. However, we should support both the IMS based and OTT architectures (such WebRTC). A close collaboration with SA2 and SA4 is also important.

Power saving is probably the most important scope for this work item. We could fine tune the scope based on Rel. 17 XR Enhancement Study.

26 – Apple Europe Limited

It is true 1a/1b/1c/1d are related to SA2/SA4's work. Here we have a little bit chicken-egg problem: if SA2/SA4 does not inform RAN what traffic information is available, RAN cannot move forward with enhancements which would require detailed traffic information such as ADU membership. One the other hand, if RAN does not indicate what traffic information would be useful, how to kick start the discussion in SA2/SA4 is an issue. It is necessary to craft the WID so RAN and SA work can move forward simultaneously.

Note the current proposal on 1a/1b/1c/1d was the outcome of the previous round of discussion, we prefer not to reopen the discussion. For the afore-mentioned reasons, 1a/1b/1c/1d are important for RAN to start its work with a clear target.

27 – Intel

Our preference is to have single objective that consolidate the key points from (1) and (2) as currently they seem a little overlapping. In addition, the primary focus should be a study phase how to support the traffic awareness at RAN, as well as, to incorporate XR specific characteristics. A possible merged objective could be as follow:

“1') Enhance RAN awareness to XR traffic and applications

1'.a) Identify the XR-specific traffic characteristics and application layer attributes (e.g. frame rate, delay, packet importance, etc.) beneficial/feasible for the gNB to incorporate them as part of 3GPP mechanisms (e.g. scheduling, radio bearer handling, etc). This includes understanding how to incorporate frame and Application Data Unit (ADU) to 3GPP system.

1'.b) Study and, if possible, specify enhancements on the RAN level making 3GPP system more aware of the requirements associated with the XR traffic characteristics and applications layer attributes, considering for example the QoS flow association and synchronization, update of QoS framework/parameters, new UE assistance information, etc).

NOTE: Coordination with SA2 and SA4 required”

For this objective, RAN2 should be the leading WG and RAN1 could be added as impacted WG.

28 – InterDigital

On KPIs and QoS (topic 1), we support the study and potential specification of 1a, 1b, 1c and 1d to be led by RAN2, with coordination with SA2. The support for enhanced granularity of QoS (e.g. ensuring QoS at different granularities, including per-service, per-flow, per-ADU, per-PDU) is particularly important for XR, as seen from the ongoing Rel17 SI discussions.

For 1d (synchronization of QoS flows) we are ok with vivo's proposed modification to include 'intra/inter' QoS flow in the objective. We also would like to suggest to remove the term 'handling' in the objective as follows:

- 1d. Study and potentially specify synchronization of intra/inter QoS flows belonging to the same XR service association and corresponding DRB control.

On application awareness (topic 2), we support study and potential specification of 2a and 2b to be led by RAN2.

We also propose to modify 2b to include 'identify' to the objective to be consistent with 2a, as follows:

- 2b. Identify application layer information (e.g. frame rate, delay, packet importance, etc.) to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc;

On UE assistance information, we are ok to separate it from 2b (similar change as proposed by vivo), as follows:

- 2c. Introduce UE assistance information (e.g. pose/control info, intra/inter flow synchronization info, ADU-level buffer status, etc.) to aid XR-specific handling

Given the overlap between topics 1 and 2, some consolidation between the topics can be useful when defining the WI scope.

29 – Qualcomm Korea

On both item #1 and #2, we agree with the comments that we need a close coordination with SA2.

On #1a, we agree that XR applications can have different QoS requirements. However, it's not clear if further specification work is required to capture the granularity of requirements. Instead, existing XR 5QIs can be adapted to suit the requirements of a given XR application. We can consider removing item 1a.

On #1b, we agree with the need for ADU-based QoS. We can consider merging this item with 2a. We believe RAN can quantify the benefits of ADU-based QoS and provide the input to SA2. We also agree with aligning the terminology with SA2. We prefer the term 'Application Data Unit' instead of 'Media Unit' since the latter is media specific.

On #1c, we strongly believe that XR-specific QoS parameters have to be studied, in particular, we need to evaluate whether PER and PDB are sufficient. We believe RAN can recommend XR-specific parameters that can improve RAN performance while meeting the required user experience.

On #1d, the requirement behind this item is not clear for XR since typically media synchronization can already be achieved in the application.

On #2, we agree that by having the application awareness (e.g., Application Data Unit – ADU) at the gNB, the gNB can better optimize for the XR traffic such that the overall quality of experience for the user is improved. By leveraging the application awareness, the gNB may be able to better schedule or prioritize to allow for better overall experiences for multiple users.

On #2a, we strongly agree with the need to study application layer attributes. We can consider merging #1b with #2a.

On #2b, we strongly agree on the need for UE assistance information to improve application awareness at RAN. Further, we think that it's important for RAN to look into mechanisms on sharing RAN information with application server, and realize benefits beyond what is possible by optimizing the RAN alone. Therefore, we would like to propose rewording of #2b as:

· 2b. Application layer information (e.g. frame rate, delay, packet importance, etc.) towards RAN and RAN information towards application to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc; One potential mechanism for this is to introduce UE assistance information;

30 – Verizon UK Ltd

We support the objectives in general. Specifically,

#1b, ADU-based QoS

#1c, support study XR-specific QoS parameters have to be studied, e.g. jitter.

#2, we think application awareness is beneficial since much true QoS is only available the the application layer. And when the info is only available at the UE, UE assistance is needed.

31 – Philips International B.V.

We agree with Ericsson

1.2 Power saving

Please provide further detailed views on scope for XR-specific power consumption aspects.

Please also provide views how best to structure work in terms of study item and work item on these aspects.

Feedback Form 2: XR-specific power saving

1 – vivo Mobile Communication Co.

For the objective of power saving enhancement for XR, we propose to modify the scope as follows:

- 3a. Study and specific XR specific power saving techniques to accommodate XR service periodicity and jitter, and XR-specific multi-flow aspects. (RAN1, RAN2)
 - o C-DRX enhancement, including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc.
 - o Enhancement on PDCCH monitoring adaptation.

The motivations are as follows:

- According to TS 38.331, the current C-DRX cycles are not suitable for XR traffic periodicities, and the enhancement for C-DRX configuration oriented to XR traffic is required. To align the start time of a C-DRX cycle with traffic arrival time, the most direct method is to extend the candidate values of C-DRX cycles to the field of non-integer, such as 8.33ms, 16.67ms. However, the non-integer C-DRX cycle(s) is not flexible due to the various traffic periodicities and the jitter impact. To solve this problem, dynamic C-DRX start offset adaptation can be considered as one potential method. Additionally, semi-static C-DRX pattern adaptation can also be investigated in order to reduce signalling overhead.

- C-DRX timers are defined by the duration with the unit of ms or slots and controlled by absolute time duration, without considering TDD pattern configuration. There will be no issue in early deployment for NR, since only long C-DRX cycle is actually configured. However, regarding XR service which has requirements of stringent latency and high data rate, shows lots of differences compared to eMBB and uRLCC services, much short C-DRX timers need to be configured for seeking the balance between power saving and capacity. Taking drx-onDurationTimer as an example, when a drx-onDurationTimer runs, some of the slots during the drx-onDurationTimer are overlapping with the UL slots. The UE have less PDCCH scheduling opportunities, which will degrade capacity performance. This problem will be further amplified if larger UL slots ratio of TDD pattern is configured e.g., DDDUU.
- The Rel-17 power saving enhancements under discussion are mainly focusing on eMBB traffic, which may still not be efficient enough to be applied to XR traffic with high data rate and critical delay requirement. As XR traffic periodicity is much denser than that for typical eMBB traffic, the signalling overhead and consumption on PDCCH monitoring for XR traffic with Rel-17 PDCCH monitoring behavior would be remarkable. Therefore, enhancement on PDCCH monitoring adaptation to accommodate XR service characteristics needs to be considered.

2 – Nokia Corporation

We see the need to study (and likely to cover in the work item phase) XR-specific power saving techniques, e.g: XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter, as well as PDCCH monitoring with XR use cases. We see WUS more generic and more related to devices having more idle-to-active transitions, thus more suited to handle with RedCap type use cases rather than doing now XR specific work on WUS. (Once WUS would be defined one of course can then see if there meaningful relation to XR or not, but work should be done elsewhere first with wider applicability in mind)

Thus, the study item objectives would focus on the following main items:

- XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter
- XR-specific multi-flow aspects
- PDCCH monitoring with XR use cases

3 – Ericsson LM

OK

4 – Samsung Research America

We support to include further study of power consumption reduction techniques during the SI phase of the R18 SI+WI. The specific solutions to be evaluated in the short SI phase can be left open. Techniques showing gains under reasonable assumptions can then be standardized in the following WI phase. However, we expect the gains from fully adaptive C-DRX to be somewhat marginal and these have large specification impact. Some proposed techniques in the R17 XR SI like WUS we do not see in scope at all for R18 XR, e.g., there is nothing specific about XR for such techniques. Optimizations to introduce better parameterization of C-DRX timers suitable for XR 30/45/60 fps don't have much specification impact.

We recommend to re-word 3a to:

“Study feasibility, benefits and required specification effort to introduce XR-specific power consumption reduction techniques suitable to XR traffic periodicity and jitter.”

5 – HuaWei Technologies Co.

We are fine to have a short study for power saving, and also share simialr view as Nokia that C-DRX and PDCCH monitoring are more XR-specific enhancements.

6 – Asia Pacific Telecom co. Ltd

We are fine with the XR-optimized C-DRX aspect. However, the last sentence "Enhancements to PDCCH monitoring and WUS" is not clear to us. In NR Rel-16, we introduced a WUS-like signaling in RRC_CONNECT, which is called DCP (DCI scrambled by PS-RNTI). In NR Rel-17, we introduces a WUS-like signaling in RRC_IDLE/INACTIVE, which is called PEI (Paging Early Indication). For PDCCH monitoring adaptation, Rel-16/Rel-17 power saving WI also introduced several schemes (e.g., SCell dormancy, PDCCH skipping, SSSG switching, etc.) It is suggested to re-word the last sentence to make it clear. For example, "Enhancements to PDCCH monitoring adaptation, such as DCP and/or other schemes introduced by power saving work item in previous releases"

7 – LG Electronics Inc.

On 3a, we want to remove the last sentence (i.e. PDCCH monitoring and WUS), which can be discussed in WI phase.

8 – Spreadtrum Communications

On the XR-specific multi-flow aspects, it seems not related to power saving. The scheduling scheme may not be different for packets belong to one flow or multi-flow.

9 – NTT DOCOMO INC.

We support XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter, e.g. New periodicity values for C-DRX based on XR traffic arrival periodicity, Adaptation of C-DRX parameters. We also support enhancements to PDCCH monitoring and WUS(DCP), e.g. PDCCH monitoring/wake up indication to align with XR service periodicity and jitter.

10 – SHARP Corporation

Power saving is key factor for XR and we are OK to the proposal.

11 – China Mobile Com. Corporation

Fine with the proposal by Nokia.

12 – Motorola Mobility España SA

We think the scope is reasonable. It would be good to have a study item first (e.g., a RAN1-led study item) followed by a work item.

We suggest adding a note to the scope to further help conclude the study: "*It is imperative to compare such power saving techniques with existing mechanisms including Rel-17 power saving techniques and gNB implementation/scheduling.*"

13 – Beijing Xiaomi Mobile Software

We are generally OK with the proposals , but:

1) suggest to remove "WUS".

In R16/17 UE Power saving, WUS, PDCCH skipping and PDCCH SS switching were introduced and we need to further study whether all those candidates can be used for XR services. We have sympathy with people that WUS may not be suitable for XR services which have stringent delay requirement.

2)About the multi-flow aspects:

We also have some doubts. Is that mean power saving is considered per UE or per flow? Based on our standing, for example, DRX configuration per DRB was studied even in LTE with very marginal gain.

14 – MediaTek Inc.

We share a similar view as Asia Pacific Telecom to clarify the objective for WUS and PDCCH monitoring (conn. mode)

15 – Fujitsu Limited

We just wonder if RAN2 needs to be involved. If the specification impact is just adding new XR-specific parameters, then only RAN1 should discuss this. After making decision in RAN1, it can be just informed from RAN1 to RAN2.

16 – Guangdong OPPO Mobile Telecom.

We are fine with proposal scope by moderator.

Before specify any solution, we prefer to have a study for potential power saving solutions and existing power saving solution, at least including R15/16 CDRX and R17 PDCCH monitoring enhancement, should be baseline. If beneficial from potential power saving solution is shown, we could specify it in WI stage.

17 – NEC Corporation

For power saving, we think the following areas should be considered:

1. Study and potentially specify the enhancement of C-DRX to handle the non-integer periodicity issue.
2. Study and potentially specify enhancement of DCI based power saving and WUS, e.g., to handle the jitter issue.

18 – Sony Europe B.V.

Power consumption enhancements would be needed to support XR scenarios, especially C-DRX scheme enhancements, for example. the alignment of Video Frame Rate and scheduled C-DRX periodicity. And potential SSSG switching enhancements.

With XR traffic characteristics (variable packet size, multi flows, etc.), more power saving technics including DG enhancement (both control channel processing design and data scheduling design, etc.) should be considered

19 – Philips International B.V.

For item 3a we like the formulation of Vivo.

20 – Futurewei Technologies

Release 17 XR evaluation SI is still ongoing. Although some power saving schemes are proposed by the companies, very limited simulation results have provided by individual companies. With only one meeting left, the R17 SI is likely not able to conclude and identify any solution for standardization. Therefore, further study for power saving is needed and the scope should be rather open and not limited to certain

schemes at this stage as there is no conclusion from the current SI. About WUS/WUR, this is discussed under RedCap thread while its use case is not limited to Redcap and hence we suggest not to discuss it here any further.

21 – ZTE Corporation

The XR-optimized C-DRX enhancements should be specified. At least dynamically change DRX parameters to align the DRX cycle, e.g., change the start time of DRX ON Duration or change DRX cycle according to fixed patterns or indication by DCI should be considered.

UL power saving schemes and DL and UL alignment schemes can be considered since multiple signals/data are transmitted in UL. An UL transmit pattern/window which confines the UL transmission within a specific time period can be considered to reduce UL transmission time and increase sleep time. In addition, SR transmission will trigger PDCCH monitoring behavior. A sparse SR resource periodicity will reduce the SR transmission and reduce power consumption. Hence SR resource periodicity adaptation to decrease SR transmission can reduce both UL and DL power consumption.

Thus, the potential XR-specific power saving techniques should include: UL transmit pattern/window to confine the UL transmission within a specific time period, SR resource periodicity adaptation to reduce SR transmission.

The study item objectives would focus on the following main items

XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter, UL power saving schemes, e.g., UL transmit pattern/window to confine the UL transmission within a specific time period, SR resource periodicity adaptation to reduce SR transmission,

UE assistance information.

Besides, Study and if needed, specify power saving schemes leveraging UE assistance information, including e.g., mechanism to ensure DL and UL alignment and dropping of some consecutive UL transmissions.

22 – VODAFONE Group Plc

Techniques are needed to handle data bursts being generated at non-integer ms rates (e.g. 8.33ms, 16.67ms). However, the XR picture reliability requirements are likely to lead to retransmissions, and, the related uplink transmissions might handle pictures being taken at 24 frames per second, so the opportunities for "UE receiver power saving" seem really minimal (and are probably minute when compared to other very power hungry tasks that are running in the device for this type of demanding service).

23 – CATT

The potential XR-specific power saving techniques should also take into consideration of system configuration and operation for XR services and other services, such as eMBB and URLLC.

The C-DRX configuration and DRX adaptation with WUS is used to achieve UE power saving for robust traffic arrival of eMBB services. The XR-optimized C-DRX might be slightly beneficial in UE power saving gain for XR services but might be detrimental to UE power consumption in eMBB services. Thus, the objective of XR-specific power saving techniques should be generalized to include the configuration of C-DRX for not only the XR services but also eMBB services based on the proposed techniques during the XR study item.

24 – Facebook

Power saving is probably one of the most important scope for the WI. We are fine with proposals.

25 – Apple Europe Limited

The existing C-DRX design cannot handle the multiple stream XR traffic well. We have several observations/comments on power saving enhancements:

1. The periodicity/offset mismatch between DRX configuration and XR traffic has been identified by companies. Note for multiple stream traffic, updating the periodicity/offset for DRX configuration won't help much.
2. One intuitive understanding of C-DRX design is if there is some activities for DL/UL data transmission, then keep the UE awake in case the gNB needs to send another grant to the UE, e.g. for HARQ retransmission.
 - 2a. For some XR packets, the first transmission or the first/second transmissions is/are the only opportunities for (re)transmission due to stringent PDB (e.g. one packet for pose/control in UL), keeping the UE awake up for non-coming retransmission just wastes UE power for no good reason.
 - 2b. Since there can be use cases for primarily using DG PDSCH/PUSCH for XR traffic and primarily using SPS/CG for XR traffic, C-DRX timer optimization for both DG (DG PDSCH/PUSCH) and semi-persistent transmissions (SPS/CG) should be considered.
3. Since the configuration of C-DRX can impact UE's PDCCH monitoring behavior regarding all search spaces, modifying C-DRX design to suit XR's multiple stream characteristics is somewhat clumsy and blunt. A solution tailored for multiple stream characteristics may provide a better support – such as embedding signaling within SPS PDSCH resource.
4. As XR traffic employs multiple parallel traffic flows one may expect a higher number of QoS flows to be simultaneously active. When multiple transport blocks end up getting spread apart in time somewhat unaligned, this can create a high demand on power consumption. Thus, related information can be scheduled in close proximity the UE and the gNB can exploit temporal locality for power benefits.

From that, we suggest to modify 3a. as:

3a. Potential XR-specific power saving techniques:

- *XR-optimized C-DRX for aligning C-DRX with XR service periodicity and jitter,*
- *XR-specific multi-flow aspects considering different flows' delay budget and reliability, and synchronization requirements.*
- *Enhancements to PDCCH monitoring/control signaling and WUS can also be considered.*

26 – Intel

We propose the following update to the objective:

“Study and specify, if needed, XR specific enhancements to CDRX configuration, taking into account XR traffic periodicity, multiple flows, QoS requirement, and jitter.”

For this objective, leading WG is RAN1, and impacted WG is RAN2.

27 – InterDigital

We are ok with the scope identified XR-specific power saving techniques, with the understanding that a study phase may be needed followed by specification (with RAN1 and RAN2 involvement) for evaluating the power savings gains and tradeoffs with capacity when considering XR-optimized CDRX, XR-specific multi-flow power saving techniques and PDCCH monitoring adaptation enhancements.

28 – Qualcomm Korea

During R17 XR SI, companies have provided evaluations results for XR. Performance gap in terms of power consumption has been also identified during the SI.

Potential enhancements schemes for UE power consumption have been evaluated by companies. However, those schemes were not discussed in detail in RAN1 time since focus was on evaluation of existing techniques. Therefore, it would be better to have study item phase for studying potential enhancements techniques including performance evaluation, complexity analysis, comparison across different techniques/approaches. We prefer to have scope open given that this is for study. We think right identification of problem and solutions are both very important.

We prefer to work on following areas.

CDRX cycle mismatch with XR traffic pattern (periodicity): Current CDRX cycle cannot provide matching cycle with XR traffic periodicity, which could increase UE awake time and power consumption. Thus, CDRX enhancements in DRX start offset / DRX cycle determination. Other schemes with periodicity such as CG, SPS, SR, etc could be also considered together.

Jitter handling: Although XR traffic is supposed to be periodically generated, variable video encoding time, packet size, network transfer time could make some level of jitter in XR traffic arrival at gNB. In certain cases, the jitter may *not* be *predictable*. In those cases, gNB cannot simply dynamically change CDRX parameters to handle jitter. To handle *unpredictable* arrival without increasing too much latency, UE can simply be awake and ready for rx / tx for a longer time. However, this requires UE to consume higher power. WUS or PDCCH monitoring enhancements could be solutions for this problem. The enhanced WUS could allow UE to wake up (from DRX OFF) immediately after XR traffic arrives at gNB side, which could minimize the latency increase. Sparse monitoring is also one technique which could reduce power but allow frequent monitoring of traffic arrival. Note that this jitter handling schemes are very much XR specific enhancements.

Frequent UL transmissions: XR has very intense traffic arrival at UL – e.g., pose or UL video. The frequent UL traffic arrival requires frequent UL scheduling and wake up or DRX timer restart. This makes it very difficult for UE to enter longer sleep. So, some level of decoupling UL activities and DRX timer operation could be beneficial to achieve lower power. We think general enhancements for CG/DG for periodic/low latency traffic should be studied.

In summary we propose to study following areas.

- CDRX enhancements to provide aligned periodicity with XR traffic.
- Jitter handling schemes (e.g., enhanced WUS, sparse PDCCH monitoring) to avoid increase of power and latency due to jitter

Decoupling of periodic UL/DL activities (CG/SPS/SR/...) and DRX timer operation to avoid frequent wake up.

29 – Verizon UK Ltd

Supportive. CDRX enhancement for sure. We also support study jitter handling - jitter is key metrics in SLA that we must be able to identify and hopefully control/optimize efficiently. It also has implication to product implementation e.g., de-jitter buffering.

1.3 Capacity

Please provide further detailed views on scope for XR-specific capacity improvement aspects.

Please also provide views how best to structure work in terms of study item and work item on these aspects.

Feedback Form 3: XR-specific capacity improvements

1 – TELECOM ITALIA S.p.A.

UL performance (capacity, latency) are key factors for XR. In particular, in TDD networks (whose frame structure is forced by regulators) UL may not be able to provide the required throughput and latency. UL enhancements, including allowing flexible TDD (see RAN94e-R18Prep-01 MIMO Evolution for Downlink and Uplink) are key to ensure the required performance.

Moreover, pre-scheduling techniques should be optimised to minimise latency

2 – TELECOM ITALIA S.p.A.

to continue the previous post... it is not clear if these objectives should be under this umbrella or under the UL enhancements umbrella.

In any case, we foresee the following objectives:

- improve UL capacity in TDD networks. Solutions as simultaneous Tx over more than 2 bands, UE supporting multiple TRP/TRS should be considered (RAN4 prime, RAN1)
- optimization of pre-scheduling techniques to optimise latency (RAN2)

3 – vivo Mobile Communication Co.

For the objectives of capacity enhancement for XR, we propose to modify the scope as follows:

- 4a. Study and specify XR specific capacity enhancement for XR for accommodate XR service periodicity and jitter, and XR-specific traffic characteristics. (RAN1, RAN2)
 - o Study and specify features to enhance radio resource allocation, including SPS/CG and dynamic scheduling, e.g. dynamic adaptive SPS/CG parameter update, multi-PDSCH/PUSCH resource allocation, XR characteristics specific scheduling, HARQ-ACK enhancement, etc.

The reasons for above changes are as follows:

- The XR traffic characteristics, in terms of non-integer periodicity with jitter, variable packet size, high data rate, etc., need to be considered. SPS and CG (configured grant) can provide the benefits of signaling overhead and monitoring reduction. Currently only fixed integer periodicity can be supported and multiple SPS/CG configurations need to be configured for accommodate the XR traffic non-integer periodicity with jitter. Therefore, due to the non-integer periodicity with jitter, SPS and CG applied for XR should be enhanced. On the other hand, dynamic scheduling to serve XR traffic efficiently need to be considered. For example, multi-PDSCH/PUSCH scheduling may be adopted when time-frequency resources across several slots may be allocated to accommodate a large packet. Besides, the scheduling can take some XR characteristics into account, when related information for these characteristics can be acquired, to better match the QoS requirements for XR traffic efficiently, e.g. delay-aware scheduling, scheduling based on QoS flows/data streams, etc. These enhancements are closely related to RAN awareness transmission as well.

4 – Nokia Corporation

The capacity related studies (in the study) should address XR-specific issues that provide more efficient resource allocation and scheduling for XR services. These issues should have clear relationship with XR-specific traffic periodicity and can include XR related SPS enhancements, as well as relaxing scheduling restrictions from RRM measurements that harms XR performance

5 – Ericsson LM

In our view, dynamic grant should be a baseline for scheduling and radio resource allocation for uncertain large traffic size with a jitter while CG/SPS is a supplementary feature which can be used in some special scenarios. For XR, it has not been established that enhancements to CG or having a dynamic CG is superior or preferable to using dynamic grant scheduling or to enhance dynamic grants. Benefits should be shown for any enhancement applicable to the XR type of traffic. These aspects should be part of what the study should conclude. For example, multi-TB SPS/CG and HARQ-ACK enhancement are not so relevant to address XR specific non-integer periodicity and jitter which are mainly about timing related issues.

Therefore, we propose the following change in the objective with focus on dynamic grants:

- Study potential XR-specific resource allocation and scheduling enhancement for dynamic grants such as dynamic multi-TB scheduling, enhanced buffer status report, link adaptation.
- Study supplementary SPS and CG enhancements to address XR-specific non-integer periodicity and jitter, e.g., dynamic parameter update.

Regarding the structure of the work, we think WGs should start with a study. The study should cover two quarters (for both RAN1 and RAN2) and a Rel-18 WI can follow.

6 – Samsung Research America

We support to include further study of XR capacity enhancement techniques in the SI phase of the R18 SI+WI. We agree that XR scheduling can be improved when XR traffic non-integer periodicity and observed jitter are better dealt with. However, the list of potential enhancement techniques shown currently in 4a is mostly about SPS/CG. We believe this is not the right premise to start the R18 SI phase. Dynamic grants are the baseline for gNB scheduling. The gains from the use of SPS/CG compared to DG have not been shown until now. We are okay to include potential techniques like dynamic SPS/CG parameter update or multi-TB SPS/CG for evaluation in the R18 SI phase, but gains/benefits/complexity compared to DG-based scheduling for XR need to be shown first and agreed upon before concluding these should be standardized in the later WI phase.

We recommend to re-word 4a to:

“Study feasibility, benefits and required specification effort for potential capacity enhancement techniques: XR-specific resource allocation and scheduling enhancement including dynamic grant or SPS/CG to address XR-specific non-integer periodicity and jitter.”

7 – HuaWei Technologies Co.

We think the scope is a bit too broad. The HARQ-ACK enhancements are generic enhancements and not specific to XR. We think we should focus on XR-specific enhancements and prefer to remove “etc.” as this may expand the scope too much. Additionally, the work on QoS and application awareness should

also be taken into account as we explained in 1.1. We in general are fine to go with a short study to evaluate the gains from candidate solutions.

Therefore we suggest to update the previous wording as below:

Study feasibility and benefits for the potential capacity enhancement techniques by taking the QoS and application awareness information into account: XR-specific resource allocation and scheduling enhancement, SPS and CG enhancements to address XR-specific non-integer periodicity and jitter.

8 – Asia Pacific Telecom co. Ltd

We are fine with the proposed scope by the moderator.

9 – LG Electronics Inc.

We are ok with moderator's suggestion.

10 – DOCOMO Communications Lab.

We support to start from SI followed by WI for identifying exact enhancements area for WI since Rel-17 XR SI will not identify them. For the study area, we agree to include SPS/CG enhancements to align with XR specific traffic characteristics such as non-integer periodicity and jitter. Besides, it is also beneficial to study potential dynamic scheduling enhancements for XR specific traffic characteristics. On the other hand, we are not clear HARQ-ACK enhancement in the example is related to XR enhancements. Therefore, we suggest to update as below:

Study feasibility and benefits for potential capacity enhancement techniques: XR-specific resource allocation and scheduling enhancement including SPS/CG such as dynamic SPS/CG parameter update, multi-TB scheduling for SPS/CG, to address XR-specific non-integer periodicity and jitter.

11 – Spreadtrum Communications

We think other factor shall be considered in XR-specific resource allocation and scheduling enhancement, for example, the assistance information of application layer, synchronization of multiple flows.

12 – SHARP Corporation

Capacity is key factor for XR. Enhancements on SPS and CG can be considered to improve capacity and efficiency while considering data size fluctuation and jitter.

13 – China Mobile Com. Corporation

Agree that we need to focus on XR-specific enhancements in R18 for this potential SI+WI.

14 – Motorola Mobility España SA

We think it would be good to have a study item first with the following updated scope (e.g., a RAN1-led study item) followed by a work item based on the findings of the study item:

4a. Identify dynamic as well as semi-persistent scheduling enhancements considering

- (a) XR-specific traffic characteristics such as non-integer periodicity and jitter
- (b) Application awareness at RAN

Note 1: The enhancements could include dynamic SPS/CG parameter update, multi-TB SPS/CG, HARQ-ACK enhancement etc.

Note 2: It is imperative to compare XR-specific SPS and CG enhancements with existing mechanisms including gNB implementation/dynamic scheduling.

15 – MediaTek Inc.

Capacity improvements are necessary for XR/Cloud Gaming. We support focusing the work on SPS and CG enhancements (wrt XR service periodicity and jitter)

16 – Fujitsu Limited

(1) We also tend to think that this topic is under this SI/WI or better to be placed under UL enhancement topic.

(2) The proposed scope seems to be too specific to the enhancement of CG. Mechanism for DG would be also considered. Furthermore, it is unclear if XR is only served on licensed band. XR traffic may tend to cause high traffic load, and if this is the case, it may be better to consider unlicensed band for the XR traffic offloading. Having said that, to keep the objective compact, it is better to clarify that the focus is on licensed band.

17 – Guangdong OPPO Mobile Telecom.

We are fine with proposal scope by moderator. We should focus on XR-specific scheduling enhancement to address XR-specific issue, e.g. large packet size, various packet size, non-integer periodicity and jitter. However, considering that this item may start from SI, we are fine to open any potential solutions, especially listed by moderator.

Regarding HARQ-ACK enhancement, HARQ-ACK is closely associated with downlink scheduling. One enhanced downlink scheduling may lead to corresponding HARQ-ACK enhancement. So to ensure enhanced scheduling techniques more efficient, corresponding HARQ-ACK enhancement can be considered. For example, to address jitter issue, multiple SPS/CG configurations can be reused directly. However, the disadvantage of multiple SPS configurations is redundant HARQ-ACK feedback, in which HARQ-ACKs associated with blank SPS PDSCHs are invalid. So to address XR-specific jitter, multiple SPS/CG configurations with enhanced HARQ-ACK feedback is an efficient direction.

18 – NEC Corporation

In order to improve the system capacity for XR traffic, which has variable packet sizes, high data rate, and low latency requirement. We think following objectives can be considered:

1. Study and potentially specify enhancement of dynamic scheduling (e.g., enhancement of multi-TB scheduling) to handle the large and varying packet size issue of XR traffic.
2. Study and potentially specify XR-specific SPS and CG enhancement to accommodate XR traffic, which may include:
 - support multi-TB per SPS/CG periodicity
 - enhance SPS/CG to address XR-specific non-integer periodicity and jitter
 - support CBG based SPS/CG transmission

19 – Sony Europe B.V.

Rel-17 XR study item has not covered potential enhancements aspect for the XR capacity improvements. Efficient resource allocation for XR services and meeting PDB air-interface shall be considered. This includes:

- Enhancements of SPS/CG to support XR services

- Dynamic Multi TB scheduling
- BSR improvements
- CSI enhancements

20 – Philips International B.V.

For 4a we like the proposal from Vivo.

21 – Beijing Xiaomi Mobile Software

We think a study phase on potential capacity enhancement would be needed, as in Rel-17 the evaluation focuses on baseline capacity and the potential enhancement is not fully discussed. The feasibility and benefit of listed potential enhancements should be first studied.

We also think both dynamic grant and SPS/CG enhancements should be included.

22 – Futurewei Technologies

Release 17 XR evaluation SI is still ongoing. There are several proposals from the companies with limited evaluation results till now. No conclusion has been drawn to identify the bottleneck issue or solution to address such issue for specification work. Furthermore, checking the list of proposals submitted into Release 17 XR SI and the discussions here, there is clearly a disconnection. What are being evaluated in the R17 SI were not listed here and what listed here were not proposed for R17 study. Furthermore, we fail to see how SPS and CG, etc. can improve the capacity over DG and where is the justification to enhance SPS/CG for capacity purpose for XR traffic. It is clear that more study is needed to identify issues and solution for XR capacity enhancement. The scope of study should be based on Release 17 SI conclusion if any or should be rather open and not limited to certain schemes at this stage.

23 – ZTE Corporation

During RAN1#106b-e, discussion on observations for enhancement was done. We prefer to progress on the elaboration of the discussed working areas e.g. the directions falling into XR-specific enhancement as following.

Adaptive inter-UE multiplexing: When XR service accesses current network, adaptive inter-UE multiplexing techniques is capable of multiplexing XR services with existing services, including, e.g., uRLLC, eMBB and so on, to address XR coexistence with current eMBB and uRLLC.

Delta MCS: Since the packet size of XR service is large, the MCS is one important factor which will affect the resource utilization and system performance. A proper MCS is capable of maximize resource utilization ratio while meeting BLER requirements. Reporting delta MCS can help gNB obtain an accurate MCS value and can be considered.

Network coding: Exploit link diversity, RAN protocol stack adaptation for application layer traffic characteristic and requirements to achieve lower packet error rate.

For SPS/CG enhancement, we prefer to postpone XR specific SPS and CG pending sufficient RAN1 evaluation results and conclusion.

24 – VODAFONE Group Plc

The scope may need adjustment once the Rel 17 study item has reached more maturity. We expect that there will be some 'radio interface' work needed to handle bursts of downlink IP packets arriving at the gNB with non-integer ms periodicity, and also some SA2/CT4/RAN 3 work needed to handle the "grouping of packets into a burst" and the "relative priority of packets within a burst".

25 – CATT

We agree with Ericsson that dynamic grant should be the baseline for the XR services. Enhancement of DL/UL dynamic grant as well as DL SPS/UL CG for XR service should be considered in the same time. In addition, the capacity enhancement should also take advantage of the awareness of XR-traffic characteristic and application attributes at the gNB and UE feedbacks on the application aspects.

26 – Facebook

We are ok with the moderator proposal. We can finetune the scopes based on the conclusion from the Rel. 17 study item.

27 – Apple Europe Limited

From previous round of discussion, many companies have identified SPS/CG enhancements as important. For capacity enhancement, better link adaptation to address reliability requirement and at the same time allow a number of UEs per cell is key, it was discussed in Rel-17 URLLC, we suggest to include both HARQ-ACK and CSI feedback enhancement in the scope.

If latency budget for a packet is made available at the gNB, discarding the packet before any gNB scheduling can be used. However, gNB may not have the non-causal view to know beforehand whether a packet can be transmitted within its latency budget. How to handle the packet in transmission may be also important to consider. Packet discarding/selective transmission can be considered.

Also related to ADU-awareness (assume it is eventually proved to be feasible from SA2 study), the UE may need to report the ADU related information for the uplink packets to the gNB, so gNB scheduler can take that into account (to squeeze a larger number of important packets in uplink and deprioritize less important packets), with that UCI enhancement is also needed.

In summary, we suggest the following changes:

4a. Potential capacity enhancement techniques: XR-specific resource allocation and scheduling enhancement, SPS and CG enhancements including dynamic SPS/CG parameter update, multi-TB SPS/CG, HARQ-ACK/CSI enhancement, specific non-integer periodicity and jitter, UCI feedback for detailed traffic information, packet discarding/selective transmission.

28 – Intel

We propose the following update to the objective:

“Study and specify, if needed, XR specific schemes for capacity enhancement, taking into account XR traffic periodicity, multiple flows, and QoS requirement.

1. Study and specify, if needed, enhancement to SPS and CG transmissions, including multi-TB scheduling.”

For this objective, leading WG is RAN1, and impacted WG is RAN2.

29 – InterDigital

We are generally ok with the scope identified for capacity enhancements for XR, given that the techniques listed are intended to address issues on meeting both high data rate and low latency requirements for XR

traffic, handling multiple flows per XR service, XR-frame dependent periodicity and jitter when performing UL and DL transmissions. Other techniques which can be considered for capacity enhancements for XR include combined DG+CG, enhanced BSR and CSI reporting aligned with XR traffic. While some enhancement techniques such as delay aware scheduling are being considered in Rel-17 SI, a brief study phase in Rel-18 can be beneficial for validating any gains of the techniques in the proposed Rel-18 scope. The study phase for capacity enhancements followed by specification in Rel 18 is to be done with RAN1 and RAN2 involvement.

30 – Qualcomm Korea

We support SPS and CG enhancements. We will expect that the study item would cover SPS and CG enhancements such as adaptability of SPS and CG configurations and parameters to link conditions, compatibility with XR traffic characteristics (e.g., frame rates), reduced overhead while supporting variable packet sizes as well as jitter handling.

In general, we think the SPS/CG enhancements should be considered not only from capacity perspective but also from power perspective since there are techniques which can benefit both capacity and power.

Further, we note that ADU based enhancements can improve capacity performance.

31 – Verizon UK Ltd

Supportive. Support SPS/CG enh in addition to dynamic grant. Both should be considered to allow implementation & optimization flexibility.

2 Intermediate round - now closed.

As per the feedback received in the Initial Phase the prevailing sentiment of companies is to **start with a Study Item**, followed by a Work Item. The Study Item is expected to run for 2 quarters.

Consequently, the focus of the Intermediate round is to start scoping out a Study Item, start defining the study objectives.

2.1 Study Item scope for XR-awareness in RAN

It is understood that the bulk of the work around KPI/QoS and Application Awareness would be lead by SA2 and SA4. Nevertheless, a limited study scope for RAN2 in this area would be useful in order to allow the timely build up of RAN2 understanding.

Proposed Study Item objectives (RAN2):

- Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc.
- Study potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association.

Feedback Form 4: Study Item objectives for XR-awareness in RAN

1 – DOCOMO Communications Lab.

We are fine with the FL proposal.

2 – Ericsson LM

In general, we are fine with the proposal. We are missing in the proposal an explicit reference to “studying the benefits” because “studying mechanisms” is not the only task. In addition, we think that the examples may attempt to frame and direct the future RAN1/RAN2 work towards a specific direction. We would like to avoid that and let the study item phase to conclude what does actually give benefits. Thus, we suggest to either remove all the examples or add more potential areas of study. It would be beneficial, for instance, to study benefits of higher layer dropping mechanisms as XR specific traffic handling mechanisms in RA to avoid redundant resource utilization by delivering too late packets or ADUs.

Therefore, we propose the following modification in the second bullet, or remove completely all the examples in both bullets.

- Study potential XR-specific traffic handling mechanisms, e.g., **enhanced high-layer packet dropping**, handling flows that belong to the same XR service association.

3 – ZTE Corporation

We are fine with FL’s proposal that work for KPI/QoS and application awareness would be led by SA2 and SA4, and the proposed Study Item objectives for RAN. But for XR traffic characteristics and application awareness transmission, we think it necessary for RAN to study how to utilize these kinds of beneficial/feasible information, including e.g. prioritization/preemption scheme for enhanced scheduling.

Therefore, we prefer to add following sub-bullet for proposed study item objectives for RAN

It is understood that the bulk of the work around KPI/QoS and Application Awareness would be lead by SA2 and SA4. Nevertheless, a limited study scope for RAN2 in this area would be useful in order to allow the timely build up of RAN2:

Proposed Study Item objectives (RAN2):

1 Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc.

1 Study potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association.

Study how application layer information (e.g. frame rate, delay, packet importance, etc.) to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc;

4 – CATT

We support the update objective.

5 – Futurewei Technologies

We are in general fine with the main parts (before ”e.g., ...”) of these two objectives, and would like to suggest to either remove ”e.g., ...” or to reword them as follows to be more aligned with 5G QoS model:

- Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. XR specific QoS parameters of the QoS flow associated with the XR service.
- Study potential XR-specific traffic handling mechanisms, e.g. handling QoS flows that belong to the same XR service.

We note that association between service and QoS flow is done at NAS layer, and is beyond the apprehension of RAN and that the principle of RAN controlling mapping of QoS flow to DRB based on QoS profile should be maintained.

6 – Nokia Corporation

We are fine with the moderator proposal. We hope SA2 will be able to progress their part in time fashion as otherwise RAN will not have understanding for example what does for example ADU based QoS mean from RAN perspective.

7 – Samsung Research America

We are generally supportive of the proposed SI objectives (RAN2) by the FL. One area not explicitly mentioned in the 2nd bullet point on XR-specific traffic handling mechanisms is packet dropping / traffic shaping. R17 RAN1 evaluations are indicative that much gains can be had at system-level when exploiting XR stream and ADU characteristics, e.g., timed scheduling of packets according to the allocated stream delay budget and avoidance of re-transmissions for packets in the XR/CG data/control streams which are in excess of the allowed bearer delay budget.

We recommend to re-word the 2nd bullet to,

- Study the gains of potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association, packet dropping and traffic shaping

8 – Apple Europe Limited

It is expected RAN2 will play a critical role in QoS related enhancements. Some aspects are fully in the scope of RAN2's work. Some other aspects or facets, which may be beneficial for system capacity and/or UE power saving, still need validation through simulation evaluation. Also some enhancements may require physical layer's enhancements. From that, we suggest add RAN1 as secondary working group in addition to RAN2 for this objective.

Moreover, we expect a lot of overlap between work in SA2 and work in RAN2 where multiple RAN enhancements will be required in support of XR, this charter should be reflected in the study scope. We therefore propose to extend the second bullet as follows:

- Study potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association, as well as handling of scheduling, related application layer information, corresponding radio bearer control, traffic prioritization, UE assistance information, etc;

9 – Apple Europe Limited

- The proposal overall looks good. On the third bullet, “Potential enhancements to PDCCH monitoring (RAN1)”, we proposed to consider also control signaling enhancements, e.g., as embedded in SPS resource occasion. Note if we can read the third bullet in a broad way, we can also study various enhancements including control signaling enhancements in the SI/WI stage.

- One the second bullet “XR-specific multi-flow aspects considering different flows' delay budget and reliability, and synchronization requirements (RAN1);” XR-specific multi-flow aspects, delay budget, and

also synchronization requirements are all more controlled by RAN2; so RAN2 should be involved if not the lead for this sub-item.

10 – Facebook

We support Apple revision on the multi-flow traffic aspects. However, this part would mostly like to further together with SA2 due to the need for end to end consideration.

11 – InterDigital

In general, we are fine with FL's proposed objectives for XR-awareness in RAN to be led by RAN2. In light of earlier discussion on the importance of ensuring intra/inter flow synchronization for XR services supporting multiple flows, we would like to propose to change the second bullet as follows:

”Study potential XR-specific traffic handling mechanisms, e.g. handling and synchronization of flows that belong to the same XR service association.“

12 – AT&T

We are generally fine with the proposal. However we have some concerns that the list of examples for the second bullet does not appear to be stable and may be a bit unclear in some cases. We suggest removing the examples for now as also suggested by Ericsson and let the WGs handle the details directly.

13 – HuaWei Technologies Co.

Regarding KPI/QoS as well as XR awareness in RAN, we would like to note that in the approved SA2 SID (S2-2108156), it is clearly mentioned that “some cooperation with RAN WG may be needed to provide end-to-end solution”. RAN2/RAN3 should do work in parallel with SA2 to formulate the E2E solution. Therefore, this should be well reflected in the objective.

In addition we are fine to add packet dropping as this was already supported by many companies in previous rounds of discussion. We do not support adding more examples as they are not previously discussed and well justified.

Thus we propose the following refinements.

Proposed Study Item objectives (RAN2):

- Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc., *including the RAN part to support WT#3 from SA2 SI*;
- Study potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association, *packet dropping etc.*

We also understand the above work does not only impact RAN2 but also RAN3. This should also be clarified.

14 – Qualcomm Korea

We agree on the first bullet. In particular, application layer attributes can improve 5G performance with XR traffic. In particular, frame-level QoS and Application Data Unit-based QoS are important application-level attributes and it makes sense to study those further.

Further, it makes sense to study XR specific QoS metrics, independent of Application layer attributes. As such, we suggest that XR specific QoS should be a separate bullet item.

On the second bullet, 5G has existing mechanisms to handle traffic with multiple flows. It has not been established if there's any specific issue on this with respect to XR traffic. We propose that this bullet be removed.

Further, we think that it's important for RAN to look into mechanisms on sharing RAN information with application server (for example, information that allows staggered UE traffic that has been evaluated by companies in R17 XR study), and realize benefits beyond what is possible by optimizing the RAN alone. We suggest adding the following bullet item related to this:

- Study RAN information that can be useful at the Application layer to improve overall XR user experience (e.g., staggered UE traffic offset) and study mechanisms that can enable sharing such RAN information towards application.

15 – Intel

General comment: we support the suggestion of having an SI phase (of 2 quarters) followed by a WI phase. We are ok with the updated objectives that aims to have a scope that does not include potential solutions but instead the key issues or areas to address during the SI phase. On the 2nd point, we suggest clarifying that this focus on RAN-centric mechanism and that it cover both XR specific traffic as well as application; therefore, we suggest reusing similar wording as in the 1st point for this last part understanding that both points are inter-related. On summary, we suggest updating the 2nd point, for example as follow:

“Study RAN-centric mechanisms or enhancements to better accommodate/support XR traffic characteristics and application layer attributes, e.g. handling flows that belong to the same XR service association”

On the inter-relation with SA2/SA4 related topic, we suggest adding a general note or statement as part of the objective section that confirms that coordination is foreseen expected/required.

16 – LG Electronics Inc.

We think 2b in the initial round needs to be captured as an objective, without the last part of 2b.

2b. Application layer information (e.g. frame rate, delay, packet importance, etc.) to aid XR-specific handling, e.g. scheduling, radio bearer handling, etc; ~~One potential mechanism for this is to introduce UE assistance information;~~

17 – vivo Mobile Communication Co.

In general, we are fine with the structure of scope for XR-awareness in RAN.

However, we suggest to either remove all the examples or add more potential examples for study.

Possible modifications we propose for the objectives are as follows

- Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of, e.g. the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS, periodicity, frame boundary, importance, delay, etc.
- Study potential XR-specific traffic handling mechanisms, e.g. handling flows that belong to the same XR service association, scheduling, radio bearer handling, packet dropping, etc.

The reasons for above changes are as follows:

- For the 1st bullet, in addition to the QoS related information, application layer information e.g., frame rate, periodicity, delay, packet importance, frame boundary etc., is added as examples, which can also be studied to aid XR-specific handling
- For the 2nd bullet, in addition to handling flows that belong to the same XR service association, we think other XR-specific handling can also be studied, e.g. scheduling, radio bearer handling, packet dropping.

18 – Motorola Mobility España SA

We are fine with moderator’s proposal. Besides that, considering the study item in SA2, there is one work task regarding QoS enhancements for XR service.

WT#3: Study whether and how the following QoS and policy enhancements for XR service and media service transmission are performed:

WT#3.1: Study the traffic characteristics of media service enabling improved network resources usage and QoE.

WT#3.2: Enhance QoS framework to take media units into account (e.g., video/audio frame, Application Data Unit, control information), where media units consist of PDUs that have the same QoS requirements.

WT#3.3: Support enhancements to QoS framework considering media unit granularity (e.g. video frame/tile granularity)

WT#3.4: Support differentiated QoS handling considering different importance of media units. e.g., eligible drop packets belong to less important media units to reduce the resource wasting.

WT#3.5: Study architecture enhancement/QoS adjustment to support trade-off among throughput and latency, with reliability and device battery life.

NOTE3: Coordination with RAN WGs may be needed for above bullet.

Considering that, it would be better to add one bullet as:

Study the potential RAN enhancements to support QoS framework enhancements for XR service e.g. support differentiated QoS handling considering different importance of media units.

19 – Sony Europe B.V.

We are fine with the proposal.

20 – NEC Corporation

We support to have a two quarters SI before the WI, and we agree to study the KPI and QoS related issues in the SI stage for RAN understanding.

Regarding the XR specific traffic handling, we think RAN1 should also be involved in the study.

21 – China Mobile Com. Corporation

We are generally fine with the revised objective.

22 – Beijing Xiaomi Mobile Software

we are generally fine with the proposed objectives for XR-awareness in RAN to be led by RAN2. However, in the 2nd bullet, the areas for study are not explicitly mentioned. Or the flow synchronization can be added as an example to make it clear. We also suggest add RAN1 as secondary working group in addition to RAN2 as we think some aspects may need RAN1 involvement.

<p>23 – SHARP Corporation</p> <p>We are fine with the proposed objectives.</p>
<p>24 – China Unicom</p> <p>We are fine with moderator’s proposal.</p>
<p>25 – Guangdong OPPO Mobile Telecom.</p> <p>We are generally fine with proposal. In our understanding, it is premature to limit detailed XR traffic characteristics and XR-specific traffic handling mechanism now, so other enhanced technics to improve XR transmission capacity or power saving other than examples should not be excluded.</p> <p>In addition, XR-awareness in RAN is associated with RAN2 directly, However, we are not clear whether there is some RAN1 work to evaluate or identify XR-specific handling mechanism.</p>
<p>26 – MediaTek Inc.</p> <p>Generally ok with the two bullets, however, we would recommend getting rid of the examples - it seems everyone wants their specific items to be listed, but the bottom line is it is premature to do so and this is very much dependent on the work of SA2+SA4 as well, so we should also indicate that.</p> <p>Proposed Study Item objectives (RAN2): (in coordination with SA2/SA4)</p> <ul style="list-style-type: none"> - Study and identify the XR traffic characteristics and application layer attributes beneficial/feasible for the gNB to be aware of. - Study potential XR-specific traffic handling mechanisms.
<p>27 – MediaTek Inc.</p> <p>One further clarification is that both UL and DL traffic are in scope</p>
<p>28 – Fujitsu Limited</p> <p>The scope looks good. Some companies seem to propose to remove “e.g...” but we think it should be kept as the rapporteur is suggesting since it is the stable consensus after the Rel-18 is started and many discussions are taken. Some addition is acceptable to us e.g. adding packet dropping, which is suggested by some companies above.</p>
<p>29 – Philips International B.V.</p> <p>We agree with Ericsson</p>

2.2 Study Item scope for XR-specific Power Saving

Proposed Study Item objectives:

- Study XR specific power saving techniques to accommodate XR service periodicity and jitter, and XR-specific multi-flow aspects. In particular:
 - C-DRX enhancement, including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc.

(RAN1, RAN2);

- XR-specific multi-flow aspects considering different flows' delay budget and reliability, and synchronization requirements (RAN1);
- Potential enhancements to PDCCH monitoring (RAN1).

Feedback Form 5: Study Item objectives for XR-specific Power Saving

1 – Ericsson LM

In general, we do not think we should limit what RAN1 and RAN2 should look at during the study item phase. By limiting which group studies something, we are already fencing the potential solutions which could be applicable already in the study item phase. So, at this stage, we would rather leave all bullets for RAN1 and RAN2 to look at, but in particular the second sub-bullet (XR-specific multi-flow aspects) should also list RAN2.

2 – CATT

The objective is too limited and might not align with the UE power saving results during the XR study. We also commented that C-DRX enhancement would have slight benefit of UE power saving for XR services but could be detrimental of UE power consumption to other services, such as eMBB data service with robust data arrival. The multi-flow aspects are optional in the XR evaluation during XR study. The multi-flow aspects are not only associated with works in SA2/SA4 and also in the commercial XR software for XR client and server. The commercial software might not provide the multi-flow XR packet to RAN. Thus, we should deprioritize the multi-flow aspect in XR work. The potential power techniques should align with XR study results. Our suggestions of modification as follows,

Study XR specific power saving techniques to accommodate XR service periodicity and jitter, ~~and XR specific multi-flow aspects~~

- C-DRX enhancement in support of XR services, ~~including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc.~~ (RAN1, RAN2);
- ~~XR-specific multi-flow aspects considering different flows' delay budget and reliability, and synchronization requirements (RAN1);~~
- Potential enhancements to PDCCH monitoring reduction (RAN1).

3 – Nokia Corporation

We are fine with the moderator proposal

4 – Samsung Research America

We think there is no fundamental issue to include the first bullet point (C-DRX enhancements) into the SI objectives. Adjustments to C-DRX cycles, starts offsets & timers to better fit XR frame rates and jitter could be considered low effort core specification-wise.

We do not support inclusion of the second (multi-flow) and third (PDCCH monitoring) bullet points into the SI objectives. Multi-flow aspects like synchronization requirements are better folded into 2.1, e.g., they are part of XR traffic characteristics. For XR & PDCCH, it has not been shown during the R17 SI that PDCCH monitoring suffers from any undue impact when scheduling XR. This is hardly surprising given the large XR payloads and relatively small number of concurrent XR users & their associated streams being serviceable in a cell capacity-wise.

We propose either one of the following two approaches (A or B) for the SI objectives,

(A) Delete 2nd (multi-flow) and 3rd (PDCCH) bullet points, but keep the 1st (C-DRX) bullet

Or, leave the specific techniques for evaluation in RAN1&2 during the SI phase open without trying to narrow it down here to specific (possibly controversial techniques).

(B) “Study feasibility and benefits of XR-specific power consumption reduction techniques suitable to XR traffic periodicity and jitter.”

5 – Futurewei Technologies

We have similar opinion as Samsung that it is premature to limit the schemes for study, especially since there is no conclusion from the ongoing R17 XR SI. Furthermore, periodicity and jitter is not the only characteristics of the XR traffics that will impact the study. Therefore, we suggest the following revision of this objective based on Samsung’s approach B:

Identify and study feasibility and benefits of power consumption reduction techniques suitable to XR traffic traffic

6 – Facebook

We are fine with the proposals.

7 – Apple Europe Limited

○ The proposal overall looks good. On the third bullet, “Potential enhancements to PDCCH monitoring (RAN1)”, we proposed to consider also control signaling enhancements, e.g., as embedded in SPS resource occasion. Note if we can read the third bullet in a broad way, we can also study various enhancements including control signaling enhancements in the SI/WI stage.

○ One the second bullet “XR-specific multi-flow aspects considering different flows’ delay budget and reliability, and synchronization requirements (RAN1);” XR-specific multi-flow aspects, delay budget, and also synchronization requirements are all more controlled by RAN2; so RAN2 should be involved if not the lead for this sub-item.

8 – InterDigital

We are ok with FL’s proposed objectives. For the second bullet, similar to Ericsson and Apple, we think RAN2 should also be involved in the XR-specific multi-flow topic for power saving.

9 – AT&T

We agree with the comment from others that the second bullet could potentially heavily involve RAN2 as well.

10 – HuaWei Technologies Co.

We largely share the view from CATT. We understand the enhancements for C-DRX and PDCCH monitoring to accommodate XR service periodicity and jitter have already been evaluated a bit in RAN1 study and were supported by many companies in previous rounds of discussion. However, for the multi-flow aspects, it is unclear what kind of specific enhancements and impacts needs to be addressed here. We understand the power saving is per UE and not dependent on a per flow granularity. This was not discussed before and not well justified. We do not think it is already mature enough to list as an explicit item and suggest to remove them.

In addition, we think even if the techniques need study, we do not think it is good to expand the scope too broad. In this case the study will be time consuming in WG-level without clear target. As Vodone

also pointed out in the first round, the overall gains of power saving could be marginal considering the XR traffic characteristics and we do not think this is the top priority for XR, and the scope should be well controlled.

11 – Qualcomm Korea

On first bullet on CDRX enhancement, during R17 XR SI, companies have identified issue (of *periodicity mismatch*) and evaluated enhanced CDRX mechanisms addressing the issue and accordingly showed the improved power saving gains. In this sense, we think there is good amount of consensus on that. Solutions wise, we think RAN1 should keep it **open so companies can study different approaches for CDRX enhancement**.

Another issue RAN1 has identified is *jitter* of XR traffic arrivals. Companies have submitted evaluation results showing impact of jitter and potential power saving gain improvement from jitter handling mechanisms. In this sense, we believe that there is good amount of consensus on identified jitter problem and understanding on its impact on capacity and power. However, regarding the potential solutions to handle jitter, there is no clear consensus. **The potential solutions should be kept open for R18 XR study** and should be further studied in RAN1 during R18. It is premature to include only PDCCH monitoring – R17 PDCCH skipping is still on-going. We see that enhanced WUS is an effective way of handling jitter – allowing gNB sends eWUS to indicate immediate UE wake up after traffic arrives. We agree with other companies view that the SI scope should be open for study detailed solutions.

On XR-specific multi-flow aspects and their synchronization requirements, there has been **no problem identification related to multi flow from power perspective in R17 XR SI RAN1, and no company has submitted power results in RAN1 based on multi streams model**. Furthermore, it is not clear if 5G should do anything beyond the mechanisms already available to handle multiple flows. To us, it is not clear why this issue is related to Power savings; there was no discussion at all in RAN1. We suggest that this bullet item be dropped in power section. The multi-flow aspect (scheduler enhancement based on application layer information) should be moved to capacity or QoS section.

We think given that XR traffic is periodic, SPS/CG like approaches should be studied from power perspective. Especially, we see that frequent UL traffic is an important issue from power perspective. CG like solution could be studied to better support frequent UL traffic.

Based on the above discussion, we propose the following modifications.

- Study XR specific power saving techniques to accommodate XR service ~~periodicity and jitter, and XR-specific multi-flow aspects~~. In particular:
 - o C-DRX enhancement to handle XR periodicity mismatch (RAN1, RAN2), ~~including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc. (RAN1, RAN2)~~;
 - o Jitter handling mechanisms, e.g., potential enhancements to PDCCH monitoring, enhanced WUS (RAN1), etc.
 - o ~~XR-specific multi-flow aspects considering different flows delay budget and reliability, and synchronization requirements (RAN1)~~;
 - o Handling frequent XR traffic, e.g., with potential enhancement on SPS/CG/etc.

12 – Intel

The first sub-objective on CDRX enhancement looks fine to us. However the 2nd sub-objective is not clear e.g. what specific enhancement is targeted considering multi-flow aspects. The main objective already captures that the multi flow aspects should be taken into account in general for enhancements. On the other hand, for the 3rd sub-objective, Rel-17 PS WI is specifying PDCCH monitoring adaptation techniques

which include both SSSG switching and PDCCH skipping, and it seems flexible enough to accommodate different traffic characteristics by suitable configuration from gNB. To this end, we think proposed enhancement to CDRX configuration is sufficient for now.

“Study XR specific power saving techniques to accommodate XR service periodicity and jitter, and XR-specific multi-flow aspects. In particular:

○ C-DRX enhancement, including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc.

(RAN2, RAN1);

~~XR-specific multi-flow aspects considering different flows delay budget and reliability, and synchronization requirements (RAN1);~~

~~Potential enhancements to PDCCH monitoring (RAN1).~~

13 – Motorola Mobility España SA

We are fine with the scope. For the second sub-bullet, RAN2 involvement might be useful/needed.

14 – vivo Mobile Communication Co.

We are generally fine with the proposed objectives for XR-specific power saving here.

Although we should not limit the scope to any specific technique at this moment, we think it is helpful to focus by keeping current sub-bullets as potential areas of study.

A minor modification to the 2nd sub-bullet is that RAN2 should be also involved.

- Study potential XR specific power saving techniques to accommodate XR service periodicity and jitter, and XR-specific multi-flow aspects. In particular:
 - C-DRX enhancement, including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s) etc. (RAN1, RAN2);
 - XR-specific multi-flow aspects considering different flows' delay budget and reliability, and synchronization requirements (RAN1, RAN2);
 - Potential enhancements to PDCCH monitoring (RAN1).

15 – NTT DOCOMO INC.

We share a similar view as Qualcomm.

For C-DRX enhancements, the issue of XR periodicity mismatch has been identified and it should be studied. To study the solutions, it is better to keep it open for now. For jitter handling, it should be kept open as well. For example, enhanced PDCCH monitoring and enhanced wake up indication can be considered.

- C-DRX enhancement to handle XR periodicity mismatch (RAN1, RAN2)
- Jitter handling mechanisms, e.g., potential enhancements to PDCCH monitoring, enhanced WUS (RAN1)

16 – Sony Europe B.V.

We are fine with the proposal.

17 – NEC Corporation

We generally agree with the moderator's proposal. However we think RAN2 should also be involved in the study of the second sub-bullet, i.e., XR-specific multi-flow aspects.

<p>18 – China Mobile Com. Corporation</p> <p>We are generally fine with the proposal.</p>
<p>19 – Beijing Xiaomi Mobile Software</p> <p>We are generally fine with moderator proposal. However, the objective at this stage should not limit people to a certain technique. For bullet one, we suggest to remove” including C-DRX cycle(s), C-DRX start offset(s), C-DRX timer(s)”.</p>
<p>20 – SHARP Corporation</p> <p>We are fine with the moderator’s proposal. Also, we agree with other companies that RAN2 would be involved in the study of the 2nd sub-bullet.</p>
<p>21 – Guangdong OPPO Mobile Telecom.</p> <p>We are generally fine with proposal and share view with Ericsson and Apple, RAN2 should be involved in the XR-specific multi-flow topic.</p>
<p>22 – LG Electronics Inc.</p> <p>Similar to the XR-specific capacity, we prefer the SI objectives to be more accommodating to the potential enhancement techniques as they can only be justified by the end of the SI phase.</p> <p>For the XR-specific considerations, considering the XR-specific characteristics/requirements for a single-flow such as latency and reliability should have a higher priority than the multi-flow aspects.</p> <p>The multi-flow aspects can only be considered “if time allows”. RAN2 should be involved in this case.</p> <p>We suggest the SI objective to be more general as follows:</p> <p>Study XR-specific power saving techniques to accommodate XR-specific traffic characteristics including periodicity, jitter, latency and reliability requirement. (RAN1, RAN2)</p>
<p>23 – Philips International B.V.</p> <p>We are ok with the rapporteur’s proposal.</p>
<p>24 – MediaTek Inc.</p> <ul style="list-style-type: none"> - C-DRX: RAN2 should be in charge i.e. (RAN2, RAN1). The list of CDRX components should be removed. - Multi-flow: RAN2 involvement is required, if this stays in
<p>25 – Philips International B.V.</p> <p>We are ok with the rapporteur’s proposal.</p>

2.3 Study Item scope for XR-specific capacity considerations

Proposed Study Item objectives:

- Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter. In particular:
 - Study enhancement to SPS and CG and dynamic scheduling, e.g. dynamic adaptive SPS/CG parameter update, multi-TB SPS and CG, HARQ-ACK enhancements, etc... (RAN1);
 - Study potential XR-specific resource allocation and scheduling enhancement for dynamic grants such as dynamic multi-TB scheduling, enhanced buffer status report, link adaptation. (RAN1).

Feedback Form 6: Study Item objectives for XR-specific capacity considerations

1 – DOCOMO Communications Lab.

We are generally fine with the FL proposal to study potential enhancements for SPS/CG and dynamic scheduling. However, we propose two updates to the objectives as follows.

Firstly, the principle to divide the two sub-bullets is not clear to us because both bullets targets for scheduling enhancements including dynamic grant scheduling and semi-static scheduling. Therefore, they should be consolidated to single bullet.

Secondly, ‘dynamic multi-TB scheduling’ in the 2nd sub-bullet has already been agreed to be supported for FR2-2 in Rel-17 52.6GHz WI. Thus, target frequency range should be clarified for ‘dynamic multi-TB scheduling.’ For example, ‘dynamic multi-TB scheduling for FR1 and FR2-1.’ Besides, as multi-PUSCH scheduling is supported in Rel-16 NR-U, it should also be taken into account when discussing ‘dynamic multi-TB scheduling.’

2 – Ericsson LM

We are in general fine with the proposal. But we do not see the need to limit which group should study solutions, hence RAN2 should also be listed for these objectives. CG/SPS is also specified in RAN2 and there could be solutions there to study. Similarly, dynamic grant mechanisms are also specified in RAN2. In overall, we do not see “capacity” as an exclusive area to be investigated by RAN1, but rather by both groups.

In response to Docomo’s comment suggesting that it is only for single-cell: It is our understanding that multi-TB scheduling based on dynamic grant is limited to single cell in today’s spec. Considering the high rate requirements of XR, it will be beneficial to study the potential extension of existing multi-TB scheduling to multi-cells especially in an intra-band case.

3 – ZTE Corporation

We agree with the second sub-bullet of study item scope for XR-specific capacity considerations. For the second sub-bullet, saying that enhancement for dynamic grants, according to RAN1#106b-e meeting, discussion on observations for enhancement was done.

We prefer to progress on the elaboration of the discussed working areas e.g. the directions falling into XR-specific enhancement as following:

Adaptive inter-UE multiplexing: When XR service accesses current network, adaptive inter-UE multiplexing techniques is capable of multiplexing XR services with existing services, including, e.g., uRLLC, eMBB and so on, to address XR coexistence with current eMBB and uRLLC.

Delta MCS: Since the packet size of XR service is large, the MCS is one important factor which will affect the resource utilization and system performance. A proper MCS is capable of maximize resource utilization ratio while meeting BLER requirements. Reporting delta MCS can be considered to help gNB obtain an accurate MCS value..

Network coding: Network coding can be considered to exploit link diversity and achieve lower packet error rate. RAN protocol stack enhancements are needed for network coding.

For the first sub-bullet, saying that SPS/CG enhancement, we prefer to postpone XR specific SPS and CG pending sufficient RAN1 evaluation results and conclusion.

Therefore, we prefer to the proposal for Study Item objectives on capacity as follows.

Proposed Study Item objectives:

l *Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter. In particular:*

v *Study potential XR-specific resource allocation and scheduling enhancement for dynamic grants such as dynamic multi-TB scheduling, enhanced buffer status report, link adaptation, **adaptive inter-UE multiplexing, delta MCS, network coding.** (RAN1).*

*Study enhancement to SPS and CG and dynamic scheduling, e.g. dynamic adaptive SPS/CG parameter update, multi-TB SPS and CG, HARQ-ACK enhancements **if there are sufficient RAN1 evaluation results and conclusion** (RAN1);*

4 – CATT

We are OK in principle of the objective for capacity enhancement. However, the proposed enhancement of DL SPS, UL CG and dynamic grant are based on the data arrival at gNB with XR-application awareness. The XR-application awareness based on UE feedback during the XR service request and the radio bearer establishment should be included in the objective. Thus, we proposed to have additional sub-bullet

- Study the UE feedback of XR-application specific traffic characteristic and attribute and receiver buffer for the handling of out-of-order packet arrival to the gNB for the assistance of gNB scheduling. (RAN1)

5 – Nokia Corporation

The resulting scope may be too large to properly study all the aspects (and potentially decide to specify some of those) within a given timeline to ensure we can also have normative work in Release 18. We also see that some formulations are now at rather general level and/or not fully connected with the specifics of the XR services. We would like to prioritize the commonly-agreed solutions that have a direct connection to the XR services, while more general solutions related to e.g., link adaptation, HARQ-ACK, enhanced buffer status report are better to be studied in other WIs. We also see that scheduling and resource allocation, including SPS and CG have a strong RAN2 impact rather than exclusively related to RAN1

6 – Samsung Research America

We are generally supportive of the proposed SI objective by the FL in the main bullet. It does not make sense however to include an explicit list of very specific candidate techniques like currently shown in the two sub-bullet points for SPS/CG and DG. There is no need. There is widespread support to include enhancements for both DG and SPS/CG in the R18 XR SI phase. Any further discussion and conclusion on whether a particular proposal like dynamic / adaptive SPS / CG update or multi-TB scheduling is a suitable capacity enhancement for XR services should be left to evaluations in the SI phase. For example, it is doubtful for us if the efficiency gains from multi-TTI PUSCH in FR2-2 due to the higher data SCS and larger resulting Tx-Rx switching time overhead with analog BF translate “as is” into gains with XR services in FR1 or FR2-1. Similar can be said about the gains motivating the use of multi-TTI PUSCH in presence of LBT in

the unlicensed bands with eLAA and NR-U. Certainly other companies may have different views on this particular proposed technique, but the point is that we should not try today to anticipate the conclusions of the SI evaluations when looking at a particular proposed technique while formulating the SI objectives. We think that any enhancements to DG and/or SPS/CG providing quantifiable benefits and reasonable complexity to provide more efficient resource allocation and scheduling for XR should be left in scope for the SI phase.

We propose to just keep the main bullet from the FL proposal,

“– Study mechanisms based on dynamic and configured grants that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter.”

Then, we should also explicitly clarify if the main bullet allows for RA and scheduling enhancements with single cell only and/or CA-based. R17 SI evaluations are clearly indicative of very meaningful capacity gains in presence of CA, e.g., due to larger BW, more significant relative gains are observed in FR2. Whether these necessitate enhancements to scheduling is a different question. We think that the R18 XR SI objective should preclude any CA-specific scheduling enhancements to improve XR to avoid diluting the scope of the SI. We recommend to include a statement in this sense in the objective.

7 – Apple Europe Limited

The proposal looks fine. We expect some aspects need RAN2’s inputs as well, such as ADU status for uplink, MAC procedures for CG/SPS, BSR, etc. From that, we suggest to add RAN2 as secondary group to this objective.

8 – Futurewei Technologies

We have similar opinion as Samsung that it is premature to limit the schemes for study, especially since there is no conclusion from the ongoing R17 XR SI. We fail to see any reason to limit the study to resource allocation and scheduling as proposed here. The identification of enhancements should be the outcome of the study. Furthermore, there is no study or justification that periodicity and jitter is the characteristics of the XR traffics that degrade the system capacity, at least not for dynamic scheduling. If any specific scheme to be explicitly listed, it should come from the candidates the companies evaluated during the R17 XR SI. Therefore, we suggest to revise the objective to be very general as following:

Identify and study feasibility and benefits of capacity enhancement techniques suitable to XR traffic traffic

9 – InterDigital

We are generally fine with FL’s proposed objectives for capacity, although some clarification/consolidation may be useful such that the sub-bullets can be associated for studying enhancements for dynamic scheduling and semi-static scheduling (SPS/CG) techniques. For both sub-bullets, we think RAN2 should also be involved, to study the potential signaling and procedures for supporting enhancements for dynamic scheduling and semi-static scheduling

10 – AT&T

We agree with the comment from others that the sub-bullets could potentially heavily involve RAN2 as well.

11 – HuaWei Technologies Co.

For the capacity enhancements, the scope is too large and many of them are not XR specific. For example, multi-TB SPS/CG, HARQ-ACK enhancement, enhanced buffer status report, and link adaptation are not

relevant to address XR specific non-integer periodicity and jitter. It is unclear why these enhancements need to be considered under XR.

Regarding to XR-specific SPS/CG enhancement, XR frame size can be very large and vary over time, which may not be suitable for SPS/CG transmission. On the other hand dynamic scheduling may well handle the non-integer periodicity and jitter issues but the overhead of control signaling would be larger than SPS/CG. Thus we doubt whether there are sufficient gains to pursue all these enhancements. In general we think the higher layer E2E mechanism is more useful to enhance the capacity to have more efficient scheduling and radio resource management.

If companies really want to do the study, we think the scope should be controlled and we suggest to update the previous wording as below:

Study feasibility and benefits for the potential capacity enhancement techniques **by taking the QoS and application awareness information into account: XR-specific resource allocation and scheduling enhancement, including DG and SPS/CG enhancements to address XR-specific non-integer periodicity and jitter.**

12 – Qualcomm Korea

We agree with the high-level objective. However, we think SI scope for capacity should be kept open given that R18 XR is SI for studying potential solutions. What has been evaluated during R17 XR SI are related mostly to section 1.1 XR-awareness in RAN. What is captured in 1.3 have never been evaluated during R17 XR SI. Although we see that there is good amount of support for CG/SPS/DG scheduling-based enhancement, given that there has been not much evaluation of any of these items, we propose to capture only those high level areas and keep the detailed scope open for detailed capacity enhancement techniques with proper evaluation in R18 XR SI.

13 – Intel

Agree in principle. We think first and second sub-objectives have some overlap such as both include dynamic scheduling. Perhaps, first sub-objective can be revised as follows so that focus remains on SPS and CG only:

*“- Study enhancement to SPS and CG **transmission** and ~~dynamic scheduling~~, e.g. dynamic adaptive SPS/CG parameter update, multi-TB SPS and CG, HARQ-ACK enhancements **for SPS**, etc [RAN1, RAN2]*

14 – Motorola Mobility España SA

The scope of link adaptation seems to be large considering the situation in Rel-17 CSI for URLLC agenda item. To achieve a meaningful study conclusion, we suggest providing detailed scope for link adaptation or removing it. In addition, we propose the following updates ((a) remove ‘dynamic scheduling from 1st sub-bullet’ as there is a separate sub-bullet for dynamic scheduling, (b)add ‘RAN2’ in the second sub-bullet as BSR is related to RAN2):

– Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter. In particular:

- Study enhancement to SPS and CG ~~and dynamic scheduling~~, e.g. dynamic adaptive SPS/CG parameter update, multi-TB SPS and CG, HARQ-ACK enhancements, etc... (RAN1);
- Study potential XR-specific resource allocation and scheduling enhancement for dynamic grants such as dynamic multi-TB scheduling, enhanced buffer status report, link adaptation. (RAN1, RAN2).

15 – vivo Mobile Communication Co.

For the main bullet, we think not only XR specific traffic periodicity and jitter needs to be handled, but also other XR traffic characteristics like variable frame size should be considered. These all motivate more efficient resource allocation and scheduling. We suggest to either modify to a general description or add more XR traffic characteristics to be addressed.

For the sub-bullets, the scope of the objectives seems to be too general, which may result in different understandings on the scope when the groups start the study. Besides, a too wide scope may also increase the difficulty of complete the study properly within the limited time, such that the time for normative work may also be affected.

We propose to consolidate the scope as follows

- Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic characteristics. In particular:
 - o Study enhancement to SPS and CG, e.g. dynamic adaptive SPS/CG parameter update, etc. (RAN1);
 - o Study enhancement for dynamic grants e.g., enhanced dynamic multi-TB scheduling, enhanced buffer status report, etc. (RAN1, RAN2).

16 – Sony Europe B.V.

We are fine with the proposal.

17 – NEC Corporation

We generally agree with the moderator's proposal. However we think RAN2 should also be involved in the study of both the two sub-bullets.

18 – CEWIT

We support the proposal in general. We align with Intel's opinion that there is lot of overlap between the first and second sub bullets. Segregating the SPS/CG enhancements and dynamic scheduling as separate sub bullets will add clarity.

19 – VODAFONE Group Plc

We agree with vivo's comment on the variable frame size, and as commented on the first round to also take into account bursts of IP packets arriving at the gNB with non-integer ms periodicity. Also agree that there may be an overlap between the two objectives, Intel's formulation on the first objective seems OK, and adding RAN2 to the second objective should be done too as commented by other companies

20 – China Mobile Com. Corporation

We share tsimilat view that RAN2 should be included as the secondary group for such study.

21 – Beijing Xiaomi Mobile Software

We are generally fine with moderator proposal but prefer a more general description on the potential enhancements, e.g. leaving only the main bullet. RAN2 can be the secondary group for this objective

22 – SHARP Corporation

We are fine with the moderator’s proposal.

23 – Guangdong OPPO Mobile Telecom.

We are generally fine with proposal. However, we are not clear why dynamic scheduling is included in the first sub-bullet. In our understanding, the first sub-bullet focuses on SPS/CG enhancement and the second-bullet focuses on dynamic scheduling. So, we suggest to delete “dynamic scheduling” in the first sub-bullet. In addition, we think RAN2 should be involved in both sub-bullets.

24 – LG Electronics Inc.

The XR-specific traffic characteristics to be considered for XR-specific capacity enhancements should include the variable packet size as well as the periodicity and jitter.

We also think the SI objectives should be more accommodating to the potential enhancement techniques as they can only be justified by the end of the SI phase.

Lastly, the enhancements to SPS/CG and dynamic scheduling should involve RAN2.

So, we suggest the SI objective to be more general as follows:

Study enhancements to SPS/CG and dynamic scheduling for XR services to handle XR specific traffic characteristics including periodicity, jitter and variable packet sizes. (RAN1, RAN2)

25 – Philips International B.V.

We agree with Ericsson

26 – Fujitsu Limited

The scope looks almost good. As for the enhanced buffer status reporting (“eBSR”), RAN2 needs to be involved. If this scope is only limited to RAN1, the wording “eBSR” should be removed, otherwise RAN2 would be added as a second WG in the scope.

27 – Philips International B.V.

We like the proposal from CATT and we also agree with Ericsson

28 – MediaTek Inc.

RAN2 involvement is necessary. We also share the view expressed by Nokia.

3 Final round - now closed

The way forward is to start with a **6 month Study Item** first, followed by a Work Item.

The focus henceforth is to finalize the scope of this Study Item.

3.1 Study Item scope for XR-awareness in RAN

Proposed Study Item objectives (RAN2):

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, and how this information aids XR-specific traffic handling. Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference
- Study the gains of potential XR-specific RAN-centric mechanisms.
- Study how XR-specific information aids XR-specific traffic handling.

Feedback Form 7: Final comments on objectives for XR-awareness in RAN

1 – AT&T

We are OK with the proposed SI objectives.

2 – Nokia Corporation

First we agree with the 6 months in general, but if we consider that RAN1 is starting earlier than RAN2, then perhaps study until end of 2022 would allow 2 quarters also for RAN2. And then WI could start from Q1/2023.

Second observation is that this "study how XR-specific information aids XR specific traffic handling" is now mentioned twice

3 – HuaWei Technologies Co.

We think the examples should be kept, these examples have been discussed and acknowledged widely and it is helpful for companies to understand what kind of aspects need to be taken into account in WG discussion. The moderator's proposal in the intermediate round seems already stable and the majority of companies seem to be fine with it. In our observation more than 14 companies supported that version and only 3 companies think examples can be removed. We therefore think the version in the intermediate round is more reasonable, which is also consistent with the formulating way that is used for power saving and capacity.

Regarding the bullet of study the gains of the mechanism, it is unclear what kind of gains needs to be studied. If the gains here refers to capacity, it should be then considered under capacity evaluation without listing here; otherwise we do not see this is needed as the benefits are clear that QoS management can be better by using enhanced E2E mechanism.

In summary we suggested the below:

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, and how this information aids XR-specific traffic handling (e.g. **the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS etc.**). Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference
- **Study the gains of potential XR-specific RAN-centric mechanisms** (if capacity gains need to be justified, this can be discussed under capacity).
- Study how XR-specific information aids XR-specific traffic handling.

4 – Ericsson LM

The proposals are fine in general.

Nevertheless, we see some clarification needed in the first subbullet. First, as we commented in the 2nd round input, RAN cannot decide the feasibility of having application layer attributes and information but it should be studied in SA2 and SA4. We therefore suggest to remove "feasible".

Second, Rel-18 SA2 has not started so that there is still uncertainty on if SA2 needs RAN support or not. Last, RAN2 is owner of RAN2 solutions and not SA2. If SA2 highlights a problems to RAN2, it is up to RAN2 to decide the solutions to address the issue. We do not think we can give a blank check to SA2 that RAN2 will blindly implement any ideas that SA2 might have. Therefore, we propose to remove the last sentence of the first bullet. Alternatively, (instead of completely removing it) we could change it to that RAN should consider the outcome of the SA2 study.

To summarize, we think we should do these changes:

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/~~feasible~~ for the gNB to be aware of, and how this information aids XR-specific traffic handling. ~~Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference~~

5 – CATT

We are OK with the objective. However, RAN1 needs to be included in this study for the techniques of NR capacity enhancement and UE power saving.

6 – Samsung Research America

We are ok with the first bullet.

The second bullet is "study capacity gains from QoS awareness", but we have already study item scope #3 where any technique with potential for XR capacity gains is evaluated. Exploiting QoS awareness and scheduling gains is one of them. So this second bullet might be redundant.

The third bullet seems to be captured by the first, so it might make sense to remove this one as well.

Regarding timeline, as commented also by Nokia, allowing 6 months for both RAN1 and RAN2 during the SI phase makes good sense. Overall, it is the future SA2/4 timeline that will determine when and how RAN2 parts of the SI can be meaningfully addressed for QoS awareness. So the start and duration of the RAN SI phase should be chosen accordingly.

7 – Futurewei Technologies

We are fine with the first bullet.

We wonder if the 2nd and 3rd bullets can be combined as "study RAN-centric mechanisms to aid XR traffic handling based on XR-specific information"?

8 – Facebook

In general, we are fine with the overall ideas. However, it is probably better to further clarify the bullet 2 and bullet 3, for example it's RAN adaptive the application related KPI/parameters or the other way round or both. It helps organize the work between RAN2 and SA2.

9 – MediaTek Inc.

First bullet: We support removing "feasible" as proposed by Ericsson

Second bullet: What does this bullet refer to? Which mechanisms and which gains? Is this related strictly to the work on capacity and/or on power saving in the other objectives? If so, then we'd suggest removing this bullet altogether. If not, then we'd suggest to remove it as well for it is indefinite in its current form.

Third bullet: We're not quite sure to understand what this means, given the first bullet should identify what is beneficial to the gNB, hence should characterize these benefits. It should probably be removed.

10 – InterDigital

We are generally ok with the objectives, with some comments. Regarding the first objective, we think it is useful to include the examples discussed during Intermediate round given that they provide clarification on what is meant by XR-specific traffic handling. We also have similar understanding with Ericsson for removing the second line in the first objective, since the aspects mentioned can be part of the study indicated in first line. Some repetitive content can also be removed in first objective. On the second objective, similar to others, we think the study on the gains may be considered under the scope of XR-specific capacity and/or power savings considerations.

As such, we propose the following changes:

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, ~~and how this information aids XR-specific traffic handling.~~ **E.g: the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS, etc. Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference**
- ~~Study the gains of potential XR-specific RAN-centric mechanisms.~~
- Study how XR-specific information aids XR-specific traffic handling.

11 – NTT DOCOMO INC.

We are OK with the moderator's proposal.

12 – vivo Mobile Communication Co.

We are generally fine with the 1st bullet. We also think the last sentence may be not necessary as RAN can decide what solutions to be studied

For the 2nd bullet, it is not clear what potential areas would be included for XR-specific RAN-centric mechanisms. Further clarifications are needed, otherwise it is better to change to the original objective in the intermedia round. Besides, the potential gains will be studied by the working group during the SI.

For the 3rd bullet, We think there may be redundancy between 1st bullet and the 3rd bullet. We suggest to either remove "and how this information aids XR-specific traffic handling" in the 1st bullet, or remove the 3rd bullet.

To summarize, we suggest the following modification on the scope.

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, and how this information aids XR-specific traffic handling. ~~Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference~~
- Study ~~the gains of~~ potential XR-specific RAN-centric mechanisms.
- Study ~~how XR-specific information aids XR-specific traffic handling.~~

13 – Verizon UK Ltd

Fine with the moderator’s proposal.

14 – Asia Pacific Telecom co. Ltd

We are generally fine with moderators’ proposal. There are only some suggestions to remove the redundant part. For ”how this information aids XR-specific traffic handling”, it has shown in the sub-bullet. For ”Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference”, we should focus on what RAN can do, it seems not need to add this sentence.

Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, ~~and how this information aids XR-specific traffic handling.~~ ~~Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference~~

- Study the gains of potential XR-specific RAN-centric mechanisms.
- Study how XR-specific information aids XR-specific traffic handling.

15 – Intel

We are ok with moderator’s suggestion.

16 – Motorola Mobility España SA

We are fine with the moderator’s proposal.

17 – LG Electronics Inc.

We think third the bullet is a duplication of the first bullet, and could be removed. In the first bullet, we want to add clarification on what the XR-specific handling is, e.g. scheduling, radio bearer handling, etc. Thus, our proposal is as follows.

Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, and how this information aids XR-specific traffic handling, **e.g. scheduling, radio bearer handling, etc.** Support the RAN-relevant parts of the corresponding SA2 Study Item //add SA2 reference

Study the gains of potential XR-specific RAN-centric mechanisms.

~~Study how XR-specific information aids XR-specific traffic handling.~~

18 – Spreadtrum Communications

We are fine with the current bullets in general.

However, it is out of the RAN scope to support the RAN-relevant parts of the corresponding SA2 Study Item.

19 – Apple Europe Limited

The proposal overall looks okay.

20 – Guangdong OPPO Mobile Telecom.

We are generally fine with proposal and time assignment for SI and WI.

For the first bullet, it belongs to SA2 scope that the feasibility for gNB to be aware of XR traffic characteristics, QoS metrics, and application layer attributes. So we share view as Ericsson that “feasible” should be delete. However, RAN2 study should synchronize with SA2 output and completely blind study in RAN2 should be avoided.

For the second bullet, it is not clear what gain of potential XR-specific RAN-centric mechanism. We guess that the gain means capacity gain or power saving gain. It will overlap with the 2nd and 3rd objective, so we prefer to delete it. For the third bullet, it repeats the sentence in the first bullet, so we prefer to delete it.

In addition, in our understanding, it is mainly SA2 work to study acquisition of XR traffic characteristics, QoS metrics, and application layer attributes and it is mainly RAN2 work scope how to use this information. However, there is some RAN3 specification work for information transfer. So we suggest to involve RAN3 in this objective. And we are open whether RAN3 is involved in SI stage or WI stage. We’d like to hear more companies’ view.

So we suggest to modify it as following:

Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial/feasible for the gNB to be aware of, and how this information aids XR-specific traffic handling. Support the RAN-relevant parts of based on output of the corresponding SA2 Study Item in parallel //add SA2 reference (RAN2,[RAN3])

~~Study the gains of potential XR-specific RAN-centric mechanisms.~~

~~Study how XR-specific information aids XR-specific traffic handling~~

21 – VODAFONE Group Plc

We are supportive of the moderator’s proposal

22 – Beijing Xiaomi Mobile Software

We are fine with the proposal. The subbullet 3 is redundant which can be deleted.

23 – NEC Corporation

There may be overlaps between the second and the third bullets, because the “XR-specific RAN-centric mechanisms” may already include the “XR-specific traffic handling”. So, we suggest to merge the two bullets as:

- Study potential XR-specific RAN-centric mechanisms (e.g., traffic handling aided by XR-specific information) and the gains of the mechanisms.

In addition, we think RAN1 should also be involved at least for the second and third bullets.

24 – Sony Europe B.V.

We are generally fine with the moderator proposal, but support further clarifications may be needed as proposed by a number of companies above, e.g. to clarify the scope and time planning in relation to other working groups, SA2, SA4, RAN3 and RAN1.

25 – China Unicom

We are supportive of the moderator’s proposal.

26 – ZTE Corporation

OK for progress

3.2 Study Item scope for XR-specific Power Saving

Proposed Study Item objective:

- Study XR specific power saving techniques to accommodate XR service characteristics (periodicity, jitter, latency, reliability, etc...)(RAN1, RAN2). E.g.: C-DRX enhancement, PDCCH monitoring enhancement, etc...

Feedback Form 8: Final comments on objectives for XR-specific Power Saving

1 – AT&T

We are OK with the proposed SI objectives.

2 – Nokia Corporation

We are fine with the current formulation, however we have some concerns (like some other companies also mentioned) if the scope is not narrowed at all like was proposed in earlier versions, they may be a risk for the SI schedule.

3 – HuaWei Technologies Co.

Latency and reliability are mainly targeting frequent transmission, we do not understand why these aspects would need to be taken into account into power saving and suggest to remove them. As we already stated, we do not see much sense to study everything, this would add difficulty on WG-level discussion on what to be studied and evaluated. We also don’t see consensus on other enhancements than C-DRX and PDCCH monitoring enhancements, the structure of the version in intermediate round is more reasonable and therefore we suggest the modification as below to aim at an efficient discussion in WG level:

Study XR specific power saving techniques to accommodate XR specific periodicity and jitter:

- **C-DRX enhancement**
- **PDCCH monitoring enhancement**

<p>It is also worth mentioning some enhancements, e.g. C-DRX enhancement is quite straight forward, not sure what really needs to be studied.</p>
<p>4 – Ericsson LM</p> <p>OK</p>
<p>5 – CATT</p> <p>We are OK with the proposed objective.</p>
<p>6 – Samsung Research America</p> <p>We are fine with the proposed SI objective #2 (power saving). Thank you for taking our Round 2 comments into account.</p>
<p>7 – Facebook</p> <p>We are fine with the proposals and what to re-emphasize the important of power saving techniques.</p>
<p>8 – MediaTek Inc.</p> <p>”E.g.: C-DRX enhancement, PDCCH monitoring enhancement, etc...””E.g” and ”etc.” make this objective open-ended and indefinite - this is not ok. E.g. and etc. ought to be removed so the work focuses only on C-DRX and PDCCH monitoring.</p>
<p>9 – InterDigital</p> <p>We are fine with the objective</p>
<p>10 – vivo Mobile Communication Co.</p> <p>We are fine with the proposed objective.</p>
<p>11 – Verizon UK Ltd</p> <p>Fine with the proposal</p>
<p>12 – Futurewei Technologies</p> <p>We are ok with the proposed objective</p>
<p>13 – Asia Pacific Telecom co. Ltd</p> <p>The proposed objective looks good to us.</p>
<p>14 – Intel</p> <p>We are ok with moderator’s suggestion, with minor revisions as follows:</p> <p><i>“Study XR specific power saving techniques to accommodate XR service characteristics (periodicity, <u>multiple flows</u>, jitter, latency, reliability, etc...)(RAN1, RAN2). E.g.: C-DRX enhancement, PDCCH monitoring enhancement, etc...”</i></p>

<p>15 – Motorola Mobility España SA</p> <p>We are fine with the moderator’s proposal.</p>
<p>16 – NTT DOCOMO INC.</p> <p>We are fine with the proposed SI objectives.</p>
<p>17 – Spreadtrum Communications</p> <p>We are fine with current proposal.</p>
<p>18 – Apple Europe Limited</p> <p>XR traffic’s multiple flow aspects are key to define enhancements which are actually useful for XR. Note the multiple data flows aspects are identified by both SA4 and RAN1. The proposal from the intermediate round is better. With the current formulation, we suggest to add back the reference to multiple data flows: Study XR specific power saving techniques to accommodate XR service characteristics (periodicity, multiple data flows, jitter, latency, reliability, etc...)(RAN1, RAN2). E.g.: C-DRX enhancement, PDCCH monitoring enhancement, etc...</p>
<p>19 – Guangdong OPPO Mobile Telecom.</p> <p>We are generally fine with proposal.</p> <p>We’d like to be open to any potential solutions at SI stage. However, the study goal should be clear. We guess “power saving techniques” shows the intention of this objective.</p>
<p>20 – VODAFONE Group Plc</p> <p>We share Huawei’s comment</p>
<p>21 – LG Electronics Inc.</p> <p>We are okay in general with the proposed SI objectives.</p> <p>The study should be XR-specific power saving, so we think we should keep the latency and reliability that are XR-specific.</p>
<p>22 – Beijing Xiaomi Mobile Software</p> <p>We are fine with the proposal.</p>
<p>23 – NEC Corporation</p> <p>We are fine with the proposed objective.</p>
<p>24 – Sony Europe B.V.</p> <p>We are fine with the moderator proposal.</p>
<p>25 – ZTE Corporation</p> <p>ok for progress</p>

3.3 Study Item scope for XR-specific capacity considerations

Proposed Study Item objective:

- Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc...

Feedback Form 9: Final comments on objectives for XR-specific capacity considerations

1 – AT&T We are OK with the proposed SI objectives.
2 – Nokia Corporation We are fine with the current formulation, however we have some concerns (like mentioned by some companies) if the scope is not narrowed at all, they may be a risk for the SI schedule. Topics studied here should have solid link with XR specific service characteristics and we should not study any generic capacity enhancements. This is something to consider towards RAN#94.
3 – HuaWei Technologies Co. We share similar worry on the broad scope. It is also unclear what needs to be studied from RAN1 and RAN2 respectively (this question also applies to power saving). In addition, as we commented in 3.1, it is unclear what kind of gains need to be studied for 3.1. If it refers to capacity gains, is the intention of study for capacity to figure out solutions which have significant capacity gains?
4 – Ericsson LM OK
5 – CATT We believe that "UE feedback" is a key element for the XR-application awareness of XR traffic characteristic and application attribute for the proposed techniques of NR capacity enhancement and should be included.
6 – Samsung Research America We are fine with the proposed SI objective #3 (capacity). Thank you for taking our Round 2 comments into account.
7 – Facebook We are ok with the proposals.
8 – MediaTek Inc. Same comment as above.

"E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc...": "E.g" and "etc." make this objective open-ended and indefinite - this is not ok. E.g. and etc. ought to be removed so the work focuses only on Enh. to SPS and CG, enh. for dynamic grants.

9 – InterDigital

We are fine with the objective

10 – NTT DOCOMO INC.

We are OK with the moderator's proposal

11 – vivo Mobile Communication Co.

Generally we are fine with the proposed objective.

However, although we understand that the SI should be open for any potential solution, we share the similar view with other companies that the scope may be too wide to complete the SI in time.

Besides, as we commented in the intermedia round, we should also take into account variable packet size, latency, reliability of XR traffic for the study. One possible modification is to align with the objective of power saving.

- Study mechanisms that provide more efficient resource allocation and scheduling for XR services to accommodate XR service characteristics (periodicity, jitter, latency, reliability, etc...) ~~to handle XR specific traffic periodicity and jitter~~ (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc...

12 – Verizon UK Ltd

Fine with the proposal

13 – Futurewei Technologies

We are general ok with the proposed objective and suggest to align this one with that for power saving as the following:

Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR **service characteristics** ~~specific traffic~~ (periodicity, ~~and jitter~~, **latency, reliability, etc.**) (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc..

14 – Asia Pacific Telecom co. Ltd

The proposed objective looks good to us.

15 – Intel

We are ok with moderator's suggestion, with minor revisions as follows

"Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic characteristics, such as periodicity and jitter, multiple flows, latency, reliability (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc..."

16 – Motorola Mobility España SA

We are fine with the moderator's proposal.

17 – Spreadtrum Communications

We are fine with the proposal. However, we think the definition of capacity shall be clarified further, the column of data, or the number of supported XR users.

18 – Apple Europe Limited

XR traffic's multiple flow aspects are key to define enhancements which are actually useful for XR. Note the multiple data flows aspects are identified by both SA4 and RAN1. The proposal from the intermediate round is better. With the current formulation, we suggest to add back the reference to multiple data flows: Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR **service characteristics** specific traffic (periodicity, **multiple data flows**, and jitter, **latency, reliability, etc.**) (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc..

19 – Guangdong OPPO Mobile Telecom.

We are generally fine with proposal.

Similar as 3.2, we'd like to clarify that study goal for this objective is capacity improvement, which will be a criterion to select techniques to be specified. Moreover, any solution to improve capacity, e.g. UE-assistance information, can be considered in this objective. So we suggest to modify it as following:

Study mechanisms that provide efficient resource allocation and scheduling to handle XR specific characteristics to handle XR specific traffic periodicity and jitter E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, UL scheduling enhancement etc. (RAN1, RAN2).

20 – VODAFONE Group Plc

We are generally fine with the proposal however we share the same comment as Vivo on taking into account variable packet size, latency, reliability of XR traffic for the study

21 – Beijing Xiaomi Mobile Software

We are fine with the moderator proposal.

22 – LG Electronics Inc.

The XR-specific traffic characteristics to be considered for XR-specific capacity enhancements should include the variable packet size as well as the periodicity and jitter.

So, we suggest to modify the SI objective as follows:

Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic **periodicity, and jitter, latency, reliability and variable packet size** (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc.

23 – NEC Corporation

We are fine with the proposed objective.

24 – Sony Europe B.V.

We are fine with the moderator proposal

25 – CEWiT

We are fine with the proposal.

26 – ZTE Corporation

XR traffic features not only quasi-periodicity, jittering but also variable/large packet size. For dynamic grant enhancement, the efficient resource allocation and scheduling shall not only deliver the aforementioned characteristics yet increased capacity outlook as well. We prefer to capture at least the following examples in the dynamic grant enhancement for better rollout of the study phase.

Adaptive inter-UE/intra-UE multiplexing: When XR service accesses network, adaptive inter-UE multiplexing technique is capable of multiplexing XR services with existing services, including, e.g., uRLLC, eMBB and so on, to address XR coexistence with concurrent eMBB and uRLLC. Intra-UE multiplexing techniques can address the cases when multiple UEs are occupied with at least multi-stream XR.

Delta MCS: Since the packet size of XR service is large, MCS is one important factor which will affect the resource utilization and system performance. A proper MCS is capable of maximizing resource utilization ratio while meeting BLER requirements. Reporting delta MCS can be considered to help gNB obtain an accurate MCS value.

Network coding: Network coding can be considered to exploit link diversity and achieve lower packet error rate. RAN protocol stack enhancements are needed for network coding.

Proposed Study Item objective:

Study mechanisms that provide more efficient resource allocation and scheduling for XR services to handle XR specific traffic periodicity and jitter (RAN1, RAN2). E.g.: Enhancement to SPS and CG, enhancement for dynamic grants, etc...

v *Enhancement to SPS and CG to handle XR specific traffic periodicity and jitter (RAN1, RAN2)*

v *Study potential XR-specific resource allocation and scheduling enhancement for dynamic grants including but not limited to, enhanced buffer status report, link adaptation, adaptive inter-UE/intra-UE multiplexing, delta MCS, network coding. (RAN1, RAN2).*

4 Summary and Conclusion

For overall setup of the work on XR enhancements the consensus is to first do a **Study Item for 6 months** for both RAN1 and RAN2, followed by a Work Item.

The definition of the scope for the Study Item has progressed well. The top level generic objectives are stable, while more finetuning could be needed for some of the details. The details potentially needing further finetuning are indicated in [].

4.1 Proposed Study Item objectives

Proposed objectives for the Study Item on XR-awareness in RAN (RAN2):

- Study and identify the XR traffic (both UL and DL) characteristics, QoS metrics, and application layer attributes beneficial for the gNB to be aware of, e.g. [the QoS flow association, frame-level QoS, ADU-based QoS, XR specific QoS].
- Study how this information aids XR-specific traffic handling.

Cooperation is needed with the corresponding study work of SA2 //add latest SA2 reference

Proposed objectives on XR-specific Power Saving (RAN1, RAN2):

- Study XR specific power saving techniques to accommodate XR service characteristics (periodicity, jitter, latency, reliability, etc...):
 - C-DRX enhancement;
 - PDCCH monitoring enhancement.
 - [Further candidate techniques can be added here, if consensus is found to add it]

Proposed objectives on XR-specific capacity considerations (RAN1, RAN2):

- Study mechanisms that provide more efficient resource allocation and scheduling for XR services:
 - Enhancement to SPS and CG;
 - Enhancement for dynamic grants.
 - [Further candidate techniques can be added here, if consensus is found to add it]