3GPP TSG-RAN2 Meeting #119-e R2-220xxxx

eMeeting, 17-26 August 2022

Agenda Item: 8.5.1

Source: Qualcomm

Title: Summary of [Post119-e][261][XR] Reply LS to SA2 on UE power savings for XRM services

Document for: Discussion and Decision

# **Introduction**

This report provides a summary of the following post-meeting email discussion:

* [Post119-e][261][XR] LS to SA2 on XR power saving (Qualcomm)

Scope: Answer SA2 LS on UE power saving (in [R2-2206966](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2206966.zip)) according to RAN2 agreements.

Intended outcome: Approved LS.

Deadline: Short

The deadlines for this discussion are the following:

* **August 31th 1200 UTC:** deadline forcompanies’ feedback;
* **August 31th 1800** **UTC**: the rapporteur will provide a summary and a draft LS for review;
* **September 1st 2400 UTC**: deadline for companies’ feedback on the draft LS.

# **Contact information**

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# **Discussion**

## Background

In its LS [1], SA2 requested RAN1 and RAN2 to reply which type of information should be provided to RAN for UE power saving enhancements for XRM services:

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| **Overall Description:**  TR38.838 evaluates the impact of power saving schemes on the performance of XR applications and identify potential enhancements under RAN2 responsibility. Specifically, the following power saving features have been identified:  - CDRX enhancements  - PDCCH monitoring enhancements  It understood that these enhancements require assistance information from the network whose specification falls under SA2 responsibility.  In 3GPP SA WG2 Meeting #S2-149E, new key issue was agreed for TR 23*.700-60* to study potential enhancements for power consumption considering traffic pattern of media services in the scope of FS\_XRM. It was agreed as follows:   * Which information (e.g., XR/media traffic characteristics, traffic pattern and statistics), if any, is needed by the RAN from the CN and/or the UE to enhance power management (i.e., CDRX)? If needed, how such information is collected?   NOTE: This Key issue requires collaboration with RAN WGs.  SA2 wants to request RAN1, RAN2 which type of information will be useful for the RAN for power saving enhancements for XR applications.  **ACTION:** SA2 kindly asks RAN1, RAN2 to take the above information into account and clarify which type of information should be provided to the RAN for power saving enhancements for XR applications. |

RAN1 provided the following information in their reply LS [2]:

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| RAN1’s understanding is that RAN2 will also discuss the XR-awareness and decide what information from core network to RAN is helpful for XR-specific traffic handling. This reply LS is only from RAN1 perspective, and RAN1 expects SA2 to take into account response from both RAN1 and RAN2. In context of SA2 LS, RAN1 discussed what type of information from the core network to RAN could be helpful for the enhancement of XR-specific UE power management, if feasible, and identified following possible candidates for each XR application flow:   * PDU set periodicity and start time of the first PDU of a PDU set: this can be helpful for e.g., configuring the periodicity and start time of CDRX or PDCCH monitoring to match with traffic period. * PDU set end indication or indication of the last PDU in a PDU set: this can be helpful for gNB, e.g., to indicate the UE to dynamically skip PDCCH monitoring once the last PDU of the PDU set is delivered. * PDU set level QoS parameters including priority and [air interface] delay budget of a PDU set: this can help the gNB to select suitable CDRX parameters (e.g., periodicities) that enable fulfilling the delay requirements for a given flow. It also helps with UE power saving, e.g., by reducing retransmission or by early dropping of a PDU that exceeds the delay deadline. Additionally, it can also be helpful for efficient radio resource management by gNB for capacity improvement. * PDU set size (number of bits) or number of PDUs in a PDU set: RAN1’s understanding is that in comparison to the statistical information, real-time or dynamic information provided to gNB, if possible, can help scheduler make more efficient scheduling decision to enable UE power saving. * PDU set identity and relationship information among PDUs within the same PDU set: gNB can use this information for early PDU dropping as mentioned above. * Jitter information such as the range of the jitter (minimum and maximum value): Here jitter refers to packet arrival time variation at gNB for DL direction. gNB could use this information to configure parameters of UE power saving schemes, e.g., CDRX OnDuration and Active Time or PDCCH monitoring duration for handling of the jitter. |

In this email discussion, we discuss **from RAN2’s perspective** what type of information should be provided to RAN for UE power savings.

## Summary of submitted proposals

Several companies have submitted proposals on what information should be included in the reply LS to SA2. They are summarized in Table 1.

Table 1. A summary of proposals from companies

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| Type of information for RAN | Media unit | Proponents |
| Traffic pattern (e.g. periodicity, start time of media unit) | Burst | [3] |
| PDU set | [4], [6], [8], [10] |
| Unspecified | [5] |
| Jitter information of media unit (e.g. range, mean, variance of jitter in the start time of a media unit) | Burst | [3] |
| PDU set | [4], [6], [7] , [8], [10] |
| Unspecified | [5] |
| Size information of media unit (e.g. avg and max size) | Burst | [3] |
| PDU set | [4], [5], [8], [10] |
| Unspecified |  |
| Boundary indication of media unit (e.g. end of burst, last PDU in a PDU set) | Burst | [3], [7] |
| PDU set | [4], [6] |
| Information for identifying a media unit (e.g. sequence number) | Burst | [3] |
| PDU set | [4], [10] |
| QoS requirements for media units (e.g. priority, PSDB, PSER) | PDU set | [4], [5], [6], [7], [8], [10] |
| Relationship information of media unit (e.g. dependency among PDUs within a PDU Set or between PDU sets) | PDU set | [4], [6] |
| Explicit indication and conditions for delivery vs discard of a media unit | PDU | [9] |

## Discussion

The rapporteur observes that most companies share similar views in what type of information is useful to RAN, e.g. traffic pattern, jitter statistics, size information, boundary indicators, etc. However, companies have different views on which type of media unit that such information should be defined for, e.g. whether the information is for a PDU Set or a Data Burst.

To facilitate the discussion, the definition of these two different media units are copied from [11] below:

* **PDU Set**: A PDU Set is composed of one or more PDUs carrying the payload of one unit of information generated at the application level (e.g. a frame or video slice for XRM Services, as used in TR 26.926 [27]).
* **Data Burst**: A set of data multiple PDUs generated and sent by the application in a short period of time. (NOTE: A Data Burst can be composed by one or multiple PDU Sets).

With the above definitions, the rapporteur’s understanding is that XR traffic periodicity is defined based on the number of UL/DL periodic bursts per second. With some codec implementation, one video frame is encoded into a single PDU Set. While in some other codec implementations, one video frame is divided into multiple slices and each of the slices is encoded into a PDU Set. In this case, the group of PDU Sets associated with that video frame forms a Data Burst.

Based on the above observations, the rapporteur suggests that we organize our discussion in the following way:

* We first discuss whether a type of information (e.g. traffic pattern, jitter statistics, etc) is useful to RAN. The list of possible types of information selected based on those summarized in Table 1.
* For each type of information, we select which type of media unit (e.g. PDU Set vs Data Burst) this information is defined for. Moreover, how often this type of information should be signalled to RAN, e.g. whether it is static (e.g. defined in specs), semi-static (e.g. network configuration) or dynamic (e.g. via user-plane signaling).
* When companies comment, please do indicate which parameter(s) of that information they prefer (e.g. for traffic pattern, a parameter can be periodicity) and justifications for your preference. (e.g. useful for configuring DRX). A parameter without proper justification will be deprioritized.

**Q1. Do you think traffic pattern is useful to RAN for UE power savings?**

If you do, which type of media unit do you think should be used to define traffic pattern?

* Option 1. PDU Set;
* Option 2. Data Burst.

In your comment, please indicate which traffic pattern parameters you prefer (e.g. periodicity, start time, etc of your preferred media unot) and justification for your preference.

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| **Company** | **Your preference**  (Op1/Op2/No) | **How traffic pattern info should be signalled?**  (static/semi-static/dynamic) | **Comments**  (Any specific traffic pattern parameter(s) you prefer and justification for your preference) |
| Qualcomm | Option 2 | Semi-static | We think that as far as power savings is concerned, Data Burst is a more appropriate media unit than PDU set. This is because the periodicity for which DRX configuration is based on should be the periodicity of video frames. Depending on the type of codec used, a frame may be encoded into one PDU Set or multiple PDU Sets. In either case, according to SA2’s definition (see above), the PDU Set(s) associated with a video frame form a Data Burst.  We think periodicity of Data Burst is useful for RAN to configure DRX cycle length. And **nominal** start time of a Data Burst can be used by RAN as a reference when configuring DRX start offset. |
| Vodafone | Option2 and Option 1 |  | We think that Data Burst is a good unit for DRX setting, but we also believe that knowing the information about PDU sets is important to in order to be able to treat different bursts in a different way depending on their e.g. priority to each other or PDB requirements. |
| Apple | Option 1 | Semi-static for the typical case, but with dynamic adjustments where needed | Data burst related assistance information already exists (and can be extended, e.g., to include burst end time), but what needs to be added for XR is a notion of PDU sets. We expect data burst related information will continue to be available, including burst parameters such as burst size, arrival time, start/stop etc.  In traditional packet based QoS, traffic information (as in TSCAI) assists the RAN to correlate data bursts of different QoS flows to adjust scheduling and power saving related parameters for one UE. With XR, we assume the QoS model will extend to include groups of packets, where periodicity, arrival time (start/stop), sequence and size of PDU sets become important factors to schedule and utilize radio resources on a finer granularity.  Periodicity is also input to CG/SPS scheduling, and it needs to map with the amount and type of radio resources required per PDU set (e.g., level of reliability), as well as its size, arrival time and timing such as start/stop. This has a direct impact on UE active time.  Even if data burst information is not available the RAN can derive the data burst related information from PDU sets, but PDU set related information we cannot derive from data bursts. |
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**Q2. Do you think jitter information is useful to RAN for UE power savings?**

If you do, which type of media unit do you think should be used to define traffic pattern?

* Option 1. PDU;
* Option 2. PDU Set;
* Option 3. Data Burst.

In your comment, please indicate which jitter parameter(s) you prefer (e.g. range, mean, variance of start time of your preferred media unit) and justification for your preference.

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| **Company** | **Your preference**  (Op1/Op2/Op3/No) | **How jitter info should be signalled?**  (static/semi-static/dynamic) | **Comments**  (Any specific jitter parameter(s) you prefer and justification for your preference) |
| Qualcomm | Option 3 | Semi-static | From power savings’ perspective, we think only the jitter of the start of a Data Burst matters most, because once UE enters DRX active time, jitters of individual PDUs matter less.  We do not think jitter for an individual PDU, PDU Set or Data Burst can be predicted ahead of its arrival. Therefore, only statistics of jitters can be provided to RAN. So semi-static signaling is a good way to provide jitter information to RAN.  Among available statistics, we think range of jitters probably is sufficient for RAN to use. |
| Vodafone | Not applicable |  | DL Jitter is important, but we are not sure if this value can come from CN as we believe that most Jitter might be highly influenced by the last mile of the transmission to the gNBs which might be different from site to site. |
| Apple | Option 2 | Semi-static for the typical case, but with dynamic adjustments where needed | It is conceivable that PDU sets of different type (e.g., importance) can be mapped to different CG/SPS, thus jitter information at the granularity of PDU sets in our view appears preferred over jitter information of data bursts.  Parameters helpful to adjust DRX cycles and resource allocation: Probability distribution, max range, mean. |
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**Q3. Do you think size information (e.g. number of PDUs in a PDU set or number of PDU Sets in a Data Burst) is useful to RAN for UE power savings?**

If you do, which type of media unit do you think this size information should be for?

* Option 1. PDU Set;
* Option 2. Data Burst.

In your comment, please indicate which parameter(s) of size information you prefer (e.g. number of PDUs in a PDU Set or a Data Burst) and justifications for your preference.

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| **Company** | **Your preference**  (Op1/Op2/No) | **How size info should be signalled?**  (static/semi-static/dynamic) | **Comments**  (Any specific parameter(s) of size information you prefer and justification for your preference) |
| Qualcomm | See comment | dynamic | No strong view.  In our understanding, size information is more useful for capacity improvement than UE power savings.  Since XR traffic often has variable frame sizes, it is more efficient to signal sizing information in-band via user-plane signaling. |
| Vodafone |  | dynamic | We think the size of information might be used to adapt C-DRX setting |
| Apple | Option 1 | See comment | The (dynamic) amount of data to be transmitted affects the resources required and indirectly the UE active time / power.  In addition, semi-static information of the nominal mean PDU set size info along with its estimated statistical distribution can be useful.  Another aspect is that generally the number of PDUs in a PDU set is good to be conveyed, especially as it can bear opportunities to enable early dropping of packets and thus prevent wasting transmission power for useless information. The same applies to the structure in a setup with multiple PDU sets in case, for example, the I-frame is lost. |
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**Q4. Do you think boundary indication for a media unit (e.g. indication for end of a PDU Set or a Data Burst) is useful to RAN for UE power savings?**

If you do, which type of media unit do you think this size information should be for?

* Option 1. PDU Set;
* Option 2. Data Burst.

In your comment, please indicate what type of boundary indication you prefer (e.g. end of a PDU Set or a Data Burst) and justifications for your preference.

For this question, the rapporteur’s understanding is that it is not possible to signal boundary information to RAN in a static or semi-static manner. Please indicate in your comments if you have a different view.

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| **Company** | **Your preference**  (Op1/Op2/No) | **Comments**  (Any specific type of boundary indication you prefer and justification for your preference) |
| Qualcomm | Option 2 | We think end of burst indication is very useful for RAN because it can use the indication to terminate DRX active time once all data in a video frame has been successfully sent to UE. Given short periodicities of XR traffic (e.g. 11ms) and typical range of jitters (e.g. 4~6ms), UE may not be able to get much sleep in a cycle if UE replies on expiry of DRX Inactivity Timer to enter sleep. Hence enhancements such as end-of-burst indication can help RAN timely terminate UE’s DRX active time and thus enable more UE power savings.  Since this indication is needed only after all data in a video frame has been received at RAN, this indication should be based on Data Burst instead of PDU Set, i.e. the last PDU Set in a Data Burst carries end-of-burst indication. |
| Vodafone |  | We see the need for “end of burst indication”, but as the burst might contain multiple PDUs belonging to multiple PDU set, It would be useful to know when the PDU sets ends and so, potentially being able to terminate “activity time” earlier compared to only doing it based on Burst information. It should also be noted that the “end” of the burst or PDU set could also be provided by indication of the “first” packet+ number of packets in the set |
| Apple | Option 1 & 2 | End of data burst indication could be given semi-statically for example by indicating the latest time the last packet could arrive. Along the same lines we think other data burst parameters such as arrival time would continue to be useful as well.  Boundary indications for PDU sets are important to enable the RAN and the UE to precisely synchronize multiple flows and/or align the activity on multiple flows, as well as ensure transmission occasions are optimally spaced apart to avoid prolonged UE active time.  Setup of appropriate DRX cycles and selection of suitable resources are additional examples with a power saving effect. Identification of the boundary of a PDU set could be achieved in several ways, for example, through an end-marker indication, a PDU set tag number, PDU set type (importance), sequence number etc. |
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**Q5. Do you think information for identifying a media unit (e.g. sequence number for PDU Sets or Data Bursts) is useful to RAN for UE power savings?**

If you do, which type of media unit do you think information for identifying a media unit should be for?

* Option 1. PDU Set;
* Option 2. Data Burst.

In your comment, please indicate what type of information you think is useful in identifying a media unit (e.g. sequence number of PDUs in a PDU Set or sequence number of PDU Sets in a Data Burst) and justifications for your preference.

For this question, the rapporteur’s understanding is that it is not possible to signal information for identifying a media unit to RAN in a static or semi-static manner. Please indicate in your comments if you have a different view.

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| **Company** | **Your preference**  (Op1/Op2/No) | **Comments**  (which type of information for identifying a media unit you prefer and justification for your preference) |
| Qualcomm | Option 1 | We think sequence numbers for PDU Sets are useful to have. At least they are needed to help end-of-burst indication work in a robust way, e.g. in case there is an out-of-order delivery, RAN needs to use sequence number of PDU Sets to identify there is a gap in received PDU Sets and not to prematurely terminate DRX active time.  We don’t expect bursts in different frames would be mixed in the same DRX cycle and hence sequence number for Data Bursts are not needed. |
| Vodafone |  | Sequence number is one approach and it is useful, but we think we should not select between PDU set and Data Burst |
| Apple | Option 1 | To identify PDU sets in a given order, a sequence number, tag or ID that is common to all PDUs in the PDU set can help achieve in-sequence delivery of PDU sets. Moreover, an ability to distinguish PDUs that belong to the same PDU Set is desired to identify the first PDU of a new PDU Set and the last PDU of the PDU Set. Information that would be useful are ‘number of packets in a PDU set’, a ‘sequence number for each packet in the PDU set’, the ‘type of PDU set’ (importance). Also, the ‘size of the PDU set’, and the expected slice or frame sequence or PDU set structure in a GOP, and information about the number of linked PDU sets. All of this information can avoid unnecessary dropping of packets, deliver packets in the required order, assign additional resources in a setup where only a few packets are outstanding for a PDU set when the configured radio resource is already exhausted, e.g., to avoid unnecessary retransmissions and tune scheduling and radio transmission parameters accordingly. |
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**Q6. Do you think QoS requirements for media units (e.g. PDSB, PSER) are useful to RAN for UE power savings?**

If you do, which type of media unit do you think this size information should be for?

* Option 1. PDU;
* Option 2. PDU set.

In your comment, please indicate what type(s) of QoS requirements you think is useful (e.g. PSDB and/or PSER for PDU Set) and justifications for your preference.

For this question, as QoS requirements are defined by SA2, the rapporteur’s view is that we do not need to discuss how they should be defined/configured/signaled. Please indicate in your comments if you have a different view.

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| **Company** | **Your preference**  (Op1/Op2/No) | **Comments**  (Any specific QoS requirements you prefer and justification for your preference) |
| Qualcomm | See comments | QoS requirements for PDU Sets are important, but we expect the legacy QoS framework enhanced with PDUS specific QoS parameters will be signalled during session establishment. And SA2 have been discussing them. Hence RAN2 do not need to request SA2 to study them in this LS. |
| Vodafone |  | I think the LS is asking about useful parameters for energy savings and we should list them and QoS requirements belong to such parameters. The granularity is in our view per PDU set |
| Apple | See comment | We think the QoS characteristics of a PDU set (such as delay budget, latency, reliability, priority, survival time, error rate, max packet, max frame size, transmission rate/distribution, etc.) are relevant to fulfil QoS requirements of the E2E service. RAN can use this information to optimize processing and transmission opportunities, which may have a power saving impact. |
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**Q7. Do you think relationship information between media units (e.g. between PDUs within a PDU Set or between PDU Sets) is useful to RAN for UE power savings?**

In your comment, please indicate what type(s) of relationship information (e.g. between PDUs within a PDU Set, or between PDU Sets) between media units you think is useful and justifications for your preference.

For this question, the rapporteur’s understanding is that it is not possible to signal relationship information between media units in a static or semi-static manner. Please indicate in your comments if you have a different view.

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| **Company** | **Your preference**  (Yes/No) | **Comments**  (which type of relationship information between media units you prefer and justification for your preference) |
| Qualcomm | No | We think such information is more related to differentiated handling of PDU Sets and capacity improvement than UE power savings. So RAN2 do not need to include them in this LS. |
| Vodafone |  | As the burst can include PDUs from different PDU sets, it would be important to know the relation between PDU sets, but if that contributes for UE battery savings is FFS |
| Apple | Yes | Without sequence numbering the packets in a PDU set may be delivered out of order causing unnecessary retransmission of a whole PDU set (rather than selected PDUs in the PDU set), e.g., in scenarios where in-sequence delivery is required, thus not only capacity but also power is wasted. |
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**Q8. Do you think any explicit indications and/or conditions for RAN to decide on delivery vs discard of a media unit would be useful for UE power savings?**

If you do, which type of media unit do you think such type of indications and/or condition sshould be for?

* Option 1. PDU;
* Option 2. PDU Set.

In your comment, please indicate what type(s) of indication and/or conditions you prefer and justifications for your preference.

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| **Company** | **Your preference**  (Op1/Op2/No) | **How such indications or conditions should be signalled?**  (static/semi-static/dynamic) | **Comments**  (Any specific type(s) of indication and/or conditions you prefer and justification for your preference) |
| Qualcomm | Option 1 | Semi-static | On downlink, we do not think such explicit indications and/or conditions are needed for UE power savings, because they are needed only in RAN’s scheduling operation.  On uplink, if a PDU has no delay budget left (i.e. becomes late), then it may be subject to discard to avoid unnecessary transmissions and thus unnecessary UE power consumption. We think network can configure whether UE should perform such discard for a DRB and, if enabled, a delay budget for UE to check whether a DPU is late or not. |
| Vodafone | Option 2 | dynamic | In UL we agree with Qualcomm, but on DL, I am not sure, why the gNB should send the packets which could be discarded and we should also think about re-transmissions of such packets as it would cause the UE to wake up. |
| Apple | Option 1 & 2 | See comment | We think that explicit indications can be useful not only in UL but also in DL. Examples: Dynamic indication of critical packets in a PDU set; dynamic indication of control information; semi-static indication of critical PDU sets in a group of pictures. A higher reliability may be needed for certain PDUs or PDU sets depending on the situation or e.g., the remaining delay budget, to avoid a loss of the whole PDU set, thus, to avoid a waste of transmission power.  Moreover, a semi-static indication on how many lost packets an application can tolerate in a PDU set has relevance not only to capacity but also to power. |
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In [3], it is stated that for XR traffic flows not based on PDU Sets, information including traffic periodicity, start offset of PDUs and range of jitter can be useful to RAN in DRX configurations, and the information can be semi-statically provided to RAN (e.g., at PDU/QoS flow establishment or modification).

**Q9. For XR traffic flows not based on PDU Sets, do you think it is useful to provide RAN with their periodicity, start offset of PDUs and range of jitters for UE power savings?**

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| **Company** | **Yes/No** | **Comments**  (Please provide you preferred parameters if they are not mentioned in Q9) |
| Qualcomm | Yes | XR application can generate multiple types of traffic flows. Some of the flows may not be based on PDU sets (e.g. audio, voice, control message, etc). It is equally useful for RAN to know the traffic characteristics of those types of flows, e.g. periodicity, start offset, range of jitters in its DRX and SPS/CG configurations. |
| Vodafone | Yes | Agree with QCM |
| Apple | Yes | These types of PDU sets could be characterized as PDU sets of packet size 1. More importantly, it would be useful to describe them in a common framework because PDU sets of these flows may have a timing relation to other PDU sets (audio and video, pose information, control packets) where synchronized treatment may be required. Proper alignment of radio resources has a power benefit. |
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**Q10. Any additional information that you think is important for RAN but is not included in any of the questions above?**

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| **Company** | **Your preferred information** | **How should the information be signalled?**  (static/semi-static/dynamic) | **Justifications for your preferred information** |
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# **Conclusions**

(To be added later)

# References

1. R2-2204523, LS on UE Power Saving for XR and Media Services (S2-2203418; contact: Nokia).
2. R2-2206923, Reply LS on UE Power Saving for XR and Media Services (R1-2205531; contact: Qualcomm).
3. R2-2207042, Draft reply LS on UE power savings for XR and media services, Qualcomm Incorporated.
4. R2-2207117, XR awareness: RAN2 areas of interest, assumptions, and inputs to SA2 LS, Intel Corporation.
5. R2-2207509, Consideration on power saving for XR service, CATT.
6. R2-2207757, Discussion on XR-specific power saving, vivo.
7. R2-2207888, Discussion on XR-specific power saving techniques, Huawei, HiSilicon.
8. R2-2208020, XR Power Saving enhancements, Nokia, Nokia Shanghai Bell.
9. R2-3308316, Discussion of SA2 LS on UE Power Saving for XR and Media Services, Meta.
10. R2-2208680, Discussion on power saving enhancements for XR, Ericsson.
11. TR 23.700-60 v0.3.0, Study on XR (Extended Reality) and media services (Rel-18).