**3GPP TSG RAN WG1 #103-e R1-20xxxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda item:** 8.14.1

**Source:** Moderator (Qualcomm)

**Title:** Email discussion approval for applications, traffic model and evaluation methodology: Other than capacity evaluation

**Document for:** Discussion and Decision

# Introduction

The first round of email discussion on XR applications, traffic model and evaluation methodology was conducted from 11/2 to 11/5 as below.

|  |
| --- |
| [103-e-NR-XR-02] Email discussion/approval for applications, traffic model and evaluation methodology – Eddy (Qualcomm) and Xiaohang (vivo)   * 1st check point: 11/5 * 2nd check point: 11/10 * 3rd check point: 11/12   In addition to XR/CG applications and traffic model, evaluation methodology for the following four aspects is to be discussed: Capacity, UE power consumption, Coverage, and Mobility.  This email discussion is structured as follows.   * **Track 1: Applications, traffic model, and evaluation methodology for UE power consumption, Coverage, and Mobility**   + To be moderated by Eddy (Qualcomm)   + Please provide your comments in the discussion document in this folder:     - <https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.14.1/XR%20applications%20TM%20EM%20for%20others> * **Track 2: Evaluation methodology for Capacity**   + To be moderated by Xiaohang (vivo)   + Please provide your comments in the discussion document in this folder:     - <https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Inbox/drafts/8.14.1/XR%20eval%20methodology%20for%20Capacity> |

A summary of the 1st round of email discussion for “Track 1” is presented in Section 3. The questionnaire for the 2nd round of email discussion for Track 2 is given in Section 2. Companies are encouraged to provide their view on the questions highlighted in green.

# 2nd Round of Email Discussion for Track 1

XR applications and traffic model

Based on the majority view from the 1st round of email discussion that is summarized in Section 3, the following proposals are made.

**Proposal on XR applications**

RAN1 confirms that diverse applications of VR1/2, AR1/2, CG [TR26.928] are of interest for study. Prioritization/down selection of these applications for evaluation, if needed, is to be discussed after detailed traffic model and evaluation assumptions are determined.

**Round 2 Question 1**: Please share if you have any comments on this proposal.

|  |  |
| --- | --- |
| Company | View |
| QC | Agreed with the proposal |
| AT&T | Agree |
| Apple | ITT4RT and 5GSTAR should also be included. |
| CATT | Agree with moderator’s proposal |
| MTK | Conditionally agree by removing “if needed” because there is no clear criterion to justify “if needed” |
| LG | Agree. In addition, we think “if needed” is necessary. Otherwise, “Potential” prioritization/down selection… would be also relevant. |

**Proposal on Traffic model**

Traffic model for DL and UL should reflect various bit rates, variable frame/slice/file/packet (definition of frame/slice/file/packet to be clarified with traffic model as necessary) size, and periodicity (how to model jitter is FFS), where statistical model is preferred. Conclusion on detailed traffic model is deferred to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available.

**Round 2 Question 2**: Please share if you have any comments on this proposed agreement.

|  |  |
| --- | --- |
| Company | View |
| QC | Agreed with the proposal |
| AT&T | Agree |
| Apple | If the SA4 traffic model is expected to become available the next year, wonder a little bit whether we have time to conclude the traffic model so soon. Maybe we can say “strive to conclude the detailed traffic model at the next RAN1 meeting (RAN1 #104-e) …” |
| CATT | Traffic model defined in SA4 is an end-to-end traffic model, which can not be directly used in RAN1 evaluation. In general, we agree the data rate, delay, and jitter should be taken into account in the traffic model. That is where the Queueing theory was used in general (e.g. FTP traffic model in RAN1 evaluation). |
| MTK | Agree with the proposal |
| LG | We agree with the general concept. On the other hand, details can be considered as example, and the target date for RAN1 decision may not be promising. Therefore, we may say, e.g.:  “Traffic model for DL and UL should reflect various aspects, e.g., bit rates, variable frame/slice/file/packet (definition of frame/slice/file/packet to be clarified with traffic model as necessary) size, and periodicity (how to model jitter is FFS), where statistical model is preferred. Conclusion on detailed traffic model is deferred to the next RAN1 meetings  ~~(RAN1 104-e)~~ where SA4 outcome on traffic model is expected to be available” |

KPIs for evaluation of XR performance over NR

The following four key performance aspects of XR evaluations for NR are presented in the SID on XR evaluations for NR ([*RP-201145*](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_88e/Docs/RP-201145.zip))

1. Power consumption
2. Capacity
3. Mobility
4. Coverage

The objectives of the SI include identification of KPIs and evaluations towards characterization of identified KPIs. While detailed KPIs and corresponding evaluation methodology related to “capacity” are being separately discussed in Track 2, Track 1 focuses on KPIs and evaluation methodology for power consumption, mobility, and coverage.

The questionnaire in the 1st round of Track 1 email discussion asked several questions regarding evaluation methodology for power consumption under the assumption that “power consumption” is one of the KPIs for XR performance over NR according to the SID. However, from the 1st round of Track 1 email discussion, there seem to be different views on whether UE power consumption is a KPI to be evaluated (see Section 3 for more detail):

* Is UE power consumption evaluation part of the study, i.e., is UE power consumption a KPI?
  + Yes (9): QC, MTK, Apple, InterDigital, vivo, Xiaomi, CATT, Facebook, Samsung
  + No (2): Nokia, HW
  + Need further discussion (7): Nokia, LGE, ZTE, FutureWei, DOCOMO, Intel, HW
  + It’s up to companies to contribute.
    - Ericsson, HW

Thus, it is desirable to confirm whether power consumption evaluation is part of the study, i.e., UE power consumption is a KPI.

**Round 2 Question 3**:

Can we confirm that XR UE power consumption is part of the study as a KPI for XR evaluations for NR?

* + Yes
  + No

Please share your view on Question 3.

|  |  |
| --- | --- |
| Company | View |
| QC | Yes |
| AT&T | It is important to understand impact of XR on UE power consumptions. However, we believe more discussion is needed to define it as a KPI. |
| Apple | Yes |
| CATT | Yes. UE power consumption should be one key performance index of XR study |
| MTK | Yes |
|  |  |

Regarding mobility and coverage, from the 1st round of Track 1 email discussion, most of companies agree with the following proposal.

**Proposal on mobility and coverage**: RAN1 is to discuss whether/how to study/evaluate mobility and coverage at a later stage, e.g., starting from Q1 2021.

**Round 2 Question 4**: Please comment on this proposal if any.

|  |  |
| --- | --- |
| Company | View |
| QC | Agree with the proposal. |
| AT&T | Mobility and coverage are important parts of the study in our view, but we are OK to defer discussion to Q1 2021. |
| Apple | Agree with the proposal |
| CATT | Agree with moderator’s proposal |
| MTK | Agree with the proposal. |
| LG | Agree with the proposal. |

Evaluation methodology for power consumption

This section presents follow-up questions on evaluation methodology for power consumption based on companies’ views collected from 1st round discussion.

Regarding baseline power evaluation methodology, the following proposal is made based on the majority view from the 1st round, summarized in Section 3.

**Proposal on baseline power evaluation methodology**

If UE power consumption is agreed as a KPI for evaluation of XR performance over NR, TR38.840 is the baseline methodology potentially with some modifications if necessary.

* FFS whether/how to model UE power consumption for UE tx power other than 0dBm and 23dBm
* FFS whether/how to model UE power consumption for UL slots that are not defined in TR38.840
* FFS whether/how to model UE power consumption for ‘S’ slot
* FFS whether/how to model UE power consumption for 400MHz in FR2 including scaling rule for FR2 BWP adaption.

**Round 2 Question 5**: Please share if you have any comments on this proposed agreement.

|  |  |
| --- | --- |
| Company | View |
| QC | Agree with the proposal. TR38.840 can be the baseline with necessary modification. We are fine with further discussion on the above bullets although we have already presented our view on the detailed evaluation methodology for the first three bullets. |
| AT&T | We have concerns about a very complicated modeling effort on the ability to complete the SI and compare results |
| Apple | The proposal is fine, but our understanding is there may be other modifications necessary, hence the FFS list may be further discussed in future RAN1 meetings. |
| CATT | In general, the power model for those FFS points were discussed during Rel-16 UE power saving study but considered not much related. We don’t see the need to have FFS points. |
| MTK | We are fine with the proposal. For the last FFS, according to 38.840 Table 21 … 4CC is 3.4x1CC |
| LG | We agree with the main bullet point. On the other hand, we may not need to define such detailed FFS points in this meeting unless we have sufficient discussion on those points. |

It would not be feasible for RAN1 to evaluate the absolute amount of XR UE power consumption, e.g., in mW or mA. Please be reminded that the power evaluation methodology in TR 38.840 defines only relative numbers of power consumption compared to ‘deep sleep state’ for different slot states (e.g., PDCCH decoding only, decoding PDCCH and PDSCH, etc.). Therefore, when it comes to XR power consumption, only “relative comparison” can be evaluated, e.g., evaluation of XR power saving (PS) gain that a certain power saving technique can provide, compared to the power consumption of a reference scheme/scenario. Therefore, in order to evaluate XR PS gain of certain PS techniques, it is critical to clearly define “reference” scenarios or schemes. In this regard, several questions were asked in the 1st round discussion for which companies’ views are summarized in Section 3. Based on the majority view, the following proposal is made.

**Proposal. Power Saving Evaluation Scenarios/Techniques**

If UE power consumption is agreed as a KPI for evaluation of XR performance over NR, the following scenarios are to be evaluated. Please note Scenario 3 is not mandatory, but optional.

* **Scenario 1 (Baseline/reference)**: No PS technique is applied, i.e., UE assumed to be always available for DL/UL scheduling/transmission, i.e., not in a sleep state. UE power consumption in this scenario is the reference to evaluate gain of any power saving technique.
  + Note: Results of baseline/reference power consumption can be collected from capacity simulations, i.e., no separate system level simulation would be needed from capacity simulation.
* **Scenario 2 (Evaluation of PS Gain)**: With a certain PS technique applied, evaluate the PS gain of the PS technique over the baseline/reference evaluated in Scenario 1.
  + FFS what power saving techniques are to be evaluated/prioritized.
    - Rel-15/16 schemes are the baseline (FFS down-selection/prioritization)
    - It is up to company to evaluate other PS schemes beyond Rel-15/16 schemes.
  + FFS the exact definition of power saving gain subject to a constraint on capacity degradation from the applied PS scheme(s).
* **Scenario 3 (Genie Power Consumption)**: “Genie” UE power consumption, defined as defined as UE power consumption for the case when the UE is assumed to enter a sleep state in all the slots with neither DL reception nor UL transmission. The Genie result is informative, not mandated, and can serve as a benchmark of the power saving gain.
  + Note: Results of Genie power consumption can be collected from capacity simulations, i.e., no separate system level simulation would be needed from capacity simulation.

**Round 2 Question 6**: Please share your view on this proposal.

|  |  |
| --- | --- |
| Company | View |
| QC | We agree that a clear definition of the reference scheme/scenario is needed to evaluate the power saving gain of power saving techniques and/or to compare effectiveness of different PS schemes. In addition, we think the “Genie” result will be very informative as it can present an upper bound for many power saving techniques. |
| AT&T | Prefer Scenario 1, although companies can of course optionally provide results with certain Rel-15/16 schemes implemented for reference as well |
| Apple | Whether system level simulation is used for power saving or not should be further discussed. The notes to scenario 1 & scenario 3 should be removed, whether capacity and power saving are studied jointly should be further studied. |
| CATT | We are OK to have scenarios 1 and 2. Scenario 3 is the upper bound and should be optional |
| MTK | As there are various power saving methods in R15/R16, some of them may also be applicable to XR with negligible capacity impact. Therefore, it would be better to include those existing R15/R16 power saving techniques as baseline for this agenda. To achieve this, **for scenario 1 we suggest to replace the word “baseline/reference” with “No power saving”**. **For scenario 2, we suggest to** modify it as:   * **Scenario 2 (Evaluation of PS Gain)**: With a certain PS technique applied, evaluate the PS gain of the PS technique over the **~~baseline/reference~~ no power saving scenario** evaluated in Scenario 1.   + FFS what power saving techniques are to be evaluated/prioritized.     - Rel-15/16 schemes are the baseline (FFS down selection/~~prioritization~~combinations to be studied)     - It is up to company to evaluate other PS schemes beyond Rel-15/16 schemes       * **FFS: the baseline for calculating power saving gain to include Rel-15/16 PS schemes applicable to XR/CG**.   + FFS the exact definition of power saving gain subject to a constraint on capacity degradation from the applied PS scheme(s). |
| LG | In general, methodology for power consumption evaluation can be discussed after we conclude if power consumption should be KPI of the study item. Regarding methodology itself, we think Rel-15/16 power saving techniques can be included as reference to avoid confusion in interpretation of companies’ results on the proposals beyond Rel-15/16 schemes. |

**Round 2 Question 7**:

If UE power consumption is a KPI and system level simulation is the baseline or an optional methodology for evaluation of UE power consumption for XR over NR, system level simulation assumptions for power evaluation are the same as in XR capacity evaluation that are being developed in the Track 2 email discussion (moderated by vivo).

Please share your view on Question 7.

|  |  |
| --- | --- |
| Company | View |
| QC | We agree with using the same simulation parameters for capacity evaluation and power evaluation. |
| AT&T | Agree |
| Apple | System level simulation is an optional methodology for power saving evaluation. |
| CATT | UE power consumption could be calculated during system level simulation. We need to agree whether the UE power consumption is captured with average of all UE power consumption or the distribution associated with geometry of UE location. |
| MTK | Agree with the proposal |
| LG | We want to see more companies’ opinions on the KPI itself. Anyhow, we agree with the proposal under the condition on the KPI as such. |

# 1st Round of Email Discussion for Track 1: Summary

XR Applications

Table 1 captured the views on XR applications of interest from different sources.

Table 1 Views on XR Applications

|  |  |
| --- | --- |
| Source | View |
| [1] | Proposal 1: FS\_NR\_XR\_eval considers selecting one application (e.g., VR2: “Split Rendering: Viewport rendering with Time Warp in device”, or CG: Cloud Gaming) as the focus of study, at least in the initial stage of the study item. |
| [2] | Proposal 1: For VR1, VR2 and CG applications, downlink traffic is studied and evaluated with higher priority. |
| [3] | Proposal 1: RAN1 studies VR2, AR1 and CG applications as high priority. |
| [5] | Proposal 1: The applications of interest of the study item include at least the following listed in RP-193241.   |  | | --- | | * VR1: Viewport dependent streaming * VR2: Split Rendering: Viewport rendering with Time Warp in device * AR1: XR Distributed Computing * AR2: XR Conversational * CG: Cloud Gaming |  * Up to one single (Rate, PDB, PER) requirement is evaluated for each application of interest * For delivery of CG applications, generalized split rendering architecture and its relevant traffic characteristics are considered. |
| [7] | Proposal 1: Prioritize the AR applications/use cases from [1] for the XR SI. Also consider cloud gaming. |
| [8] | Proposal 1: Confirm the XR and cloud gaming applications in the SI for XR evaluations |
| [12] | Proposal: Classify AR1 and AR2 as essential applications in the RAN1 Rel-17 study item for evaluation of XR for NR. |
| [13] | Proposal 1: Prioritize the evaluation of CG over AR/VR considering the highest business value of CG among VR/AR/CG.  Proposal 2: Prioritize the evaluation of AR over VR considering the higher popularity of AR service. If VR is considered, prioritize indoor deployment scenario, e.g. Indoor Hotspot (InH).  Proposal 3: Adopt the following study priorities on applications and deployment scenarios for R17 XR/CG: |
| [16] | Proposal 1 RAN1 to confirm that the VR1/VR2/AR1/AR2/Cloud gaming applications are of interest for Rel-17 study on XR evaluation for 5G NR and determine which of the use cases would need to be prioritized for the evaluation study.  Proposal 2 In the XR evaluation SI, RAN1 to treat cloud gaming with first priority, AR use cases with second priority, and VR use cases with third priority. |
| [17] | Proposal 1:   * CG and VR can be discussed in the RAN1#103-e meeting considering the availability of traffic models in SA4 TR. As for AR, it needs to wait for SA4 progress. |
| [18] | Proposal 1: RAN1 considers all the XR applications described in the RAN XR SID for evaluation (i.e., VR, AR, and CG). More details, e.g., prioritization and/or down-selection of them can be further discussed once the outcome of SA4 study on XR traffic model becomes available. |
| [9] | Consider XR applications including studies ITT4RT and 5GSTAR, and XR\_Traffic |

**Summary**

Companies have shown their views on application of interests. Following table captures the indicated priorities of applications of interest from sources. “1” = highest priority, “2”=second highest priority, etc.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | VR1 | VR2 | AR1 | AR2 | CG |
| [3] | 2 | 1 | 1 | 2 | 1 |
| [13] |  |  | 3 | 2 | 1 |
| [1] |  | 1 |  |  | 1 |
| [16] | 3 | 3 | 2 | 2 | 1 |
| [17] | 1 | 1 | 2 | 2 | 1 |
| [7] |  |  | 1 | 1 | 1 |
| [12] |  |  | 1 | 1 |  |

**FL Proposal 1**: RAN1 confirms that diverse applications of VR1/2, AR1/2 (including low rate AR), CG [TR26.928] are of interest for evaluation. Prioritization/down selection of these applications for evaluation, if needed, is to be discussed after detailed traffic model and evaluation assumptions are determined.

**Question 1**. Please share your comments on Proposal 1 if any.

|  |  |
| --- | --- |
| Company | View |
| QC | All VR1/VR2/AR1/AR2(including low rate AR)/CG are interesting to us. In particular, low rate AR is interesting application to study because it may be one of the most relevant applications in the near term market. Any decision related to the prioritization or down-selection of applications for evaluation should be made after we have a good understanding, in particular on traffic model. |
| MTK | We are fine with the FL proposal. However, given that CG is marked as “1” for the most companies, we prefer to further prioritize CG, and choose 1 or 2 applications from AR1/2, VR1/2 later. |
| ZTE, Sanechips | We don't think low rate AR should be explicitly captured here given the traffic related discussion is still pending at this moment. Moreover, given the prioritization is still open in the proposal, it's suggested changing evaluation to study to avoid confusion. The preferred change to the proposal would be:  **FL Proposal 1**: RAN1 confirms that diverse applications of VR1/2, AR1/2 ~~(including low rate AR)~~, CG [TR26.928] are of interest for ~~evaluation~~ study. Prioritization/down selection of these applications for evaluation, if needed, is to be discussed after detailed traffic model and evaluation assumptions are determined. |
| Nokia, NSB | We agree that the selection of the applications should be done after the understanding of the appropriate traffic models. |
| FUTUREWEI | We also think prioritization and down-selection should wait after better understanding of traffic model is reached. |
| Apple | We think prioritization and down-selection should be done later. Recall studies from SA4 are still ongoing. |
| DOCOMO | We are fine with the FL proposal. Down-selection of applications should be done after we have better understanding of the traffic models. |
| LG | We are fine with FL’s proposal. |
| InterDigital | We think all VR1/2, AR1/2 and CG applications should be considered for the evaluations. Whether to prioritize/deprioritize any of the applications may be discussed once the details on traffic models are available from SA4. |
| Intel | We think VR1/2, AR1/2, CG should be considered in this study. We think the second sentence is not necessary  **FL Proposal 1**: RAN1 confirms that diverse applications of VR1/2, AR1/2 ~~(including low rate AR)~~, CG [TR26.928] are of interest for ~~evaluation~~ study~~. Prioritization/down selection of these applications for evaluation, if needed, is to be discussed after detailed traffic model and evaluation assumptions are determined.~~ |
| CMCC | Support FL proposal. There is no need for down-selection at this point. |
| Ericsson | We are fine with deferring prioritization/down selection to a later stage. |
| vivo | We agree with FL’s suggestion. |
| Xiaomi | We are fine with the FL proposal, although we think VR1 can be deprioritized. |
| Huawei, HiSilicon | We think that the five XR applications described in the SID (i.e., VR1/VR2/AR1/AR2/CG) are of interest. As for “low rate AR”, some company [18] mentioned it is currently being studied in SA4. According to the following Note in chairman notes, RAN1 will not discuss this application in this meeting.   * *NOTE: SA4 has ongoing work in the XR area, RAN1 will not address these SA4 aspects but will wait for SA4’s outcome*   For the prioritization of five applications, since the traffic model of each application is unclear, it is premature to prioritize among them.  We suggest to study the traffic models for all 5 applications so that RAN1 can have better understanding of each application. After that, we may pick some representative cases for performance evaluation considering the simulation workload.  So we suggest the following changes to Proposal 1:  **Proposal 1**: RAN1 confirms that diverse applications of VR1/2, AR1/2 ~~(including low rate AR)~~, CG [TR26.928] are of interest for ~~evaluation~~study. Prioritization/down selection of these applications for evaluation, if needed, is to be discussed after detailed traffic model and evaluation assumptions are determined. |
| Nokia, NSB2 | We agree that the selection of the applications should be done after the understanding of the appropriate traffic models. If the choice is to be made straightaway, our 1st preference if GC, the 2nd preference is VR, and the 3rd is AR. Furthermore, we think that low-rate AR is less interesting than high-rate AR and it could be excluded from the study. |
| CATT | VR1/2, AR1/2 and CG are interested applications. Since all these applications could apply to different field, RAN1 should target generic modelling of these 5 traffic types for Uu evaluation. |
| Facebook | In general, we agree with the FL’s proposal. We also want to echo the importance of low rate AR for near term market. Although not specifically mentioned in the SID, we don’t see there is a restriction on this particular use case. This is just a subset of AR and it’s just normal procedure for working group to further discuss the detail. |
| Samsung | Fine with proposal. Realistically, there has to be prioritization. AR (including ‘low rate’) is preferred. |

Traffic Model

### DL Traffic Model

Table 2 captures the views from different sources on DL traffic model.

Table 2 View on DL Traffic Model

|  |  |
| --- | --- |
| Source | View |
| [1] | Proposal 2: RAN1 notifies SA4 that RAN1 prefers a statistical XR traffic model in FS\_NR\_XR\_eval studies and kindly asks SA4 to confirm that such a statistical XR traffic model can be provided as an outcome of SA4’s related study item on XR. |
| [2] | Proposal 3: For VR and CG performance evaluation, periodic traffic with frame arrival interval 1/F seconds is considered as a starting point, where F is frame rate in FPS. |
| [3] | Proposal 23: For XR and Cloud Gaming, the following two traffic source types can be considered for evaluation, assuming frame rate is X FPS.   * Traffic source type 1: every 1/X s, the packets of both eyes arrive at the same time for each frame. * Traffic source type 2: every 1/(2\*X) s, the packets of left eye and right eye arrive in turn, e.g. the packet of left eye arrives at odd frames, while the packet of right eye arrives at even frames.   Proposal 24: For XR and Cloud Gaming, following options for packet modelling can be considered,   * Option 1: an application level packet is modelled as a packet during simulation, i.e. one frame consisting of one or more IP level packets ≈ one packet in simulation. * Option 2: an IP level packet is modelled as a packet during simulation, i.e. one IP level packet ≈ one packet in simulation.   Proposal 25: For DL, traffic models in Table 7 and Table 8 are considered as the starting point for XR and Cloud Gaming evaluation, respectively.  Proposal 26: For UL, traffic model in Table 9 is considered as the starting point for XR and Cloud Gaming evaluation. |
| [4] | Proposal 9: The XR traffic model could consider the packet size, including fixed value and random distribution, and the packet arrival time, including periodic and non- periodic. |
| [5] | Proposal 2: The following 2 categorizations of XR representative services for DL services as the starting point   * , 300, fixed periodicity, fixed packet size * 100Mbps,, [5-30] fixed periodicity and fixed packet size/statistical model for fluctuating traffic * FFS periodicity values and the modeling of variant inter arrival rate * FFS statistical model for fluctuating traffic, target to down-select in RAN1#103-e between Gaussian distribution and Pareto distribution   Proposal 3: Adopt the three-step methodology to derive the traffic models for Gaussian/Pareto distribution of file size.  Step 1: Generate the mean packet size according to the packet arrival rate and the data rate requirement.  Step 2: Determine the minimum file size or the standard derivation parameter based on the relationship between the mean data rate and the minimum/maximum (i.e. truncated) data rate.  Step 3: Determine the remaining parameter, if any, by jointly considering the mean file size and the parameter obtained from step 2. |
| [6] | Proposal 1: The frame size of DL follows a random distribution, while the frame size of UL can be assumed as two different values, one is for pose and control information, and the other is for scene update information. |
| [7] | Proposal 2: Down-select between the Gaussian and Pareto distributions for modelling packet arrivals and jitter and select a small set of packet sizes, jitter values, and packet arrival rates for evaluation. |
| [9] | Proposal 1:   * In the traffic model for XR, multiple data streams (e.g. for audio and video) for each direction (DL or UL) are generated for a UE; * Each data stream can be configured separately with * Periodicity * Packet size distribution (e.g. fixed or following a distribution)   Data flow specific latency and reliability requirements |
| [10] | Proposal 1: For evaluations, RAN1 to use a generalized/parametric XR traffic model with configurable parameters that can represent any of the XR traffic. The configurable parameters in the generalized XR traffic model are:   * UL:   + Traffic arrival distribution: [Quasi-periodic with configurable inter-packet arrival rate] (e.g. 60 to 500Hz)   + Traffic file distribution: [Uniform distribution with configurable packet size] (e.g. 30 to 250B)   + Number of data streams: [Configurable number of streams, configurable traffic parameters common to all streams] (e.g. single/multiple streams with bounded latency)   + Traffic parameters of each data stream: [Configurable data rate, latency and reliability]   (e.g. 500kbps, 10ms, 10E-04 PER)   * DL:   + Traffic arrival distribution: [Quasi-periodic with configurable inter-packet arrival time duration] (e.g. FTP3, inter-packet arrival proportional to 1/frame-rate)   + Traffic file size distribution: [Truncated Gaussian distribution or Parero distribution with configurable mean, σ, min, max] (e.g. mean: 1200B)   + Number of data streams: [Configurable number of streams, configurable traffic parameters common to all streams] (e.g. isochronous multi-stream with bounded latency)   + Traffic parameters of each data stream: [Configurable data rate, latency and reliability]   (e.g. 100Mbps, 10ms, 10E-04 PER) |
| [11] | VR1   |  |  |  | | --- | --- | --- | |  | DL Traffic Model | UL Traffic Model | | Traffic model | FTP Model 3 | Periodic traffic | | Rate | HEVC @ 60 fps:   * 4K: 43 Mbit/s | Period = 1/X, X=100-200ms | | PDB | 10ms | 10ms | | PER | 1e-4 | 1e-4 | | Packet size | 1500 byte | 100 bytes | | Packet size distribution | Constant | Constant | | Transport protocol | TCP (DASH/HTTP) | TCP (DASH/HTTP) |   VR2   |  |  |  | | --- | --- | --- | |  | DL Traffic Model | UL Traffic Model | | Traffic model | FTP Model 3 | CBR | | Rate | 50-100 Mbps | Several 100 kbps | | PDB | 20 ms | < 10 ms | | PER | 1e-4 | 1e-4 | | Packet size | 1500 byte | 100 bytes | | Packet size distribution | Constant | Constant |   AR1   |  |  |  | | --- | --- | --- | |  | DL Traffic Model | UL Traffic Model | | Traffic model | FTP Model 3 (option 2), CBR (option 3) | FTP Model 3 (option 2,3) | | Rate | Option 2:  HEVC @ 60 fps:   * 4K: 43 Mbit/s   Option 3:   * 10 kbit (small object) every 5s * 10 Mbit (large object) every 5s | Option 2,3:  HEVC @ 60 fps:   * 720p: 10 Mbit/s * 1080p: 29 Mbit/s * 4K: 43 Mbit/s | | PDB | 10ms | 10ms | | PER | 1e-6 | 1e-6 | | Packet size | 1500 byte | 1500 byte | | Packet size distribution | Constant | Constant | | Transport protocol | UDP (RTP) | UDP (RTP) |   CG   |  |  |  | | --- | --- | --- | |  | DL Traffic Model | UL Traffic Model | | Traffic model | FTP Model 3 | CBR | | Rate | HEVC @ 60 fps:   * 720p: 10 Mbit/s * 1080p: 29 Mbit/s * 4K: 43-45 Mbit/s | 0.2-0.7 Mbit/s | | PDB | 10ms | 10ms | | PER | 1e-4 | 1e-4 | | Packet size (interval) | 1200 byte | 100 byte | | Packet size distribution | Constant | Constant | | Transport protocol | UDP (GQUIC) | UDP (GQUIC) | |
| [12] | Proposal: RAN1 should develop relevant over-the-air traffic model for AR1 and AR2 applications as well as VR1, VR2 and CG applications based on the output of SA4 study item during the RAN1 Rel-17 study item for evaluation of XR for NR. |
| [13] | Proposal 4: Adopt the proposed traffic model for cloud gaming traffic.    Proposal 5: The jitter should be modelled as a parameter in the traffic model.  Proposal 6: For the XR traffic, the Cloud Gaming traffic model could be used as a baseline and extended as needed. |
| [14] | Proposal-1: A simplified baseline DL model (media) is to consider periodic traffic (arriving at framerate) together with a truncated distribution for packet size. The addition of randomness to this periodic traffic burst due to jitter might be required. |
| [15] | Proposal 3: Periodic traffic can be assumed for the DL and UL traffic of the VR service |
| [16] | Proposal 3 The frame size for the video traffic may include a variance, e.g., Gaussian distribution, in time to be more realistic.  Proposal 4 The frame arrival time to RAN for the video traffic may be approximated to be periodic and equal to the inverse of a frame refresh rate.  Proposal 5 RAN1 should decide the exact video traffic parameters further when SA WG4 XR study is finalized [3]. The parameters can include a frame size in terms of mean, variance, the maximum and the minimum value at least for the minimal acceptable encoding rate and the frame generation interval.  Proposal 6 Both DL and UL should be studied to understand the impact of a wide-spread deployment of XR services in a cellular network. |
| [18] | **Proposal 2:** RAN1 defers its conclusion on XR traffic model to be used for performance evaluations until the outcome of SA4 study on XR traffic model is available. |

**Summary**

Companies have shown their initial view on following aspect of DL traffic model.

* DL file inter arrival: this could be roughly inverse of frame rate (Fps). Depending on jitter modeling, it could be periodic (i.e., w/o jitter) or random w/ jitter
  + Periodic (w/o jitter): [2] [3] [4] [5] [9] [14] [15] [16]
  + Random (w/ jitter): [4] [7] [10] [11] [13] [14]
* File size distribution: this is also related to whether to model each file as IP packet or frame.
  + Fixed: [4] [5] [11]
  + Random: [3] [4] [6] [7] [9] [10] [13] [16]
    - Ex : truncated Gaussian, Pareto, etc
* Multiple data streams to model e.g., video, audio, etc.
  + [9] [10]
* Views to take into account SA4 outcome in traffic model discussion given that SA4 is working on traffic model
  + [1][3][12][16][18]

### UL Traffic Model

Table 3 captures the views on UL traffic model from different sources. Some of views commented with DL are already captured in Table 2 are not captured here.

Table 3 Views on UL Traffic Model

|  |  |
| --- | --- |
| Source | View |
| [3] | Table 9. UL traffic model for XR/Cloud Gaming   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Traffic model** | Model 1 | Model 2 | Model 3 | Model 4 | | **Packet size distribution** | Fixed, 100Bytes | Fixed, 100Bytes | Fixed, 100Bytes | Fixed, 100Bytes | | **Packet arrival interval (ms)** | 1 | 2 | 5 | 20 | | **Packet delay budget (ms)** | 10 | 10 | 10 | 10 |   Proposal 26: For UL, traffic model in Table 9 is considered as the starting point for XR and Cloud Gaming evaluation. |
| [5] | Proposal 4: The following 2 categorizations of XR representative services for UL services as the starting point.   * , 300, fixed periodicity, fixed packet size * 2.7-50Mbps,, [5-30] fixed periodicity and fixed packet size/statistical model for fluctuating traffic * FFS periodicity values and the modeling of variant inter arrival rate * FFS statistical model for fluctuating traffic, target to down-select in RAN1#103-e between Gaussian distribution and Pareto distribution |
| [9] | UL traffic |

**Summary**

Companies have provided views on UL traffic model in following aspects.

* UL file inter arrival
  + Periodic: [3] [5] [15] [11] [10][9]
  + Random: [11] [10]
* UL file size
  + Fixed: [3] [5] [10] [6] [11]
  + Random: [5] [10][9]
* Multiple streams: [9] [10]
* Views to take into account SA4 outcome in traffic model discussion given that SA4 is working on traffic model
  + [1][3][12][16][18]

**FL Proposal 2**: Traffic model for DL and UL should reflect various bit rates, variable frame/slice/file/packet size, and periodicity with jitter, where statistical model is preferred. Conclusion on detailed traffic model is deferred to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available.

**Question 2**. Please share your comments on Proposal 2 if any.

|  |  |
| --- | --- |
| Company | View |
| QC | Decisions on traffic model should be made after SA4 provides its outcome to RAN1. |
| MTK | We can accept to defer the conclusion on detailed traffic model to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available. |
| ZTE, Sanechips | It would be better to clarify that it's not mandatory to consider the variable frame frame/slice/file/packet size or periodicity with jitter for all the applications of interest as confirmed in Q1 given at least for VR case, it seems jitter-free periodic traffic with fixed packet size for both UL/DL is sufficient per SA4 TR26.928. Alternatively, we are also fine to initiate the traffic model related discussion in RAN1#104-e  A modified proposal would be,  Traffic model for DL and UL ***for certain application(s) of interest*** should reflect various bit rates, variable frame/slice/file/packet size, and periodicity with jitter, where statistical model is preferred. Conclusion on detailed traffic model is deferred to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available. |
| Nokia, NSB | We agree that the RAN1 study conclusions should be in line with the SA4 outcome. At the same time, we believe it is important to start discussing (at least discussing, not mandatory concluding) this topic straightaway, as it holds many other important discussions. We can at least start collecting the companies’ view on how many traffic models do we need in RAN1 (e.g., 5 as the use cases, less models, where one model is representative to several use cases, more than one model per use case), etc.  Note that reference [11] was missing from UL traffic size inputs (added with highlight) |
| FUTUREWEI | Our understanding is that almost all the companies are proposing a statistical traffic model with near-periodic packet arrival (with jitter as proposed by some) and certain packet size distribution. We should try to reach some high-level consensus towards that direction while waiting for inputs from SA4. |
| APPLE | In our view, the same traffic model can be applied for both downlink and uplink, from SA4’s studies on ITT4RT and 5GSTAR, and some use cases from XR\_Traffic, uplink traffic can have the same characteristics as downlink’s, reference from [9] is added with highlight. |
| DOCOMO | Agree with the proposal. It should be better to wait for SA4 outcome for alignment between SA4 and RAN1. |
| LG | We support FL’s proposal. RAN1 discussion before SA4 outcome may cause potential confusion and unnecessary RAN1 overhead. |
| InterDigital | Although in principle we agree with the proposal, we think the use of a configurable traffic model for DL and UL as proposed in [9] and [10] can be considered as baseline. The parameters (e.g. bit rates, periodicity, PDB), to be applied in the configurable traffic model can be updated based on SA4 outcome |
| Intel | We are ok to wait for SA4 outcome for better alignment. |
| CMCC | Support FL proposal in principle. We also prefer to discuss the baseline configurable traffic model since the traffic model is relevant to all the evaluations. |
| Ericsson | We are mostly fine with the proposal. However, we do not see that jitter is part of the traffic model, and SA4 will not provide modelling of the jitter. Jitter is the result of varying delays in the transport and core networks and can be mitigated by appropriate network design and dimensioning.  Therefore, we suggest the following reformulation:  **FL Proposal 2**: Traffic model for DL and UL should reflect various bit rates, variable frame/slice/file/packet size, and periodicity, where statistical model is preferred. Conclusion on detailed traffic model is deferred to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available. How to model jitter is FFS. |
| vivo | We agree with FL’s suggestion. |
| Xiaomi | We are fine to defer conclusion until RAN4 makes decision. However, we are not sure whether jitter or variable packet size should be considered for UL traffic of VR and CG use cases. |
| Huawei, HiSilicon | Please could FL explain what does “slice, file” mean? And why they are relevant to RAN1? And packet refers to IP packet, PDCP packet, or else? Since RAN1 will wait for SA4 outcome, maybe just mentioning “frame” is enough at this stage.  Periodicity without jitter should also be considered.  The final traffic model may depend on SA4 outcome. But for the sake of progress, we suggest in this meeting, RAN1 can also have some discussions on traffic model, such as frame size distribution, frame arrival interval, etc. This can help companies in RAN1 have a better understanding of each application.  In summary, we suggest to revise Proposal 2 as follows:  **FL Proposal 2**: Traffic model for DL and UL should reflect various bit rates, variable frame~~/slice/file/packet~~ size, and periodicity without or with jitter, where statistical model is preferred. ~~Conclusion on detailed traffic model is deferred to the next RAN1 meeting (RAN1 104-e) where SA4 outcome on traffic model is expected to be available.~~ |
| CATT | In principle, we agree with FL’s intention and summary of traffic model. However, we need to define the underline theory and assumption of these configured parameters, such as packet size, interarrival time, for traffic modelling. We could define the traffic arrival process of XR services based on statistical/stochastic or deterministic process in queueing theory, such as M/M/1, M/M/N, G/M/1, D/D/1 process, to capture the characteristics of different XR applications. |
| Facebook | We agree with the proposal that we can wait for SA4 outcome to make decision on the traffic model, although we also think that some initial discussion in RAN1 would be helpful. |
| Samsung | Agree with the proposal from FL. |

Evaluation of UE Power Consumption for XR

### Evaluation Methodology for UE power consumption for XR

Companies’ view on evaluation of UE power consumption for XR is collected in Table 4.

Table 4 Companies’ Views on evaluation of UE power consumption for XR

|  |  |
| --- | --- |
| Source | View |
| [3] | Both the power saving gain and the capacity performance loss need to be considered.  For power consumption evaluation, both the power saving gain and the capacity performance loss need to be considered.  During the evaluation, power consumptions for different cases can be collected for subsequent comparisons as depicted in Figure 3, including:   * Case 1: No power saving mechanism is introduced. It is the performance baseline to show the consumed power and corresponding capacity performance. * Case 2: The DRX mechanism for connected mode in NR is introduced which can be a starting point. Each UE may be configured with different DRX offset   For XR power consumption evaluation,   * Power consumption performance is evaluated by using power consumption model in TR 38.840. * Capacity performance is evaluated by considering different DRX configurations.   + Details of DRX configuration are reported by companies |
| [4] | For XR service evaluation, the power consumption evaluation methodology and metric in TR38.840 could be reused. |
| [6] | Besides, the trade-off between power consumption and other performance should be considered, e.g. 60fps with lower power consumption or up to 90fps performance boost with higher power consumption, can be chosen in the game settings.  The power consumption model in TR 38.840 can be reused to evaluate the power consumption performance of XR and Cloud Gaming |
| [7] | Rel-16/17 UE power savings mechanisms and potential enhancements are considered subject to minimal/no additional scheduling latency and minimal/no increase in PDCCH blocking probability.  The power consumption models developed in TR 38.840 and Rel-16 and Rel-17 mechanisms for power savings can be a starting point subject to considerations for minimal/no additional scheduling latency and minimal/no increase in PDCCH blocking probability. |
| [13] | Coverage evaluation should be done in the agenda of R17 coverage enhancement considering that coverage is a trade-off with capacity.  Reuse the evaluation assumption agreed in R17 power saving as baseline with necessary modifications   * R1-2007419: LS on evaluation for connected mode UE power saving |
| [15] | The power consumption model and performance metrics in TR 38.840 can be reused for the evaluation of power consumption. |
| [16] | Evaluations for existing connected mode UE power savings techniques so far have shown that achieving power savings generally comes with a throughput/latency trade-off.  Baseline XR performance should be evaluated assuming that the UE is always available for scheduling (i.e., DRX or other power saving techniques are not considered) and any studies on power savings techniques should consider latency/throughput impact compared to the baseline. |
| [17] | The followings can be considered for KPIs for XR evaluations:   * Capacity: TR38.824 can be baseline for both URLLC independent case and eMBB/URLLC coexistence case * Mobility: up to 300 km/h or 500 km/h should be taken into account * Power: TR38.840 can be starting point * Coverage: Rel-17 coverage enhancement study can be starting point |
| [18] | Power and capacity has trade-off relation.  RAN1 performs system level simulation method for power evaluation, especially to accurately evaluate the capacity-power tradeoff.  In case power saving gain of power saving techniques is quantified, the gain is evaluated, compared, and captured subject to a given capacity constraint.  The grey point is the baseline scheme w/o power saving scheme: UE in always ON state (i.e., no DRX enabled).  For XR power evaluation, RAN1 consider various power saving schemes including R15/R16/R17 power saving techniques and various assumptions having high impact on UE power consumption. |
| [9] | TR 38.840 and additional modelling details from the ongoing power saving work item and RedCap study item from Rel-17 can be used as a starting point for XR power consumption evaluation.  Focus the evaluation on capacity and UE power consumption. The considering on mobility and coverage can be built into the evaluation methodology itself: e.g. 3 km/hr, indoor deployment and/or outdoor deployment, etc. Then separate efforts to evaluate enhancements for mobility and coverage are not needed. |

**System level evaluation**

It is discussed in [18] that UE power consumption for XR in reality is affected by various aspects including UE geometry, link adaptation, user selection by gNB scheduler in case of multi-UEs in the network, parameter configuration of applied power saving techniques (e.g., CDRX parameters), etc. It is therefore proposed in [18] that system level simulations should be conducted to accurately evaluate effect of those aspects since link level simulations have limitations to capture those aspects in evaluation for UE power consumption.

**Question 3.** Please share your view on whether system level simulation should be the baseline for evaluation of UE power consumption for XR.

|  |  |
| --- | --- |
| Company | View |
| QC | We support the system level simulation study for power evaluation. The operations of dynamic power saving schemes highly depend on PS (power saving) control signal reception (via DCI), and DRX timer values (determining Active Time/non Active Time), and/or scheduling decision across multiple UEs. Thus, we think that system level study should be used to accurately capture the impact of these aspects on UE power consumption. |
| MTK | We support to use system level simulator, while RAN1 should choose a reasonable amount of parameter combinations to avoid a too large simulation effort. |
| ZTE, Sanechips | As expressed in our response to the email thread under 8.14 TR skeleton, it would be good to have a discussion on prioritization among the potential evaluations related to XR given the TU allocated and the work load. We believe power saving related evaluations could be deferred a bit (e.g., to 2021 Q2) compared to capacity and coverage. |
| Nokia, NSB | We should first establish whether we will engage in power consumption evaluation in the first place. It is premature to have this level of detail at this stage. The questionnaire already assumes, not just that a power consumption evaluation is to be made but also has a very specific split of work built into it. What we need to discuss is whether we do power evaluation, and then what is the appropriate level of work. It is also important to avoid work duplication over what is done in the power saving enhancements WID.  Notably power consumption evaluation is not part of the SID objectives and we should first start by agreeing if UE power consumption is a relevant KPI to measure the performance.  *3. Identify evaluation methodology to assess XR and CG performance along with identification of KPIs of interest for relevant deployment scenarios* |
| FUTUREWEI | We also think traffic model and identification of KPIs should be done before this discussion as directed in the SID. |
| Apple | We agree power consumption is key for XR. How to perform power consumption evaluation should be discussed, including whether system level simulation is used, and what studies to be conducted, etc. |
| DOCOMO | We agree that system level simulation should be baseline for UE power consumption evaluation but the decision should be deferred. We think it needs to be discussed first whether evaluation for power consumption is done or not. Considering work load, it would be better to prioritize capacity evaluation. |
| LG | Considering the comments so far, we may need to discussion priority of power consumption analysis in this study first. If we do power consumption analysis, we think link-level approach would be basic one while system level evaluation can be additionally done. |
| InterDigital | For the purpose of evaluating the capacity vs power consumption tradeoff in XR, we agree that system level simulations can be considered for UE power consumption evaluation. |
| Intel | We think we can come back to this after we have some converged views on KPIs, requirements and basic EVM |
| Ericsson | We think it’s not necessary to agree on this at this early stage. It’s up to companies to contribute. |
| vivo | We support FL’s proposal to use SLS for power consumption evaluation, since both the power saving gain and the capacity performance loss need to be considered. |
| Huawei, HiSilicon | So far, many issues are unclear, such as the traffic models, evaluation methodology and KPIs, etc. We think it’s premature to decide whether SLS is needed or not.  There is no need to discuss this issue in this meeting. And companies are free to submit simulation results.  In addition, the simulation workload should also be considered due to the limited TU of the study item. |
| CATT | The power model for UE power consumption defined in TR38.840 are the relative value to the deep sleep. The UE power consumption for any traffic arrival does not require system level simulation. The UE power consumption and UE perceived throughput (latency) could be evaluated together as those evaluated in Rel-16 UE power saving in TR38.840 |
| Facebook | We think power consumption is critical for XR use case. Hence, we support the proposal on adopting the system level simulation capturing the impacts of different features and system parameters. |
| Samsung | We agree that UE power consumption is one of the key metrics. But the primary one are the performance requirements (e.g. PER, PDB) and UE power consumption can be a complementary metric under the performance requirements.  A concern with SLS is that, especially under the current setting of meetings, it may difficult to calibrate or decipher reasons for potential large discrepancies. Despite their limitations and required abstractions, analytical approaches based on well-calibrated LLS should also be complementary. |

**Summary**

* Is UE power consumption evaluation part of the study, i.e., is UE power consumption a KPI?
  + Yes (9): QC, MTK, Apple, InterDigital, vivo, Xiaomi, CATT, Facebook, Samsung
  + No (2): Nokia, HW
  + Need further discussion (7): Nokia, LGE, ZTE, FutureWei, DOCOMO, Intel, HW
  + It’s up to companies to contribute.
    - Ericsson, HW
* If UE power consumption is evaluated, which is more appropriate between system level evaluation vs. link level simulation
  + System level (5): QC, MTK, InterDigital, vivo, Facebook
  + Link level (3): LG, CATT, Samsung
  + Up to company (2): Ericsson, HW

**Baseline UE power consumption: UE power consumption w/ no power saving scheme**

Multiple companies emphasize the importance of evaluation of UE power consumption for XR, including evaluation of power saving gain from various power saving techniques that have been developed since Rel-15. The power saving gain can be evaluated compared to a baseline UE consumption result. Multiple companies propose to define the baseline UE power consumption to be the power consumption for the case when the UE is always available for scheduling, i.e., the UE never goes into a sleep state (in others words, no power saving technique is applied).

**Question 4.** Please share your view on the above definition of baseline UE power consumption to be used for evaluation of the gain of a UE power saving technique.

|  |  |
| --- | --- |
| Company | View |
| QC | The baseline power consumption scheme is always ON scheme (w/o any power saving scheme, e.g., no CDRX, no BWP switching, no WUS, etc). The power saving gain of other power saving schemes can be compared w.r.t this baseline. This will allow the comparison of different schemes with the same reference point. |
| MTK | Considering the power-capacity trade-off, we can accept to use the FL proposed baseline for first wave evaluation. If RAN1 found that some existing power saving techniques introduce negligible capacity loss, a new baseline can be applied. |
| ZTE, Sanechips | We agree that no power saving scheme should be considered as the baseline. The impact of power saving schemes on the KPIs, such as capacity, coverage, mobility, should be evaluated. |
| Nokia, NSB | Should the UE power consumption be agreed as a relevant XR performance KPI, there is no reason to exclude DRX or other power saving techniques specified in Rel-15 – Rel-17 if they are applicable with a given traffic model. It is, however, premature to discuss how to evaluate the baseline before we have agreed to do the work at all. If the answer is yes, then at that point we should look at what power saving tools Rel-15 – Rel-17 that are applicable with the traffic models applicable for XR services. |
| FUTUREWEI | When discussing the power consumption (if identified as a KPI) later, at least the relevant features developed in R16 should be included. |
| Apple | The FL proposal is fine to us as a baseline scheme needs to be simple. However, exactly how that is conducted, e.g. with SLS or LLS should be discussed. |
| DOCOMO | Firstly, we think this should be discussed after we make a conclusion to do evaluations for power saving. However, if needed, we should clarify what power saving schemes are applicable for XR traffic models. The schemes should include at least Rel-15/16. |
| LG | While it is fine to perform analysis with no power saving schemes, Rel-16 power saving techniques should be also included when applicable to avoid introducing unnecessary enhancements (which is the case for Rel-17 power saving WI) |
| InterDigital | We think different baseline cases can be considered for XR, e.g. without any power savings and with basic power saving (e.g. assuming generic DRX configuration for eMBB/URLLC traffic) |
| Intel | Similar view as DOCOMO and Nokia, we think identification of KPIs and basic EVM is a priority– we can check this after there is a conclusion to pursue power savings eval. |
| Ericsson | We agree the baseline should be that the UE is always available for scheduling. |
| vivo | We agree with FL’s suggestion that the baseline scheme for power consumption evaluation is no power saving technique is adopted |
| Xiaomi | We agree with FL’s proposal. |
| Huawei, HiSilicon | According to RAN plenary decision (RP-202111, copied below), it’s clear that power saving related issues are not within the scope of this RAN1 meeting. So this question is premature and should not be discussed.   * Study on XR Evaluations for NR (RAN1)   + Applications, Traffic Model and Evaluation Methodology *Focus on applications and evaluation methodology including identification of KPIs of interest for relevant deployment scenarios*   + Others   + *NOTE: SA4 has ongoing work in the XR area, RAN1 will not address these SA4 aspects but will wait for SA4’s outcome* |
| CATT | Rel-16 UE power saving study and work had clear definition of baseline assumption in TR38.840. Those baseline assumptions could be used for XR evaluation. |
| Facebook | We agree with FL’s proposal. |
| Samsung | Agree with the FL’s proposal. Also agree with evaluating impacts of UE PS mechanisms on KPIs. |

**Summary**

* Agree (12): QC, MTK, ZTE, Apple, LG, InterDigital, Ericsson, vivo, Xiaomi, CATT, Facebook, Samsung
* Rel-16 power saving scheme should be evaluated:
  + HW, DOCOMO, LG (FL note: this seems to be assumed by all companies although many companies do not explicitly address this point).
* Premature: Nokia, Intel, DOCOMO

**Upper bound of UE power saving gain: Genie UE power consumption**

As another useful reference for evaluation of UE power consumption for XR, “Genie” UE power consumption is proposed in [18], defined as UE power consumption for the case when the UE is assumed to enter a sleep state in all the slots with neither DL reception nor UL transmission. Which sleep state (micro, light, or deep) the UE can enter is determined based on the duration of consecutive slots with no DL reception and no UL transmission. The Genie result can serve as the upper bound of the power saving gain of a power saving technique, which may potentially motivate development of new power saving techniques that can approach the Genie performance.

**Question 5.** Please share your comment if any on evaluation of the “Genie” UE power consumption as a benchmark.

|  |  |
| --- | --- |
| Company | View |
| QC | We support the evaluation of Genie scheme in XR power evaluation. Identifying gap between any considered scheme and upper bound could be an important outcome of XR power study in the sense that it can identify potential issues and solutions. |
| MTK | We can accept to include the evaluation of the “Genie” UE power consumption as a benchmark. However, it should be noted that the upper bound can not address the power saving schemes that applied BW scaling, MIMO layer adaptation, or UL/DL transmission timing relaxation. |
| ZTE, Sanechips | We think the “Genie” UE power saving consumption can be informative but not mandated. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance |
| FUTUREWEI | Not sure this is the right topic for discussion at this point. Also how to define a “Genie” scheme and what is the purpose of such a benchmark for further study? |
| Apple | The evaluation of a genie scheme can be informative. |
| DOCOMO | We understand the “Genie” UE power consumption result can be informative but this should be discussed later. First, we should discuss whether to do evaluations for power consumption. |
| LG | No objection to see Genie UE power consumption reference, but it doesn’t need to be mandatory analysis. |
| InterDigital | We think that if the intention of the Genie UE power consumption is to characterize the best case or upper bound performance, then possibly other methods of identifying when the UE can enter into micro, light or deep sleep can be formulated rather than based on duration of Tx/Rx inactivity. For example, the alternative method can include the use of different sleep/on profiles to serve as upper bound, where these sleep/on profiles are aligned/optimized with known (benchmark) traffic profiles for VR, XR and CG applications |
| Intel | Premature to discuss |
| Ericsson | Too early to even discuss. |
| vivo | We agree with FL’s suggestion.  Genie scheme for power consumption evaluation can be evaluated to investigate the upper bound of power saving gain without the capacity performance loss.  To clarify the genie scheme, we think a UE with genie scheme can enter the power saving mode when there is no DL reception and UL transmission, and can wake up immediately for DL reception and UL transmission, where the Rel-16 defined power model should be followed. |
| Xiaomi | We agree with other companies that genie scheme can be optional. |
| Huawei, HiSilicon | Premature to discuss. As replied under Question 4, power saving related issues are not within the scope of this RAN1 meeting. This study item should focus on some general issues first, i.e., applications, traffic models, KPIs and evaluation methodology. |
| CATT | The power consumption modelling is very clearly specified in TR38.840. We could refer to those in TR38.840 for the power saving study in XR |
| Facebook | We support the development of upper bound on the power saving/UE power consumption. As mentioned previously, power consumption is critical to the XR use cases. Hence, the evaluation provides a good indication on how far we are from ideal scenario. |
| Samsung | The proposal from the FL is reasonable – together with the one from Q4, it can establish lower bounds and upper bounds for UE PS mechanisms in order to better understand potential ‘deltas’. |

**Summary**

* Agree (12): QC, MTK, ZTE, Apple, LG, InterDigital, Ericsson, vivo, Xiaomi, CATT, Facebook, Samsung
* Rel-16 power saving scheme should be evaluated:
  + HW, DOCOMO, LG (FL note: this seems to be assumed by all companies although many companies do not explicitly address this point).
* Premature: Nokia, Intel, DOCOMO

**Evaluation of UE power saving gain of power saving schemes**

It is highly beneficial to study the power saving gain of various power saving schemes, e.g.,

* Rel-15/16/17 UE power saving techniques, e.g., CDRX, BWP switching, cross-slot scheduling, etc.
* Potential future enhancements (e.g., CDRX enhancements if needed, etc.).

In addition, it will be useful to explicitly study and better understand the impact of certain critical features/configurations on UE power consumption, e.g.,

* **DL rx and UL tx alignment**: In case DL and UL transmissions to/from a UE are consecutive, UE can stay longer in a deeper sleep state. It will be useful to see the power performance difference between DL/UL alignment vs. misalignment.
* **Impact of jitter in UE power consumption**: Effect of certain power saving techniques, e.g., CDRX can be substantially reduced by jitter (as packet arrival times at gNB vary over time which are not aligned with the beginning of the configured CDRX on duration). Although jitter may be part of traffic model, it would be highly beneficial to explicitly evaluate UE power consumption with and without jitter. The study outcome may potentially motivate development of a new power saving technique that is more effective with jitter.

**Question 6**. Please share your view on which power saving techniques among various candidates discussed above are to be evaluated with high priority in terms of power saving gain over the baseline discussed above.

|  |  |
| --- | --- |
| Company | View |
| QC | It is very important to evaluate existing power saving schemes to understand power consumption aspect in XR support. However, due to the limited time, it would not be doable to evaluate all the combinations of the power saving schemes defined in R15/R16 as well as potentially in R17. To reduce workload without missing any potentially important study results, RAN1 should focus on PS schemes which have the highest impact on UE power consumption. We think at least following scheme should be evaluated in this SI.   * CDRX   In addition to the specific PS schemes, we could also consider evaluation of configurations/assumptions with high impact on power consumption. We agree that UL/DL alignment can reduce power consumption by reducing UE’s wake up and extend potential sleep duration. Jitter is another critical aspect to study especially when DRX is used. With jitter, the expected delay for packet transmission can increase which potentially have negative impact on power and capacity as well. |
| MTK | Since RAN1 has developed various power saving schemes in R15/R16/R17(on-going) power saving agenda, to avoid duplicated effort in RAN1 discussion, we prefer to first evaluate existing power schemes in R15/R16 power saving agenda, ex., “CDRX, BWP switching, cross-slot scheduling, SCell dormancy”, to observe the capacity-power trade-off for existing schemes. After this, if it is observed that a significant power saving gain gap exists, new power saving schemes in R17 power saving agenda or other new schemes can be evaluated. |
| ZTE, Sanechips | To have a better understanding of the impact and potential problems of the legacy power saving solutions, we think the schemes including C-DRX, BWP switch, and cross-slot scheduling specified in Rel-15/16, and Rel-17 candidate enhancements (e.g., dynamic PDCCH reduction) needs to be evaluated. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. Notably this SI is not a study of what power saving gains the already specified power saving features offer over no power saving features applied. These components should end up as part of the baseline if such evaluation is decided to be needed. |
| FUTUREWEI | As stated in our answers above, features related to power consumption developed in R16 (and even in R17) should be included if such evaluation is agreed to carry out in this SI. |
| APPLE | We can investigate power saving techniques first then come to the candidate solutions. |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | This point may not need to be discussed at this stage since companies proposals on potential enhancements should be discussed later stage of the SI in a more structured manner. |
| InterDigital | We think power savings schemes such as CDRX and other techniques are not agnostic to the traffic profile/model, including the DL/UL alignment and jitter-aware techniques, can be considered in the evaluations. The details of power consumption techniques can be deferred for later discussion |
| Intel | Premature to discuss |
| Ericsson | We think it’s not necessary to do prioritization exercise at this early stage. It’s up to companies to contribute. |
| Vivo | Rel-15/16/17 UE power saving techniques should be evaluated with high priority. The DRX configurations and parameters for evaluation need further discussions. Since the power saving gain would be highly depending on the traffic mode, it is necessary to determine the appropriate DRX configuration/parameter for a given application and traffic model.  Potential future enhancements can also be considered for power evaluation.  We are open to further evaluate DL-UL alignment and impact of jitter as optional features. |
| Xiaomi | We agree with other companies that it is premature to discuss this issue. |
| Huawei, HiSilicon | Premature to discuss. As replied under Question 4, power saving related issues are not within the scope of this RAN1 meeting. At this stage, it’s up to companies. No need to make agreements to prioritize or down-prioritize some techniques. |
| CATT | Rel-16/17 Power saving techniques could be used for XR. However, jitter buffering and other aspects are mostly UE implementation and can’t be captured in UE power consumption evaluation completely. |
| Facebook | We agree that Rel. 15/16/17 power saving techniques can serve as a starting point for evaluation. We are open to the discussion of power saving schemes and potential enhancements at the early stage given the importance of the features. |
| Samsung | Consideration of the suggested configuration aspects for UE PS mechanisms is reasonable but of course discussion is needed for conclusions. Agree that comprehensive evaluation is not possible and a reasonable down-scoping should be discussed for UE PS mechanisms. Considerations on CDRX and jitter-aware mechanisms are justified. |

**Summary**

* R15/16 power saving techniques potentially with down-selection
  + MTK, QC, ZTE, FutureWei, Apple, InterDigital, CATT, Facebook, Samsung
* Additional techniques
  + QC, Apple, InterDigital
* Premature
  + Nokia, DOCOMO, LG, Intel, Xiaomi, Huawei,
* Up to company to contribute
  + Ericsson

**Power saving gain taking into account capacity-power tradeoff**

As captured in Table 4, multiple companies have observed and pointed out that there exist tradeoff relations among different performance aspects: capacity, power, coverage. For example, [3][6][16][18] have observed the tradeoff between capacity and power. [13] has observed the tradeoff between coverage and capacity. One good example is tradeoff between power saving gain and capacity. In network/UE operation, applying a power saving scheme may result in delayed packet scheduling (as the UE is supposed to be in a sleep state for a certain duration depending the applied power saving scheme), which can increase the chance of violating packet delay budget and consequently lead to lower capacity.

Understanding the tradeoff of the evaluated power saving technique is important, e.g., for fair comparison of schemes/assumptions since one scheme may have higher hit on one performance metric than other schemes (e.g., scheme A={CDRX with cycle=50ms} has higher power saving gain than scheme B={CDRX with cycle=5ms}, but A would have lower capacity than B). Thus, when the gain of a power saving technique is evaluated, the capacity loss compared to the baseline scheme (i.e., no power saving scheme) needs to be evaluated together.

**FL proposal**: The UE power saving gain of a power saving technique is defined to be the reduction (%) in UE power consumption compared to the baseline UE power consumption (i.e., UE power consumption with no power saving scheme), subject to at most Y% (e.g., Y=5) system capacity reduction induced by the applied power saving technique. When the power saving gain of a power saving technique is submitted, the following should be reported together: (i) the amount of capacity loss caused by the evaluated power saving technique and (ii) how far is from the “Genie” UE power consumption (i.e., additional power consumption in % compared to the Genie power consumption).

**Question 7**. Please share your view on the above proposal and appropriate Y value.

|  |  |
| --- | --- |
| Company | View |
| QC | Putting a constraint on capacity loss in power number evaluation/comparison is required to make it as a fair evaluation/comparison across different power saving schemes. We think Y=5 would be a reasonable value. |
| MTK | We think the FL proposal is reasonable and Y=5 or 10 can be considered. We also think one value for Y is enough. |
| ZTE, Sanechips | The user experience is strongly relevant to the system capacity, we think Y=2.5% is reasonable. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. |
| FUTUREWEI | Too early to discuss this. |
| Apple | UE power consumption and capacity are important issues, whether trade-offs and how trade-offs can be made can be discussed later. Now it is rather premature to start with that. |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | We think this is somewhat detail and has to be discussed later. |
| InterDigital | We are in principle supportive of the methodology provided in the proposal for i) evaluating the power saving gain with respect to a benchmark power saving technique and ii) the tradeoff in terms of the loss in capacity. While a specific Y value may not be needed as a constraint in the evaluations, 5% may be used as starting point. The evaluation results should show the power savings achieved for different values of capacity so that the tradeoff curve can be derived. We also think that the details of power consumption evaluations can be discussed later |
| Intel | Premature to discuss |
| Ericsson | This proposal can be deferred, as some aspects are not yet clear/should be sorted out first, such as a proper definition of upper bound. |
| vivo | We agree to evaluate the tradeoff between power saving gain and system capacity.  We would like to further clarify how to evaluate power consumption performance considering the definition of system capacity in the [XR-02-Capacity] discussion. It is proposed to define the system capacity as “**maximum number of users per cell with at least X % of UEs being satisfied**”.  In addition to simulating the power consumption performance in the case of system capacity, we think the power consumption evaluation should be also provided with different cell loads (in terms of different RUs or different number of UEs per cell which are less than system capacity), e.g. low load, medium load, high load, etc. For a given cell load, the capacity performance metrics (e.g. UPT) should be reported together with power consumption performance. |
| Huawei, HiSilicon | Premature to discuss. As replied under Question 4, power saving related issues are not within the scope of this RAN1 meeting. |
| CATT | The power saving techniques in Rel-16 and Rel-17 do not have any tradeoff in system capacity. Some power saving techniques, such as cross-slot scheduling, might have degradation on User Perceived throughput. However, most of power saving techniques, such as DRX adaptation, Maximum MIMO layer adaptation, and SCell dormancy, do not have impact on the system capacity. |
| Facebook | We agree that this is one area to be further looked into but agree can be discussed at later stage. |
| Samsung | The proposal is reasonable but detailed discussion/conclusion at this stage is not. Good for further consideration.  One side note is that nearly all questions/issues so far focused on UE power consumption. While that is undoubtedly an important metric, it is not the only one for XR and probably it is not the most important. Mechanisms for meeting the (challenging) KPIs under challenging conditions without vacating the network from all other services should have at least a same (if not higher) level of priority in the discussions. |

**Summary**

* X = 2.5%
* X = 5%
  + QC, InterDigital
* X = 5 or 10%
  + MTK
* Premature
  + Nokia, FutureWei, DOCOMO, Apple, Intel, Ericsson, vivo, HW, Facebook, Samsung

### Other Evaluation Assumptions

Following sources captured in Table 5 have provided their views.

Table 5 Views on Evaluation Methodology on Power

|  |  |
| --- | --- |
| Source | View |
| [3] | **Proposal 19**: For XR power consumption evaluation,  • power consumption performance is evaluated by using power consumption model in TR 38.840.  • capacity performance is evaluated by considering different DRX configurations.  - details of DRX configuration are reported by companies. |
| [4] | **Proposal 5**: For XR service evaluation, the power consumption evaluation methodology and metric in TR38.840 could be reused. . |
| [6] | **Proposal 2**: The power consumption model in TR 38.840 can be reused to evaluate the power consumption performance of XR and Cloud Gaming. |
| [7] | The power consumption models developed in TR 38.840 [4] and Rel-16 and Rel-17 mechanisms for power savings can be a starting point subject to considerations for minimal/no additional scheduling latency and minimal/no increase in PDCCH blocking probability. |
| [13] | **Proposal 9**: Reuse the evaluation assumption agreed in R17 power saving as baseline with necessary modifications   * R1-2007419: LS on evaluation for connected mode UE power saving |
| [15] | Power consumption  The power consumption model and performance metrics in TR 38.840 can be reused for the evaluation of power consumption. |
| [17] | Proposal 4:   * The followings can be considered for KPIs for XR evaluations: * Capacity: TR38.824 can be baseline for both URLLC independent case and eMBB/URLLC coexistence case * Mobility: up to 300 km/h or 500 km/h should be taken into account * Power: TR38.840 can be starting point * Coverage: Rel-17 coverage enhancement study can be starting point |

Given that R16 UE PS SI provides a good starting point power evaluation methodology, many companies have suggested it as a starting point. There was also a view [17] that R17 UE PS evaluation method should be the baseline with necessary modification.

**FL Proposal**. For XR UE power evaluation, use TR38.840 as baseline power evaluation methodology with necessary modifications if necessary.

**Question 8**. Please share your comments on the above proposal if any.

|  |  |
| --- | --- |
| Company | View |
| QC | Agree to use 38.840 as the baseline power evaluation methodology. We think it need further enhancement in UL power modeling to better capture increased power contribution from UL activities of XR devices. Our view on such enhancements is presented below by answering relevant questions. |
| MTK | We think R17 UE PS evaluation method should be the baseline with necessary modification. However, we can accept to use 38.840 since it also includes various R16 power saving techniques for evaluation. |
| ZTE, Sanechips | We agree to take TR38.840 as the baseline. And further enhancements (see our reply to Q9, Q10, Q11, and Q14) are also needed. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. |
| FUTUREWEI | Too early to discuss this. |
| Apple | Consider 38.840 and modifications from RedCap and Rel-17 power saving as starting point |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | We are fine with FL’s proposal. |
| InterDigital | We support the proposal for using TR 38.840 as baseline with enhancements for power evaluations |
| Intel | Premature to discuss |
| Ericsson | We are fine with this proposal. |
| vivo | We agree with FL’s proposal. |
| Xiaomi | We agree with FL’s proposal. |
| Huawei, HiSilicon | Premature to discuss. We should first discuss whether power consumption is a relevant KPI. |
| CATT | Yes. TR38.840 should be used for UE power consumption related study. |
| Facebook | Fine with the proposal. |
| Samsung | Agree with MTK. |

**Summary**

* Agree potentially with necessary modifications (11)
  + QC, MTK, Apple, LG, InterDigital, Ericsson, vivo, Xiaomi, CATT, Facebook, Samsung
* Premature (5)
  + Nokia, FutureWei, DOCOMO, Intel, HW

**Linear Interpolation based UL Power Consumption Estimate for different Tx Power**

In some XR applications, UL data transmissions may include pose/control/scene upload. Their data rates range from e.g., 1Mbps ~ 10Mbps with short interval (2ms ~ 100ms) between two consecutive transmissions. This makes UL power consumption contribution to total power consumption increase significantly. Thus, it is critical to evaluate UE power consumption from UL transmissions. The power model defined in TR 38.840 is available only for two values of UE tx power: 0dBm and 23dBm, not available for other power levels. Thus, in order to effectively capture different tx power contributions from UEs with different tx power in various locations in the cell (also depending on various interference levels), UE power consumption model for power levels other than 0dBm and 23dBm is needed. For instance, linear interpolation model (that is already used in TR 38.840 to estimate the power consumption for different number of blind decoding) is proposed in [18].

**Question 9**. Please share your view on how to model UE power consumption for UE tx power other than 0dBm and 23dBm.

|  |  |
| --- | --- |
| Company | View |
| QC | We think it is quite reasonable to use linear interpolation technique to estimate intermediate power consumption values for tx power other than 0dBm and 23dBm. Based on our study, the linear interpolation in linear power domain could provide quite a good estimate which is close to actual measurements. This is because the scaled power is mostly due to power consumed at power amplifier (PA) and its power consumption scaling w.r.t output tx power is close to linear in the regime of interest.  This should be applied to not only the UL slots in 38.840 but also other potential UL slots to be added if necessary. |
| MTK | We are open to model UE power consumption for UE tx power other than 0dBm and 23dBm. The exact method may need to be further discussed and aligned to provide consistent assumptions between companies. |
| ZTE, Sanechips | We think the UE power consumption model for other UE transmission power are necessary. The following issues need discussion/clarification towards linear interpolation,  1)PA output seems to be linear in real domain thus there could be need for a conversion from log domain to real domain  2) We are not quite sure whether linear alone would be sufficient for the whole range of interest including that larger than 23dBm  Furthermore, the UL transmission power for FR2 in38.840 (copied as below) is unclear and should be decided before the discussion of scaling rule for FR2 transmission power adaptation.   |  |  |  |  | | --- | --- | --- | --- | | Power State | Characteristics | Relative Power | | | FR1 | FR2 | | UL | Long PUCCH or PUSCH. | 250 (0 dBm)  700 (23 dBm) | 350  (FFS Tx power level) | |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. |
| FUTUREWEI | Too early to discuss this. |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | We tend to feel this can be discussed later, but open to discussion. |
| InterDigital | We are open for using the linear interpolation model from TR 38.840 for modelling UE Tx power. However, the details can be discussed later |
| Intel | Premature to discuss |
| Ericsson | It is not clear to us if new power consumption models are in-scope of the SI. If it is in-scope, more discussions are needed to define a proper model. |
| Vivo | Linear interpolation can be a starting point |
| Huawei, HiSilicon | Premature to discuss. |
| CATT | During Rel-16 UE power saving study, the interpolation of UE power consumption should be performed after subtract the minimum power consumption of micro sleep. |
| Facebook | Can be the starting point for further discussion. |
| Samsung | Linear interpolation can be a starting point. |

**Summary**

* Linear interpolation as a starting point (7)
  + QC, ZTE, vivo, CATT, Facebook, InterDigital, Samsung
* Agree with the necessity of developing model for UE tx power other than 0dBm and 23dBm. FFS details (1)
  + MTK
* Premature, to be discussed later (6)
  + Nokia, FutureWei, DOCOMO, Intel, HW, LG

**Additional UL Slots for Power Evaluation**

The UL power model in 38.840 needs to be further improved for UL power evaluation of XR applications. The power model in TR 38.840 has power state for UL (or PUSCH or long-PUCCH) or short-PUCCH (or SRS). However, these two states are not enough to capture different power consumption values generated from various UL activities such as pose/control, scene upload, ACK/NACK for PDSCH, SR, CSI, or SRS especially across different Ues in system level study. In system level study, since multiple Ues’ UL transmissions can be multiplexed in the same slot, additional UL slot modelling is required. For example, in a UL slot with PUSCH+PUCCH+SRS, two Ues could be scheduled: PUSCH for the first UE, and PUCCH+SRS for the second UE. Since the power model in TR 38.840 does not have power state for e.g., PUSCH + gap, or gap+PUCCH+SRS, etc, the current model needs to be improved to capture more diverse slots to more accurately evaluate power consumptions in such cases.

**Question 10**. Please provide your view on additional UL slot power modeling discussed above.

|  |  |
| --- | --- |
| Company | View |
| QC | The R16 UE PS study was mostly focused on DL side, and UL modelling got less attention than DL. In order to better study UE power consumption for XR, additional UL power modelling is required.  We think a new slot of PUSCH(12)+PUCCH(1)+SRS(1) can be considered which supports multi-UE simulation in system level to support PUSCH, PUCCH, and SRS in the same slot. Note that the number inside parenthesis is the # of OFDM symbols for the corresponding channel/signal. Depending on the UL activity of Ues, there are various UL transmissions in a UL slot, e.g., PUSCH only, PUCCH and SRS, etc.  The derivatives of the slot (which are generated depending on UE’s activity) are captured in the following table. The basic power numbers for 0dBm and 23dBm are based on existing UL slots in TR 38.840.  The baseline slots #1 and #5 are based on TR 38.840. Other slots #2~#4 are estimated based on linear interpolation based on # of active UL symbols considered in each case.   |  |  |  |  | | --- | --- | --- | --- | | # | Power state | Power number | Note | | 1 | PUSCH(12)+PUCCH(1)+SRS(1) | [250] (0dBm)  [700] (23dBm) | Same as UL power state | | 2 | PUSCH(12) + PUCCH(1) + Gap(1)  PUSCH(12) + Gap(1) + SRS(1) | [235] (0dBm)  [660] (23dBm) | Applied linear interpolation method to get power number for 13 UL symbols case with two end points A and B where A=power number for PUSCH(14) slot, B= power number short-PUCCH(1) | | 3 | PUSCH(12) + Gap(2) | [225] (0dBm)  [625] (23dBm) | Applied linear interpolation method to get power number for 12 UL symbols case with two end points A and B where A=power number for PUSCH(14) slot, B= power number short-PUCCH(1) | | 4 | MS(12) + PUCCH(1) + SRS(1) | [90] (0dBm)  [248] (23dBm) | Applied linear interpolation method to get power number for 2 UL symbols case with two end points A and B where A=power number for PUSCH(14) slot, B= power number short-PUCCH(1) .  Assumed that PUCCH and SRS power are the same. | | 5 | MS(13) + SRS(1) | [75] (0dBm)  [210] (23dBm) | As defined in 38.840, same as short-PUCCH | |  | \* PUSCH(X): X symbols of PUSCH  \* PUCCH(Y): Y symbols of PUCCH  \* SRS(Z): Z symbols of SRS  \* MS(N): N symbols of Micro Sleep  \* Gap(M): M symbols of gap  \* This is the case for UE’s number of Tx antenna = 1 | | | |
| MTK | We do not really feel the necessity of introducing additional UL slot power modelling since the power value of #1, #2, #3 and #4, #5 are actually close in QC’s suggested table. (#1 is close to #2, #3, and #4 is close to #5) |
| ZTE, Sanechips | We also observe that the UL states in TR38.840 are limited to PUSCH, Long PUCCH, short PUCCH and SRS. We agree to consider more UL power states to precisely simulate the UL UE behavior. And the combinations of UL transmission could be further discussed. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. |
| FUTUREWEI | Too early to discuss this. |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | We tend to feel this can be discussed later, but open to discussion. |
| InterDigital | We agree that the UL power model needs updating in order to take into account the different types of traffic that can be multiplexed within an UL slot. However, the details can be discussed later |
| Intel | premature to discuss |
| Ericsson | It is not clear to us if new power consumption models are in-scope of the SI. If it is in-scope, more discussions are needed to check the necessity. |
| Vivo | UL slots including multiple types of UL transmissions from one or multiple Ues, e.g. PUSCH+PUCCH, PUSCH+SRS, etc., can be considered for the power evaluation. |
| Huawei, HiSilicon | Premature to discuss. |
| CATT | The principle of power scaling in TR38.840 could be reused although there is no specification on certain channel combination. In TR38.840, the power consumption is based on the average power of one slot. For one symbol transmission/reception, the UE power consumption is one symbol power consumption of specific model averaged with 13 symbols of micro sleep power consumption. |
| Samsung | Deprioritize – the issue is much smaller in relative importance and unclear why it requires additional consideration over TR 38.840 (i.e. what sort of decisive ‘delta’ is expected). |

**Summary**

* Most of companies think that it is premature, while some indicate the necessity.

**Special (S) Slot Power Consumption**

The power model in TR 38.840 for special(S) slots is available only for one specific configuration, “PDCCH+PDSCH+PUCCH” assumed to have the same power number as PDCCH+PDSCH state, which may hold only for 0dBm case. The reasoning based on this approximation is that PUCCH tx power at 0dBm is not significantly different from power consumption required for DL reception. For other tx power level, e.g., 23dBm tx power, this reasoning may not hold any more. Once S slot’s 23dBm power number is available, then power number for other tx power levels may be estimated by linear interpolation between power number for 0dBm and power number for 23dBm.

**Question 11**. Please share your view on power consumption model for S slot for XR power evaluation.

|  |  |
| --- | --- |
| Company | View |
| QC | The modelling of S slot is useful in case the TDD frame structure to be evaluated includes S slot. The first step is to define power number for 0dBm and 23dBm.  PDCCH+PDSCH+PUCCH+SRS = [300] for 0dBm  PDCCH+PDSCH+PUCCH+SRS = [450] for 23dBm  Power for 0dBm case is based on PDCCH+PDSCH. Power for 23dBm is based on estimation and PA power measurement data points.  Power consumption for different tx power could be computed based on linear interpolation in linear power domain. |
| MTK | We are open to discuss S slot’s 23dBm power number. At the same time, we are curious how to model the SRS periodicity since this depends on NW implementation. |
| ZTE, Sanechips | To reduce the transmission delay, the special slot can be considered in the simulation to enable UE to feedback the HAQR-ACK/pose/position,etc. as soon as possible. We think it is necessary to discuss the power consumption of the special slot. And the combinations of different number of DL and UL symbols should be further discussed. We also agree the power consumption of special slot with different UL transmission power is needed. |
| Nokia, NSB | Premature to discuss, no agreement even on whether the UE power consumption is a KPI of interest for assessing the XR and CG performance. |
| FUTUREWEI | Too early to discuss this. |
| DOCOMO | Same comment as previous questions. It should be discussed later. |
| LG | We tend to feel this can be discussed later, but open to discussion. |
| Interdigital | We are fine for employing linear interpolation between power numbers for 0dBm and 23dBm to approximate the Tx power number for other TX powers. We also think this can be discussed later |
| Intel | Premature to discuss |
| Ericsson | It is not clear to us if new power consumption models are in-scope of the SI. If it is in-scope, more discussions are needed to check the necessity. |
| Vivo | Power model for the S slot could be considered for power evaluation. If introduced, limited models of slot format for the S slot are assumed. |
| Huawei, HiSilicon | Premature to discuss. |
| CATT | Power consumption for S slot should not be much different to normal slot since UE does not have sufficient time to perform micro sleep. This issue was discussed during power model discussion in Rel-16 UE power saving study. |
| Samsung | Similar to Q10. Deprioritize – compared to other aspects, that is a marginal issue. |

**Summary**

* Most of companies think that it is premature, while some indicate the necessity.

Evaluation Methodology for Coverage

Table 8 captures the views from different sources on evaluation methodology for coverage evaluation.

Table 8 Views on Evaluation Methodology for Coverage

|  |  |
| --- | --- |
| Source | View |
| [2] | Proposal 6: The CDF of XQI is used to evaluate the coverage performance of the network. |
| [3] | Proposal 15: For XR coverage evaluation, link budget can be adopted as the evaluation methodology, and max isotropic loss (MIL) can be used as the performance metrics. |
| [5] | Proposal 5: Consider the capacity metric and coverage enhancement metric in XR evaluation.  - Capacity metric should include both the number/percentage of Ues satisfying the PDB/PER/Rate requirement and the statistical metrics regarding the CDF of UPT.  - Coverage metric should use the service based metric i.e. calculate MPL and compare it with the ISD. For the link level simulations used to generate the MPL, the following discussion points should be settled.   * For DL, the number of PRBs should be generated by considering the full bandwidth dedicated. TBS should be determined by an agreed MCS. * For UL, the PRBs/TBS/MCS should be set in accordance with the UL traffic. * Target BLER should be set in accordance with the traffic, e.g. or . |
| [6] | Proposal 3: The capacity and coverage can be evaluated by the number of Ues and X% Ues that meet the requirement. |

To better manage RAN1 workload for XR evaluations for NR, it is proposed by the rapporteur in [19] to defer detailed discussion on evaluation methodology for XR mobility to 2021 Q2. The delayed start will also benefit from stable evaluation methodology and assumptions available for capacity and power evaluations.

**Question 12**. Please share your view on delay of discussion on evaluation methodology for XR mobility to 2021 Q2. Also please feel free to comment on any other aspects w.r.t. XR ~~mobility~~ coverage evaluation.

|  |  |
| --- | --- |
| Company | View |
| QC | Defer mobility discussion to 2021 Q2. |
| MTK | Defer mobility discussion to 2021 Q1 or Q2 seems fine. |
| ZTE, Sanechips | There seems to be a typo in the question. We think coverage related discussion should be prioritized and we prefer to re-use the coverage related metrics/methodologies in the NR coverage enhancement study item such as MPL and ISD comparison. This is of interest of XR services given a large number of companies expressed interest towards scenarios such as Umi and Uma. Considering the high data rate requirement of typical XR services, coverage aspect is quite challenging and vital for the smooth delivery. |
| Nokia, NSB | Should the question be about coverage as the text above seems to belong to section 5 on mobility?  **Mobility evaluation** need and methodology discussion can be deferred to a later meeting.  **Coverage evaluation** may not necessitate its own evaluation, as the capacity evaluation can produce a percentage of the users served in a given deployment scenario that is indicative of the service coverage. Anyway, we can defer discussion on whether a specific coverage evaluation is needed to a later meeting (after we have established the capacity evaluation methodology)  Notably neither mobility nor coverage are mentioned in the SID objectives and we should first start by agreeing if one of the two or both quality as a relevant KPI to measure the XR and CG performance.  *3. Identify evaluation methodology to assess XR and CG performance along with identification of KPIs of interest for relevant deployment scenarios* |
| FUTUREWEI | Defer the discussion to Q2 after KPI and traffic model discussions. |
| Apple | Coverage is automatically included in the evaluation assumption already, e.g. indoor, Umi, no separate evaluation is necessary. |
| DOCOMO | Agree with the proposal. |
| LG | We are fine with delaying both mobility aspect and coverage aspect (there seems to be mismatch between section and proposal in the FL paper. Please check. ☺) Especially regarding mobility aspect, we are not sure whether/how RAN1 should perform evaluation in the SI. |
| InterDigital | We support delaying the discussion on methodology for XR coverage evaluation to 2021 Q1 |
| Intel | yes, we can defer |
| Ericsson | We agree **mobility evaluation** can be deferred. Contents of section 4 and 5 seem to be mixed up. |
| Vivo | Fine to defer the discussion of XR coverage evaluation to keep a reasonable evaluation workload. |
| Xiaomi | Agree |
| Huawei, HiSilicon | Ok to defer mobility discussion.  (PS: it seems Section 4 refers to coverage) |
| CATT | We prefer to defer mobility discussion. |
| Facebook | Agree can be deferred. |
| Samsung | Fine to defer mobility discussion to 2021 Q2. |

Evaluation Methodology for Mobility

Table 9 shows the captured views from different sources on evaluation methodology on mobility evaluation.

Table 9 Views on Evaluation Methodology for Mobility

|  |  |
| --- | --- |
| Source | View |
| [3] | Proposal 16: For XR mobility evaluation, performance metrics should be identified considering impacts on XR performance due to mobility, such as interruption delay, handover failure rate and cell-edge transmission performance. |
| [6] | Proposal 4: Different UE speeds for VR, AR and Cloud Gaming users can be assumed when evaluate the mobility. |

To better manage RAN1 workload for XR evaluations for NR, it is proposed by the rapporteur in [19] to defer detailed discussion on evaluation methodology for XR coverage to 2021 Q1. The delayed start will also benefit from stable evaluation methodology and assumptions available for capacity and power evaluations as well as available outcome of Rel-17 coverage enhancement study.

**Question 13**. Please share your view on delay of discussion on evaluation methodology for XR coverage to 2021 Q1. Also please feel free to comment on any other aspects w.r.t. XR coverage evaluation.

|  |  |  |
| --- | --- | --- |
| Company | View | |
| QC | Defer coverage discussion to 2021 Q1. | |
| MTK | Since there are related discussion of coverage enhancement in R17 RedCap UE and R17 coverage enhancement, we think coverage can be further deferred after the discussion of mobility. | |
| ZTE, Sanechips | There seems to be a typo in the question. We think mobility related discussion should be prioritized and we prefer to initiate the study by considering different UE speeds in the system level simulation. The capacity metrics could be re-used to reflect the impact in terms of mobility. | |
| Nokia, NSB | Should the question be about mobility as the text above seems to belong to section 4 on coverage?  **Mobility evaluation** need and methodology discussion can be deferred to a later meeting.  **Coverage evaluation** may not necessitate its own evaluation, as the capacity evaluation can produce a percentage of the users served in a given deployment scenario that is indicative of the service coverage. Anyway, we can defer discussion on whether a specific coverage evaluation is needed to a later meeting (after we have established the capacity evaluation methodology)  Notably neither mobility nor coverage are mentioned in the SID objectives and we should first start by agreeing if one of the two or both quality as a relevant KPI to measure the XR and CG performance.  *3. Identify evaluation methodology to assess XR and CG performance along with identification of KPIs of interest for relevant deployment scenarios* | |
| FUTUREWEI | | Defer the discussion to Q2 after KPI and traffic model discussions. |
| Apple | Mobility consideration can be included in the UE speed assumption already, e.g. 3 km/hr. | |
| DOCOMO | Agree with MTK. | |
| LG | We are fine with delaying both mobility aspect and coverage aspect (there seems to be mismatch between section and proposal in the FL paper. Please check. ☺) Especially regarding mobility aspect, we are not sure whether/how RAN1 should perform evaluation in the SI. | |
| InterDigital | We support delaying the discussion on methodology for XR mobility evaluation to 2021 Q1 | |
| Intel | We are fine to defer | |
| Ericsson | We agree **coverage evaluation** can be deferred. Contents of section 4 and 5 seem to be mixed up. | |
| vivo | Fine to defer the discussion of XR mobility evaluation to keep a reasonable evaluation workload. | |
| Xiaomi | Agree | |
| Huawei, HiSilicon | Ok to defer coverage discussion. | |
| CATT | Agree to defer coverage discussion | |
| Facebook | Agree with the proposal | |
| Samsung | Fine to defer – should be for later than 2021 Q1 considering the meeting schedule and progress in relevant R17 WIs. | |

**Summary**

* Most of companies agree to defer discussion on mobility and coverage to a later stage.

**Question 14**. Please feel free to comment on any other aspects w.r.t. XR evaluations for NR that are not addressed above.

|  |  |
| --- | --- |
| Company | View |
| MTK | There could be intensive simulation effort for XR agenda due to the various user number, performance requirement, and system aspects. RAN1 should strive to limit the simulation efforts to a reasonable level. |
| ZTE, Sanechips | In addition to the power consumption methodology discussed in section 3, the following aspects should also be considered.   1. For FR2, the system bandwidth is 100MHz for both DL and UL in 38.840, while in the XR simulation, the bandwidth for FR2 is assumed to be 400MHz. Since there is no scaling rule for FR2 BWP adaptation, we need to discuss it as well. 2. The number of transmission antenna is 1 in 38.840, while in XR simulation assumption, the Tx configuration is 2Tx or 4Tx. The scaling factor for Tx adaptation in TR38.840 is not sufficient and should be discussed.  |  | | --- | | Reference Configuration for FR1(in 38.840):  Uplink: TDD  - Tx antenna configuration: 1TX,  - Power levels: 0dBm and 23dBm  Reference **configuration** for FR2 (in 38.840):  Downlink: TDD, FR2  -....  - System Bandwidth: 100 MHz  ....  - Uplink: TDD, FR2  - ....  - Number of carrier = 1CC  - System Bandwidth = 100MHz  - Tx antenna configuration: 1TX chain | |
| Nokia, NSB | In order to keep the simulation effort to a reasonable level, RAN1 should identify the smallest subset of traffic models, deployment scenarios, systems aspects and KPIs that closely capture the essential aspects of XR and CG applications and avoid work duplication with other SID/WID. |
| Samsung | As previously commented, the questions so far were heavily focused on UE power consumption. Evaluations of mechanisms that enable achieving the KPIs, such as enhancements to CG-PUSCH, M-TRP, DAPS, ICIC, power control, … should be considered even if/when corresponding evaluations are to be deferred. |

**Summary**

* Strive to keep the simulation effort to a reasonable level, e.g., identifying a reasonable number of simulation configurations (traffic models, deployment scenarios, and so forth)
* For FR2, the system bandwidth is 100MHz for both DL and UL in 38.840, while in the XR simulation, the bandwidth for FR2 is assumed to be 400MHz. Since there is no scaling rule for FR2 BWP adaptation, we need to discuss it as well.
* Evaluations of mechanisms that enable achieving the KPIs, such as enhancements to CG-PUSCH, M-TRP, DAPS, ICIC, power control, … should be considered even if/when corresponding evaluations are to be deferred.

# References

1. R1-2007555 XR applications and scenarios, FUTUREWEI
2. R1-2007561 Discussion on applications, traffic model, and evaluation methodology for XR and Cloud Gaming, Huawei, HiSilicon
3. R1-2007698 Discussion on XR applications, traffic model and evaluation methodologies, vivo
4. R1-2007843 XR use cases, evaluation methodologies and traffic model, CATT
5. R1-2007976 Discussion on applications, traffic model and evaluation methodology for XR, ZTE
6. R1-2008037 Discussion on XR evaluation and Challenges for NR, CMCC
7. R1-2008198 Applications, Evaluation Methodology, and KPIs for XR, Samsung
8. R1-2008311 XR evaluations for NR: Applications and Evaluation Methodology, AT&T
9. R1-2008454 XR Applications, Traffic Model and Evaluation Methodology, Apple
10. R1-2008818 Discussion on traffic models and evaluation assumptions for XR, InterDigital, Inc.
11. R1-2008896 Applications, Traffic Model and Evaluation Methodology for XR evaluations for NR, Nokia, Nokia Shanghai Bell
12. R1-2008939 Discussion for study in XR evaluation for NR, LG Electronics
13. R1-2008967 On Applications, Traffic Model, and Evaluation Methodology for XR and CG, MediaTek Inc.
14. R1-2009006 Scenarios, Traffic Model and EVM for XR, Intel Corporation
15. R1-2009041 Discussion on XR application and evaluation methodology, Xiaomi
16. R1-2009087 XR use cases, traffic modelling and performance measure, Ericsson
17. R1-2009198 Discussion on study on XR evaluations for NR, NTT DOCOMO, INC.
18. R1-2009280 Evaluation Methodology for XR, Qualcomm Incorporated
19. R1-2009293 On work plan for Rel-17 SI on XR evaluations for XR, Qualcomm Incorporated