**3GPP TSG RAN WG1 #104-e R1-20xxxxx**

**e-Meeting, Jan 25th – Feb 5th, 2021**

**Agenda item:** 8.14.1

**Source:** Moderator (Qualcomm)

**Title:** Email discussion/approval for traffic model and capacity KPI for XR

**Document for:** Discussion and Decision

# Introduction

This document presents a summary of contributions on traffic model for XR and CG [2-20], based on which way forwards for XR traffic model and KPI for XR evaluation are discussed.

[104-e-NR-XR-01] Email discussion/approval for traffic model and capacity KPI – Eddy (Qualcomm)

* 1st check point: 1/28
* 2nd check point: 2/2
* 3rd check point: 2/4

# Traffic Model

Statistical Traffic Model

As to XR traffic model for evaluation, RAN1 #103e made the following agreement.

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| Agreement (#103e)  Traffic model for DL and UL should reflect various aspects, e.g., various bit rates, variable frame/packet (definition of frame/packet to be clarified with traffic model as necessary) size, and periodicity (how to model jitter is FFS).  RAN1 will strive to conclude on detailed traffic models in the next RAN1 meeting (104-e) where SA4 outcome on traffic model is expected to be available.   * Statistical model is preferred. * It is preferred traffic model for both UL and DL have a certain degree of variability so that and the total number of traffic models can be reduced. * Note: Taking into account the fact that the decision on traffic models may hold many other crucial decisions, discussion on traffic model in the next RAN1 meeting is prioritized from the beginning. |

SA4 has been working on XR traffic model and delivered its outcome in a LS to RAN1[1]. Considering the SA4 input, companies discuss XR traffic model [2-20]. Table 2 captures the views from companies.

Table 2 Companies view on SA4 Traffic Models

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| Company | View |
| FutureWei | However, from RAN1’s point of view, it will be more convenient if a statistical XR traffic model can be provided for system performance evaluation purpose.  *Proposal 1: FS\_NR\_XR\_eval adopts a statistical XR traffic model with inter packet arrival time modeled as a period plus some jitter, where the period is the inverse of frame rate, and with packet size modeled as Gaussian distributed.* |
| OPPO | Based on the outcome of XR/CG work in other groups (e.g., SA4) [3][4][5], we note there are too many configurations of XR/CG services. From our understanding, it is difficult for RAN1 to evaluate all the recommended configurations due to the huge workload. Thus, RAN1 should try to determine a limited number of traffic models based on the current 3GPP work on XR/CG and other groups’ inputs.  Proposal 9: RAN1 sends a LS to SA4 to provide a set of parameters for traffic models and ask for the corresponding values for each parameter, e.g., |
| Huawei | *Proposal 2: For the traffic model of XR and CG,*   * *Statistical model is adopted, and the statistical model can be developed based on SA4 outcomes.* * *RAN1 continues to discuss whether P-Trace based traffic model is applicable in RAN1 evaluations or not.* |
| Vivo | *Proposal 3: Support to adopt statistical model for XR evaluation as the starting point, P-Trace model can be optionally evaluated.* |
| ZTE | 1. RAN1 schedules a conference call for XR related QA sessions during the first week of RAN1#104-e, i.e. from January 25th covering at least the following discussion points   - The appropriate arrival rate for UL/DL traffic  - Whether/how to model jittering for UL traffic  - The IP packet level reliability requirement and corresponding slice recovery strategy that should be assumed in RAN simulation  - The E2E latency used for RAN1 evaluation  - The CRF setting and packet size assumption for the simulation  - Packet delay modeling  - whether to consider packet jittering in the reTx phase  - whether to consider jittering related to file size  - whether the packet delay should be i.i.d from a predefined distribution or fixed within a given buffer window.  - Clarification on typo regarding the delay threshold setting in cloud gaming  - Whether to prioritize some case of traffic modeling for both eyes |
| LG | *Observation 2: it may be necessary to communicate with SA4 on what kind of input RAN1 is expecting from SA4 and what kind of input SA4 can provide to RAN1 regarding XR traffic model.* |
| Sony | Proposal 3: RAN1 needs to derive traffic models and its parameters suitable for physical layer simulation based on higher-layer XR application parameters as identified by SA4. |
| Xiaomi | Proposal 1: Use the packet size distribution and packet inter-arrival time distribution achieved from SA4 trace data to randomly generate UE traffic in RAN1 evaluations. |
| Ericsson | 1. RAN1 should decide the exact video traffic parameters further based on input from SA WG4 XR study. The necessary parameters include a frame size in terms of mean, variance, the maximum and the minimum value at least for the minimal acceptable encoding rate, in addition to the frame generation interval. |
| QC | Proposal 1: RAN1 continues to assess SA4 traffic models and make conclusion at RAN1#105e.  Proposal 2: RAN1 supports the statistical DL traffic model in Table 1.  Proposal 6: RAN1 continues to discuss/determine the statistical models for VR1 and AR1 considering corresponding traffic model discussion in SA4. |
| Apple | **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms |   **We have the following in our contribution.**  **Observation 2: From SA4 traffic model on XR conversational, it is clear that uplink traffic is with substantial throughput requirements.**  **Observation 3: SA4 study on AR2 indicates multiple data flows are present in both downlink and uplink.**  **Proposal 1: It is key to include uplink traffic with substantial throughputs in the study of AR2.**  **Proposal 2: In RAN1 study, data flows with different QoS requirements in XR study should be modeled separately.**  **From SA4 study and LS to RAN1, there are two important points which should be reflected in RAN1 study:**   * + - 1. **Importance of UL traffic**       2. **Multiple data flows for each direction (DL and UL)** |

**Summary**

* Adopt a statistical model in RAN1 with parameters based on SA4 input: FutureWei, Huawei, vivo, QC, Sony, Xiaomi, Ericsson
* Communicate with SA4 to get further information (e.g., on model parameters) from SA4: Oppo, ZTE, LG

**Proposal 1**. RAN1 adopt a parameterized statistical traffic model for evaluation of XR and CG. RAN1 strive to agree on distributions and parameter values during RAN1 #104e, based on SA4 input.

**Question 1**. Please share your view on Proposal 1.

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| Company | View |
| OPPO | We support statistical traffic model and agree to start work based on SA4 input. Once we find the information is missing for some parameter of the statistical traffic model, then we can ask SA4 for further information. In summary, we support FL’s proposal. |
| MTK | We are ok with Proposal 1 and no need for another LS to SA4 as this may take time and could be a long process.  We suggest RAN1 to use V-trace from SA4 to determine the statistical model (frame size distribution, mean, variance) with multiple DL data streams  For V-trace source file not available in the SA4 LS (Ex. AR, CG), RAN1 can determine the appropriate statistical numbers.  For instance, for V-trace of applications (AR, CG) not provided by SA4, adopt the following values for I frame:   * AR: mean = 83334 bytes (40Mbps), STD = 10900 bytes, max size = 120000 bytes, period = 16.67ms * CG: mean = 41667 bytes (20Mbps), STD = 5450 bytes, max size = 60000 bytes, period = 16.67ms   and the following values for P frame   * AR: mean = 41667 bytes (20Mbps), STD = 5450 bytes, max size = 60000 bytes, period = 16.67ms * CG: mean = 20833 bytes (10Mbps), STD = 2725 bytes, max size = 30000 bytes, period = 16.67ms |
| Xiaomi | We are fine with FL proposal. However, we suggest to send LS to SA4 on RAN1 decision to decide the distribution and parameter values based on SA4 input. If they have any concern, they can contact us. |
| QC | We agree on Proposal 1. |
| Nokia, NSB | We generally agree with Proposal 1. We just need to take into account that SA4 input might not be able to cover all parameters needed for RAN1. |
| Apple | **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms |   We are fine with statistical models, note SA4 study indicates multiple data flows are present for both DL and UL, the modeling of data flows other that of video stream is straight forward (constant rate is assumed). However, those data flows do have different periodicities than the video stream. For power consumption evaluation, if just the video stream is modelled then the evaluation may not be realistic, essentially with video stream only modeling, the UE can stay in a less-power consuming mode while there is no video packet, in reality the UE may need to be ready to receive/transmit packets for other data flows (audio, data stream, etc). We hope UE power consumption evaluation and capactiy evaluation are conducted with more realistic setup.  We are also aware of the modeling effort, so the number of data flows should be discussed, but a key fact from SA4 study should not be forgot in RAN1 study. |
| CATT | We are OK with the principle of Proposal 1. However, the XR traffic model by SA4 is an end-to-end traffic model between UE and XR server. For XR evaluation in RAN, the traffic arrival to gNB from XR server needs to incorporate the transport delay and jitter from XR server to the gNB. The traffic model in RAN1 is the queueing model at the gNB scheduler. Thus, a generic stochastic model (statistical data distribution and statistic packet inter-arrival time) is generally used with XR traffic model by SA4 as the reference for the parameter of XR traffic model. |
| Futurewei | We support Proposal 1 in principle. |
| InterDigital | We are ok with Proposal 1. For reducing the number of iterations for communicating with SA4 we think it would be worthwhile to consider deriving the statistical model based on the V-traces/P-traces provided by SA4 for the available use cases. |

DL Traffic Model

In following sections, details of DL video traffic model are discussed.

### Packet Arrival Modeling: Video Frame level vs IP-Packet level

In this section, we discuss DL *packet* arrival modeling. Depending on layer it models, the size of packet, traffic arrival pattern, performance requirement could be different. We capture two views on modeling: frame level model vs IP-packet level model, based on contributions [2-20]. In case of frame level, a *packet* corresponds to a XR video frame. Whereas, in IP-Packet level modeling, a *packet* corresponds to an IP-packet of which size is usually smaller (e.g., <=1500 bytes).

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| Company | View |
| FutureWei | *Proposal 1: FS\_NR\_XR\_eval adopts a statistical XR traffic model with inter packet arrival time modelled as a period plus some jitter, where the period is the inverse of frame rate, and with packet size odelled as Gaussian distributed.* |
| OPPO | Proposal 4: Regarding the packet modelling for XR/CG, an application level packet is modelled as a packet during RAN1 simulation. |
| Huawei | *Proposal 4: For XR/CG performance evaluation, frame segmentation is not considered* *for simplicity, i.e., one video frame is modelled as one packet during simulation.*   * *Note: Each packet might be further segmented into one or multiple TBs for transmission in physical layer.* *The number of TBs and the size of each TB are up to radio resource, scheduling, etc.* |
| CATT | *Proposal 1: A data frame from Application is considered as the packet in the traffic model for XR. The jitter is characterized by the stochastic process of those segmented packets related to the same data frame.* |
| Vivo | *Proposal 5: For statistical model, 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.* |
| InterDigital | * + Traffic file size distribution: [Truncated Gaussian distribution or Parero distribution with configurable mean, σ, min, max] (e.g. mean: 1200B, max: 1500B) |
| MTK | *Proposal 2: Two traffic models should be considered depending on the location of the XR/CG server (cloud/Edge).*  *Proposal 3: No MTU packet size restriction when the XR/CG server is located at the Edge.* |
| Samsung | For RAN1 evaluation purposes, option 1 is applicable – an application level packet can be modeled as a packet for SLS. |
| Ericsson | 1. When a jitter is modelled, it should be simple enough to simulate, e.g., uniform or truncated Gaussian, and the effect of IP segmentation needs to be avoided for RAN1 evaluation. |
| QC | * File arrival: a file is a burst of related data belong to a frame arriving together |
| Nokia | ***Proposal 3****: For VR1 packet size distribution, adopt a constant size packet in uplink and downlink. Assume a 1200 byte for the downlink packet size, while 100 byte for the uplink packet size.* |
| Apple | **Proposal 3:**   * **In the traffic model for XR, multiple data flows (e.g. for audio and video) for each direction (DL or UL) are generated for a UE;** * **Each data flows can be configured separately with** * **Periodicity** * **Packet size distribution (e.g. fixed or following a distribution)** * **Data flow specific latency and reliability requirements**   **Proposal 4:**   * **For XR conversational, for each data flow, the following can be configured separately:**   + **Periodicity**   + **Packet size distribution (e.g., fixed or following a distribution)**   + **Data flow specific latency and reliability requirements** * **downlink traffic includes the following data flows:**   + **2D video**   + **Audio**   + **Data stream** * **uplink traffic includes the following data flows:**   + **Video + Depth**   + **Front facing Camera**   + **3/6 DOF Pose**   + **Audio**   + **Data stream**   ***As indicated above, the number of data flows for DL and UL can be reduced to make modeling work easier. In SA4 study, multiple data flows are present for DL and UL, so we should reflect that in our study.***  ***For video stream, audio stream, and data stream, the periodicity can be different, e.g. video with 60 fps (50/3 ms for periodicity), audio is with 20 ms for periodicity, and data stream with 10 ms for periodicity.*** |
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**Summary**

* (XR application video) Frame level modeling: FutureWei, Oppo, Huawei, CATT, vivo, MTK, Samsung, Ericsson, QC
* IP packet level modeling: InterDigital, vivo, MTK, Nokia

**Question 2**. Please present your view on frame level vs. IP packet level XR traffic modeling for evaluation. If you prefer IP packet level modeling, please explain how IP packets are mapped to a video frame, the relation of IP packet size to the corresponding video frame size, and how latency is evaluated (e.g., apply a given delay budget, e.g., 10ms for each IP packet, or latency is measured from the point when the first IP packet of a frame to the point when the last IP packet of the frame is successfully delivered to UE).

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| Company | View |
| OPPO | Support Frame level modelling rather than IP packet level modelling. IP packed level modelling will involve more factors, which will make the modelling more complicated and make it more difficult for companies to convergence to the detailed models. |
| MTK | We prefer to use frame level modelling and define reliability/latency in terms of frame level. We understand that one frame still needs to be segmented into multiple packets in real network, but RAN1 can apply a simpler model in simulation, since in physical layer data are all transformed into TBs. |
| Xiaomi | Support frame level modelling rather than IP packet level. Another question for IP level simulation is whether we need to assume radio layer can get higher layer information such as whether two packets belong to the same frame, etc.? |
| QC | We prefer to have frame level modelling. In this model, by construction, data belonging to a frame has the same PDB. This is an important latency requirement to capture in XR evaluation. The periodic nature of packet arrival could be also easily captured.  In an IP packet level approach, it gets more complicated and difficult to capture these aspects. Model should be able to track a set of IP packets belonging to the same frame and they should have the same PDB. Two different levels of packet inter arrival time modelling would be needed; inter-frame and inter IP packet.  Thus, frame level modelling is preferred. |
| Nokia, NSB | We propose to model an IP packet. There is no need to go to the application level and model the application level frames for RAN1 simulations. The latency is measured for each IP packet, and satisfaction of a user is measured by monitoring how many of those IP packets are correctly received within the PDB. Adopting this approach, we don’t need to explicitly model video frames in RAN1 simulations. |
| Apple | We are flexible with the modelling choice here. It seems the difference between two approaches will be more pronounced, if the inter-IP packet generation is large. |
| CATT | Frame level should be sufficient for RAN1 XR evaluation in Uu interface. If IP level packet is defined, PDCH and RLC functions, such as segmentation/reassembly and RLC error control, needs to be included in the simulation. |
| Futurewei | We prefer frame level modelling. Using frame level modelling is sufficient for RAN1 evaluation purpose, just like in RAN1’s FTP traffic models, we do not model the IP level packets but use the file model instead. Using frame level modelling also make it easier to define KPI. |
| InterDigital | We are generally ok to consider either of the modelling options. Typically, when the frames are encoded into slices, each slice may be carried in different IP packets. The number of IP packets per frame/slice may also vary depending on the type of the frame (e.g. I, P, B). For simplifying RAN1 evaluations and avoiding any complexities related to segmentation and encoding, we think it fine to assume a packet corresponds to a frame. |

### Traffic Inter Arrival Time Distribution

In this section, views on modeling of DL packet inter arrival time are captured.

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| Company | View |
| FutureWei | *Proposal 1: FS\_NR\_XR\_eval adopts a statistical XR traffic model with inter packet arrival time modeled as a period plus some jitter, where the period is the inverse of frame rate, and with packet size modeled as Gaussian distributed.* |
| oppo | Proposal 2: For XR/CG evaluation, the data arrival is assumed as periodic and the periodicity can be two different options (X FPS is the frame rate):   * Option 1: Periodicity is 1/X s * Option 2: Periodicity is 1/2X s * X = 60, 120 |
| Huawei | *Proposal 6: For XR and CG performance evaluation, periodic traffic with frame arrival interval 1/FPS seconds is considered as a starting point.* |
| CATT | *Proposal 3:* *The jitter is modeled in packet interval time in the traffic model for XR, similar* *as the 3GPP RAN1 traffic models, e.g. FTP model 3.*  *Proposal 4: The Exponential distribution and Pareto distribution are both considered for the packet interval time under the different network load.* |
| vivo | * + Option 1: PDB is affected by jitter, e.g. residual PDB (k) = PDB – jitter (k), k is the index of a packet.   + Option 2: PDB is not affected by jitter, e.g. PDB is constant.   *Proposal 7: RAN1 should further consider and discuss the jitter modelling in traffic model.* |
| Sony | Proposal 4: RAN1 to decide whether network jitter in XR applications is considered or not in the evaluation assumptions. |
| MTK | *Proposal 4: Jitter modelling is required and shall be taken into account in simulations* |
| InterDigital | * + Traffic arrival distribution: [Quasi-periodic with configurable inter-packet arrival time duration] (e.g. FTP3, inter-packet arrival proportional to 1/frame-rate) |
| AT&T | Proposal 2: The XR Traffic model packet inter-arrival times should be based on a specified fixed interval (e.g. inverse of media frame generation rate). |
| Xiaomi | Proposal 1: Periodic traffic can be assumed for the DL and UL traffic of the VR service |
| Samsung | Proposal 2: For the traffic models for XR evaluations in RAN1, consider the following:   1. Periodic packet arrivals 2. Truncated Gaussian distribution for modeling packet size and jitter 3. Both DL and UL and discuss whether to prioritize UL 4. Conclude in RAN1#104-e on values of periodicity, packet sizes, target BLER, and end-to-end PHY latency, and on whether to concurrently simulate multiple data flows. |
| Ericsson | When a jitter is modelled, it should be simple enough to simulate, e.g., uniform or truncated Gaussian, and the effect of IP segmentation needs to be avoided for RAN1 evaluation. |
| Apple | * Each data flows can be configured separately with * Periodicity * Packet size distribution (e.g. fixed or following a distribution) * Data flow specific latency and reliability requirements   ***For video stream, audio stream, and data stream, the periodicity can be different, e.g. video with 60 fps (50/3 ms for periodicity), audio is with 20 ms for periodicity, and data stream with 10 ms for periodicity.*** |
| QC | * File arrival time for   + Without jitter, periodic with periodicity of sec, i.e.,   for   * + With jitter, a random jitter is added to each expected file arrival time, i.e., , where is a random variable following truncated Gaussian distribution truncated between - and |
| Nokia, NSB | ***Proposal 1****: For VR1, consider FTP Model 3 as a downlink traffic model. Assume an average bitrate of 58 Mbit/s (Full HD) and 90 Mbit/s (4K video).*  ***Proposal 6:*** *For AR1 option 1 (augmented video traffic in downlink), consider the FTP Model 3 as a downlink traffic model. Assume an average bitrate of 58 Mbit/s and 90 Mbit/s for 1080p (Full HD) and 4K video quality, respectively.*  ***Proposal 7:*** *For AR1 option 2 (video objects in downlink), consider the Periodic Traffic as a downlink traffic model. Assume a traffic source generating objects of 10kbit and 10Mbit every 5 seconds.* |
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**Summary**

Packet inter arrival time modeling

* Periodic with jitter: FutureWei, Oppo, Huawei, InterDigital, AT&T, Xiaomi, Samsung, Apple, QC, CATT, vivo, MTK, Samsung, Ericsson
  + Jitter distribution
    - Truncated Gaussian: Samsung, Ericsson, truncated Gaussian
    - Uniform: Ericsson
* Exponential: CATT, InterDigital, Nokia
* Pareto: CATT

**Proposal 4**.

* RAN1 adopt periodic arrival with jitter for DL packet arrival modeling for XR/CG applications
  + Periodicity: 16.67ms(=1/60fps).
* Jitter follows truncated Gaussian distribution.
  + Please present your view on the values of mean, variance, truncation bound.
* The jitter for a packet affects the packet delay budget (PDB) of the packet, i.e., positive jitter (late arrival) gives smaller PDB and negative jitter (early arrival) gives larger PDB for a given packet.

**Question 4**. Please share your view on Proposal 4.

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| Company | View |
| OPPO | Support the proposal in principle. I suggest to add the periodicity corresponding to 120fps since the UE supporting 120fps will be the trend in the near feature. As this work is an study item, the specification will be done in the future releases. By considering 120fps, we can better future-proof the output |
| MTK | We are fine with Proposal 4 and suggest that jitter follows truncated Gaussian distribution with   * Mean: 0 * STD: 3 * Max absolute value: 7   If multiple DL streams are applied, all of them would have the same distribution. If multiple streams have the same time arrival, they would share the same jitter value. If multiple streams are staggered, then the jitter values should be highly correlated. We prefer to have the same time arrival for multiple streams and same jitter. |
| Xiaomi | Agree with FL proposal. We can generally define the periodicity as 1/fps, and discuss the value of fps as a different issue. From our point of view, multiple values of fps may need to be evaluated. Same or different fps values can be set for different XR applications. |
| QC | We support periodic packet arrival with jitter modelling. We propose to evaluate 60Fps.  The impact of jitter needs to be captured such that the jitter could affect the PDB of each packet as described in proposal 4. We support modelling jitter as a random variable with truncated Gaussian distribution with mean of 0, variance of [2]ms and truncation bound of [-4, 4]. Note that truncation bound and frame rate should be chosen such that jitter should not introduce out of order packet arrival. |
| Nokia, NSB | We support FTP Model 3 with Exponential inter-arrival packet time. The reason is that it is well capable of simulating the burst of packets arriving to the destination. Moreover, in order to parametrize the model, we just need one value (rate or mean) in contrast to Proposal 4, where four values needed to parametrize the arrival time. Therefore, we propose the following:  RAN1 adopt FTP model 3 for the downlink arrival modeling for XR/CG applications, where packets inter-arrival time follows Exponential distribution with parameter Y. The exact value of Y is FFS. |
| Apple | ***For video stream, audio stream, and data stream, the periodicity can be different, e.g. video with 60 fps (50/3 ms for periodicity), audio is with 20 ms for periodicity, and data stream with 10 ms for periodicity.*** |
| CATT | We don’t agree with proposal 4. The statistic model of inter-arrival time of XR traffic model characterized network transport delay and jitter should be have one stochastic model instead of deterministic periodicity and statistic model for network jitter.  The stochastic model of Poisson process is used in 3GPP as FTP-1/FTP-2 for single session and FTP-3 as multi-Sessions. We believe that FTP-3 with Poisson inter-arrival time (aggregate traffic of multiple sessions with each session having exponential inter-arrival time) is sufficient for periodic traffic. |
| Futurewei | We support Proposal 4 in principle. We support a frame rate of 60 fps as a baseline. Companies can optionally bring in results for other frame rate(s) if they want to. |
| InterDigital | We are generally ok with FL’s proposal. For the parameter values corresponding to periodicities and those of truncated Gaussian distribution for jitter, we prefer using the values derived from SA4 traces or provided by SA4 for each of the considered/available applications. |

### Frame/Packet Size distribution

XR/CG frame sizes are varying depending on video encoding schemes. The following table captures views on packet size modeling.

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| Company | View |
| FutureWei | *Proposal 1: FS\_NR\_XR\_eval adopts a statistical XR traffic model with inter packet arrival time modeled as a period plus some jitter, where the period is the inverse of frame rate, and with packet size modeled as Gaussian distributed.* |
| Oppo | Proposal 8: For RAN1 evaluation of VR2/AR2/CG, use the truncated Gaussian distribution to model the packet size. |
| Huawei | *Proposal 8: For XR and CG performance evaluation, the frame size is modelled as truncated Gaussian distribution. FFS: mean and variance.* |
| CATT | *Proposal 2: The Gaussian and Pareto distribution could both be considered for modeling the XR packet size.* |
| vivo | Table 3. DL traffic models for XR   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Traffic model | Model 1  (50Mbps) | Model 2  (50Mbps) | Model 3  (100Mbps) | Model 4  (100Mbps) | | Packet size distribution | Truncated Gaussian distribution | | | | | Mean packet size (Bytes) | 104000 | 52000 | 208000 | 104000 | | STD of packet sizes (Bytes) | 13000 | 6500 | 26000 | 13000 | | Maximum packet size (Bytes) | 162500 | 81250 | 325000 | 162500 | | Minimum packet size (Bytes) | 67 | | | | | Packet arrival interval (ms) | 16.67 | 8.33 | 16.67 | 8.33 | | Packet delay budget (ms) | 10 | | | |   Table 4. DL traffic model for Cloud Gaming   |  |  | | --- | --- | | Traffic model | Model 5 (25Mbps) | | Packet size distribution | Truncated Gaussian distribution | | Mean packet size (Bytes) | 52000 | | STD of packet sizes (Bytes) | 6500 | | Maximum packet size (Bytes) | 81250 | | Minimum packet size (Bytes) | 67 | | Packet arrival interval (ms) | 16.67 | | Packet delay budget (ms) | 15 |   *Proposal 9: For DL, traffic models in Table 3 and Table 4 are considered as the starting point for XR and Cloud Gaming evaluation, respectively.* |
| ZTE | 1. Adopt the three-step methodology to derive the traffic models for Pareto distribution of file size. |
| InterDigital | * + Traffic file size distribution: [Truncated Gaussian distribution or Parero distribution with configurable mean, σ, min, max] (e.g. mean: 1200B, max: 1500B) |
| AT&T | Proposal 1: The XR Traffic model packet size should be based on a truncated Gaussian distribution with specified mean size, variance, min file size, and max file size. |
| Samsung | 1. Truncated Gaussian distribution for modeling packet size and jitter |
| Ericsson | 1. The frame size for the video traffic may include a variance, e.g., Gaussian distribution, in time to be more realistic. |
| QC | * File size: random size following truncated Gaussian distribution with   + mean   + standard deviation   + Truncation between 0 and |
| Nokia, NSB | ***Proposal 3****: For VR1 packet size distribution, adopt a constant size packet in uplink and downlink. Assume a 1200 byte for the downlink packet size, while 100 byte for the uplink packet size.*  ***Proposal 9:*** *For AR1 packet size distribution, adopt a constant size packet in uplink and downlink. Assume a 1200 byte for a packet size in uplink and downlink.*  ***Proposal 13:*** *For CG packet size distribution, adopt a constant size packet in uplink and downlink. Assume a 1200 byte as a downlink packet size while 100 byte as an uplink packet size.* |
| Apple | ***Besides video stream, constant bit rate can be assumed for audio: 10.24 kbps for a packet (50 packets per second);***  ***5 kbps for a data stream packet (100 packets per second)***  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |

**Summary**

Distribution of DL packet size

* (Truncated) Gaussian: FutureWei, Oppo, Huawei, CATT, vivo, InterDigital, AT&T, Samsung, QC
* Pareto: CATT, InterDigital, ZTE
* Constant packet size: Nokia

**Proposal 6**.

* RAN1 uses truncated Gaussian distribution as DL packet size distribution of XR/CG applications.
  + Please present your view on mean, variance, truncation bound for different applications.

**Question 6**. Please share your view on Proposal 6.

|  |  |
| --- | --- |
| Company | View |
| OPPO | Support the propsoal |
| MTK | Agree truncated Gaussian distribution as DL packet (= video frame) size distribution for XR/CG applications with statistical values derived from V-trace provided by SA4.  For V-trace source file not available in the SA4 LS (Ex. AR, CG), adopt the following values for I frame:   * AR: mean = 83334 bytes (40Mbps), STD = 10900 bytes, max size = 120000 bytes, period = 16.67ms * CG: mean = 41667 bytes (20Mbps), STD = 5450 bytes, max size = 60000 bytes, period = 16.67ms   and the following values for P frame   * AR: mean = 41667 bytes (20Mbps), STD = 5450 bytes, max size = 60000 bytes, period = 16.67ms * CG: mean = 20833 bytes (10Mbps), STD = 2725 bytes, max size = 30000 bytes, period = 16.67ms |
| Xiaomi | We agree with FL proposal |
| QC | We support using truncated Gaussian with mean = (byte), standard deviation ], maximum size where is the DL bitrate (in Mbps) considered and is frame rates (fps) in DL. |
| Nokia, NSB | From the analysis of CG based on Google Stadia platform, we observe that the packet size is almost always constant. Therefore, we propose to consider the constant packet size. |
| CATT | We agree with the proposal to use truncated Gaussian. The mean and variance of truncated Gaussian random variable for XR traffic should be determined in RAN1#104-e based on SA4 XR traffic model. |
| Futurewei | We support Proposal 6 in principle. Qualcomm’s suggestion on mean, variance, and truncation bound is a good starting point. |
| InterDigital | We support FL’s proposal. For the parameter values for the DL packet size distribution, we prefer using the values derived from SA4 traces or provided by SA4 for each of the available applications. |

### Packet Delay Budget

|  |  |
| --- | --- |
| Company | View |
| Vivo | *Proposal 10: The PDB requirement is assumed to be 10ms for XR traffic, and it could be relaxed to 15ms for Cloud Gaming traffic.* |
| ZTE | As discussed above, a packet which is delayed more than PDB is counted as a loss. The PDB is associated with two values, one is a fixed ‘Delay for RAN1’ (i.e., 20ms), the other is ‘remaining PDB for RAN1’ (i.e., 13-45ms for split rendering). The PDB can be determined as a minimum of Delay for RAN1 and remaining PDB for RAN1.   1. A packet which is delayed more than PDB is counted as a loss. The PDB is obtained by min(Delay for RAN1, remaining PDB for RAN1). |
| MTK | Proposal 9: For XR/CG evaluation, if one frame is mapped to one packet, a UE is satisfied if 99% files are delivered within packet delay budget (PDB) = 10ms. For requirements defined in SA2 LS S2-2009227 (5ms/99.9% and 10ms/99.9%), they can serve as optional (advanced) user satisfaction criterion. |
| **QC** |  |
| **Apple** | **The delay budgets for different streams are different, we can consider reduction of number of data flows**  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |

**Summary**

Suggested packet delay budget values

* VR, AR: 10ms, 20ms
* CG: 15ms, 30ms

**Proposal 7**. RAN1 adopt over the air packet delay budget for packet transfer. The considered values for PDB are

* VR, AR: [10ms, 20ms]
* CG: [15ms, 30ms]

**Question 7**. Please share your view on Proposal 7.

|  |  |
| --- | --- |
| Company | View |
| MTK | We prefer to have one value for each application to limit simulation effort.   * VR, AR: 10ms * CG: 15ms |
| Xiaomi | We prefer to the same PDB for all applications, e.g. 10ms. |
| QC | We support proposal 7. PDB of 10ms and 20ms for VR and AR is a reasonable choice to evaluate AR/VR applications requiring different latency requirements.. PDB of 15ms and 30ms is a reasonable choice for CG as CG generally has less stringent latency requirement than AR/VR. |
| Nokia, NSB | We suggest to modify Proposal 7 to decrease the number of simulations:  **Proposal 7**. RAN1 adopt over the air packet delay budget for packet transfer. The considered values for PDB are   * VR, AR: [10ms, 20ms] * CG: Mandatory: [15ms]; Optional: [30ms] |
| Apple | According to SA4 study, the delay budget can be different for different data flows:  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |
| CATT | We are OK of Proposal 7 as working assumption. The final budget should consider the network delay, inter-arrival time of actual traffic model and SA traffic model. |
| Futurewei | We support Proposal 7 in principle. To reduce the number of simulations, we propose using a single PDB of 15 ms for VR/AR/CG. The value of 15 ms is a good choice as it is in the middle of 10 ms and 20 ms for VR/AR and is part of the original PDB for CG. |
| InterDigital | We are ok with the values proposed by FL. However, to capture the application requirements more realistically and for reducing the number of simulation parameters the use of more stringent value for PDB per application, as proposed by MTK and Nokia, can be considered. |

### Bitrates for evaluation

|  |  |
| --- | --- |
| Company | View |
| Oppo | Proposal 5: For VR2/AR2/CG evaluations, consider the following typical DL rates   * 90Mbps * 45Mbps * 24Mbps * 12Mbps. |
| Huawei | *Observation 1: For 4K VR video at 60fps, the* *bitrate would be about 60 Mbps. For CG, the bitrate would be about 35Mbps.* |
| CATT | *Observations 1: For the basic 4K VR video, the average bit rate would be 63Mbps per eye for the independent VR video streaming and 116Mbps for dual-eyes streaming. The new VVC codec would have addition 30-50% better compression ratio.* |
| MTK | Table 3: Cloud gaming traffic parameters |
| QC |  |
| Nokia | ***Proposal 1****: For VR1, consider FTP Model 3 as a downlink traffic model. Assume an average bitrate of 58 Mbit/s (Full HD) and 90 Mbit/s (4K video).*  ***Proposal 6:*** *For AR1 option 1 (augmented video traffic in downlink), consider the FTP Model 3 as a downlink traffic model. Assume an average bitrate of 58 Mbit/s and 90 Mbit/s for 1080p (Full HD) and 4K video quality, respectively.*  ***Proposal 7:*** *For AR1 option 2 (video objects in downlink), consider the Periodic Traffic as a downlink traffic model. Assume a traffic source generating objects of 10kbit and 10Mbit every 5 seconds.*  ***Proposal 11:*** *For CG, consider the FTP Model 3 as a downlink traffic model. Assume a traffic source generating 29 Mbit/s, and 45 Mbit/s as bitrate for 1080p (Full HD) and 4K video quality, respectively.* |
| Apple | ***Constant date rate for audio and data stream should be considered.*** |

**Summary**

* VR: 12, 24, 45, 90, 60, 116, 30, 60 Mbps
* AR: 12, 24, 45, 90, 30, 60 Mbps
* CG: 12, 24, 45, 90, 35, 5-20, 10-30, 8, 30 Mbps

Note that SA4 has provided following set of DL bit rates.

* VR2: 30, 60 Mbps
* AR2: 30, 60 Mbps
* CG: 8, 30 Mbps

**Proposal 8**. RAN1 adopt following DL bit rates based on SA4 input.

* AR/VR: [30, 60] Mbps
* CG: [8, 30] Mbps

**Question 8**. Please share your view on Proposal 8.

|  |  |
| --- | --- |
| Company | View |
| OPPO | It seems the values in Proposal 8 are the media bitrates suggested by SA4. However, in S4aV200632 or S4aV200640 (included in the SA4 LS), the bitrate in RAN should be 1.5 times of media bitrate. Thus, the above values should be changed to 30\*1.5, 60\*1.5, 8\*1.5, 30\*1.5. I copied the corresponding part as below |
| MTK | We prefer to have one value for each application.   * AR/VR: 60 Mbps * CG: 30 Mbps |
| Xiaomi | We also prefer to a single value for each application, 30 for CG and 60 for AR/VR.. |
| QC | We support proposal 8. The values are reasonable choices to evaluate applications requiring different bitrate applications. |
| Nokia, NSB | In general, we support Proposal 8. However, we think the lowest values for AR/VR and CG refer to the resolution 720p, which might be a bit low for the considered applications. We also think it is beneficial to consider a 4K resolution and the associated bit rates at least for CG. We thus propose to modify the proposal 8:  **Proposal 8**. RAN1 adopt following DL bit rates based on SA4 input.   * AR/VR: [~~30~~, 60] Mbps   CG: [~~8~~, 30, 45] Mbps |
| Apple | As we discussed above, XR traffic is not only about video stream, other streams should be considered also.  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |
| CATT | We are OK with proposal 8 as working assumption pending the consistence with SA4 traffic model. |
| Futurewei | We prefer to have a single value for each application to reduce the number of simulations. We suggest 60 Mbps for AR/VR and 30 Mbps for CG, similar to what MTK and Xiaomi suggested. |
| InterDigital | We have a similar understanding with Nokia regarding bitrates for 4K resolution. As such, the proposed values for DL bitrates should be revised to 60Mbps for AR/VR and [30,45] Mbps for CG. |

### Multiple Flows

|  |  |
| --- | --- |
| Company | View |
| Huawei | *Proposal 11: The following general traffic model is considered for the XR and CG:*   * *#M data streams for DL and #N data streams for UL, where each data stream has separate* |
| InterDigital | * + Number of data streams: [Configurable number of streams, configurable traffic parameters common to all streams] (e.g. isochronous multi-stream with bounded latency) |
| MTK | *Proposal 5: traffic model shall take into account different traffic types and possibly differentiated frames within the same application, in both UL and DL directions* |
| Apple | Proposal 2: In RAN1 study, data flows with different QoS requirements in XR study should be modeled separately.  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |

**Summary**

* Support multiple traffic flows in DL/UL with different QoS requirements/date rates: Huawei, InterDigital, MTK, Apple

**Question 9**. Some companies are proposing to explicitly evaluate multiple traffic flows in DL/UL with different QoS requirements/date rates. Please share your view on this. If you support, please explain the details of how to evaluate multiple traffic flows, via examples, e.g., voice flow of X1 Mbps, Y1 fps, Z1 delay budget and video frame of X2 Mbps, Y2 fps, Z2 delay budget, how to define whether UE is satisfied or not, etc.

|  |  |
| --- | --- |
| Company | View |
| OPPO | We support single traffic flow in the simulation. If there are multiple traffic flows with different QoS requirements, should the NW differentiate different flows and optimize the scheduling? The performance will heavily depend on the implementation of QoS-aware scheduling. As a result, it will be difficult for a fair comparison. For example, if one result show better performance flow A and worse performance for flow B compared to another results, what’s the conclusion we can made based on these two results.  On the other hand, multiple traffic flows will require additional efforts for evaluation/simulation. |
| MTK | For DL, we suggest to model two streams:  1. DL stream 1: I frame in V-trace  2. DL stream 2: P frame in V-trace   * + FFS: Different QoS (PER and PDB) requirement for I/P frame   + FFS: FoV v.s. non-FoV streams   For UL, we suggest to model three streams for AR:  1. Gaming command traffic   * Interval: 8 ms * Size: 61 bytes   2. Background traffic   * Interval: 170 ms * Size: 360 bytes   3. Video traffic (1080x720, 30 fps)   * Interval: 33 ms * Size: 10k bytes   For UL, we suggest to model two streams for CG/VR:  1. Gaming command/pose information   * Interval: 4 ms * Size: 61 bytes   2. Background traffic   * Interval: 170 ms * Size: 360 bytes   FFS: Different QoS (PER and PDB) requirement for different UL streams |
| Xiaomi | We support to use a single traffic flow in the evaluation. For audio and data traffic, it has much lower data rate compared with video traffic. |
| QC | We think **single flow could be supported in DL**. In XR application, when video and voice are transmitted together, the amount of data traffic is usually much larger than voice traffic and performance requirement of video is tighter than that of voice in terms of bitrate, reliability, and latency. Thus, we think having additional modelling for the voice traffic would not make a significant impact to the result. Therefore, given the amount of complexity, we think, in DL, evaluating single flow would be good enough.  **In UL, up to two flows can be discussed for AR use case**– one for pose and the other for scene update, especially in case traffic arrival periodicity, delay/reliability requirement, and data rate requirement for these two traffics are very different; In this case, these two traffics could differently affect resource allocation/gNB scheduling, UE capacity and power, which is worth evaluating.  For UL pose, we can discuss [0.2, 1] Mbps, 60 - a few hundreds fps, PDB=[10]ms. [PER=1e-2]  For UL scene upload, we suggest to use [10, 20] Mbps, [60]fps, PDB=[100]ms. [PER=1e-2]  UE is satisfied if both flows satisfied reliability and latency requirement. |
| Nokia, NSB | We do not support modelling multiple flows per each direction. We propose to focus on one flow (e.g., most challenging one) per each direction as a baseline. |
| Apple | **For AR2, it is clear multiple data flows are present for both DL & UL. Study with a single flow won’t be realistic. Considering evaluation effort, we are open to discussion in reducing the number of data flows for RAN1 study.**  **Note the LS from SA4 to RAN1 includes details for traffic modeling which can be found at**  **https://www.3gpp.org/ftp/tsg\_sa/WG4\_CODEC/3GPP\_SA4\_AHOC\_MTGs/SA4\_VIDEO/Docs/S4aV200640.zip**  **One table is pasted below:**   |  |  |  | | --- | --- | --- | | **Media** | **Format and Model** | **E2E Latency requirement** | | 3/6DOF Pose | Same as for split rendering | UL: 5-10 ms | | Video + Depth | 1080p, Capped VBR 10/20 Mbit/s for UL | Conversational 100ms, 200ms | | 2D Video is split rendering | 1080p or 4K (2 eyes) same model as split rendering | 60ms  100ms | | Front Facing Camera\* | 720p, CBR 3 Mbit/s for UL | Conversational  100ms, 200ms | | Audio (MPEG-H) | 256/512 kbps for both UL/DL | Conversational 100ms, 200ms | | Data Stream | 0.5 Mbps for both UL/DL | Conversational 100ms, 200ms | |
| CATT | **We are Ok to model multi-flow with FTP-3. FTP-3 with Poisson inter-arrival distribution is a multi-flow with each flow as exponential interarrival.** |
| Futurewei | We support modelling single traffic flow on each direction as a baseline. Companies can optionally bring in evaluation results for multiple traffic flows if they want to. |
| InterDigital | We think it is important to model different number of flows in DL and UL per application, where each flow may be subject to different QoS requirements (e.g. PDB, PER), for realistically reflecting the XR/CG application and to capture the impacts of potential QoS degradation of a subset of flows on overall user satisfaction. For minimizing the number of flows considered, the flows which have common traffic characteristics (e.g. periodicity) may be grouped and evaluated collectively with respect to the QoS requirements. |

### Other issues

|  |  |
| --- | --- |
| Company | View |
| vivo | *Proposal 6: Adopt random offset for modelling traffic arrival offset among UEs per cell.*  *Proposal 12: For statistical XR traffic model, 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 13: For DL/UL packet arrival time relationship, following options can be considered,*   * *Option 1: DL and UL packet arrival times are independently modelled.* * *Option 2: DL and UL packet arrival times are correlated, e.g.* *the uplink pose information triggers the corresponding downlink traffic, where the interval between DL and UL packet arrival times may be uniform or subject to a certain distribution.* |
| ZTE | According to [7], traffic modeling for both eyes could be considered for the case of split rendering. In this case, we believe eye staggering should be considered and modeled since packetization based on smaller packets could be used to model the case of packets for both eyes arriving at the same time. |
| Ericsson | 1. Traffic arrival time offset among XR users needs to be included, e.g., random offset with the simple uniform distribution of [0 1/FPS] where FPS is a frame refresh rate |
| QC | Traffic start offset: different users could have different traffic start offset, which shifts the actual file arrival times of each UE |
| InterDigital | For the evaluations of capacity, both random offset and uniform offset can be considered. |

**Summary**

* Interleaved two eye buffer modeling: vivo, ZTE, QC
* Traffic arrival time offset across UEs: vivo, Ericsson, QC
* Dependency of DL and UL traffic: vivo

**Question 10**. Please share your view on (i) whether/how to evaluate two eye buffers, (ii) how to model traffic arrival time offset across UEs, (iii) whether/how to evaluate dependency of DL and UL traffic.

|  |  |
| --- | --- |
| Company | View |
| OPPO | 1. We support to consider the case of interleaved two eye buffer model. We prefer to reuse the above modelling except that the bitrate is 50% of that in section 2.2.5  2. We prefer to evaluate DL and UL independently. However, we also can live with the joint evaluation of DL and UL if majority companies support it. |
| MTK | (i) No need to evaluate two eye buffers because we do not see the need in RAN1 unless the two buffers are staggered and this could be possibly useful for better capacity. Also, V-trace provided by SA4 does not have L/R information.  (ii) uniform random offset from 0~16.67ms  (iii) Interesting idea but how to model this dependency is FFS |
| Xiaomi | We support to use separate evaluation for UL and DL. |
| QC | It may be beneficial to evaluate **two eye buffers** as an optional configuration as there may be diverse implementations to handle two eye buffers in reality. We can evaluate and compare performance among different options for packet arrival and PBD, e.g., interleaved arrival of two eye buffers at gNB vs. aligned arrival of two eye buffers at gNB, where how PDB is defined can be further discussed.  **As to Traffic arrival time across UE,** random offset among UEs can be the baseline, while we can evaluate the performance impact of equal or different offsets among UEs (assuming the offsets can be coordinated between gNB and edge server).  **Evaluating dependency between UL and DL** requires knowledge and modelling in network side, e.g., rendering time, network delay, etc. At this point, it seems that there is no strong reason to capture this. Having no dependency could also make it easy to do independent DL or UL evaluation. |
| Nokia, NSB | Our view is as following:  (i) whether/how to evaluate two eye buffers - the packets of both eyes arrive at the same time for each frame.  (ii) how to model traffic arrival time offset across UEs – uniform time distribution.  (iii) whether/how to evaluate dependency of DL and UL traffic - an independent modelling of DL and UL traffic as a baseline is preferred. |
| CATT | Two-eye buffering is one of the use cases for multi-session Poisson inter-arrival if we use FTP-3. |
| Futurewei | Our views are as follows:   1. No need to model two eye buffers. 2. Traffic arrival time offset across UEs can be modelled as uniform distribution. 3. DL and UL should be modelled independently to reduce the complexity of the evaluation work. |
| InterDigital | (i) We prefer the interleaved model where the frames associated with 2 eye buffers can be staggered to reduce the total bitrate. Since the P-traces contain the information on left/right eye, it would be possible to evaluate the performance of each buffer separately and collectively.  (ii) Uniform distribution for modelling the packet arrival offset among UEs  (iii) Independent arrival for UL and DL is preferred for simplifying the evaluation effort |

UL Traffic Model

This section discusses UL traffic model.

Table 6 captures the views on UL traffic model from different sources.

Table 6 Views on UL Traffic Model

|  |  |
| --- | --- |
| Source | View |
| Oppo | Proposal 6: For VR2/AR2/CG evaluations, RAN1 doesn’t need to consider the UL traffic and only evaluate the DL traffic in the NR system. |
| Vivo | Table 7. UL traffic model for media service   |  |  | | --- | --- | | Traffic model | Model 6 (13Mbps) | | Packet size distribution | Truncated Gaussian distribution | | Mean packet size (Bytes) | 27040 | | STD of packet sizes (Bytes) | 3380 | | Maximum packet size (Bytes) | 42250 | | Minimum packet size (Bytes) | 67 | | Packet arrival interval (ms) | 16.67 | | Packet delay budget (ms) | 10 |   *Proposal 14: For UL* *media services, the traffic model in Table 7 is considered as the starting point for the evaluation of AR case.*  Table 8. UL traffic model for interactive/pose services   |  |  | | --- | --- | | Traffic model | Model 1 (200kbit/s) | | Packet size distribution | Fixed, 100Bytes | | Packet arrival interval (ms) | 4 | | Packet delay budget (ms) | 10 |   *Proposal 15: For UL interactive/pose services, the traffic model in Table 7.* UL traffic model for media service   |  |  | | --- | --- | | Traffic model | Model 6 (13Mbps) | | Packet size distribution | Truncated Gaussian distribution | | Mean packet size (Bytes) | 27040 | | STD of packet sizes (Bytes) | 3380 | | Maximum packet size (Bytes) | 42250 | | Minimum packet size (Bytes) | 67 | | Packet arrival interval (ms) | 16.67 | | Packet delay budget (ms) | 10 |   *Proposal 14: For UL* *media services, the traffic model in Table 7 is considered as the starting point for the evaluation of AR case.*  Table 8 *is considered as the starting point for XR and Cloud Gaming evaluation.* |
| InterDigital | Proposal 3: The configurable parameters in the generalized XR traffic model for UL transmissions are:   * + 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) |
| Xiaomi | Proposal 1: Periodic traffic can be assumed for the DL and UL traffic of the VR service |
| Apple | Proposal 1: It is key to include uplink traffic with substantial throughputs in the study of AR2.  Proposal 3:   * In the traffic model for XR, multiple data flows (e.g. for audio and video) for each direction (DL or UL) are generated for a UE; * Each data flows can be configured separately with * Periodicity * Packet size distribution (e.g. fixed or following a distribution) * Data flow specific latency and reliability requirements   Proposal 4:   * For XR conversational, for each data flow, the following can be configured separately:   + Periodicity   + Packet size distribution (e.g., fixed or following a distribution)   + Data flow specific latency and reliability requirements * downlink traffic includes the following data flows:   + 2D video   + Audio   + Data stream * uplink traffic includes the following data flows:   + Video + Depth   + Front facing Camera   + 3/6 DOF Pose   + Audio   + Data stream |
| QC | Proposal 3: RAN1 supports the following statistical model for pose/control traffic in UL for XR evaluation.   * Data rate is given. * File is generated periodically. * File size is fixed.   Proposal 4: RAN1 supports the following statistical model for scene update traffic in UL for XR application.   * Data rate is given. * File is generated periodically. * File size is random following truncated Gaussian distribution * File need to be transmitted within file delay budget |
| Nokia, NSB | ***Proposal 2****: For VR1, consider a periodic traffic model as an uplink traffic model. Assume a constant inter-arrival time of 1 packet every 100 ms, where the average bitrate is equal to 8 kbit/s.*  ***Proposal 8:*** *For AR1, consider the FTP Model 3 as an uplink traffic model for Option 1 and Option 2. For Option 1, assume a traffic source generating 58 Mbit/s and 90 Mbit/s as a bitrate for 1080p (Full HD) and 4K video quality, respectively. For Option 2, assume a traffic source generating 10 Mbit/s as a bitrate for 720p video quality.*  ***Proposal 12:*** *For CG, consider the Periodic traffic model as uplink traffic model.* *Assume an inter-arrival time of X/bitrate [seconds] where X is the packet size for uplink transmissions. A transmission bitrate of 2 kbit/s can be assumed.* |

**Summary**

* No UL modeling required: Oppo
* UL modeling required: vivo, InterDigital, Xiaomi, Apple, QC

Given that UL pose/control is common UL traffic for VR/AR/CG, we make following proposal.

**Proposal 11**: RAN1 adopts following UL traffic model for pose information for VR2/AR2/CG

* Periodicity: [2/4/8/16ms]
* Packet size: 100byte
* PDB: 10ms

**Question 11**. Please share your comments on Proposal 11.

|  |  |
| --- | --- |
| Company | View |
| OPPO | We are ok with the evaluation of UL traffic if majority companies support it. |
| MTK | * Periodicity: 4 ms * Packet size: 61 bytes * PDB: 10ms |
| Xiaomi | We prefer to a single periodicity value 4ms. Agree with others. |
| QC | Considering simulation workload, we can evaluate two values of pose information periodicity, 2 and 16.7ms. Packet size of 100bytes and PDB of 10ms seem reasonable. |
| Nokia, NSB | We propose to agree on the number of flows per each direction first and only then proceed with discussion on the possible parameters. |
| CATT | We are OK with the principle of Proposal 11. However, we need to consider the SR and scheduling delay |
| Futurewei | Agree with Nokia that we should first agree on the number of traffic flows on each direction. If the group agrees on single traffic flow modelling on UL, this proposal might not be necessary. Furthermore, our opinion is that evaluation/modelling of DL should take higher priority than UL. |
| InterDigital | We are fine with FL’s proposal on periodicity and PDB. For packet size we prefer using values [100B, 250B] to account for different resolution in pose information for XR/CG applications |

UL scene (camera feed) is additional UL traffic for AR application.

**Proposal 12**: RAN1 adopts following UL traffic model for UL scene (camera) information for AR

* Bit rate: 10, 20Mbps
* Periodicity: 16.67ms
* PDB: 60ms

**Question 12**. Please share your comments on Proposal 12.

|  |  |
| --- | --- |
| Company | View |
| OPOO | We have the similar comment as for DL traffic that 120fps should be included for better future-proof |
| MTK | Video (scene) traffic (1080x720, 30 fps)   * Interval: 33 ms * Size: 10k bytes (2.4Mbps) * PDB: 40ms |
| QC | We support the modelling UL scene in Proposal 12. |
| Nokia, NSB | We propose to agree on the number of flows per each direction first and only then proceed with discussion on the possible parameters. |
| CATT | We are OK with the proposal. |
| Futurewei | Agree with Nokia that we should first agree on the number of traffic flows on each direction. Furthermore, our opinion is that evaluation/modelling of DL should take higher priority than UL. |
| InterDigital | We are fine with FL’s proposed values |

# Per UE KPI (whether UE is sa

During RAN1 103-e, the following agreement was made.

|  |
| --- |
| **Agreement 6**: System capacity is defined as the maximum number of users per cell with at least X % of UEs being satisfied.   * X=90 (baseline) or 95 (optional) * Other values of X can also be evaluated optionally   Note: The exact ‘satisfied’ requirements will be discussed separately  FFS: how to calculate the percentage of satisfied users across multiple drops of simulations |

In this section, we discuss how to define the ‘satisfied’ requirements. This completes the system capacity definition, according to the above agreement.

Capacity KPI

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| --- | --- |
| Company | View |
| FutureWei | *Proposal 7: The capacity is defined as the maximum number of users that can be supported with percentage of users that satisfy both latency and PER requirements above a threshold (e.g., 90%)* |
| Oppo | Proposal 9: For each identified traffic/service, whether a UE is satisfied or not is not determined based on the following tuples, where the detailed values is to be determined based on the traffic models.   * DL: {Data rate, Packet Delay Budget, Packet Error Rate} * UL: {Data rate, Packet Delay Budget, Packet Error Rate}   Proposal 10: For each identified traffic/service, the following results are provided   * CDF of achievable data rate * CDF of packet delay |
| Huawei | *Proposal 7: RAN1 needs to identify a KPI that can reflect the user experience in XR and CG services*   * *The identified KPI can reflect the impact of network transmission on* *the user experience.* * *The identified KPI can be calculated with RAN available information.*   *Proposal 8: The identified KPI can be calculated with RAN available information, such as packet loss information, packet delay information, and some XR/CG source related information if they can be available within RAN.* |
| CATT | *Proposal 8: For XR service evaluation, the latency could be defined as the delay budget of Air interface is 20*%*~25% of end-to-end latency requirement.*  *Proposal 9: For XR service evaluation in RAN1, the reliability could be specified by mapping of end-to-end PER of XR service requirements to BLER in Uu interface.*  *Proposal 10: For XR service evaluation, short term throughput, which is be defined as throughput of MAC PDU within delay budget, could be considered as the UPT of XR services.* |
| vivo | *Proposal 3: A UE is regarded as satisfied if the packet error ratio measured for it is equal to or less than the given PER.*  *Proposal 4: The following metrics can be considered for XR capacity evaluation,*   * *Percentage of satisfied UEs* * *System capacity* * *CDF of packet error ratio* * *CDF of packet latency* * *CDF of user-perceived throughput* * *Resource utilization*   *Proposal 5: Percentage of UEs being satisfied for each drop can be calculated separately, and then averaged over all the drops.*  *Proposal 7:* *The user interaction delay can be used as a key metric for uplink capacity evaluation for uplink interaction and pose information traffic.*  *Proposal 8:* *The number of satisfied users for interaction and pose information is defined as the maximum number of users per cell for which the A%-tile user interaction delay is equal to or less than the uplink PDB, where the threshould A% should be discussed and determined, when only interaction and pose information are modelled in uplink.* |
| ZTE | 1. UE is satisfied if the packet loss rate is less than 10-3 or 10-4 for VR2, AR2 and CG.  * Delay threshold for VR2 and AR2 is 60ms and delay threshold for CG is 80ms. * Note: The packet loss rate for both left and right eye should be less than 10-3 or 10-4 if traffic for two eyes is considered |
| InterDigital | Proposal 1: Given the XR applications, define user experience satisfaction by the percentage (70%, 90%) of achieved maximum throughput, which is derived from the traffic parameters of the XR application.  Proposal 2: Evaluate capacity for XR applications by analyzing CDF of UEs achieving an average throughput that is at least equal to the required throughput for the given XR application. |
| MTK | Proposal 8: For XR/CG evaluation, if one frame is mapped to several packets (Ex. constant packet size), then the packet size, and mapping between PDB/PER and frame error rate/QoS needs to be further clarified.  Proposal 9: For XR/CG evaluation, if one frame is mapped to one packet, a UE is satisfied if 99% files are delivered within packet delay budget (PDB) = 10ms. For requirements defined in SA2 LS S2-2009227 (5ms/99.9% and 10ms/99.9%), they can serve as optional (advanced) user satisfaction criterion. |
| Intel | * *Proposal-2: Consider defining the following KPIs for capacity evaluations:*   + *Average data-rate requirement*   + *Packet delay statistics and Packet delay budget (PDB)*   + *Average packet error rate (PER) statistics and reliability requirement*   + *User satisfaction ratio* |
| Nokia | **Proposal 8:** *The percentage of satisfied users from a simulation campaign with N separate drops of M users is calculated for the NxM samples of user satisfaction.*  Proposal 9: *Distinguish UL and DL KPIs and evaluations, allowing conclusions such as “Up to 10 XR devices running VR1 can be supported in a given scenario, while the corresponding UL traffic can only be supported for no more than 7 VR1 XR devices.”*  Proposal 10: *Adopt the following definition for a satisfied UE: “A satisfied UE operates with target link reliability R under L latency bound rate.” The exact values for R, L can be determined after the traffic model and the use case are agreed.*  Proposal 11: *Reliability is defined as a percentage of (DL or UL) packets delivered within a certain packet delay budget (PDB): fraction of (DL or UL) packets that have been correctly received within the preconfigured PDB with respect to the packets generated by the XR application during the simulation time.*  Proposal 12: *Latency bound L is defined as a packet delay budget (PDB), where a packet delay is measured as the difference between the time the packet is received at Layer-2 at the transmitter and the time when it is forwarded from Layer-3 at the receiver end to the upper layers. To facilitate the comparison of results reported by different companies, we propose to set the core network delay to zero.* |
| Xiaomi | Proposal 3: Packet loss rate and delay can be used as the criteria to identify whether UE is satisfied.  Proposal 4: DL capacity and UL capacity can be evaluated separately |
| Samsung | *Observation 3:* *System capacity for a XR application corresponds to a % of UEs for which a target data rate with a latency bound for the XR application is achieved.*  *Observation 4:* *XR can re-use the definitions for system capacity and % of satisfied UEs used in URLLC.*  Proposal 9: PDCCH blocking is part of the XR SI in the evaluation of the latency KPI. |
| Ericsson | Proposal 4: The fraction of satisfied users subject to frame latency bound with a reliability target should be considered as the main system performance measure.  Proposal 5: Latency and reliability metrics for XR use cases should be measured per application PDU but exclude latency and errors contributed by non-RAN aspects such as application, core network, and transport layer.  Proposal 6: RAN1 should decide exact parameters for latency and reliability criteria further when ongoing SA WG4 XR study is finalized [3]. |
| Apple | Proposal 4: propose a UE is deemed satisfied if the QoS requirements for all its data flows are met. |
| QC | Proposal 2: For XR DL evaluation, use following performance metrics for evaluation.   * File error rate and a corresponding threshold (99%) to determine satisfaction of the quality condition * Transmission delay * FFS: Percentage of damaged area and a corresponding threshold to determine satisfaction of the quality condition   Proposal 3: For XR UL scene upload evaluation, use following performance metrics for evaluation.   * File error rate and a corresponding threshold to determine satisfaction of the quality condition * Transmission delay * FFS: Percentage of damaged area and a corresponding threshold to determine satisfaction of the quality condition   Proposal 4: For XR UL pose/control info evaluation, use following metrics for evaluation.   * Age of pose (AOP) |

**Summary**

* Definitions of satisfied UE
  + Satisfying reliability, latency requirement

Based on views from companies we make following proposal.

**Proposal 13.** A UE is declared a **satisfied** UE if more than X=99(%) of packets are successfully transmitted within a given packet delay budget (PDB), where packets which cannot meet its PDB requirement are counted as lost (dropped from Tx queue).

**Question 13**. Please share your comments on Proposal 13.

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| --- | --- |
| Company | View |
| OPPO | Support FL’s proposal |
| MTK | Agree on Proposal 13 |
| Xiaomi | Agree with FL proposal. |
| QC | We support proposal 13. This is a clean definition capturing both reliability and latency requirements. In practice, it may be up to gNB implementation whether to server packets with a long delay in queue/buffer. However, in our evaluation, given that we assume a fixed PDB per packet for over the air transmission – this may not be the case in practice, **it may be a reasonable assumption to drop packets from the queue/buffer that have stayed longer than PDB**. In addition, having common assumptions among companies would help to reduce variance of results from different companies. |
| Nokia, NSB | We propose to naturally separate the proposal on UE satisfaction metric from the modelling aspects. We also propose to leave the exact value of X% until the decision on traffic has been made. Therefore, we suggest the following modified proposal:  **Proposal 13.** A UE is declared a **satisfied** UE if more than X (%) of packets are successfully transmitted within a given packet delay budget (PDB). The exact value of X is FFS. |
| CATTT | We are OK with Proposal 13. |
| Futurewei | We support Proposal 13. |
| InterDigital | We think Proposal 13 can be considered as one of the KPIs for evaluating user satisfaction. However, a more comprehensive definition of satisfied UE should also account for satisfying a target data rate requirement along with PDB and PER. |

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