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XR Enhancements for Rel-19

Apple

Rel-19 XR | Rel-18 Observations

- Rel-18 XR has targeted to enhance system efficiency by taking XR traffic characteristics into account, including:
  - Awareness of XR traffic characteristics at RAN for configurations of DRX and resource allocation (e.g. CG)
  - DRX enhancement with considerations of XR frame rates
  - BSR/DSR enhancement with considerations of XR traffics with high data rates and/or delay sensitivity.
  - Packet discarding with considerations of congestion and need of whole PDU Set at Application
  - CG enhancements with considerations of variable packet size and jitter of XR traffics

- Most of Rel-18 XR work have targeted at use cases with single traffic flow, with goals of power saving and capacity improvements. **However, XR services for the end user is delivered based on coordinations among multiple traffic flows and modalities potentially with diverse requirements and characteristics. On the other hand, Rel-18 enables packet discarding to improve capacity, but not much has been considered on how to minimise packet discarding to optimise user experience.**

- **Observations:**
  - **Rel-18 XR is lack of considerations on multiple traffic flows and minimisation of packet discarding, which are crucial for XR user experiences.**

Rel-19 XR | Justification for Multiple Traffic Flows Considerations

- **Justification**
  - Operations of XR applications may require multiple data flows with different QoS requirements for both DL and UL. Bidirectional traffic with multiple data flows is key to enable infotainment and productivity XR applications. Furthermore, each data flow is either periodic or quasi-periodic, and XR devices need to cope with multiple co-existing traffic flows with very different periodicities (e.g. video frame rate may be 60 FPS (16.67ms) while audio stream periodicity may be 10ms). It is inefficient and not flexible enough to support multiple traffic flows concurrently with only one active DRX configuration.
  - On the other hand, some of these traffic flows may correspond to modalities that have synchronisation requirement, which means ideally the packets associating with multiple different modals (e.g. video and audio) should be delivered concurrently, in order to achieve the desirable user experience.
  - Moreover, smooth interaction between the user activity and the content is a key to provide truly immersive experiences, and this requires very tight coordination between mutually dependent UL/DL flows. For example, the XR server hosted in the network needs to process pose/control information sent in UL by a UE, and renders the corresponding media content, which should be transmitted in DL immediately. In other words, the round-trip delay between UL and DL should be minimised.

- **Proposal 1:**
  - **Rel-19 XR should include objectives that allow 5G NR to support handling and coordination among multiple traffic flows with the same/different directions, including:**
    - **Specify mechanisms that allow multiple active DRX configurations to handle traffic flows with different periodicities**
    - **Specify mechanisms that enable synchronised delivery of multiple traffic flows/modalities**
    - **Specify mechanisms that facilitate minimisation of round trip delay between a UL flow and a DL flow.**

Rel-19 XR | Justification for Timely Minimisation of Packet Discarding

- **Justification**
  - Rel-18 has considered both PSIHI-based discarding mechanism and PSI-based discarding mechanism. This makes packet discarding a much more frequent event in Rel-18 XR. Although this improves system capacity, the XR user experience may be impacted. According to the LS from SA4 (S4-220505), any packet losses in video generally result in degradation of the user-perceived quality of experience, and it is beneficial if the network can minimise the video packet loss. Since the success of XR use case is relevant to both user experience and system efficiency, some mechanism may be needed to strike a balance.
  - Buffer delay reporting in Rel-18 may allow the gNB to perform scheduling by taking buffer delay into account, which facilitates on time delivery of uplink packets. However, timely reporting of buffer delay information is subject to availability of UL-SCH resource, and scheduling delay at the gNB cannot be neglected. Thus, some delay-aware UE operations to minimise packet discarding may be considered, which allows the UE to take actions immediately when the risks of packet discarding is foreseeable.

- **Proposal 2:**
  - **Rel-19 XR should include objectives that allow 5G NR to support timely minimisation of packet discarding:**
    - **Specify mechanisms that allow delay-aware UE operations to facilitate minimisation of packet discarding.**

Rel-19 XR | Justification for CSI Measurement/Reporting Periodicities

- **Justification**
  - CSI measurement and reporting may not be aligned with XR periodicity, which can lead to unnecessary UE power consumption and capacity loss as interference measurement may not reflect interference the XR traffic really suffers from.

- **Proposal:**
  - **Rel-19 XR can be enhanced to optimise/enable CSI measurement and reporting aligned with XR periodicity.**

Rel-19 XR | Justification for enhanced HARQ/CSI feedback

- **Justification**
  - Conventional HARQ feedback for a transport block is a single bit indicating success or failure of the decoding of the transport block. When NACK is indicated, it may take multiple rounds for the transmitter to send enough coded bits in retransmissions so the receiver can decode the transport block; and the multiple rounds of HARQ feedback/retransmissions take time. It would be desirable if retransmission can finish quickly so system capacity within latency budget can be achieved and also prolonged (re)-transmissions are avoided to achieve UE power saving.

- **Proposal:**
  - **Rel-19 XR can be enhanced to optimize HARQ feedback to indicate the required amount of redundancy transmission to close gap to full decoding, and the UE can indicate the preferred redundancy version sequence to the network.**

Rel-19 XR | Enhancement to UTO signaling design

- **Justification**
  - In Rel-18, UTO signaling design limited to a single CG configuration. In Rel-19, UTO signaling's extension to multiple CG configurations may be motivated.
  - Allowing efficient statistical multiplexing is conducive to system capacity. Allowable UTO patterns can introduced to allow efficient statical multiplexing

- **Proposal:**
  - **Consider UTO signaling's extension to multiple CG configurations so UTO signaling consistency is maintained within a CG configuration and also across relevant CG configurations.**
  - **Introduce different UTO pattern configurations for different UEs to facilitate efficient statistics multiplexing of PUSCH resources from different UEs.**

Conclusions | Potential Objectives for Rel-19 XR

- **Potential Rel-19 WI Objectives:**
  1. Specify mechanisms that allow multiple active DRX configurations to handle traffic flows with different periodicities [RAN2, RAN1]
  2. Specify mechanisms that enable synchronised delivery of multiple traffic flows/modalities [RAN2, RAN1]
  3. Specify mechanisms that facilitate minimisation of round trip delay between a UL flow and a DL flow [RAN2]
  4. Specify mechanisms that allow delay-aware UE operations to facilitate minimisation of packet discarding [RAN2].
  5. Specify CSI measurement/reporting framework based on XR frame rates [RAN1]
  6. Specify HARQ mechanisms with indications of required/preferred redundancy [RAN1]
  7. Specify enhancements of UTO-UCI signalling for multiple CG configurations and statistical multiplexing [RAN1, RAN2]

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