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RP-232963

Discussion of R19 work on XR Evolution

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Outline

- Overview of Progress on Rel-19 XR scoping
- Discussions of some RAN2-led items for Rel-19 work on XR evolution
  - Enhancements of PDCP retransmission
  - Enhancements of PDCP duplication with selectivity
  - Enhancements of PDU discard with signaling
  - Enhancements of CG with non-integer periodicity
- Proposed Rel-19 XR WI Scope

Overview of Progress on R19 XR scoping (1/2)

- In RAN#101, progress was made primarily on RAN1-led items, e.g., Meas. Gaps/Scheduling restrictions “Agreeable” and CQI/CSI enh. “Almost agreeable” to be considered further [1]. However,
  - Measurement Gaps /Scheduling restrictions were discussed in R18 XR SI without consensus on normative work. At least, RAN4 study is needed to assessment the impact to relevant measurements.
  - CQI/CSI link adaption enhancement were discussed extensively in R17 and R18 with many variants and achieved no consensus of benefit. CQI/CSI link adaptation enhancement should not be included as normative work for R19
- Furthermore, some “to be considered further” items were not clearly defined yet, for examples,
  - Delay aware / Delay adaptive (remaining time) scheduling (5)
  - Power saving (8), DRX and PDCCH skip (excluding power saving for Multi-modal)

[1] RP-232619 Moderator's summary for REL-19 RAN2 topic Enhancements for XR

Overview of Progress on R19 XR scoping (2/2)

- In addition, some “to be considered further” items also depend on other WGs, for examples,
  - Enhancements for Multi-Modal flows (19) – “**SA2/SA4 support is required**”.
  - PDCP Discard enhancements for PDU set discard enhancements for inter-PDU Set dependencies – “**Can consider, if SA2 agrees**”.
  - RAN involved congestion mitigation / rate adaptation (4) – **“feasibility dependent on SA”**
  - FEC awareness at AS – “**Dependent on SA2, SA4**”.
- On the other hand, there was a lack of consensus on many RAN2-led items, for examples,
  - **Selective duplication, RLC bearer switching (6-7),**
  - **PDU discard with signalling (1),**
  - **Latency reduction (4).**

In this Tdoc, we discuss them in detail and propose a scope for R19 XR work.

Discussions of some RAN2-led items for Rel-19 work on XR evolution

Enhancements of PDCP retransmission

- Currently, PDCP retransmission can be triggered by error indication from lower layer (for RLC AM only) or by PDCP Status Report (SR), which is sent only in specific CP events. As RLC UM may be extensively used in XR due to low latency, **it may be challenging to meet the PER/PSER requirements with only HARQ retransmissions** due to, e.g., possible error in UL HARQ feedback or in DCI of UL grant for HARQ retransmission.
- Therefore, for Rel-19 XR evolution, we **propose the following enhancements of PDCP retransmission** to further improve PER/PSER performance and QoE:
  - **Introducing polling mechanism** (e.g., polling bit in the PDCP header) for a transmitting PDCP entity to solicit PDCP SR, e.g., at the last PDU of a PDU Set or of a data burst.
  - The receiving PDCP entity **sends PDCP Status Report in response to the polling**.
  - The transmitting PDCP entity **retransmits failed PDCP PDUs if the remaining time associated with is sufficient** for a PDCP retransmission.
- Facilitating timely PDCP retransmissions can help to meet the PER/PSER requirements
  - without having to target the HARQ operation at a very low residual error rate, and/or
  - in the presence of errors in UL HARQ feedback or in DCI of UL grant for HARQ retransmission.
- Timely PDCP Status Reports may also facilitate PSER measurement at the UE.

Enhancement of PDCP duplication with selectivity

- In RAN#101, selective duplication/RLC bearer switching was marked as “Not agreeable”.
- Observation 1. Different types of PDU Sets tend to significantly differ in average PDU Set sizes (in the number of PDUs), hence if RLC bearer(s) always operate at fixed PER target, without any differentiation in PDCP handling, **large-sized PDU Sets tend to have higher (worse) achievable PSER than small-sized PDU Sets.** To make the matter worse, the type(s) of PDU Sets that are associated with worse achievable PSER tend to be dependent upon by other types of PDU Sets at the application layer and hence are more critical.
- Observation 2. Currently, PDCP duplication can be (de)activated via MAC CE, which is slow and, in XR, lack of proper trigger because dynamic PDU Set info (e.g., PSI, PDU Set size) isn’t transmitted over the Uu. Therefore, duplication (and extra resource), if used, is blindly used on all PDUs regardless of the types of the PDU Sets, hence reducing radio efficiency.
- We propose enhancing **PDCP duplication with selectivity** based on dynamic PDU Set info
  - With awareness of dynamic PDU Set info (e.g., PSI, PDU Set size), **UE** can proactively (i.e., without MAC CE) **(de)activate PDCP duplication on a per PDU basis**, e.g., based on PSI or PDU Set size of the PDU.
  - Resources for duplication are always configured, but **when the duplication is deactivated by the UE, unused resources can be indicated to the gNB using UTO-UCI** as soon as the first PDU of the PDU Set arrives at the UE, providing ample time for the gNB to reuse the resources for other UEs.

Enhancements of PDU discard with signaling

- In RAN#101, there was “No consensus” on enhancements of PDU discard with signalling.
- PDU Set discard and PSI based SDU discard introduced in R18 may create **COUNT gap** at receiving PDCP entity, **causing reordering delay** in delivering subsequently received PDCP SDUs to upper layer and possibly rendering them obsolete at the application layer.
  - The transmitting PDCP entity may be unable to avoid causing the COUNT gap at the receiving PDCP entity because it **cannot reuse the to-be-discarded COUNT values** on other SDUs, e.g., due to lack of time or power (for UEs) or due to security risks of reusing the same pair of security key and COUNT value on different payloads (for CU-DU split gNBs).
- In RAN2#124, RAN2 discussed possibility of introducing, in R18 XR WI, signaling for the transmitting PDCP entity to notify the receiving PDCP entity of the COUNT values being discarded. No solution was adopted in the end. However, **many companies (11 in total) supported a new PDCP control PDU** with similar design as the PDCP Status Report [2].
- We propose to introduce such simpler solution in Rel-19 XR to provide benefits such as not mandating out-of-order delivery be configured, not forcing UEs to spend precious time and power in reusing COUNT values, and not compromising security for CU-DU split gNBs in reusing COUNT values when the discarded PDUs are already submitted to RLC.

[2]. R2-2313923 [AT124][019][XR] PDCP discard.

Enhancements of CG with non-integer periodicity

- RAN2 discussed possibility of introducing non-integer CG periodicities in R18 XR WI to match non-integer traffic periodicities but concluded not to do so in R18. Some companies believe that a non-integer periodicity can be handled by multiple CG configurations.
- However, an **issue with multiple CG configurations is that the queuing time** from the moment that the first PDU of a PDU Set or data burst arrives at the UE for transmission until the next available CG PUSCH-O to begin the transmission **keeps changing** and cycling through a finite range. Despite the finite range, a constantly changing queuing time for transmission **causes the remaining delay budget**, once the transmission begins, **to also keep changing.** Hence, the number of HARQ and/or RLC (AM) **retransmissions that fit in the remaining delay budget also keep changing**. As a result, **the PER/PSER performance may be time-varying, or** the target error rate in the HARQ operation or the maximal number of HARQ/RLC retransmissions allowed may need to be time-varying, **complicating the operations at the lower layers**.
- We propose to **introduce non-integer CG periodicities in Rel-19 XR to match non-integer traffic periodicities** so that the queuing time is not only kept relatively stable but also be optimized (i.e., minimized), especially in the absence of UL jitters, maximizing the remaining delay budget for a higher number of HARQ/RLC retransmissions allowed and thereby improving error performance and/or spectral efficiency.

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Proposed Rel-19 XR WI Scope

- Specify the enhancements related to PER/PSER performance
  - Enhancements of PDCP retransmission [RAN2]
    - Introducing polling mechanism for transmitting PDCP entity to solicit PDCP SR.
    - The receiving PDCP entity sends PDCP SR in response to the polling.
    - The transmitting PDCP entity retransmits failed PDCP PDUs if the remaining time associated with is sufficient for a PDCP retransmission.
  - Enhancements of PDCP duplication with selectivity based on dynamic PDU Set info to achieve PSER uniformly among different types of PDU Sets [RAN2]
- Specify the enhancements related to latency reduction
  - Enhancements of PDU discard with signaling [RAN2]
    - Introducing new PDCP control PDU, with similar design as PDCP SR, for the transmitting PDCP entity to inform the receiving PDCP entity of the discarded COUNT values to avoid reordering delay.
  - Enhancements of CG with non-integer periodicities [RAN2]

Thank You.

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