3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023

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Source: Apple
Agenda Item: 5

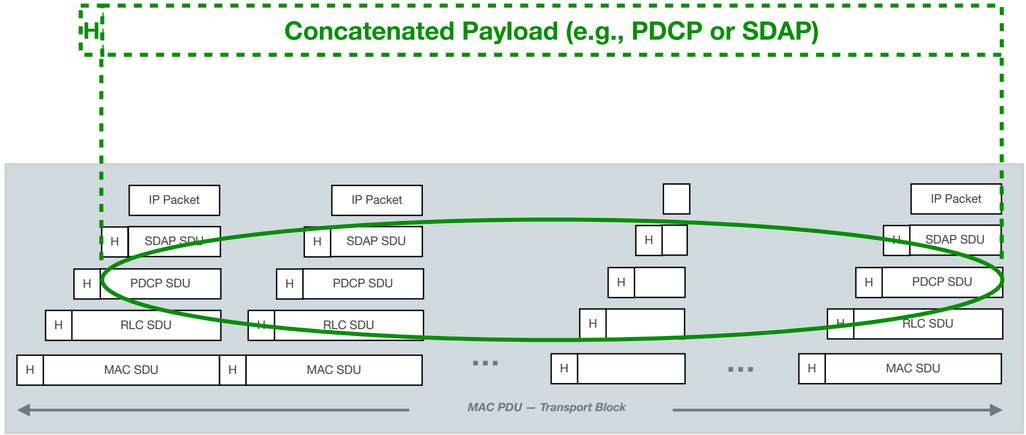
Views on Rel-19 User Plane Enhancements

Apple

Rel-19 UP | L2 Header Processing Enhancements

- **Motivation**
  - The NR data structure was designed to support efficient HW processing, however, at the cost of higher L2 overhead
    - The ratio of header vs payload reduces the number of user data bytes overall
    - Plus, every SDU needs header processing at multiple layers (e.g., SDAP/PDCP/RLC/MAC)
  - UPIP is mandatory since Rel-16, which involves additional processing
    - The time required for payload processing does not scale linearly with the payload size
  - 5G-Advanced scales to higher data rates with heterogeneous payloads and a mix of many packets (e.g., 8K streaming, gaming)
    - User Plane performance decreases and UE power consumption increases
  - Efficiency gains are possible if a lower number of packets is processed at once
    - Load reduction for security operations
    - Load reduction for packet generation and LCP

- **Proposals**
  - Study enhancements to simplify the L2 processing and reduce the number of L2 headers
  - Potential solutions may include combining multiple SDUs into one concatenated SDU
  - Ensure compatibility with earlier releases by introduction of an optional add-on feature



Rel-19 UP | Selective Out-of-Order Delivery

- **Motivation**
  - PDCP *outOfOrderDelivery* enables out of order delivery *for all packets* received on a configured DRB
    - This applies to all QoS flows including all types of L3/L4 packets, TCP data, and TCP ACK packets. The current PDCP protocol does not allow a DRB to deliver some packets out-of-order and other packets in-order.
    - Traffic flows that do not require in-order delivery are often mapped to the same DRB together with traffic flows that require strict in-order delivery. Even for a single traffic flow with strict in-order delivery, performance improvements are possible when certain packets are delivered out-of-order.
  - To obtain a latency benefit from the current *outOfOrderDelivery* method, traffic not requiring strict in-sequence delivery needs to be mapped to a separate DRB
    - For 5G-Advanced, the amount and variety of SDFs and QoS flows coming into PDCP is going to raise further. Spreading those flows over separate DRBs would utilize a higher number of DRBs, causing higher processing and memory demands and increased power consumption.
    - Thus, system operation with limited number of DRBs is desirable.

- **Proposals**
  - Study benefits of out-of-order processing over the Uu interface and in higher layers
  - Explore the possibility of selective out of order delivery for a DRB

Rel-19 UP | SDAP Enhancements

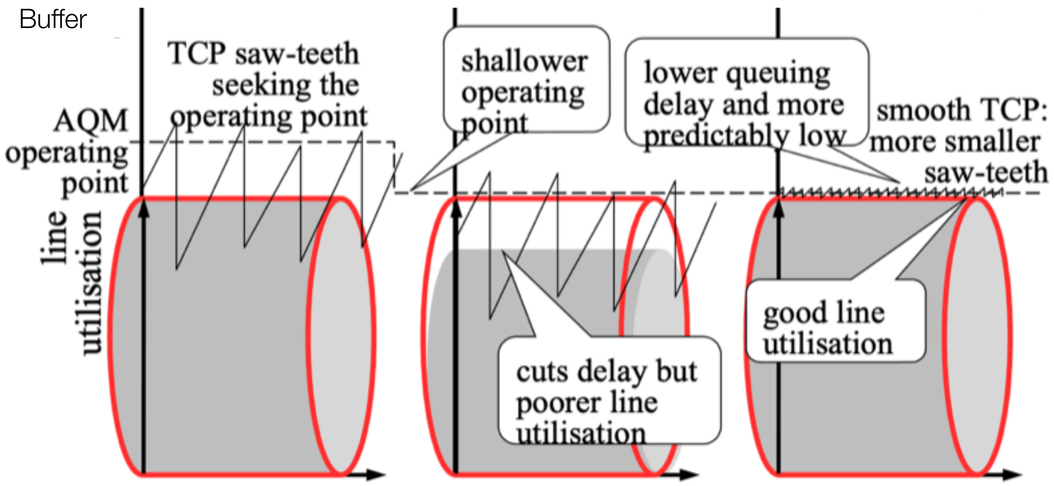
- **Motivation**
  - The SDAP layer was defined in Rel-15 when RLC AM was prevalent, without wide-spread deployment of new services over SDAP
    - 5G advanced supports a mix of heterogeneous payloads and with varying QoS requirements
  - Features introduced later 5G releases often utilize RLC UM on radio bearers that cannot tolerate large delays
    - This necessitates enhanced transmission for DL packets carrying RDI marking and UL packets carrying end-marker control PDUs
  - The stateless nature of NAS RQoS implies that every packet sent from the UPF to the UE is tagged with the RQI and QFI
      - The SDAP layer at the UE notifies the NAS layer every time it receives a packet with the RQI bit set
      - At high data rates, redundant processing of the RQI bit is inefficient from UE perspective
  - For HO, if multiple QoS flows are mapped to the same DRB in the source and target gNBs, then in-order delivery cannot be guaranteed
    - The associated PDCP entity can only guarantee in-order delivery within a DRB, not within the QoS flows carried by the DRB
  - Address QoS performance limitations by making 5G NR more adaptive
    - Head-of-line blocking can delay important packets (RTCP, UL TCP ACKs, etc.) behind regular data packets
    - Packet reordering in the receiving PDCP entity causes delayed processing of ACK packets

- **Proposals**
  - Study enhancements to ensure reliable transmission of SDAP content (RQI, RDI, end-marker) over RLC UM
  - Study enhancements to reflective QoS and redundant processing of RQI, and reliability improvements
  - Study enhancements to SDAP for handover
  - Study enhancements to QoS, for example, by utilizing AQM techniques
  - Can liaise with SA and CT groups as necessary, but expect minimal impact to their specifications

Rel-19 UP | Low latency low loss scale throughput (L4S)

- **Motivation**
  - As 5G evolves to includes more delay sensitive services, efficient congestion management techniques are paramount for scalability and optimized use of network resources — especially for traffic using acknowledged mode such TCP or QUIC
  - 5G NR supports L4S/ECN where the UE and the gNB may set a CE codepoint ('11') in PDCP SDUs (in the IP packet). The principle of L4S is to change the ECN bits in the IP header as soon as queues start to grow. It is important to signal congestion early.
    - Benefits include better queue utilization and lower buffer states, which can be associated with less jitter and reduced delay through a finer saw-teeth, leading to better use of network resources and faster rate adaptation
  - Given that the L2 buffer can be very large and grant scheduling delays exist, an ECN/L4S marking at the end of the PDCP queue comes with the disadvantage of additional delay for the CE codepoint reaching its destination
  - Congestion detection at conditions tailored to the L2 protocol can help keep the latency low and the throughput high
  - The User Plane may further utilize the detection of congestion as a trigger to scale certain parameters of a DRB, for example, to adjust the priority level or conditionally apply a congestion policy

- **Proposals**
  - Study enhancements to insert an L4S marking at the queue head of Layer2
  - Study enhancements for congestion detection at the UE and the gNB
  - Study enhancements for configuration and policy adjustments



Source: https://bobbriscoe.net/presents/1706L4S-for-operators/1707L4S-BobBriscoe.pdf

Rel-19 UP | Scheduling and Resource Efficiency Enhancements

- **Motivation**
  - Queuing typically applies to packets on both gNB and UE side. Throughput drops may occur for a sustained period of time, e.g., in NLOS over FR2. Additionally, the link may experience packet retransmissions at several layers. Based on the conditions, packets are queued up waiting for a scheduling opportunity, causing a buffer bloat at L2 and/or congestion.
  - A growing amount of application layer operations possess a cumulative nature where the last packet is most relevant — such as TCP/QUIC ACKs, TFTP, IPSec, OSPF, certain AI algorithms, etc.
    - 5G NR user plane protocols do not take advantage of this type of traffic where the critical operation is the delivery of the latest packet
  - To help assist the application, it is also imperative to treat the most important packets of a given flow in due time
    - For example, user experience of a data transmission associated with RTCP, multimedia control or transport protocols may benefit from faster and/or more reliable feedback
  - Resource efficiency enhancements can lead to overall improved system performance from both UE and gNB perspective, e.g., by reducing the impact of unimportant packets, head of line blocking, etc.

- **Proposals**
  - Study enhancements to natively support cumulative operations as part of 3GPP protocols to address QoS and performance limitations
  - Study mechanisms to enhance the packet forwarding treatments of important packets and/or traffic flows for reduced power consumption and optimized usage of spectrum

Rel-19 UP | Asymmetric Data-rate Handling

- **Motivation**
  - With the introduction of higher SCS with B52 WI, we can potentially have large differences in the SCS used on the carriers in CA.
  - Larger difference in SCS between carriers result in asymmetric transfer of data among carriers
    - For eg., 980 kHz SCS carrier TBs at a much shorter TTI compared to 15 kHz SCS carrier
    - If data resources (for eg RBs) are mapped to both carriers, then the L2/L3 ACK mechanism can have issues in dealing with large bursts of data on a carrier while waiting on data from the “slow” carrier, leading to data stalls/inefficient ACK handling

- **Proposals**
  - Study enhancements to L2/L3 user plane protocols to handle asymmetric data-rate from carriers with different SCS.

Rel-19 UP | Summary of Potential Enhancement Areas

User Plane improvements to help create a well-rounded 5G-Advanced

- Simplified L2 processing (e.g., SDU concatenation)
- SDAP Enhancements
  - Reliability enhancements for RLC UM: end-marker, RDI, etc.
  - Reflective QoS
  - Handover
  - Adaptive QoS enhancements and AQM
- Selective Out-of-Order Delivery
- More fine-granular QoS and Congestion Control
  - L4S Enhancements: Addressing the buffer bloat on wireless links
- Address QoS and performance limitations
  - TCP ACKs / RTCP / small packets
  - HOL blocking
  - Utilize the cumulative nature of the most popular Internet transport mechanism
- Dynamic (selective) PDCP duplication
  - For example, for certain traffic flows, important packets, or groups of packets
  - Reduced power consumption and optimized usage of spectrum
- RLC/PDCP/MAC enhancements to handle data transferred by carriers with different SCS

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