**3GPP SA4 #129-e S4-241502**

**Online, 19 August 2024 Revision of S4aR240040**

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| *CR-Form-v12.0* | | | | | | | | |
| **PSEUDO CHANGE REQUEST** | | | | | | | | |
| n | | | | | | | | |
|  | **26.822** | **CR** | pseudo | **rev** | **-** | **Current version:** | **0.0.1** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **x** | Radio Access Network | **x** | Core Network | **x** |

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| ***Title:*** | **[FS\_5G\_RTP\_Ph2]** **Congestion control enhancements for AL-FEC awareness** | | | | | | | | | |
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| ***Source to WG:*** | Qualcomm Incorporated | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | FS\_5G\_RTP\_Ph2 | | | | |  | ***Date:*** | | | 08/19/2024 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Rel-19 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)*  *Rel-17 (Release 17)*  *Rel-18 (Release 18)* | |
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| ***Reason for change:*** | | This addresses Key issue #4: Application-layer FEC awareness for PDU Set handling, and in particular  network dropping extra PDUs in a PDU Set encoded with application-layer FEC, if any, may send a false signal to the application on the packet loss rate and the congestion level in the network, and lead to undesired adaptation from the application such as increased redundancy ratio and reduced sending rate.  This paper proposes a solution to handling the packet losses resulting from AL-FEC awareness PDU Set handling and addresses comments on S4-241295 endorsed during the SA4 #128 meeting. | | | | | | | | |
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| ***Summary of change:*** | | Added a solution to handling the packet losses resulting from AL-FEC awareness PDU Set handling and edits to address comments on S4-241295 endorsed during the SA4 #128 meeting. | | | | | | | | |
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| ***Consequences if not approved:*** | | 3GPP may not be vested to pursue solutions to enabling application-layer FEC awareness for PDU Set handling that could be beneficial. | | | | | | | | |
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| ***Clauses affected:*** | |  | | | | | | | | |
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|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  |  | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
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| ***This CR's revision history:*** | |  | | | | | | | | |

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\* \* \* \* 1st change \* \* \* \*

## 6.x Solution #x: Congestion control enhancement to support AL-FEC awareness handling

### 6.x.1 Key Issue mapping

This maps to Key Issue #4.

### 6.x.2 Description

### 6.x.2.1 Background of using AL-FEC for real-time communication in cellular networks

There are inherent losses in the over-the-air transmission in cellular networks. To recover from the losses, retransmission in PDCP, RLC and MAC may be used. However, the low-latency requirements for XR applications put constraints on the use of PDCP and RLC layer retransmissions.

If retransmission is needed, MAC layer HARQ retransmssion is preferred. However, RAN implementations typically have an instaneous BLER (iBLER) of 10% for high spectral efficiency. That requires a large number of HARQ retransmissions, resulting in large delays. If AL-FEC is used, the need for HARQ retransmission is greatly reduced. This is illustrated in the simulation study below.

**Scenario:** TDD with subframe format DDDSU, 30kHz SCS, HARQ turnaround time about 5ms, 100MHz bandwidth, 60fps, video frame size following a truncated Gaussian (STD, Max, Min) distribution: (10.5%, 150%, 50%) of average frame size, the average frame size 0.5Mbits, the average SNR 5dB, iBLER 10% and the subsequent BLERs for HARQ retransmissions following a BLER correlation model on the successes/failures of the HARQ transmissions based on field data (which gives the probability that the current TB is successfully transmitted in the *n*th attempt conditioned on that the previous TB is successfully transmitted in the *m*th attempt, where *n*=1, …, 5, *m*=1,…5), RLC acknowledged mode (AM) (t-reassembly 25ms, t-StatusProhibit 10ms), and MDS AL-FEC code each time applied to the PDUs of a single video frame. RLC AM is used to handle the 0.22% residual BLER resulting from the BLER correlation model given that we evaluate 99.9 percentile latency (otherwise with RLC UM, 0.22% of the PDUs will never be delivered successfully and the 99.9 percentile latency for the “No AL-FEC case” will be infinity).

Table 5.3-1 Delay without and with AL-FEC

|  |  |  |  |
| --- | --- | --- | --- |
| **Scheme** | **Redundancy ratio** | **Latency (ms)** | |
| **99.9 percentile** | **99 percentile** |
| No AL-FEC | 0 | 55 | 43.5 |
| With AL-FEC | 30% | 15 | 14 |

We see from the table that AL-FEC reduces the 99-percentile delay from 43.5ms to 14 ms and reduces the 99.9-percentile delay from 55ms to 15ms.

**Observation 1:** AL-FEC can reduce the delay for practical RAN implementations.

### 6.x.2.2 Potential Benefits of Application-layer FEC awareness for PDU Set handling

When the RTP source adds redundant PDUs for an ADU, the redundancy is over budgeted to account for error in the estimation of the packet loss rate in the network. That is, there are more packets than needed for reconstructing the ADU. At the last hop of the PDU Set delivery, if the base station is aware of AL-FEC, it can drop PDUs that are no longer needed for rescontructing the ADU. This has two benefits:

* Reducing the usage of resources and hence improving the spectral efficiency (the amount of resources per PDU Set)
* Lowering the power consumption of the UE because the network can let the UE go to the sleep mode earlier.

This AL-FEC aware PDU Set handling is illustrated in the Figure 6.x-1. Packets 0 and 1 are served in the first time slot (which is a ‘D’ slot), and packets 2 and 3 in the second slot, and so on. In Case-1, without AL-FEC awareness, the redundant packets are still transmitted, which wastes network resources and keeps the UE awake longer before the network lets the UE go to the sleep mode. In contrast, in Case-2, with AL-FEC awareness, the use of network resources becomes more efficient, and the UE goes to the sleep mode earlier.

For ease of exposition, we assume that the number of source packets is 20 in Figure 6.x-1.

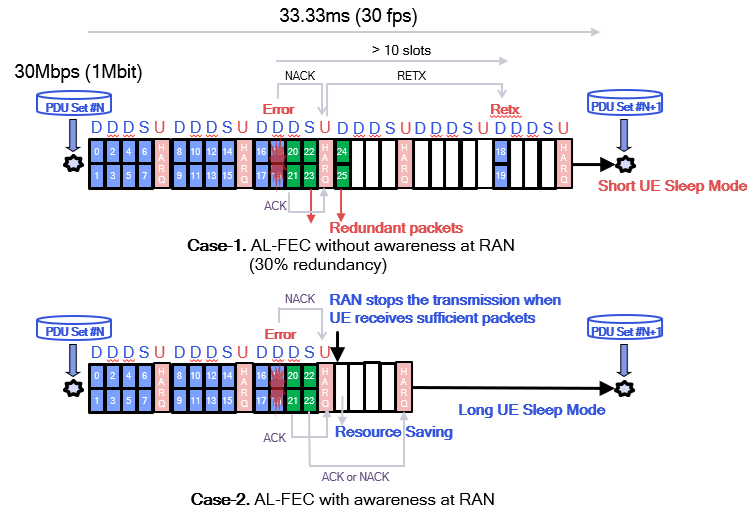


Figure 6.x-1 Potential Benefits of AL-FEC awareness at RAN

A Simulation study was carried out for the following scenario to quantify the benefits:

The video frame size being fixed at 1Mbits, TDD with slot pattern DDDSU, 30kHz SCS, HARQ retransmission (initial transmission and up to 2 retransmissions), 100MHz bandwidth, iBLER = 10%, the BLER after the 2nd HARQ transmission being 5%, the BLER after the 3rd HARQ transmission being 1%, the minimum value for the PDSCH to HARQ feedback timing indicator (i.e., K1) being 2 time slots (allowing the NACK for packets 18 and 19 and the ACK for packets 20 and 21 to be multiplexed in the same U slot in Figure 6.x-1), the power saving feature being Rel-18 eCDRX + PDCCH skipping,

30fps, MDS AL-FEC code each time applied to the PDUs of a single video frame, redundancy ratio 30% (FEC code rate = 22%). The power consumption values are presented by relative power as defined in TS 38.840, and it accounts for the power consumed by the modem for both uplink and downlink.

Table 6.x-1 Potential Benefits of AL-FEC aware PDU Set handling at RAN

|  |  |  |  |
| --- | --- | --- | --- |
|  | 99-Percentile Latency  (ms) | Power Consumption | Network loading |
| Case 1 – without AL-FEC awareness at RAN | 27 | 312 | 91.08% |
| Case 2 – with AL-FEC awareness at RAN | 27  (0%) | 270  (-13%) | 74.03%  (-19%) |

We see from the table that AL-FEC aware handling reduces power consumption of the UE by 13%, which is significant for the UE. It also reduces the network loading by 19%, and this allows the network to accommodate more users.

**Observation 2:** AL-FEC aware PDU Set handling can potentially reduce the UE power consumption and network loading.

To perform intentional discard, the NG-RAN needs to retain state variables (e.g., how many PDUs have been delivered successfully for each PDU Set). The associated complexity may be acceptable given that a base station typically serves a much smaller number of UEs than the UEs served by a UPF.

### 6.x.2.3 Implications of Application-layer FEC awareness for PDU Set handling on congestion control

Many congestion control algorithms, such as Google congestion control algorithms [28], NADA [29] and SCReAMv2 [30], use packet losses as a signal of network congestion. Therefore, it is important for the congestion control algorithms to correctly interpret packet losses in the case of AL-FEC awareness handling of the PDU Set.

### 6.x.2.4 The Proposed Solution

### 6.x.2.4.1 Case 1: In congestion

When there is congestion, as long as the AL-FEC awareness handling of the PDU Set does not alter the packet loss statistics, there is no impact on congestion control. Examples are given below.

**Example 1:** the network can discard repair packets rather than source packets in the case of FlexFEC without changing the overall packet loss rate, which will not lead to over reduction of the sending rate.

**Example 2:** the network can discard redundant packets across different PDU Sets while still meeting the required redundancy ratios for reconstructing the respective ADUs.

### 6.x.2.4.2 Case 2: Not in congestion

When there is no congestion, the network can discard obsolete packets (by obsolete, it means that the packets are no longer needed for reconstructing the ADU at the receiver), which will increase the packet loss rate observed by the RTP sender, and to avoid the RTP sender mis-interprets the packet losses as signals of congestion, the network can indicate to the RTP sender that there is no network congestion and such packet losses should not be taken into account by the congestion control algorithm for determining the sending rate.

FFS: how the network provides feedback to the application on obsolete packets dropped in the network.

NOTE: Although congestion control is currently not in the scope of TS 26.522, it could be studied in TR 26.822.

**Conclusion:** The behavior of the application at the sender may be impacted because congestion control that may be triggered by RAN discard needs to be handled differently than in current implementations (i.e., not see RAN intentional discard as an indication of congestion).

\* \* \* \* End of 1st change \* \* \* \*