**SA WG2 Meeting #161 S2-240xxxx**

**Febuary 26 – March 1, 2024, Athens, Greece (Rev of S2-2402396, 2536, 2034, 2387, 2979, 2020)**

**Source: InterDigital Inc., vivo, Meta USA, OPPO, Lenovo, Samsung**

**Title: KI#1, New Solution: PDU Set based QoS handling based on FEC Assistance Information**

**Document for: Approval**

**Agenda Item: 19.3**

**Work Item / Release: FS\_XRM\_Ph2/ Rel-19**

*Abstract of the contribution:* *This paper proposes a new solution for Key Issue #1. The solution how the network can detect if certain packets correspond to source/data packets or repair/redundancy packets.*

1. Discussion

Key Issue #1 is described as follows:

This key issue will study PDU set based QoS handling enhancements considering both control plane and user plane perspectives. In particular, this KI will address:

- whether, what and how PDU Set based handling (e.g. new standardized 5QI, enhancements to Alternative QoS profiles, FEC, etc.) and PDU Set information (including Control Plane and/or User plane information) provided by the AF/AS are enhanced.

NOTE: This will require close coordination with SA WG4 and RAN WGs.

This solution proposes that UPF is configured to detect that certain traffic uses Flex-FEC or discard ratio from the AS and determine whether certain packets correspond to source/data packets or repair/redundancy packets. The UPF then sends such FEC related information to the RAN in the GTP-U header of the downlink packets. RAN can use this information when making packet discarding decisions. For example, when packet discarding needs to take place due to congestion, it may be preferable to discard repair packets instead of source packets.

2. Proposals

It is proposed to adopt the following text in TR.23.700-70 v0.3.0.

\*\*\* First Change \*\*\*

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Solutions | Key Issue # | | | | | | | | |
|  | <KI #1> | <KI#2> | <KI#3> | <KI#4> | <KI#5> | <KI#6> | <KI#7> | <KI#8> | <KI#9> |
| #1: PDU Set content ratio awareness at RAN | x |  |  |  |  |  |  |  |  |
| #2: Discarding of redundant PDUs (FEC) and reporting | x |  |  |  |  |  |  |  |  |
| #3: FEC mechanism and PSI based PDU Set QoS Handling Enhancement | x |  |  |  |  |  |  |  |  |
| #4: PDU Set FEC-based PDU Set QoS Handling | x |  |  |  |  |  |  |  |  |
| #5: PDU Set Handling and Information marking …for PSDB/PSER/PSIHI | x |  |  |  |  |  |  |  |  |
| #6: Enhanced Alternative QoS Profiles for PDU set based QoS handling | x |  |  |  |  |  |  |  |  |
| #7: Enhancing alternative QoS profile …PDU set QoS parameters | x |  |  |  |  |  |  |  |  |
| #8: Consistent PDU Set Handling between AF and 5GS | x |  |  | x |  |  |  |  |  |
| #9: PDU Set information identification for encrypted traffic |  | x |  | x |  |  |  |  |  |
| #10: PDU Set information identification based on MoQ |  | x |  |  |  |  |  |  |  |
| #11: RTP over QUIC based Encrypted Traffic …QoS flows mapping |  | x |  |  |  |  |  |  |  |
| #12: Obfuscated Metadata to Classify Payload in Encrypted Media Packets |  | x |  | x | x |  |  |  |  |
| #13: Multiple DSCP markings per QoS Flow |  |  | x |  |  |  |  |  |  |
| #14: Extending Packet Filter … within a single transport connection |  |  |  | x |  |  |  |  |  |
| #15: Traffic Detection and QoS mapping for XR and Media services |  |  |  | x |  |  |  |  |  |
| #16: AS based trigger of data boost handling with reflective QoS |  |  |  |  | x |  |  |  |  |
| #17: L4S in non-3GPP access networks |  |  |  |  |  | x |  |  |  |
| #18: PDU Set handling in wireline/wireless non-3GPP access |  |  |  |  |  |  | x |  |  |
| #X: Enhancing PDU Set QoS Handling with Dynamic FEC Related Information Marking in GTP-U | x |  |  |  |  |  |  |  |  |

\*\*\* Next Change (All New Text) \*\*\*

## 6.X Solution #X: Enhancing PDU Set QoS Handling with Dynamic FEC Related Information Marking in GTP-U

### 6.X.1 Key Issue mapping

This solution addresses Key Issue #1, "Support of PDU set based QoS handling enhancement".

### 6.X.2 Description

The XRM traffic may undergo Forward Error Correction, where source data packets are used to generate additional data, called repair packets. Repair packets are generated according to the FEC scheme and transmitted with the source data packets. The repair packets help in the detection and correction of errors in the data stream. As explained in RFC 8627 [32], if the receiver successfully receives all the source packets, then the repair packets are not needed by the receiver. However, if the receiver does not successfully receive some of the source packets, then the receiver can use the repair packets to recover the information that was contained in the source packets that were not successfully received.

In some configurations, source and repair packets may be sent via different IP Port Numbers. In other configurations, source and repair packets may be sent via the same IP Port Numbers but different RTP streams.

* For example, Flex FEC, defined in RFC 8627 [32], is widely used where a number of FEC repair packets are generated from a set of source packets from one or more source RTP streams. These FEC repair packets are sent in a redundancy RTP stream separate from the source RTP stream(s) that carries the source packets. This (i.e. source packets and repair packets are transmitted in two RTP streams) actually provides a backward compatibility for the receivers that do not support Flex FEC. According to RFC 7656 [x], a redundancy RTP stream is an RTP stream that contains no original source data and only redundant data. Furthermore, as explained in reference [y], "although some FEC codes allow for static redundancy ratio, the K/N ratio is not always static during a media delivery session. For example, Video usually relies on Flex-FEC configurations. In such a case, the application is expected to update the 5GS with any configuration change".

The repair packets for each PDU Set may be dynamic due to the network conditions and the relative importance for real-time communication as shown following text from [32].

*- It is RECOMMENDED that the amount and type (row, column, or both) of FEC protection is adjusted dynamically based on the packet loss rate and burst loss length observed by the applications.*

*- This would enable differential protection, i.e., application of FEC selectively to packets that require a higher level of reliability than the other packets in the source stream.*

The principles of this solution are:

* The AF may provide the following information with Flow Descriptors:
  + Option1: The Assistance Information that indicates whether traffic that matches the Flow Descriptor (e.g. SSRC) is a source or a repair packet and optionally indicate the information can be used to detect what source packet a repair packet is associated with.
  + Option2: The protocol description which indicates that the RTP protocol can provide discard ratio and discard ratio marking request.

NOTE 1: The discard ratio can by replaced by e.g. the ratio for PDUs of a PDU Set are needed for the usage of the PDU Set. Which ratio is used can be decided at the conclusion phase.

* The PCF may authorize and send the above Assistance Information to the SMF in PCC Rules.
* The SMF may
  + Option1: indicate in the Packet Detection Rules (PDR) that it sends to the UPF whether traffic that matches PDR is a source or a repair packet and request to mark the repair packet and the information for the source packet a repair packet is associated with.
  + Option2: send the Protocol Description and discard ratio marking request indication to the PSA UPF.
* The UPF
  + Mark the following information in the GTP-U header in DL based on N4 rules and the protocol header of DL packet received from N6:
    - Repair packet and optionally information for the source packet the repair packet is associated with.
    - a discard ratio.
* The AS may include a discard ratio in the RTP header extension.

NOTE 2: Including a discard ratio into the RTP header extension requires coordination with SA WG4.

* The RAN may use the information in GTP-U header from the UPF, e.g. to make packet discarding decisions in case of QoS flow congestion.

### 6.X.3 Procedures

Figure 6.x.1-1: Setting up with FEC Assistance Information

1. The AF invokes Nnef\_AFsessionWithQoS\_Create to the NEF. The message includes Flow description(s).

For each flow description, the AF may provide Assistance Information that

- indicates whether traffic that matches the Flow Descriptor (e.g. SSRC of source packets and the SSRC of repair packets) is a source or a repair packet and optionally indicate what information can be used detect what source packet a repair packet is associated with.

- alternatively, includes the protocol description which indicates that the RTP protocol can provide discard ratio and discard ratio marking request.

NOTE 1: The discard ratio can by replaced by e.g. the ratio for PDUs of a PDU Set are needed for the usage of the PDU Set. Which ratio is used can be decided at the conclusion phase.

1. The NEF authorizes the request from the AF.
2. The NEF sends the flow description and the Assistance Information (from step 1) to the PCF.
3. The PCF responds to the NEF.
4. The NEF responds to the AF.
5. The SMF Receives PCC Rules from the PCF. The PCC Rules include FEC Assistance Information.
6. The SMF responds to the PCF.
7. The SMF sends N4 Rules to the UPF.

The PDRs of the N4 Rules can indicate whether traffic that matches the PDR is source or repair packets and requests to mark the repair packet and information for the source packet the repair packet is associated with. For example, the PDR can indicate the SSRC of source packets and the SSRC of repair packets.

Alternatively, the N4 Rules include discard ratio marking request indication.

1. The PSA UPF responds to the SMF.
2. The PSA UPF receives downlink data and uses the N4 Rules to detect whether the packet it is a source or repair packet and extract information from the FEC header to associate repair packets with source packets. The PSA UPF marks the above information in the GTP header in step 11.

Alternatively, if the AS includes a discard ratio in the PDU Set Information Header in the RTP header, the PSA UPF marks the discard ratio for the PDU Set in the GTP-U header based on N4 rules in step 11.

1. The PSA UPF sends downlink data to the RAN.

- The PSA UPF includes an FEC source or FEC repair indication in the GTP-U header. When the packet is a repair packet, the PSA UPF also include information in the GTP-U header for the source packet the repair packet is associated with (e.g. information from the FEC header such as the Sequence Number (SN), the L/D offset, mask, etc.).

- Alternatively, the PSA UPF may include a discard ratio for PDU Set in the GTP-U header based on information that was detected in the RTP header extension.

The PSA UPF sends the traffic to the RAN. The RAN may use this information when making packet discarding decisions in the QoS Flow in case of congestion happens for the QoS flow.

NOTE 2: This solution requires coordination with SA WG4 and RAN WGs.

### 6.X.4 Impacts on services, entities and interfaces

- AF:

- Provides Assistance Information to the NEF (or to the PCF directly).

- NEF:

- Receives Assistance Information from the AF.

- Provides Assistance Information to the PCF.

- PCF:

- Receives Assistance Information from the NEF (or directly from the AF).

- Creates PCC Rules that indicate include the Assistance Information.

- SMF:

- Creates N4 Rules that indicate

- Option1: whether traffic that matches a PDR is source or repair packet and requests to mark repair packet and information for the source packet the repair packet is associated with.

- Option2: discard ratio marking request indication.

- AS (for option2):

- Includes a discard ratio in the RTP header extension.

- UPF:

- Receives N4 Rules that indicate

- Option1: whether traffic that matches a PDR is source or repair packet and requests to mark the repair packet and information for the source packet the repair packet is associated with.

- Option2: discard ratio marking request indication.

- Includes the following information in the GTP-U header based on received N4 rules:

- Option1: an FEC source or FEC repair indication in the GTP-U header and information for the source packet a repair packet is associated with.

- Option2: a discard ratio in the GTP-U header.

- RAN:

- may use the information in GTP-U header from the UPF, e.g. to make packet discarding decisions in the QoS Flow in case of congestion happens for the QoS flow.

- UE:

- No impact.

\*\*\* Next Change \*\*\*

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.501: "System Architecture for the 5G System (5GS); Stage 2".

[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4] 3GPP TS 23.503: "Policies and Charging control framework for the 5G System; Stage 2".

[5] IETF RFC 3711: "The Secure Real-time Transport Protocol (SRTP)", March 2004.

[6] IETF RFC 6904: "Encryption of Header Extensions in the Secure Real-time Transport Protocol (SRTP)".

[7] IETF RFC 9335: "Completely Encrypting RTP Header Extensions and Contributing Sources".

[8] IETF draft-ietf-avtcore-rtp-over-quic: "RTP over QUIC (RoQ)".

[9] IETF draft-ietf-moq-transport: "Media over QUIC Transport".

[10] IETF experimental draft-ietf-avtext-framemarking: "Frame Marking RTP Header Extension".

[11] IETF RFC 9000: "QUIC: A UDP-Based Multiplexed and Secure Transport".

[12] TR 26.926 v18.1.0: "Traffic Models and Quality Evaluation Methods for Media and XR Services in 5G Systems".

[13] TR 26.925 v18.1.0: "Typical traffic characteristics of media services on 3GPP networks".

[14] IETF RFC 9330: "Low Latency, Low Loss, and Scalable Throughput (L4S) Internet Service: Architecture.

[15] IETF RFC 9331: "The Explicit Congestion Notification (ECN) Protocol for Low Latency, Low Loss, and Scalable Throughput (L4S)".

[16] IETF draft-ietf-tsvwg-ecn-encap-guidelines-22: "Guidelines for Adding Congestion Notification to Protocols that Encapsulate IP".

[17] 3GPP TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".

[18] CableLabs DOCSIS MULPI: "Data-Over-Cable Service Interface Specifications DOCSIS 3.1, MAC and Upper Layer Protocols Interface Specification".

[19] IETF RFC 9332: " Dual-Queue Coupled Active Queue Management (AQM) for Low Latency, Low Loss, and Scalable Throughput (L4S)".

[20] 3GPP TS 26.522: "5G Real-time Media Transport Protocol Configurations".

[21] IETF [draft-ietf-tsvwg-udp-options:](https://datatracker.ietf.org/doc/draft-ietf-tsvwg-udp-options/) "Transport options for UDP".

[22] IETF RFC 6363: "Forward Error Correction (FEC) Framework".

[23] IETF RFC 6364: "Session Description Protocol Elements for the Forward Error Correction (FEC) Framework".

[24] IETF RFC 6681: "Raptor Forward Error Correction (FEC) Schemes for FECFRAME".

[25] IETF RFC 6682: "RTP Payload Format for Raptor Forward Error Correction (FEC) ".

[26] IETF RFC 6695: "Methods to Convey Forward Error Correction (FEC) Framework Configuration Information".

[27] IETF RFC 6816: "Simple Low-Density Parity Check (LDPC) Staircase Forward Error Correction (FEC) Scheme for FECFRAME".

[28] IETF RFC 6865: "Simple Reed-Solomon Forward Error Correction (FEC) Scheme for FECFRAME".

[29] IETF RFC 8680: "Forward Error Correction (FEC) Framework Extension to Sliding Window Codes".

[30] IETF RFC 8681: "Sliding Window Random Linear Code (RLC) Forward Erasure Correction (FEC) Schemes for FECFRAME".

[31] 3GPP TS 38.300: "NR; NR and NG-RAN Overall description; Stage-2".

[32] IETF RFC 8627: "RTP Payload Format for Flexible Forward Error Correction (FEC)".

[x] IETF RFC 7656: "A Taxonomy of Semantics and Mechanisms for Real-Time Transport Protocol (RTP) Sources".

[y] S2-2210181: "Reply LS on further details on XR traffic".

Editor's note: References [8], [9] and [10] cannot be formally referenced until published as RFC.

\*\*\* Next Changes \*\*\*

Annex How does source packet associates repair packet in Flex FEC

The FEC header of the repair packet contains three formats according to R and F in the FEC header. Hence association of source packet and the corresponding repair packet can be done via (1) flexible bitmasks or (2) fixed L and D offsets, based on the format of FEC header of the repair packet. (The FEC header for retransmission is not needed for associating source packet and its corresponding repair packet)

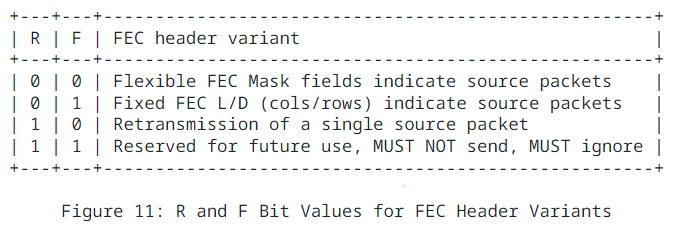


Figure 1: FEC repair packet header format

For **(1) Using Bitmasks**: it is for the case when R=0 and F=0.

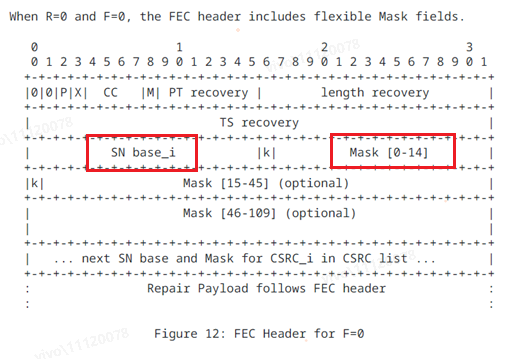


Figure 2: FEC repair packet header format when using bitmask to associate repair packets and source packets

The association mechanism are:

The header of repair packet carries a base of SN (i.e. *SN base\_i*) of the source packet. The source packet is associated with the help of *Mask* parameter. The *Mask* can be a length of 15, 46, or 110. Take *Mask* = 15 for example:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Mask =15 | 1 | 2 | 3 | 4 | … | 14 | 15 |
| Bit value | 0 | 1 | 0 | 1 | … | 1 | 1 |

The above means that, the SN from *SN base\_i* to *SN base\_i*+15 is source packet if and only if the corresponding bit value of the *Mask* is set to 1, e.g. SN+1, SN+3,…, SN+13, SN+14 is the source packet that protected by the repair packets.

For **(2) using L and D offsets**: it is for the case when R=0 and F=1.

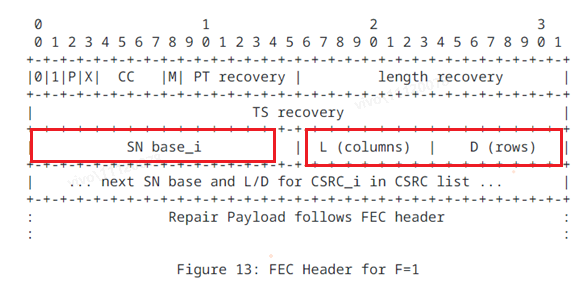


Figure 3: FEC repair packet header format when using L/D offset to associate repair packets and source packets

The association mechanism are:

The header of repair packet carries a base of SN (i.e. *SN base\_i*) of the source packet. The source packet is associated with the help of *L* and *D* parameter:

|  |
| --- |
| **RFC 8627**  *For each SSRC (in CSRC list):*  *When D <= 1: Source packets for each row: SN, SN+1, ..., SN+(L-1)*  *When D > 1: Source packets for each col: SN, SN+L, ..., SN+(D-1)\*L* |

**Observation: The association of source packets and the corresponding repair packets can be done via (1) flexible bitmasks or (2) L and D offsets, based on the format of FEC header of the repair packet.**

\*\*\* End of Changes \*\*\*