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RTP Payload Format for Raptor Forward Error Correction (FEC)

Abstract

This document specifies an RTP payload format for the Forward Error Correction (FEC) repair data produced by the Raptor FEC Schemes. Raptor FEC Schemes are specified for use with the IETF FEC Framework that supports the transport of repair data over both UDP and RTP. This document specifies the payload format that is required for the use of RTP to carry Raptor repair flows.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc6682.

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1. Introduction

The FEC Framework [RFC6363] defines a general framework for the use of Forward Error Correction in association with arbitrary packet flows, including flows over UDP and RTP [RFC3550]. Forward Error Correction operates by generating redundant data packets ("repair data") that can be sent independently from the original flow. At a receiver, the original flow can be reconstructed provided a sufficient set of redundant data packets and possibly original data packets are received.

The FEC Framework provides for independence between application protocols and FEC codes. The use of a particular FEC code within the framework is defined by means of a FEC Scheme, which may then be used with any application protocol compliant to the framework.

Repair data flows may be sent directly over a transport protocol, such as UDP, or they may be encapsulated within specialized transports for multimedia, such as RTP.

This document defines the RTP payload format for the Raptor FEC Schemes defined in [RFC6681].

2. Conventions, Definitions, and Acronyms

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Media Format Background

The Raptor and RaptorQ codes are efficient block-based fountain codes, meaning that from any group of source packets (or 'source block'), one can generate an arbitrary number of repair packets. The Raptor and RaptorQ codes have the property that the original group of source symbols can be recovered with a very high probability from any set of symbols (source and repair) only slightly greater in number than the original number of source symbols. The RaptorQ code additionally has the property that the probability that the original group of source symbols can be recovered from a set of symbols (source and repair) equal in number to the original number of source symbols is in many cases also very high.

[RFC6681] defines six FEC Schemes for the use of the Raptor and RaptorQ codes with arbitrary packet flows. The first two schemes are fully applicable to arbitrary packet flows (using Raptor and RaptorQ respectively). The third and fourth schemes are slightly optimized versions of the first two schemes, which are applicable in

applications with relatively small block sizes. The fifth and sixth schemes are variants of the third and fourth schemes, which are applicable to a single source flow that already has some kind of identifiable sequence number. The presence of a sequence number in the source flow allows for backwards-compatible operation (the source flows do not need to be modified in order to apply FEC). In this case, in the language of the FEC Framework, there is no need for an explicit FEC Source Payload ID; therefore, it is not included in the packets.

This document specifies the payload format for RTP repair flows and can be used with any of the FEC Schemes defined in [RFC6681].

4. Payload Format for FEC Repair Packets

4.1. RTP Header Usage

Header fields SHALL be set according to the rules of [RFC3550]. In addition, the following rules and definitions apply for the RTP headers used with FEC repair packets:

- Marker bit: The marker bit SHALL be set to 1 for the last protection RTP packet sent for each source block, and otherwise set to 0.

- Payload Type (PT): The payload type codes SHALL be assigned dynamically through non-RTP means. If the Session Description Protocol (SDP) is used for signaling, the rules in Section 7 apply.

- Timestamp: This field contains the time at which the packet is transmitted. The time SHOULD be as close as possible to the packet's actual time of transmission. The timestamp value has no use in the actual FEC protection process. However, implementations SHOULD supply a value that can be used for packet-arrival timing or jitter calculations. The timestamp rate is specified using the "rate" media type parameter defined in Section 6. The operator SHALL select a "rate" larger than 1000 Hz to provide sufficient resolution to the Real-Time Transport Control Protocol (RTCP) operations, and the operator SHOULD select the rate that matches the rate of the protected source RTP stream.

- Synchronization Source (SSRC): The SSRC values MUST be set according to [RFC3550]. The SSRC value of the RTP repair flow MUST be different from the SSRC value of the protected source flow.

4.2. Payload Header

There is no payload header in this payload format.

4.3. Payload Data

Procedures and data formats for the use of Raptor Forward Error Correction in a FECFRAME context are fully defined in [RFC6363] and [RFC6681] and are not duplicated here. The procedures of those documents apply in order to generate repair data streams to be carried by the payload formats defined in this document.

The RTP Payload SHALL contain a Repair FEC Payload ID as defined in [RFC6363] and [RFC6681].

5. Congestion Control Considerations

See [RFC6363].

6. Media Types

6.1. Registration of the 'application/raptorfec' Media Type

This RTP payload format is identified using the 'application/raptorfec' media type that is registered in accordance with [RFC4855] and uses the template of [RFC4288].

6.1.1. Media Type Definition

Type name: application

Subtype name: raptorfec

Required parameters:

- rate: The RTP timestamp (clock) rate. The RTP timestamp (clock) rate is specified in Hz and the format is unsigned integer.

- raptor-scheme-id: The value of this parameter is the FEC Scheme ID for the specific Raptor FEC Scheme that will be used as defined in [RFC6681].

- Kmax: The value of this parameter is the FEC Framework Configuration Information element, Maximum Source Block Length (MSBL), as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- T: The value of this parameter is the FEC Framework Configuration Information element, encoding symbol size, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- repair-window: The maximum time that spans the source packets and the corresponding repair packets. The size of the repair window is specified in microseconds and the format is unsigned integer.

Optional parameters:

- P: The value of this parameter is the FEC Framework Configuration Information element, Payload ID Format, as defined in [RFC6681]. The default value of this parameter (when it does not appear explicitly) is 'A'.

Encoding considerations: This media type is framed and binary; see Section 4.8 in [RFC4288]

Security considerations: Please see the security considerations in [RFC6363].

Interoperability considerations:

Published specification: [RFC6681]

Applications that use this media type: Real-time multimedia applications like video streaming, audio streaming, and video conferencing.

Additional information:

Magic number(s): <none defined>

File extension(s): <none defined>

Macintosh file type code(s): <none defined>

Person & email address to contact for further information:
Thomas Stockhammer, stockhammer@nomor.de

Intended usage: COMMON

Restrictions on usage: This media type depends on RTP framing, and hence is only defined for transfer via RTP [RFC3550]. Transport within other framing protocols is not defined at this time.

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Change controller: IETF PAYLOAD working group delegated from the IESG.

6.2. Registration of the 'video/raptorfec' Media Type

This RTP payload format is identified using the 'video/raptorfec' media type that is registered in accordance with [RFC4855] and uses the template of [RFC4288].

6.2.1. Media Type Definition

Type name: video

Subtype name: raptorfec

Required parameters:

- rate: The RTP timestamp (clock) rate. The RTP timestamp (clock) rate is specified in Hz and the format is unsigned integer.
- raptor-scheme-id: The value of this parameter is the FEC Scheme ID for the specific Raptor FEC Scheme that will be used as defined in [RFC6681].
- Kmax: The value of this parameter is the FEC Framework Configuration Information element, MSBL, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].
- T: The value of this parameter is the FEC Framework Configuration Information element, encoding symbol size, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].
- repair-window: The maximum time that spans the source packets and the corresponding repair packets. The size of the repair window is specified in microseconds, and the format is unsigned integer.

Optional parameters:

- P: The value of this parameter is the FEC Framework Configuration Information element, Payload ID Format, as defined in [RFC6681]. The default value of this parameter (when it does not appear explicitly) is 'A'.

Encoding considerations: This media type is framed and binary; see Section 4.8 in [RFC4288].

Security considerations: Please see the security considerations in [RFC6363].

Interoperability considerations:

Published specification: [RFC6681]

Applications that use this media type: Real-time multimedia applications like video streaming, audio streaming, and video conferencing.

Additional information:

Magic number(s): <none defined>

File extension(s): <none defined>

Macintosh file type code(s): <none defined>

Person & email address to contact for further information: Thomas Stockhammer, stockhammer@nomor.de

Intended usage: COMMON

Restrictions on usage: This media type depends on RTP framing, and hence is only defined for transfer via RTP [RFC3550]. Transport within other framing protocols is not defined at this time.

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Change controller: IETF PAYLOAD working group delegated from the IESG.

6.3. Registration of the 'audio/raptorfec' Media Type

This RTP payload format is identified using the 'audio/raptorfec' media type that is registered in accordance with [RFC4855] and uses the template of [RFC4288].

6.3.1. Media Type Definition

Type name: audio

Subtype name: raptorfec

Required parameters:

- rate: The RTP timestamp (clock) rate. The RTP timestamp (clock) rate is specified in Hz and the format is unsigned integer.

- raptor-scheme-id: The value of this parameter is the FEC Scheme ID for the specific Raptor FEC Scheme that will be used as defined in [RFC6681].

- Kmax: The value of this parameter is the FEC Framework Configuration Information element, MSBL, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- T: The value of this parameter is the FEC Framework Configuration Information element, encoding symbol size, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- repair-window: The maximum time that spans the source packets and the corresponding repair packets. The size of the repair window is specified in microseconds and the format is unsigned integer.

Optional parameters:

- P: The value of this parameter is the FEC Framework Configuration Information element, Payload ID Format, as defined in [RFC6681]. The default value of this parameter (when it does not appear explicitly) is 'A'.

Encoding considerations: This media type is framed and binary; see Section 4.8 in [RFC4288].

Security considerations: Please see the security considerations in [RFC6363].

Interoperability considerations:

Published specification: [RFC6681]

Applications that use this media type: Real-time multimedia applications like video streaming, audio streaming, and video conferencing.

Additional information:

Magic number(s): <none defined>

File extension(s): <none defined>

Macintosh file type code(s): <none defined>

Person & email address to contact for further information:
Thomas Stockhammer, stockhammer@nomor.de

Intended usage: COMMON

Restrictions on usage: This media type depends on RTP framing, and hence is only defined for transfer via RTP [RFC3550]. Transport within other framing protocols is not defined at this time.

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Change controller: IETF PAYLOAD working group delegated from the IESG.

6.4. Registration of the 'text/raptorfec' Media Type

This RTP payload format is identified using the 'text/raptorfec' media type that is registered in accordance with [RFC4855] and uses the template of [RFC4288].

6.4.1. Media Type Definition

Type name: text

Subtype name: raptorfec

Required parameters:

- rate: The RTP timestamp (clock) rate. The RTP timestamp (clock) rate is specified in Hz and the format is unsigned integer.

- raptor-scheme-id: The value of this parameter is the FEC Scheme ID for the specific Raptor FEC Scheme that will be used as defined in [RFC6681].

- Kmax: The value of this parameter is the FEC Framework Configuration Information element, MSBL, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- T: The value of this parameter is the FEC Framework Configuration Information element, encoding symbol size, as defined in [RFC6681], encoded as a unsigned integer. For specific requirements for this value, refer to [RFC6681].

- repair-window: The maximum time that spans the source packets and the corresponding repair packets. The size of the repair window is specified in microseconds and the format is unsigned integer.

Optional parameters:

- P: The value of this parameter is the FEC Framework Configuration Information element, Payload ID Format, as defined in [RFC6681]. The default value of this parameter (when it does not appear explicitly) is 'A'.

Encoding considerations: This media type is framed and binary; see Section 4.8 in [RFC4288].

Security considerations: Please see the security considerations in [RFC6363].

Interoperability considerations:

Published specification: [RFC6681]

Applications that use this media type: Real-time multimedia applications like video streaming, audio streaming, and video conferencing.

Additional information:

Magic number(s): <none defined>

File extension(s): <none defined>

Macintosh file type code(s): <none defined>

Person & email address to contact for further information:
Thomas Stockhammer, stockhammer@nomor.de

Intended usage: COMMON

Restrictions on usage: This media type depends on RTP framing, and hence is only defined for transfer via RTP [RFC3550]. Transport within other framing protocols is not defined at this time.

Author: Thomas Stockhammer, Nomor Research.

Change controller: IETF PAYLOAD working group delegated from the IESG.

7. Mapping to the Session Description Protocol (SDP)

Applications that are using RTP transport commonly use the Session Description Protocol (SDP) [RFC4566] to describe their RTP sessions. The information that is used to specify the media types in an RTP session has specific mappings to the fields in an SDP description. Note that if an application does not use SDP to describe the RTP sessions, an appropriate mapping must be defined and used to specify the media types and their parameters for the control/description protocol employed by the application.

The mapping of the above defined payload format media type and its parameters SHALL be done according to Section 3 of [RFC4855], following the suggestion therein regarding the mapping of payload-format-specific parameters into the "a=fmtp" field.

When the RTP payload formats defined in this document are used, the media type parameters defined above MUST use the media types in this document and MUST NOT use those specified in [RFC6364].

8. Offer/Answer Considerations

When offering Raptor FEC over RTP using SDP in an Offer/Answer model [RFC3264], the following considerations apply:

- Each combination of the Kmax and T parameters produces different FEC data and is not compatible with any other combination. A sender application MAY desire to provide multiple offers with different sets of Kmax and T values, which is possible as long as the parameter values are valid. The receiver SHOULD normally choose the offer with the largest value of the product of Kmax and T that it supports.

- The size of the repair window is related to the maximum delay between the transmission of a source packet and the associated repair packet. This directly impacts the buffering requirement on the receiver side and the receiver must consider this when choosing an offer.

- When the P parameter is not present, the receiver MUST use FEC Payload ID Format A. In an answer that selects an offer in which the P parameter was omitted, the P parameter MUST either be omitted, or included with value "A".

9. Declarative SDP Considerations

In declarative usage, like SDP in the Real-Time Streaming Protocol (RTSP) [RFC2326] or the Session Announcement Protocol (SAP) [RFC2974], the following considerations apply:

- The payload format configuration parameters are all declarative and a participant MUST use the configuration that is provided for the session.

- More than one configuration MAY be provided (if desired) by declaring multiple RTP payload types. In this case, the receivers should choose the repair session that is best for them.

10. Repair Flow Generation and Recovery Procedures

10.1. Overview

This document only specifies repair flow construction when the repair packets are delivered with RTP. Source packet construction is covered in [RFC6681]. This section provides an overview on how to generate a repair flow, including the repair packets and how to reconstruct missing source packets from a set of available source and repair packets. Detailed algorithms for the generation of Raptor and RaptorQ symbols are provided in [RFC5053] and [RFC6330], respectively.

As per the FEC Framework document [RFC6363], the FEC Framework Configuration Information includes, among others, the identification of the repair flow(s) and the source flow(s). Methods to convey FEC Framework Configuration Information are provided in [FEC-SIG]. Specifically, the reader is referred to the SDP elements document [RFC6364], which describes the usage of the 'SDP' encoding format as an example encoding format for FEC Framework Configuration Information.

For the generation of a repair flow:

- repair packets SHALL be constructed according to Section 10.2, and

- RTCP SHALL be used according to Section 10.3.

For the reconstruction of a source packet of a source RTP session at the receiver, based on the availability of a source RTP session and a repair RTP session, the procedures in Section 10.4 may be used.

10.2. Repair Packet Construction

The construction of the repair packet is fully specified in Section 4. A repair packet is constructed by the concatenation of

- an RTP header as specified in Section 4.1, and
- payload data as defined in Section 4.3.

Repair Packet Construction may make use of the Sender Operation for RTP repair flows as specified in see [RFC6363], Section 4.2.

10.3. Usage of RTCP

RTCP SHALL be used according to [RFC3550]. If the repair RTP session is sent in a separate RTP session, the two sessions MUST be associated using RTCP CNAME (Canonical Name).

10.4. Source Packet Reconstruction

Source Packet Reconstruction may make use of the receiver operation for the case of RTP repair flows as specified in [RFC6363], Section 4.3. Depending on the FEC Scheme using the ones defined in [RFC6681], the appropriate source blocks are formed. If enough data for decoding any or all of the missing source payloads in the source block has been received, the respective FEC decoding procedures are applied.

In case the FEC Scheme uses Raptor codes as defined in [RFC5053], then the Example FEC Decoder, as specified in [RFC5053], Section 5.5, may be used.

In case the FEC Scheme uses RaptorQ codes as defined in [RFC6330], then the Example FEC Decoder, as specified in [RFC6330], Section 5.4, may be used.

11. Session Description Protocol (SDP) Example

This section provides an SDP [RFC4566] example. Assume we have one source video stream (mid:S1) and one FEC repair stream (mid:R1). The 'group' attribute and the FEC grouping semantics defined in [RFC5888] and [RFC5956], respectively, are used to associate source and repair flows. We form one FEC group with the "a=group:FEC S1 R1" line. The source and repair streams are sent to the same port on different multicast groups. The repair window is set to 200 ms.

```
v=0
o=ali 1122334455 1122334466 IN IP4 fec.example.com
s=Raptor RTP FEC Example
t=0 0
a=group:FEC-FR S1 R1
m=video 30000 RTP/AVP 100
c=IN IP4 233.252.0.1/127
a=rtpmap:100 MP2T/90000
a=fec-source-flow: id=0
a=mid:S1
m=application 30000 RTP/AVP 110
c=IN IP4 233.252.0.2/127
a=rtpmap:110 raptorfec/90000
a=fmtp:110 raptor-scheme-id=1; Kmax=8192; T=128;
        P=A; repair-window=200000
a=mid:R1
```

12. IANA Considerations

IANA has registered 'application/raptorfec' as specified in Section 6.1.1, 'video/raptorfec' as specified in Section 6.2.1, 'audio/raptorfec' as specified in Section 6.3.1, and 'text/raptorfec' as specified in Section 6.4.1. The media type has also been added to the IANA registry for "RTP Payload Format media types" (http://www.iana.org/assignments/rtp-parameters).

13. Security Considerations

Security Considerations related to the use of the FEC Framework are addressed in [RFC6363]. These considerations apply in full to users of the RTP payload formats defined in this document, since these are defined in terms of the FEC Framework.

No further security considerations related specifically to the Raptor FEC Schemes defined in [RFC6681] have been identified.

RTP packets using the payload format defined in this specification are subject to the security considerations discussed in the RTP specification [RFC3550] and in any applicable RTP profile. The main security considerations for the RTP packet carrying the RTP payload format defined within this memo are confidentiality, integrity, and source authenticity. Confidentiality is achieved by encrypting the RTP payload. Integrity of the RTP packets is achieved through a suitable cryptographic integrity protection mechanism. Such a cryptographic system can also allow the authentication of the source of the payload. A suitable security mechanism for this RTP payload format should provide confidentiality, integrity protection, and at least source authentication capable of determining if an RTP packet

is from a member of the RTP session. Note that the appropriate mechanism to provide security to RTP and payloads following this memo MAY vary. It is dependent on the application, transport, and signaling protocol employed. Therefore, a single mechanism is not sufficient; although, if suitable, using the Secure Real-Time Transport Protocol (SRTP) [RFC3711] is RECOMMENDED. Other mechanisms that may be used are IPsec [RFC4301] and Transport Layer Security (TLS) [RFC5246] (RTP over TCP); other alternatives exist.

14. References

14.1. Normative References

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14.2. Informative References

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