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Frame Marking RTP Header Extension
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Abstract

This document describes a Frame Marking RTP header extension used to convey information about video frames that is critical for error recovery and packet forwarding in RTP middleboxes or network nodes. It is most useful when media is encrypted, and essential when the middlebox or node has no access to the media encryption keys. It is also useful for codec-agnostic processing of encrypted or unencrypted media, while it also supports extensions for codec-specific information.

Status of This Memo

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1. Introduction

Many widely deployed RTP [RFC3550] topologies used in modern voice and video conferencing systems include a centralized component that acts as an RTP switch. It receives voice and video streams from each participant, which may be encrypted using SRTP [RFC3711], or extensions that provide participants with private media via end-to-end encryption that excludes the switch. The goal is to provide a set of streams back to the participants which enable them to render the right media content. In a simple video configuration, for example, the goal will be that each participant sees and hears just the active speaker. In that case, the goal of the switch is to receive the voice and video streams from each participant, determine the active speaker based on energy in the voice packets, possibly using the client-to-mixer audio level RTP header extension, and select the corresponding video stream for transmission to participants; see Figure 1.

In this document, an "RTP switch" is used as a common short term for the terms "switching RTP mixer", "source projecting middlebox",

"source forwarding unit/middlebox" and "video switching MCU" as discussed in [RFC7667].

```
         +---+      +------------+      +---+
         | A |<---->|            |<---->| B |
         +---+      |            |      +---+
                    |    RTP     |
         +---+      |   Switch   |      +---+
         | C |<---->|            |<---->| D |
         +---+      +------------+      +---+
```

Figure 1: RTP switch

In order to properly support switching of video streams, the RTP switch typically needs some critical information about video frames in order to start and stop forwarding streams.

- o Because of inter-frame dependencies, it should ideally switch video streams at a point where the first frame from the new speaker can be decoded by recipients without prior frames, e.g switch on an intra-frame.
- o In many cases, the switch may need to drop frames in order to realize congestion control techniques, and needs to know which frames can be dropped with minimal impact to video quality.
- o Furthermore, it is highly desirable to do this in a way which is not specific to the video codec. Nearly all modern video codecs share common concepts around frame types.
- o It is also desirable to be able to do this for SRTP without requiring the video switch to decrypt the packets. SRTP will encrypt the RTP payload format contents and consequently this data is not usable for the switching function without decryption, which may not even be possible in the case of end-to-end encryption of private media.

A comprehensive discussion of SFU considerations around codec agnostic selective forwarding of RTP media is described in [I-D.aboba-avtcore-sfu-rtp].

By providing meta-information about the RTP streams outside the encrypted media payload an RTP switch can do selective forwarding without decrypting the payload. This document provides a solution to this problem.

2. Key Words for Normative Requirements

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. Frame Marking RTP Header Extension

The solution uses RTP header extensions as defined in [RFC5285]. A subset of meta-information from the video stream is provided as an RTP header extension to allow an RTP switch to do generic selective forwarding of video streams encoded with potentially different video codecs.

The Frame Marking RTP header extension is encoded using the one-byte header or two-byte header as described in [RFC5285]. The one-byte header format is used for examples in this memo. The two-byte header format is used when other two-byte header extensions are present in the same RTP packet, since mixing one-byte and two-byte extensions is not possible in the same RTP packet.

3.1. Extension for Non-Scalable Streams

The following RTP header extension is used for non-scalable streams. The ID is assigned per [RFC5285], and the length is encoded as L=0 which indicates 1 octet of data.

```
 0                   1
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=? |  L=0  |S|E|I|D|0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The following information are extracted from the media payload and sent in the Frame Marking RTP header extension.

- o S: Start of Frame (1 bit) - MUST be 1 in the first packet in a frame; otherwise MUST be 0.
- o E: End of Frame (1 bit) - MUST be 1 in the last packet in a frame; otherwise MUST be 0.
- o I: Independent Frame (1 bit) - MUST be 1 for frames that can be decoded independent of prior frames, e.g. intra-frame, VPX keyframe, H.264 IDR [RFC6184], H.265 IDR/CRA/BLA/RAP [RFC7798]; otherwise MUST be 0.

- o D: Discardable Frame (1 bit) - MUST be 1 for frames that can be discarded, and still provide a decodable media stream; otherwise MUST be 0.
- o The remaining (4 bits) - MUST be 0 for non-scalable streams.

3.2. Extension for Scalable Streams

The following RTP header extension is used for scalable streams. The ID is assigned per [RFC5285], and the length is encoded as L=2 which indicates 3 octets of data.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=? |  L=2  |S|E|I|D|B| TID |   LID         |    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The following information are extracted from the media payload and sent in the Frame Marking RTP header extension.

- o S: Start of Frame (1 bit) - MUST be 1 in the first packet in a frame within a layer; otherwise MUST be 0.
- o E: End of Frame (1 bit) - MUST be 1 in the last packet in a frame within a layer; otherwise MUST be 0.
- o I: Independent Frame (1 bit) - MUST be 1 for frames that can be decoded independent of prior frames, e.g. intra-frame, VPX keyframe, H.264 IDR [RFC6184], H.265 IDR/CRA/BLA/RAP [RFC7798]; otherwise MUST be 0.
- o D: Discardable Frame (1 bit) - MUST be 1 for frames that can be discarded, and still provide a decodable media stream; otherwise MUST be 0.
- o B: Base Layer Sync (1 bit) - MUST be 1 if this frame only depends on the base layer; otherwise MUST be 0. If no scalability is used, this MUST be 0.
- o TID: Temporal ID (3 bits) - The base temporal layer starts with 0, and increases with 1 for each higher temporal layer/sub-layer. If no scalability is used, this MUST be 0.
- o LID: Layer ID (8 bits) - Identifies the spatial and quality layer encoded. If no scalability is used, this MUST be 0 or omitted. When omitted, TL0PICIDX MUST also be omitted.
- o TL0PICIDX: Temporal Layer 0 Picture Index (8 bits) - Running index of base temporal layer 0 frames when TID is 0. When TID is not 0, this indicates a dependency on the given index. If no scalability is used, this MUST be 0 or omitted. When omitted, LID MUST also be omitted.

The layer information contained in TID and LID convey useful aspects of the layer structure that can be utilized in selective forwarding. Without further information about the layer structure, these identifiers can only be used for relative priority of layers. They convey a layer hierarchy with TID=0 and LID=0 identifying the base layer. Higher values of TID identify higher temporal layers with higher frame rates. Higher values of LID identify higher spatial and/or quality layers with higher resolutions and/or bitrates.

With further information, for example, possible future RTCP SDES items that convey full layer structure information, it may be possible to map these TIDs and LIDs to specific frame rates, resolutions and bitrates. Such additional layer information may be useful for forwarding decisions in the RTP switch, but is beyond the scope of this memo. The relative layer information is still useful for many selective forwarding decisions even without such additional layer information.

3.2.1. Layer ID Mappings for Scalable Streams

3.2.1.1. H265 LID Mapping

The following shows the H265 [RFC7798] LayerID (6 bits) mapped to the generic LID field.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=2 |  L=2  |S|E|I|D|B| TID |0|0|  LayerID  |    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3.2.1.2. VP9 LID Mapping

The following shows VP9 Layer encoding information (4 bits for spatial and quality) mapped to the generic LID field.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=2 |  L=2  |S|E|I|D|B| TID |0|0|0|0| RS| RQ|    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3.2.1.3. VP8 LID Mapping

The following shows the header extension for VP8 that contains only temporal layer information.


```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=2 |  L=2  |S|E|I|D|B| TID |0|0|0|0|0|0|0|0|    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3.2.1.4. H264-SVC LID Mapping

The following shows H264-SVC [RFC6190] Layer encoding information (3 bits for spatial and 4 bits quality) mapped to the generic LID field.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=2 |  L=2  |S|E|I|D|B| TID |0| DID |  QID  |    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3.2.1.5. H264 (AVC) LID Mapping

The following shows the header extension for H264 (AVC) that contains only temporal layer information.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ID=2 |  L=2  |S|E|I|D|B| TID |0|0|0|0|0|0|0|0|    TL0PICIDX  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

3.3. Signaling information

The URI for declaring this header extension in an extmap attribute is "urn:ietf:params:rtp-hdrext:framemarking". It does not contain any extension attributes.

An example attribute line in SDP:

```
a=extmap:3 urn:ietf:params:rtp-hdrext:framemarking
```

3.4. Considerations on use

The header extension values MUST represent what is already in the RTP payload.

When a RTP switch needs to discard a received video frame due to congestion control considerations, it is RECOMMENDED that it preferably drop frames marked with the "discardable" bit.

When a RTP switch wants to forward a new video stream to a receiver, it is RECOMMENDED to select the new video stream from the first switching point (I bit set) and forward the same. A RTP switch can request a media source to generate a switching point for H.264 by sending Full Intra Request (RTCP FIR) as defined in [RFC5104], for example.

4. Security Considerations

In the Secure Real-Time Transport Protocol (SRTP) [RFC3711], RTP header extensions are authenticated but not encrypted. When header extensions are used some of the payload type information are exposed and is visible to middle boxes. The encrypted media data is not exposed, so this is not seen as a high risk exposure.

5. Acknowledgements

Many thanks to Bernard Aboba, Jonathan Lennox, and Stephan Wenger for their inputs.

6. IANA Considerations

This document defines a new extension URI to the RTP Compact HeaderExtensions sub-registry of the Real-Time Transport Protocol (RTP) Parameters registry, according to the following data:

Extension URI: urn:ietf:params:rtp-hdrext:framemarkinginfo
Description: Frame marking information for video streams
Contact: mzanaty@cisco.com
Reference: RFC XXXX

Note to RFC Editor: please replace RFC XXXX with the number of this RFC.

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

7.2. Informative References

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[I-D.aboba-avtcore-sfu-rtp]
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[RFC3550] Schulzrinne, H., Casner, S., Frederick, R., and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications", STD 64, RFC 3550, DOI 10.17487/RFC3550, July 2003, <http://www.rfc-editor.org/info/rfc3550>.

[RFC3711] Baugher, M., McGrew, D., Naslund, M., Carrara, E., and K. Norrman, "The Secure Real-time Transport Protocol (SRTP)", RFC 3711, DOI 10.17487/RFC3711, March 2004, <http://www.rfc-editor.org/info/rfc3711>.

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[RFC6184] Wang, Y., Even, R., Kristensen, T., and R. Jesup, "RTP Payload Format for H.264 Video", RFC 6184, DOI 10.17487/RFC6184, May 2011, <http://www.rfc-editor.org/info/rfc6184>.

[RFC6190] Wenger, S., Wang, Y., Schierl, T., and A. Eleftheriadis, "RTP Payload Format for Scalable Video Coding", RFC 6190, DOI 10.17487/RFC6190, May 2011, <http://www.rfc-editor.org/info/rfc6190>.

[RFC7798] Wang, Y., Sanchez, Y., Schierl, T., Wenger, S., and M. Hannuksela, "RTP Payload Format for High Efficiency Video Coding (HEVC)", RFC 7798, DOI 10.17487/RFC7798, March 2016, <http://www.rfc-editor.org/info/rfc7798>.

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