Internet Engineering Task Force (IETF)
Request for Comments: 6469
Obsoletes: 3189
Category: Standards Track
ISSN: 2070-1721

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December 2011

RTP Payload Format for DV (IEC 61834) Video

Abstract

This document specifies the packetization scheme for encapsulating the compressed digital video data streams commonly known as "DV" into a payload format for the Real-Time Transport Protocol (RTP). This document obsoletes RFC 3189.

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/rfc6469.

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1. Introduction

This document specifies payload formats for encapsulating both consumer- and professional-use Digital Video (DV) format data streams into the Real-Time Transport Protocol (RTP) [RFC3550]. DV compression audio and video formats were designed for a recording format on helical-scan magnetic tape media. The DV standards for consumer-market devices, the IEC 61883 and 61834 series, cover many aspects of consumer-use digital video, including mechanical specifications of a cassette, magnetic recording format, error correction on the magnetic tape, Discrete Cosine Transform (DCT) video encoding format, and audio encoding format [IEC61834]. The digital interface part of IEC 61883 defines an interface on the IEEE 1394 system [IEC61883][IEEE1394]. This specification set supports several video formats: SD-VCR (Standard Definition), HD-VCR (High Definition), SDL-VCR (Standard Definition - Long), PALPlus, DVB (Digital Video Broadcast), and ATV (Advanced Television). North American formats are indicated with a number of lines and "/60", while European formats use "/50". DV standards extended for professional use were published by the Society of Motion Picture and Television Engineers (SMPTE) as 314M and 370M, for different sampling systems, higher color resolution, and higher bit rates [SMPTE314M][SMPTE370M].

In summary, there are two kinds of DV, one for consumer use and the other for professional. The original "DV" specification designed for consumer-use digital VCRs is approved as the IEC 61834 standard set. The specifications for professional DV are published as SMPTE 314M and 370M. Both encoding formats are based on consumer DV and used in SMPTE D-7, D-9, and D-12 video systems. The RTP payload format specified in this document supports IEC 61834 consumer DV and professional SMPTE 314M and 370M (DV-based) formats.

IEC 61834 also includes magnetic tape recording for digital TV broadcasting systems (such as DVB and ATV) that use MPEG2 encoding. The payload format for encapsulating MPEG2 into RTP has already been defined in RFC 2250 [RFC2250] and elsewhere.

Consequently, the payload specified in this document will support six video formats of the IEC standard: SD-VCR (525/60, 625/50), HD-VCR (1125/60, 1250/50), and SDL-VCR (525/60, 625/50). It also supports eight of the SMPTE standards: 314M 25 Mbit/s (525/60, 625/50), 314M 50 Mbit/s (525/60, 625/50), and 370M 100 Mbit/s (1080/60i, 1080/50i, 720/60p, and 720/50p). In the future, it can be extended into other video formats managed by the 80-byte DV Digital Interface Format (DIF) block.

Throughout this specification, we make extensive use of the terminology of IEC and SMPTE standards. The reader should consult the original references for definitions of these terms.

1.1. Terminology

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 RFC 2119 [RFC2119].

2. RTP Payload Format

2.1. The DV Format Encoding

The DV format only uses the DCT compression technique within each frame, contrasted with the interframe compression of the MPEG video standards [ISO/IEC11172][ISO/IEC13818]. All video data, including audio and other system data, is managed within the picture frame unit of video.

The DV video encoding is composed of a three-level hierarchical structure, i.e., DCT super block, DCT macro block, and DCT block. A picture frame is divided into rectangle- or clipped-rectangle-shaped DCT super blocks. DCT super blocks are divided into 27 rectangle- or square-shaped DCT macro blocks, and each DCT macro block consists of a number of DCT blocks. Each DCT block consists of 8x8 pixels and represents a rectangle region for each color, Y, Cb, and Cr.

Audio data is encoded in Pulse Code Modulation (PCM) format. The sampling frequency is 32 kHz, 44.1 kHz, or 48 kHz and the quantization is 12-bit non-linear, 16-bit linear, or 20-bit linear. The number of channels may be up to 8. Only certain combinations of these parameters are allowed, depending upon the video format; the restrictions are specified in each document [IEC61834][SMPTE314M] [SMPTE370M].

A frame of data in the DV format stream is divided into several "DIF sequences". A DIF sequence is composed of an integral number of 80-byte DIF blocks. A DIF block is the primitive unit for all treatment of DV streams. Each DIF block contains a 3-byte ID header that specifies the type of the DIF block and its position in the DIF sequence. Five types of DIF blocks are defined: DIF sequence header, Subcode, Video Auxiliary (VAUX) information, Audio, and Video. Audio DIF blocks are composed of 5 bytes of Audio Auxiliary (AAUX) data and 72 bytes of audio data.

Each RTP packet starts with the RTP header as defined in RFC 3550 [RFC3550]. No additional payload-format-specific header is required for this payload format.

2.2. RTP Header Usage

The RTP header fields that have a meaning specific to the DV format are described as follows:

Payload type (PT): The payload type is dynamically assigned by means outside the scope of this document. If multiple DV encoding formats are to be used within one RTP session, then multiple dynamic payload types MUST be assigned, one for each DV encoding format. The sender MUST change to the corresponding payload type whenever the encoding format is changed.

Timestamp: 32-bit 90 kHz timestamp representing the time at which the first data in the frame was sampled. All RTP packets within the same video frame MUST have the same timestamp. The timestamp SHOULD increment by a multiple of the nominal interval for one DV frame time, as given in the following table:

Mode	Frame rate (Hz)	Increase of 90 kHz timestamp per DV frame
525-60	29.97	3003
625-50	25	3600
1125-60	30	3000
1250-50	25	3600
1080-60i	29.97	3003
1080-50i	25	3600
720-60p	59.94	3003(*)
720-50p	50	3600(*)

(*) Note that even in the 720-line DV system, the data in two video frames shall be processed within one DV frame duration of the 1080-line system. Audio data and subcode data in the 720-line system are processed in the same way as the 1080-line system. Therefore, in the 720-line system, the timestamp increase given in the third column corresponds to two video frames time.

Marker bit (M): The marker bit of the RTP fixed header is set to one on the last packet of a video frame; on other packets, it MUST be zero. The M bit allows the receiver to know that it has received the last packet of a frame so it can display the image without waiting for the first packet of the next frame to arrive to detect the frame

change. However, detection of a frame change MUST NOT rely on the marker bit since the last packet of the frame might be lost. Detection of a frame change MUST be based on a difference in the RTP timestamp.

2.3. Payload Structures

Integral DIF blocks are placed into the RTP payload beginning immediately after the RTP header. Any number of DIF blocks may be packed into one RTP packet, but all DIF blocks in one RTP packet MUST be from the same video frame. DIF blocks from the next video frame MUST NOT be packed into the same RTP packet even if more payload space remains. This requirement stems from the fact that the transition from one video frame to the next is indicated by a change in the RTP timestamp. It also reduces the processing complexity on the receiver. Since the RTP payload contains an integral number of DIF blocks, the length of the RTP payload will be a multiple of 80 bytes.

Audio and video data may be transmitted as one bundled RTP stream or in separate RTP streams (unbundled). The choice MUST be indicated as part of the assignment of the dynamic payload type and MUST remain unchanged for the duration of the RTP session to avoid complicated procedures of sequence number synchronization. The RTP sender could omit the DIF sequence header and subcode DIF blocks from a stream when the information either is known from out-of-band sources or is not required for the application. Note that time code in DIF blocks is mandatory for professional video applications. When unbundled audio and video streams are sent, any DIF sequence header and subcode DIF blocks MUST be included and sent in the video stream.

DV streams include "source" and "source control" packs that carry information indispensable for proper decoding, such as video signal type, frame rate, aspect ratio, picture position, quantization of audio sampling, number of audio samples in a frame, number of audio channels, audio channel assignment, and language of the audio. However, describing all of these attributes with a signaling protocol would require large descriptions to enumerate all the combinations. Therefore, no Session Description Protocol (SDP) [RFC4566] parameters for these attributes are defined in this document. Instead, the RTP sender MUST transmit at least those VAUX (Video Auxiliary) DIF blocks and/or audio DIF blocks with AAUX (Audio Auxiliary) information bytes that include "source" and "source control" packs containing the indispensable information for decoding.

In the case of one bundled stream, DIF blocks for both audio and video are packed into RTP packets in the same order as they were encoded.

In the case of an unbundled stream, only the header, subcode, video, and VAUX DIF blocks are sent within the video stream. Audio is sent in a different stream if desired, using a different RTP payload type. It is also possible to send audio duplicated in a separate stream, in addition to bundling it in with the video stream.

When using unbundled mode, it is RECOMMENDED that the audio stream data be extracted from the DIF blocks and repackaged into the corresponding RTP payload format for the audio encoding (DAT12, L16, L20) [RFC3551][RFC3190] in order to maximize interoperability with non-DV-capable receivers while maintaining the original source quality.

In the case of unbundled transmission that is compelled to use both audio and video in the DV format, the same timestamp SHOULD be used for both audio and video data within the same frame to simplify the lip synchronization effort on the receiver. Lip synchronization may also be achieved using reference timestamps passed in RTP Control Protocol (RTCP) as described in [RFC3550]. In this case, the audio stream uses the 90 kHz clock rate, and the timestamp uses the same clock rate as the video.

The sender MAY reduce the video frame rate by discarding the video data and VAUX DIF blocks for some of the video frames. The RTP timestamp MUST still be incremented to account for the discarded frames. The sender MAY alternatively reduce bandwidth by discarding video data DIF blocks for portions of the image that are unchanged from the previous image. To enable this bandwidth reduction, receivers SHOULD implement an error-concealment strategy to accommodate lost or missing DIF blocks, e.g., repeating the corresponding DIF block from the previous image.

3. Payload Format Parameters

This section specifies the parameters that MAY be used to select optional features of the payload format and certain features of the bitstream. The parameters are specified here as part of the media type registration for the DV encoding. A mapping of the parameters into the Session Description Protocol (SDP) [RFC4566] is also provided for applications that use SDP. Equivalent parameters could be defined elsewhere for use with control protocols that do not use SDP.

3.1. Media Type Registration

This registration is done using the template defined in RFC 4288 [RFC4288] and following RFC 4855 [RFC4855].

3.1.1. Media Type Registration for DV Video

Type name: video

Subtype name: DV

Required parameters:

encode: type of DV format. Permissible values for encode are:
SD-VCR/525-60
SD-VCR/625-50
HD-VCR/1125-60
HD-VCR/1250-50
SDL-VCR/525-60
SDL-VCR/625-50
314M-25/525-60
314M-25/625-50
314M-50/525-60
314M-50/625-50
370M/1080-60i
370M/1080-50i
370M/720-60p
370M/720-50p
306M/525-60 (for backward compatibility)
306M/625-50 (for backward compatibility)

Optional parameters:

audio: whether the DV stream includes audio data or not. Permissible values for audio are bundled and none. Defaults to none.

Encoding considerations:

DV video can be transmitted with RTP as specified in RFC 6469 (this document). Other transport methods are not specified.

Security considerations:

See Section 4 of RFC 6469 (this document).

Interoperability considerations: Interoperability with previous implementations is discussed in Section 8.

Public specifications:

IEC 61834 Standard
SMPTE 314M
SMPTE 370M
RFC 6469 (this document)
SMPTE 306M (for backward compatibility)

Applications that use this media type: Audio and video streaming and conferencing tools.

Additional information: NONE

Person & email address to contact for further information:

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Intended usage: COMMON

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

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Change controller:

IETF Audio/Video Transport working group delegated from the IESG

3.1.2. Media Type Registration for DV Audio

Type name: audio

Subtype name: DV

Required parameters:

encode: type of DV format. Permissible values for encode are:
SD-VCR/525-60
SD-VCR/625-50
HD-VCR/1125-60
HD-VCR/1250-50
SDL-VCR/525-60
SDL-VCR/625-50

314M-25/525-60
314M-25/625-50
314M-50/525-60
314M-50/625-50
370M/1080-60i
370M/1080-50i
370M/720-60p
370M/720-50p
306M/525-60 (for backward compatibility)
306M/625-50 (for backward compatibility)

Optional parameters:

audio: whether the DV stream includes audio data or not. Permissible values for audio are bundled and none. Defaults to none.

Encoding considerations:

DV audio can be transmitted with RTP as specified in RFC 6469 (this document). Other transport methods are not specified.

Security considerations:

See Section 4 of RFC 6469 (this document).

Interoperability considerations: Interoperability with previous implementations is discussed in Section 8.

Published specifications:

IEC 61834 Standard
SMPTE 314M
SMPTE 370M
RFC 6469 (this document)
SMPTE 306M (for backward compatibility).

Applications that use this media type: Audio and video streaming and conferencing tools.

Additional information: NONE

Person & email address to contact for further information:

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Intended usage: COMMON

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

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3.2. SDP Parameters

3.2.1. Mapping of Payload Type Parameters to SDP

The information carried in the media type specification has a specific mapping to fields in the Session Description Protocol (SDP), which is commonly used to describe RTP sessions. When SDP is used to specify sessions employing the DV encoding, the mapping is as follows:

- The media type ("video") goes in SDP "m=" as the media name.
- The media subtype ("DV") goes in SDP "a=rtpmap" as the encoding name. The RTP clock rate in "a=rtpmap" MUST be 90000, which for the payload format defined in this document is a 90 kHz clock.
- Any remaining parameters go in the SDP "a=fmtp" attribute by copying them directly from the media type string as a semicolon-separated list of parameter=value pairs.

In the DV video payload format, the "a=fmtp" line will be used to show the encoding type within the DV video and will be used as below:

a=fmtp:<payload type> encode=<DV-video encoding>

The required parameter "encode" specifies which type of DV format is used. The DV format name will be one of the following values:

SD-VCR/525-60
SD-VCR/625-50
HD-VCR/1125-60
HD-VCR/1250-50
SDL-VCR/525-60
SDL-VCR/625-50
314M-25/525-60

```
314M-25/625-50
314M-50/525-60
314M-50/625-50
370M/1080-60i
370M/1080-50i
370M/720-60p
370M/720-50p
306M/525-60 (for backward compatibility)
306M/625-50 (for backward compatibility)
```

In order to show whether or not the audio data is bundled into the DV stream, a format-specific parameter is defined:

```
a=fmtp:<payload type> encode=<DV-video encoding> audio=<audio
bundled>
```

The optional parameter "audio" will be one of the following values:

```
bundled
none (default)
```

If the fmtp "audio" parameter is not present, then audio data MUST NOT be bundled into the DV video stream.

3.2.2. Usage with the SDP Offer/Answer Model

The following considerations apply when using SDP offer/answer procedures [RFC3264] to negotiate the use of the DV payload in RTP:

- The "encode" parameter can be used for sendrecv, sendonly, and recvonly streams. Each encode type MUST use a separate payload type number.

- Any unknown parameter in an offer MUST be ignored by the receiver and MUST NOT be included in the answer.

In an offer for unbundled streams, the group attribute as defined in the Session Description Protocol (SDP) Grouping Framework [RFC5888] can be used in order to associate the related audio and video. The example usage of SDP grouping is detailed in [RFC5888].

3.3. Examples

Some example SDP session descriptions utilizing DV encoding formats follow.

3.3.1. Example for Unbundled Streams

When using unbundled mode, the RTP streams for video and audio will be sent separately to different ports or different multicast groups. When unbundled audio and video streams are sent, SDP carries several "m=" lines, one for each media type of the session (see [RFC4566]).

An example SDP description using these attributes is:

```
v=0
o=ikob 2890844526 2890842807 IN IP4 192.0.2.1
s=POI Seminar
i=A Seminar on how to make Presentations on the Internet
u=http://www.example.net/~ikob/POI/index.html
e=ikob@example.net (Katsushi Kobayashi)
c=IN IP4 233.252.0.1/127
t=2873397496 2873404696
m=audio 49170 RTP/AVP 112
a=rtpmap:112 L16/32000/2
m=video 50000 RTP/AVP 113
a=rtpmap:113 DV/90000
a=fmtp:113 encode=SD-VCR/525-60 audio=none
```

This describes a session where audio and video streams are sent separately. The session is sent to a multicast group 233.252.0.1. The audio is sent using L16 format, and the video is sent using SD-VCR 525/60 format, which corresponds to NTSC format in consumer DV.

3.3.2. Example for Bundled Streams

When sending a bundled stream, all the DIF blocks including system data will be sent through a single RTP stream.

An example SDP description for a bundled DV stream is:

```
v=0
o=ikob 2890844526 2890842807 IN IP4 192.0.2.1
s=POI Seminar
i=A Seminar on how to make Presentations on the Internet
u=http://www.example.net/~ikob/POI/index.html
e=ikob@example.net (Katsushi Kobayashi)
c=IN IP4 233.252.0.1/127
t=2873397496 2873404696
m=video 49170 RTP/AVP 112 113
a=rtpmap:112 DV/90000
a=fmtp:112 encode=SD-VCR/525-60 audio=bundled
a=fmtp:113 encode=314M-50/525-60 audio=bundled
```

This SDP record describes a session where audio and video streams are sent bundled. The session is sent to a multicast group 233.252.0.1. The video is sent using both 525/60 consumer DV and SMPTE standard 314M 50 Mbit/s formats, when the payload type is 112 and 113, respectively.

4. Security Considerations

RTP packets using the payload format defined in this specification are subject to the security considerations discussed in the RTP specification [RFC3550] and any appropriate RTP profile. This implies that confidentiality of the media streams is achieved by encryption. Because the data compression used with this payload format is applied end-to-end, encryption may be performed after compression so there is no conflict between the two operations.

A potential denial-of-service threat exists for data encodings using compression techniques that have non-uniform receiver-end computational load. The attacker can inject pathological datagrams into the stream that are complex to decode and cause the receiver to be overloaded. However, this encoding does not exhibit any significant non-uniformity.

As with any IP-based protocol, in some circumstances, a receiver may be overloaded simply by the receipt of too many packets, either desired or undesired. Network-layer authentication may be used to discard packets from undesired sources, but the processing cost of the authentication itself may be too high. In a multicast environment, mechanisms for joining and pruning of specific sources are specified in IGMPv3, Multicast Listener Discovery Version 2 (MLDv2) [RFC3376][RFC3810] or Lightweight-IGMPv3 (LW-IGMPv3), LW-MLDv2 [RFC5790] and in multicast routing protocols to allow a receiver to select which sources are allowed to reach it [RFC4607].

5. Congestion Control

The general congestion control considerations for transporting RTP data apply; see RTP [RFC3550] and any applicable RTP profile like Audio-Visual Profile (AVP) [RFC3551].

6. IANA Considerations

This document obsoletes [RFC3189], and some registration forms have been updated by this document. The registration forms (based on the RFC 4855 [RFC4855] definition) for the media types for both video and audio are shown in Section 3.1.

7. Major Changes from RFC 3189

The changes from [RFC3189] are:

1. Specified that support for SMPTE 306M is only for backward interoperability, since it is covered by SMPTE 314M format.

2. Added SMPTE 370M 100 Mbit/s High Definition Television (HDTV) (1080/60i, 1080/50i, 720/60p, and 720/50p) format.

3. Incorporated the Source-Specific Multicast (SSM) specification for avoiding overloaded traffic source in multicast usage. Added a reference to the Source-Specific Multicast (SSM) specification as a way to reduce unwanted traffic in a multicast application.

4. Clarified the case where a sender omits subcode DIF block data from the stream.

5. Added considerations for the offer/answer model.

6. Revised media types registration form based on new registration rule [RFC4855].

8. Interoperability with Previous Implementations

In this section, we discuss interoperability with implementations based on [RFC3189], which is obsoleted by this document.

[RFC3189] regards SMPTE 306M [SMPTE306M] and SMPTE 314M [SMPTE314M] as different encoding formats, although the format of SMPTE 306M is already covered by SMPTE 314M. Therefore, this document recommends that the definition depending on SMPTE 306M SHOULD NOT be used, and SMPTE 314M SHOULD be used instead. An RTP application could handle a stream identified in SMPTE 306M encoding as SMPTE 314M encoding instead.

An offer MAY include SMPTE 306M encoding coming from a legacy system, and receivers SHOULD support this value.

If an initial offer that did not include SMPTE 306M was rejected, the offerer MAY try a new offer with SMPTE 306M. For this case, an RTP application MAY handle a stream identified in SMPTE 306M encoding as SMPTE 314M encoding instead.

In addition, the SDP examples in [RFC3189] provide incorrect SDP "a=fmtp" attribute usage.

9. Acknowledgment

Thanks to Akimichi Ogawa, a former author of this document.

10. References

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