RTP Payload for SMPTE ST 291 Ancillary Data
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Abstract

   This memo describes a real-time transport protocol (RTP) payload
   format for the Society of Motion Picture and Television Engineers
   (SMPTE) Ancillary data, as defined by SMPTE ST 291-1. SMPTE
   Ancillary data is generally used along with professional video
   formats to carry a range of ancillary data types, including time
   code, Closed Captioning, and the Active Format Description (AFD).

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1. Introduction

   This memo describes a real-time transport protocol (RTP) payload
   format for the Society of Motion Picture and Television Engineers
   (SMPTE) Ancillary data (ANC), as defined by SMPTE ST 291-1 [ST291].
   ANC data is transmitted in the ancillary space of serial digital
   video interfaces, the space outside of the active video region of
   images intended for users to view. Ancillary space roughly
   corresponds to vertical and horizontal blanking periods required by
   cathode ray tube type displays. ANC can carry a range of data types,
   including time code, Closed Captioning, and the Active Format
   Description (AFD).

   ANC is generally associated with the carriage of metadata within the
   bit stream of a Serial Digital Interface (SDI) such as SMPTE ST 259
   [ST259], the standard definition (SD) Serial Digital Interface (with
   ANC data inserted as per SMPTE ST 125 [ST125]), or SMPTE ST 292-1
   [ST292], the 1.5 Gb/s Serial Digital Interface for high definition
   (HD) television applications.

   ANC data packet payload definitions for a specific application are
   specified by a SMPTE Standard, Recommended Practice, Registered
   Disclosure Document, or by a document generated by another
   organization, a company, or an individual (an Entity). When a
   payload format is registered with SMPTE, an application document
   describing the payload format is required, and the registered

ancillary data packet is identified by a registered data
identification word.

This memo describes an RTP payload that supports carriage of ANC data
packets with origin from any location within any SMPTE defined SDI
signal, or even if the ANC packets did not originate in an SDI
signal. Sufficient information is provided to enable the ANC data
packets at the output of the decoder to be restored to their original
locations in the serial digital video signal raster (if that is
desired). An optional Media Type parameter allows for signaling of
carriage of one or more types of ANC data as specified by Data
Identification (DID) or Secondary Data Identification (SDID) words.
Another optional Media Type parameter allows for the identification
of a link number, stream number, or image number of multi-link,
multi-stream, or multi-image SDI interfaces.

It should be noted that the ancillary data flag (ADF) word is not
specifically carried in this RTP payload. The ADF may be specified
in a document defining an interconnecting digital video interface,
otherwise a default ADF is specified by SMPTE ST 291-1 [ST291].

This ANC payload can be used by itself, or used along with a range of
RTP video formats. In particular, it has been designed so that it
could be used along with RFC 4175 [RFC4175] "RTP Payload Format for
Uncompressed Video" or RFC 5371 [RFC5371] "RTP Payload Format for
JPEG 2000 Video Streams."

The data model in this document for the ANC data RTP payload is based
on the data model of SMPTE ST 2038 [ST2038], which standardizes the
carriage of ANC data packets in an MPEG-2 Transport Stream.

1.1. Requirements Language

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 for SMPTE ST 291 Ancillary Data

An example of the format of an RTP packet containing SMPTE ST 291
Ancillary Data is shown below:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P|X| CC    |M|    PT       |         sequence number       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           timestamp                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           synchronization source (SSRC) identifier            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Extended Sequence Number    |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ANC_Count     | F |                reserved                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|C|   Line_Number       |   Horizontal_Offset   |   reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       DID       |      SDID       |     Data_Count      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       User_Data_Words...
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
            |   Checksum_Word    |        word_align            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|C|   Line_Number       |   Horizontal_Offset   |   reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       DID       |      SDID       |     Data_Count      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       User_Data_Words...
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                             |  Checksum_Word   |word_align |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
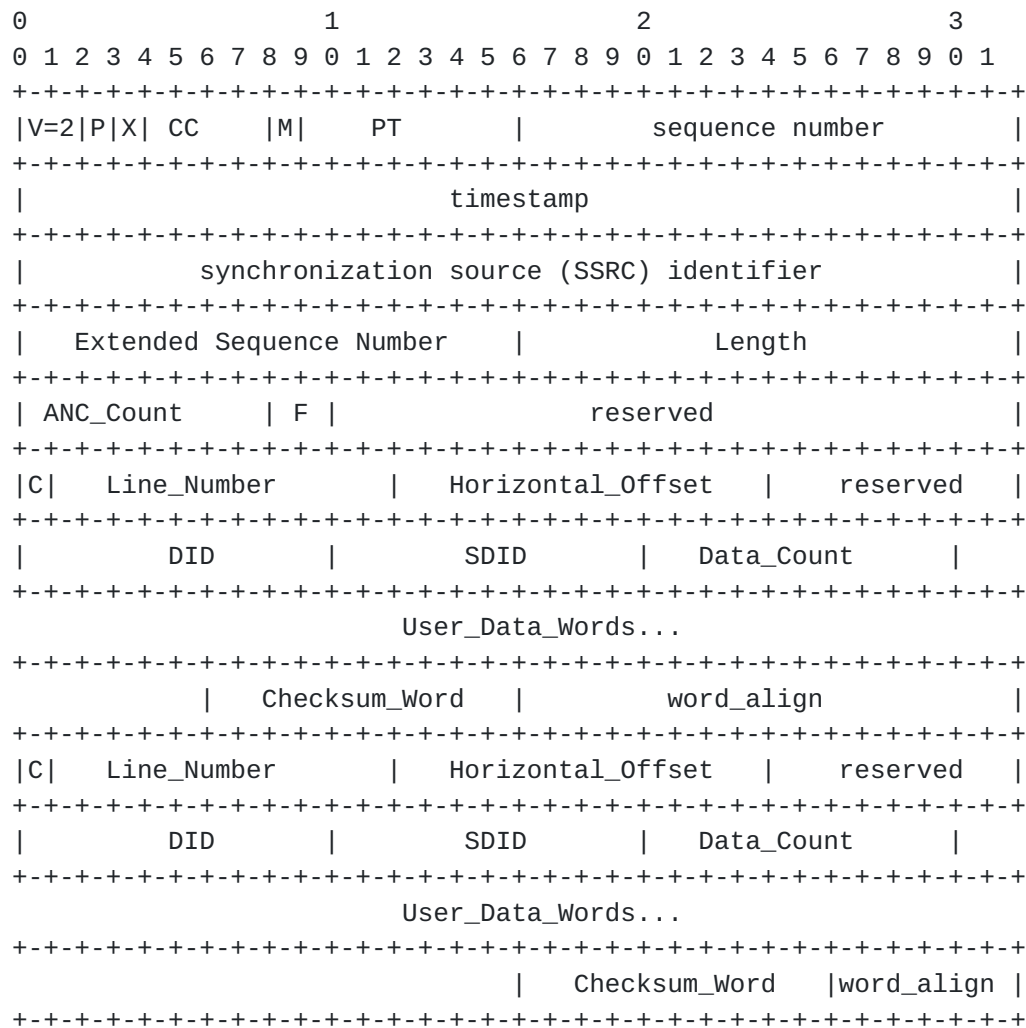
Figure 1: SMPTE Ancillary Data RTP Packet Format

In this example, two ANC data packets are present. The first has
four 10-bit User Data Words, and the second has five 10-bit User Data
Words.

Use of the term "network byte order" in the payload format shall be
as defined in RFC 791 [RFC0791].

RTP packet header fields SHALL be interpreted as per RFC 3550
[RFC3550], with the following specifics:

Timestamp: 32 bits
        The timestamp field is interpreted in a similar fashion to
        RFC 4175 [RFC4175]:

        For progressive scan video, the timestamp denotes the
        sampling instant of the frame to which the ancillary data in

the RTP packet belongs. RTP packets MUST NOT include ANC
data from multiple frames, and all RTP packets with ANC data
belonging to the same frame MUST have the same timestamp.

For interlaced video, the timestamp denotes the sampling
instant of the field to which the ancillary data in the RTP
packet belongs. RTP packets MUST NOT include ANC data from
multiple fields, and all RTP packets belonging to the same
field MUST have the same timestamp.

If the sampling instant does not correspond to an integer
value of the clock, the value SHALL be truncated to the next
lowest integer, with no ambiguity. Section 3.1 describes
recommended timestamp clock rates.

Marker bit (M): 1 bit
        The marker bit set to "1" indicates the last ANC RTP packet
        for a frame (for progressive scan video) or the last ANC RTP
        packet for a field (for interlaced video).

2.1. Payload Header Definitions

The ANC RTP payload header fields are defined as:

Extended Sequence Number: 16 bits
        The high order bits of the extended 32-bit sequence number,
        in network byte order. This is the same as the Extended
        Sequence Number field in RFC 4175 [RFC4175].

Length: 16 bits
        Number of octets of the ANC RTP payload, beginning with the
        "C" bit of the first ANC packet data, as an unsigned integer
        in network byte order. Note that all word_align fields
        contribute to the calculation of the length field.

ANC_Count: 8 bits
        This field is the count of the total number of ANC data
        packets carried in the RTP payload, as an unsigned integer.
        A single ANC RTP packet payload cannot carry more than 255
        ANC data packets.

        If more than 255 ANC data packets need to be carried in a
        field or frame, additional RTP packets carrying ANC data MAY
        be sent with the same RTP timestamp but with different
        sequence numbers. ANC_Count of 0 indicates that there are no
        ANC data packets in the payload (for example, for an RTP
        packet with the marker bit set indicating the last ANC RTP
        packet in a field/frame, even if that RTP packet carries no

actual ANC data packets.) If ANC_Count is 0, Length will
also be 0.

F: 2 bits
These two bits relate to signaling the field specified by the
RTP timestamp in an interlaced SDI raster. A value of 0b00
indicates that either the video format is progressive or that
no field is specified. A value of 0b10 indicates that the
timestamp refers to the first field of an interlaced video
signal. A value of 0b11 indicates that the timestamp refers
to the second field of an interlaced video signal. The value
0b01 is not valid.

reserved: 22 bits
The 22 reserved bits of value "0" follow the F field to
ensure that the first ANC data packet header field in the
payload begins 32-bit word-aligned to ease implementation.

For each ANC data packet in the payload, the following ANC data
packet header fields MUST be present:

C: 1 bit
For HD signals, this flag, when set to "1", indicates that
the ANC data corresponds to the color-difference channel (C).
When set to "0", this flag indicates that the ANC data
corresponds to the luma (Y) channel. For SD signals, this
flag SHALL be set to "0". For ANC data packets that do not
originate from SDI sources, if the ANC data type definition
requires the use of the C or Y channel, the C flag SHALL
reflect that requirement, otherwise the C flag SHALL be set
to "0".

Line_Number: 11 bits
This field contains the line number (as defined in ITU-R
BT.1700 [BT1700] for SD video or ITU-R BT.1120 [BT1120] for
HD video) that corresponds to the location of the ANC data
packet in an SDI raster as an unsigned integer in network
byte order. A value of 0x7FF (all bits in the field are '1')
indicates that the ANC data is carried without a specific
line location within the field or frame. A value of 0x7FE
indicates that the ANC data may be placed into any legal area
of VANC, specifically.

Note that the lines that are available to convey ANC data are
as defined in the applicable sample structure specification
(e.g., SMPTE 274M [ST274], SMPTE ST 296 [ST296], ITU-R BT.656
[BT656]) and may be further restricted per SMPTE RP 168
[RP168].

   Horizontal_Offset: 12 bits
           This field defines the location of the ANC data packet in an
           SDI raster relative to the start of active video (SAV) as an
           unsigned integer in network byte order. A value of 0 means
           that the Ancillary Data Flag (ADF) of the ANC data packet
           begins immediately following SAV. For HD, this is in units
           of luma sample numbers as specified by the defining document
           of the particular image (e.g., SMPTE 274M [ST274] for 1920 x
           1080 active images, or SMPTE ST 296 [ST296] for 1280 x 720
           progressive active images). For SD, this is in units of
           (27MHz) multiplexed word numbers, as specified in SMPTE ST
           125 [ST125]. A value of 0xFFF (all bits in the field are
           '1') indicates that the ANC data is carried without any
           specific location within the line. A value of 0xFFE
           indicates that the ANC data may be placed into any legal area
           of HANC, specifically.

           Note that HANC space in the digital blanking area will
           generally have higher luma sample numbers than any samples in
           the active digital line.

   reserved: 8 bits
           One octet is reserved between Horizontal_Offset and DID
           fields, and contains "0" bits. These reserved bits ensure
           that the ANC data packet begins on a 32-bit word-aligned
           boundary for ease of implementation.

   An ANC data packet with the header fields Line_Number of 0x7FF and
   Horizontal_Offset of 0xFFF SHALL be considered to be carried without
   any specific location within the field or frame.

   For each ANC data packet in the payload, immediately after the ANC
   data packet header fields, the following data fields MUST be present,
   with the fields DID, SDID, Data_Count, User_Data_Words, and
   Checksum_Word representing the 10-bit words carried in the ANC data
   packet, as per SMPTE ST 291-1 [ST291]:

   DID: 10 bits
           Data Identification Word

   SDID: 10 bits
           Secondary Data Identification Word. Used only for a "Type 2"
           ANC data packet. Note that in a "Type 1" ANC data packet,
           this word will actually carry the Data Block Number (DBN).

   Data_Count: 10 bits
           The lower 8 bits of Data_Count, corresponding to bits b7
           (MSB) through b0 (LSB) of the 10-bit Data_Count word, contain

the actual count of 10-bit words in User_Data_Words. Bit b8
is the even parity for bits b7 through b0, and bit b9 is the
inverse (logical NOT) of bit b8.

User_Data_Words: integer number of 10 bit words
User_Data_Words (UDW) are used to convey information of a
type as identified by the DID word or the DID and SDID words.
The number of 10-bit words in the UDW is defined by the
Data_Count field. The 10-bit words are carried in order
starting with the most significant bit and ending with the
least significant bit.

Checksum_Word: 10 bits
The Checksum_Word can be used to determine the validity of
the ANC data packet from the DID word through the UDW. It
consists of 10 bits, where bits b8 (MSB) through b0 (LSB)
define the checksum value and bit b9 is the inverse (logical
NOT) of bit b8. The checksum value is equal to the nine
least significant bits of the sum of the nine least
significant bits of the DID word, the SDID word, the
Data_Count word, and all User_Data_Words in the ANC data
packet. The checksum is initialized to zero before
calculation, and any end carry resulting from the checksum
calculation is ignored.

At the end of each ANC data packet in the payload:

word_align: bits as needed to complete 32-bit word
Word align contains enough "0" bits as needed to complete the
last 32-bit word of ANC packet's data in the RTP payload. If
an ANC data packet in the RTP payload ends aligned with a
word boundary, there is no need to add any word alignment
bits. Word align should be used even for the last ANC data
packet in an RTP packet. Word align should not be used if
there are zero ANC data packets being carried in the RTP
packet.

When reconstructing an SDI signal based on this payload, it is
important to place ANC data packets into the locations indicated by
the ANC payload header fields C, Line_Number and Horizontal_Offset,
and also to follow the requirements of SMPTE ST 291-1 [ST291]
Section 7 "Ancillary Data Space Formatting (Component or Composite
Interface)", which include rules on the placement of initial ANC data
into allowed spaces as well as the contiguity of ANC data packet
sequences within those spaces in order to assure that the resulting
ANC data packets in the SDI signal are valid.

Senders of this payload SHOULD transmit available ANC data packets as
soon as practical to reduce end-to-end latency, especially if
receivers will be embedding the received ANC data packet into an SDI
signal emission. One millisecond is a reasonable upper bound for the
amount of time between when an ANC data packet becomes available to a
sender and the emission of an RTP payload containing that ANC data
packet.

ANC data packets with headers that specify specific location within a
field or frame SHOULD be sent in raster scan order, both in terms of
packing position within an RTP packet and in terms of transmission
time of RTP packets.

3. Payload Format Parameters

This RTP payload format is identified using the video/smpte291 media
type, which is registered in accordance with RFC 4855 [RFC4855], and
using the template of RFC 6838 [RFC6838].

Note that the Media Type Definition is in the "video" tree due to the
expected use of SMPTE ST 291 Ancillary Data along with video formats.

3.1. Media Type Definition

Type name: video

Subtype name: smpte291

Required parameters:

   Rate:
      RTP timestamp clock rate.

      When an ANC RTP stream is to be associated with an RTP video
      stream, the RTP timestamp rates SHOULD be the same to ensure
      that ANC data packets can be associated with the appropriate
      frame or field. Otherwise, a 90 kHz rate SHOULD be used.

      Note that techniques described in RFC 7273 [RFC7273] can
      provide a common reference clock for multiple RTP streams
      intended for synchronized presentation.

Optional parameters:

   DID_SDID:
      Data identification and Secondary data identification words.

The presence of the DID_SDID parameters signals that all ancillary data packets of this stream are of a particular type or types, i.e., labeled with a particular DIDs and SDIDs. DID and SDID values of SMPTE Registered ANC packet types can be found on the at the SMPTE Registry for Data Identification Word Assignments [SMPTE-RA] web site.

"Type 1" ANC packets (which do not have SDIDs defined) SHALL be labeled with SDID=0x00.

DID and SDID values can be registered with SMPTE as per SMPTE ST 291-1 [ST291].

The absence of the DID_SDID parameter signals that in order to determine the DID and SDID of ANC packets in the payload, the DID and SDID fields of each ANC packet must be inspected.

LinkNumber:
    This integer parameter specifies that ANC data in the stream is associated with a specific link number, stream number, or image number of multi-link, multi-stream, or multi-image SDI interfaces.

Encoding considerations: This media type is framed and binary; see Section 4.8 of RFC 6838 [RFC6838].

Security considerations: See Section 7 of [this RFC]

Interoperability considerations: Data items in smpte291 can be very diverse. Receivers might only be capable of interpreting a subset of the possible data items. Some implementations may care about the location of the ANC data packets in the SDI raster, but other implementations may not care.

Published specification: [this RFC]

Applications that use this media type: Devices that stream real-time professional video, especially those that must interoperate with legacy serial digital interfaces (SDI).

Additional Information:

    Deprecated alias names for this type: N/A

    Magic number(s): N/A

    File extension(s): N/A

      Macintosh file type code(s): N/A

   Person & email address to contact for further information: T.
   Edwards <thomas.edwards@fox.com>, IETF Payload Working Group
   <payload@ietf.org>

   Intended usage: COMMON

   Restrictions on usage: This media type depends on RTP framing, and
   hence is only defined for transfer via RTP RFC 3550 [RFC3550].
   Transport within other framing protocols is not defined at this time.

   Author: T. Edwards <thomas.edwards@fox.com>

   Change controller: The IETF PAYLOAD working group, or other party as
   designated by the IESG.

4. SDP Considerations

   The mapping of the above defined payload format media type and its
   parameters SHALL be done according to Section 3 of RFC 4855
   [RFC4855].

   o The type name ("video") goes in SDP "m=" as the media name.

   o The subtype name ("smpte291") goes in SDP "a=rtpmap" as the
      encoding name, followed by a slash ("/") and the required rate
      parameter.

   o The optional parameters LinkNumber and DID_SDID, when present, are
      included in the "a=fmtp" attribute line of SDP as a semicolon-
      separated list of parameter=value pairs.

   DID and SDID values SHALL be specified in hexadecimal with a "0x"
   prefix (such as "0x61"). The ABNF as per RFC 5234 [RFC5234] of the
   DID_SDID optional parameter SHALL be:

         TwoHex = "0x" 1*2(HEXDIG)
         DidSdid = "DID_SDID={" TwoHex "," TwoHex "}"

   For example, EIA 608 Closed Caption data would be signalled with the
   parameter DID_SDID={0x61,0x02}. If a DID_SDID parameter is not
   specified, then the ancillary data stream may potentially contain
   ancillary data packets of any type.

   Multiple DID_SDID parameters may be specified (separated by
   semicolons) to signal the presence of multiple types of ANC data in
   the stream. DID_SDID={0x61,0x02};DID_SDID={0x41,0x05}, for example,

signals the presence of EIA 608 Closed Captions as well as AFD/Bar
Data. Multiple DID_SDID parameters do not imply any particular
ordering of the different types of ANC packets in the stream.

If the optional parameter LinkNumber is present, it SHALL be present
only once in the semicolon-separated list, taking a single integer
value.

A sample SDP mapping for ancillary data is as follows:

```
m=video 30000 RTP/AVP 112
a=rtpmap:112 smpte291/90000
a=fmtp:112 DID_SDID={0x61,0x02};DID_SDID={0x41,0x05};LinkNumber=3
```

In this example, a dynamic payload type 112 is used for ancillary
data. The 90 kHz RTP timestamp rate is specified in the "a=rtpmap"
line after the subtype. In the "a=fmtp:" line, DID 0x61 and SDID
0x02 are specified (registered to EIA 608 Closed Caption Data by
SMPTE), and also DID 0x41 and SDID 0x05 (registered to AFD/Bar Data).
The LinkNumber is 3.

4.1. Grouping ANC Streams with other Media Streams

To associate an ANC RTP stream with other media streams, implementers
may wish to use the Lip Synchronization (LS) grouping defined in RFC
5888 [RFC5888], which requires that "m" lines that are grouped
together using LS semantics MUST synchronize the playout of the
corresponding media streams.

A sample SDP mapping for grouping ANC data with RFC 4175 video using
LS semantics is as follows:

```
v=0
o=Al 123456 11 IN IP4 host.example.com
s=Professional Networked Media Test
i=A test of synchronized video and ANC data
t=0 0
a=group:LS V1 M1
m=video 50000 RTP/AVP 96
c=IN IP4 233.252.0.1/255
a=rtpmap:96 raw/90000
a=fmtp:96 sampling=YCbCr-4:2:2; width=1280; height=720; depth=10
a=mid:V1
m=video 50010 RTP/AVP 97
c=IN IP4 233.252.0.2/255
a=rtpmap:97 smpte291/90000
a=fmtp:97 DID_SDID={0x61,0x02};DID_SDID={0x41,0x05}
a=mid:M1
```

5. Offer/Answer Model and Declarative Considerations

   Receivers may with to receive ANC data streams with specific DID_SDID
   parameters. Thus when offering ANC data streams using the Session
   Description Protocol (SDP) in an Offer/Answer model [RFC3264] or in a
   declarative manner (e.g., SDP in the Real-Time Streaming Protocol
   (RTSP) [RFC2326] or the Session Announcement Protocol (SAP)
   [RFC2974]), the offerer may provide a list of ANC streams available
   with specific DID_SDID parameters in the fmtp line. The answerer may
   respond with all or a subset of the streams offered along with fmtp
   lines with all or a subset of the DID_SDID parameters offered. Or
   the answerer may reject the offer. There are no restrictions on
   updating DID_SDID parameters in a subsequent offer.

6. IANA Considerations

   One media type (video/smpte291) has been defined and needs
   registration in the media types registry. See Section 3.1

7. 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 in any applicable RTP profile such as
   RTP/AVP [RFC3551], RTP/AVPF [RFC4585] RTP/SAVP [RFC3711] or RTP/SAVPF
   [RFC5124]. However, as "Securing the RTP Protocol Framework: Why RTP
   Does Not Mandate a Single Media Security Solution" [RFC7202]
   discusses, it is not an RTP payload format's responsibility to
   discuss or mandate what solutions are used to meet the basic security
   goals like confidentiality, integrity and source authenticity for RTP
   in general. This responsibility lays on anyone using RTP in an
   application. They can find guidance on available security mechanisms
   and important considerations in Options for Securing RTP Sessions
   [RFC7201]. Applications SHOULD use one or more appropriate strong
   security mechanisms. The rest of this security consideration section
   discusses the security impacting properties of the payload format
   itself.

   To avoid potential buffer overflow attacks, receivers should take
   care to validate that the ANC data packets in the RTP payload are of
   the appropriate length (using the Data_Count field) for the ANC data
   type specified by DID & SDID. Also the Checksum_Word should be
   checked against the ANC data packet to ensure that its data has not
   been damaged in transit, but the Checksum_Word is unlikely to provide
   a payload integrity check in case of a directed attack.

   Some receivers will simply move the ANC data packet bits from the RTP
   payload into a serial digital interface (SDI). It may still be a

good idea for these "re-embedders" to perform the above mentioned
validity tests to avoid downstream SDI systems from becoming confused
by bad ANC data packets, which could be used for a denial of service
attack.

"Re-embedders" into SDI should also double check that the Line_Number
and Horizontal_Offset leads to the ANC data packet being inserted
into a legal area to carry ancillary data in the SDI video bit stream
of the output video format.

8. References

8.1. Normative References

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