RTP with TCP Friendly Rate Control

Status of this Memo

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Abstract

   This memo specifies how the TCP Friendly Rate Control (TFRC) of RTP
   flows can be supported using the RTP/AVPF profile and the general RTP
   header extension mechanism. AVPF feedback packets and RTP header
   extensions are defined to support the exchange of control information
   between RTP TFRC senders and receivers. TFRC is an equation-based
   congestion control scheme for unicast flows operating in a best
   effort Internet environment.

1. Introduction

[Note to RFC Editor: All references to RFC XXXX are to be replaced
with the RFC number of this memo, when published]

This memo specifies how the TCP Friendly Rate Control (TFRC) of RTP
flows can be supported using the RTP/AVPF [RFC3550][RFC4585] profile
and RTP header extensions, by defining a new header extension and
AVPF feedback packet, and related parameters.

TFRC is an equation-based congestion control scheme for unicast flows
operating in a best effort Internet environment and competing with
TCP traffic. TFRC computes a TCP-friendly data rate based on current
network conditions, as represented by the latest round trip time and
packet loss calculations. The complete TFRC mechanism is described in
detail in [RFC3448.bis].

To calculate a TCP-friendly data rate and keep track of round trip
times and packet losses, TFRC senders and receivers rely on
exchanging specific information between each other, i.e: the sender
provides the receiver with the latest updates to round trip time
calculations, while the receiver provides feedback needed to compute
round trip times and on packet losses. This memo defines how this
information can be exchanged between TFRC senders and receiver with
RTP header extensions and an AVPF feedback packet.

2. 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].

3. Relation to the Datagram Congestion Control Protocol

The TFRC congestion control mechanism is one of a set of congestion
control methods provided by the Datagram Congestion Control Protocol
(DCCP) [RFC4340] In this section we detail the pros and cons of using
TFRC with RTP versus DCCP.

DCCP is a minimal general purpose transport-layer protocol with
unreliable yet congestion controlled packet delivery semantics and
reliable connection setup and teardown [RFC4336]. DCCP currently
supports both TFRC [RFC4341] and TCP-like [RFC4341] congestion
control, and the protocol is structured to support new congestion
control mechanisms defined in the future. A DCCP mapping for RTP has
been standardised for media applications [RFCxRTP]. In addition DCCP
supports a host of other features, such as: use of Explicit
Congestion Notification (ECN) and the ECN Nonce, flexible options

processing, reliable option negotiation, DTLS [ID.DTLS], Path Maximum
Transfer Unit (PMTU) and Service Codes. Naturally an application
using RTP/DCCP as its transport protocol will benefit from the
protocol features supported by DCCP.

However there are a number of benefits to be gained by the
development and standardization of the use RTP with TFRC:

  o Media applications lacking congestion control can incorporate
    congestion controlled transport without delay by using RTP with
    TFRC. Widespread deployment of the DCCP protocol is not currently
    in place.

  o Use of RTP with TFRC is not contingent on any OS level changes
    and can be quickly deployed, because RTP is implemented at the
    application layer.

  o RTP/UDP flows face the same restrictions in firewall traversal
    as do UDP flows and do not require NATs and firewall
    modifications.   DCCP flows, on the other hand, do require NAT
    and firewall modifications, however once these modifications are
    in place, they can result in easier NAT and firewall traversal
    for RTP/DCCP flows in the future.

  o Use of RTP with TFRC with various media applications will give
    researchers, implementors and developers a better understanding
    of the intricate relationship between media quality and
    equation-based congestion control. Hopefully this experience
    with congestion control and TFRC will ease the migration of media
    applications to DCCP once DCCP is deployed.

Using the AVPF/RTP profile and header extension to support TFRC
provides an immediate means for congestion control in media streams,
in the time until DCCP is deployed.

Additionally, there are also a number of technical differences as to
how (and which) congestion control information is exchanged between
DCCP with CCID3 and RTP:

  o Using header extensions the RTP TFRC sender transmits a
    send timestamp to the RTP TFRC receiver with every data packet.
    In addition to congestion control the send timestamp can be
    used by the receiver for jitter calculations.

    In contrast DCCP with CCID3 transmits a quad round trip
    counter to the receiver.

  o The RTP TFRC receiver only provides the RTP TFRC sender

with the loss event rate as computed by the receiver.

In contrast DCCP with CCID3, provides 2 other options for the
transport of loss event rate. A sender may choose to receive
loss intervals or an Ack Vector. These two options provide the
sender with the necessary information to compute the loss event
rate.

o Sequence number: DCCP supports a 48 bit and a 24 bit sequence
  number, whereas RTP only supports a 16 bit sequence number. While
  this makes RTP susceptible to data injection attacks, it can be
  avoided by using the SRTP [RFC3711] profile.

4. The TFRC Information Exchange Loop

TFRC depends on the exchange of congestion control information
between a sender and receiver. In this section we reiterate which
items are exchanged between a TFRC sender and receiver as discussed
in [RFC3448.bis]. We note how RTP can accommodates these exchanges.

4.1. Data Packets

As stated in [RFC3448.bis] a TFRC sender transmits the following
information in each data packet to the receiver:

o A sequence number, incremented by one for each data packet
  transmitted.

o A timestamp indicating the packet send time and the sender's
  current estimate of the round-trip time, RTT. This information
  is then used by the receiver to compute the TFRC loss intervals.
  - or -
  A course-grained timestamp incrementing every quarter of a
  round trip time, which is then used to determine the TFRC loss
  intervals.

The standard RTP sequence number suffices for the functionality
provided by TFRC. A RTP header extension [hdrtxt] is used to
transmit the send timestamp and RTT. This extension is defined in
Section 5.

4.2. Feedback Packets

As stated in [RFC3448.bis] a TFRC receiver provides the following
feedback to the sender at least once per RTT or per data packet
received (which ever time interval is larger):

   o The send timestamp of the last data packet received, t_i.

   o The amount of time elapsed between the receipt of the last
     data packet at the receiver, and the generation of this feedback
     report, t_delay. This is used by the sender for RTT computations.

   o The rate at which the receiver estimates that data was received
     since the last feedback report was sent, x_recv.

   o The receiver's current estimate of the loss event rate, p, a real
     value between 0 and 1.0.

   To accommodate the feedback of these values a new AVPF transport
   layer feedback message is defined, as detailed in Section 6.

5. The Header Extension

   The form of the extension block is depicted in Figure 1. The length
   field for the extension takes the value 6 to indicate that the
   payload is 7 bytes. Two header extension fields are defined and used
   as follows:

   Send timestamp (t_i): 32 bits
     The timestamp indicating when the packet is sent. This timestamp
     is measured in microseconds and is used for round trip time
     calculations.

   Round trip time (RTT): 24 bits
     The round trip time as measured by the RTP TFRC sender in
     microseconds.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      0xBE      |      0xDE      |            length=2           |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  ID   | len=6 |                    RTT                         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                      send timestamp  (t_i)                     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
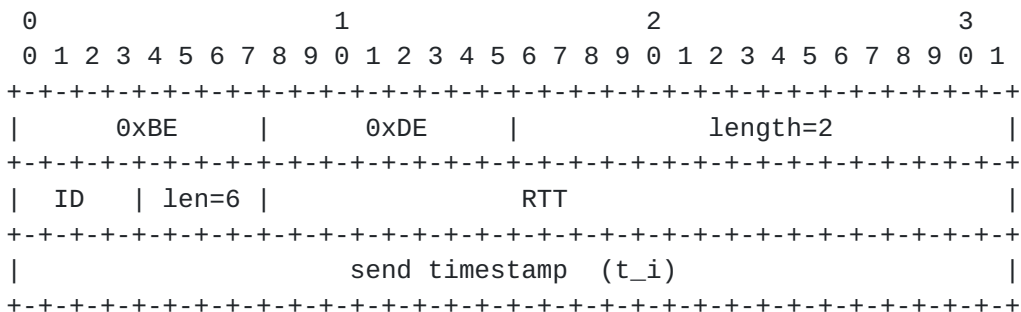   Figure 1: RTP Sender Header Extension Block

6.   TFRC-FB: A New AVPF Transport Layer Feedback Message

   A new transport layer AVPF feedback message is defined to support
   feedback from the receivers: TFRC-FB. This message is depicted in
   Figure 2. It is defined according to [RFC4585] and includes the
   following four fields:

   Send timestamp (t_i): 32 bits
     The send timestamp of the last data packet received by the
     RTP TFRC receiver, t_i, in microseconds.

   Delay (t_delay): 32 bits
     The amount of time elapsed between the receipt of the last data
     packet at the RTP TFRC receiver, and the generation of this
     feedback report in microseconds. This is used by the RTP TFRC
     sender for RTT computations.

   Data rate (x_recv): 32 bits
     The rate at which the receiver estimates that data was received
     since the last feedback report was sent in bytes per second.

   Loss event rate (p): 32 bits
     The receiver's current estimate of the loss event rate, p,
     expressed as a fixed point number with the binary point at the
     left edge of the field. (That is equivalent to taking the integer
     part after multiplying the loss event rate by 2^{32}.)


```
     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|  FMT=2  |  PT=RTPFB     |            length             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                     SSRC of packet sender                     |
     +=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
     |                  SSRC (SSRC of first source)                  |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                     send timestamp (t_i)                      |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                      delay  (t_delay)                         |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                 data rate at the receiver (x_recv)            |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                     loss event rate (p)                       |
     +=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```
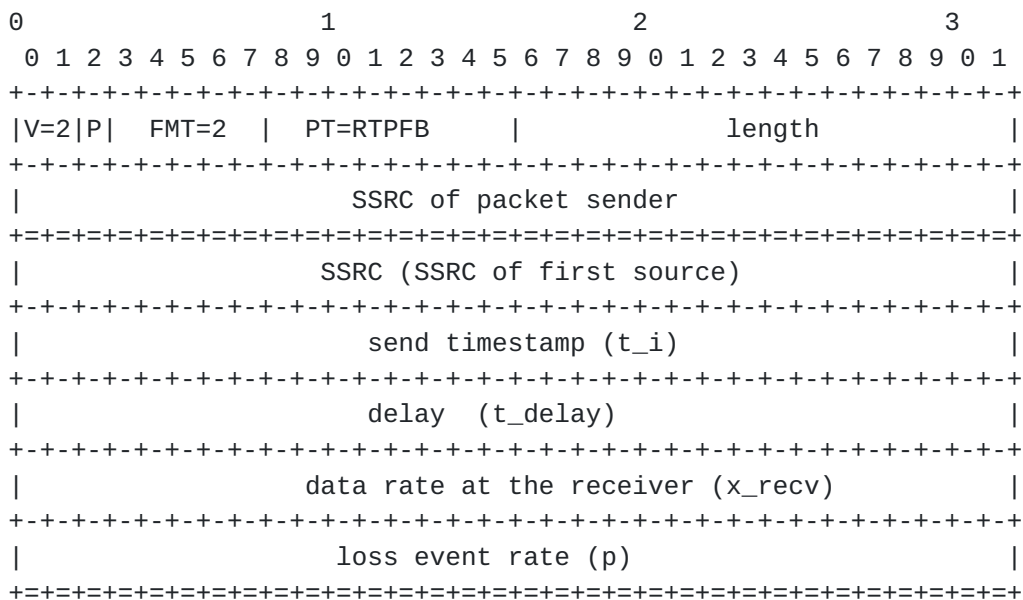   Figure 2: The AVPF TFRC-FB RTCP Transport Layer Feedback Message

7. RTCP Transmission Intervals and Bandwidth Requirements

   When using TFRC rate controlled RTP, the RTCP transmission intervals
   must be set according to the requirements of the TFRC algorithm. TFRC
   requires a receiver to generate a feedback ack packet at least once
   per RTT or per packet received (based on the larger time interval).
   These requirements are to ensure timely reaction to congestion.

   The TFRC requirements of receiving feedback once per RTT can at times
   conflict with the AVP RTCP bandwidth constraints, particularly at
   small RTTs of 20 ms or less. Assuming only one TFRC-FB report per
   RTCP compound packet, Table 1 lists the RTCP bandwidths at RTTs of 2,
   5, 10 and 20 ms and the minimum corresponding RTP data rates, where
   RTCP(X) <= (0.05)*RTP(X) is true.   For example, according to Table
   1, a TFRC RTP flow of less than 3.2 Mbps and a RTT of 5 ms, can not
   comply with the 5% RTCP bandwidth constraints (Table 1 assumes each
   RTCP packet is 100 bytes).   RTP flows facing such circumstances
   should take into account the additional RTCP bandwidth needed when
   signaling their bandwidth information in SDP [RFC2327].

   Based on initial assumptions on round trip time if more than the
   recommended 5% is needed for RTCP bandwidth, the applications SHOULD
   use the SDP bandwidth modifiers RS and RR [RFC3556] to signal the
   amount of RTCP bandwidth needed. If the round trip time assumptions
   change after the RTP flows start running, the application MAY
   recalculate the amount of RTCP bandwidth needed and resignal this new
   value using its signaling protocol of choice.

                    RTT   RTCP(X)   RTP(X)
             +------------------------------+
             | 20 ms | 40 kbps | 0.8 Mbps |
             | 10 ms | 80 kbps | 1.6 Mbps |
             | 5 ms | 160 kbps | 3.2 Mbps |
             | 2 ms | 400 kbps | 8.0 Mbps |
             +------------------------------+
      Table 1: RTCP bandwidth for TFRC flows with corresponding
      RTTs of 20, 10, 5 and 2 ms. Assuming, 100 byte RTCP packets
      and one RTCP packet per RTT.

Additionally, to support the transmission of a feedback packet once per
RTT, the AVPF T_rr_interval variable MUST NOT be set to a value larger
than the current round trip time, RTT, as this would prevent generating
feedback packets at least once per RTT (see RFC 4585, Section 3.4,m).

8. SDP Example

RTP flows using TFRC congestion control MUST signal their use of the
AVPF profile and RTCP feedback packets, the round trip time (RTT) and
send timestamp extension, and MAY also signal an initial RTCP
bandwidth usage:

```
v=0
o=alice 2890844526 2890844526 IN IP4 host.example.com
s=congestion control with TFRC
c=IN IP4 host.example.com
m=video 5400 RTP/AVPF 112
a=rtpmap:112 H261/90000
a=extmap:4 urn:ietf:params:rtp-hdtext:rtt-sendts
a=rtcp-fb * tfrc
b=AS:400
b=RS:800
b=RR:4000
```

9. IANA Considerations

In this section we detail IANA registry values that need to be
registered.

The new RTP/AVPF feedback packet, TFRC-FB, must be registered. For
the RTPFB range of packets, the following format (FMT) values are
needed:

```
Value name:  TFRC-FB
Long name:   TFRC feedback
Value:  5
Reference:   RFC XXXX
```

Also for the AVPF profile, the rtcp-fd-id tfrc must be registered.

For the new header extension, the name rtt-sendts must be registered
into the rtp-hdrext section of the urn:ietf: namespace, referring to
RFC XXXX.

10. Security Considerations

This memo defines how to use the RTP AVPF profile and the general RTP
header extensions to support TFRC congestion control. Therefore RTP
packets using these mechanisms are subject to the security
considerations discussed in the RTP specification [RFC3550], the
RTP/AVPF profile specification [RFC4585] and the general header

extensions mechanism [hdrtxt]. Combining these mechanisms does not
pose any additional security implications. Applications requiring
authentication and integrity protection can use the SAVPF [SAVPF]
profile.

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