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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. Any of the AVPF based RTP profiles, such as SAVPF, can be used to support TFRC RTP flows.

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 [RFC3448bis].

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 [RFC4342] 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 standardized 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:

- 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.

- 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.

- 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.

- 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:

- 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.

- 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.

- 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 [RFC3448bis]. We note how RTP can accommodates these exchanges.

4.1. Data Packets

As stated in [RFC3448bis] a TFRC sender transmits the following information in each data packet to the receiver:

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

- 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 [RFC3448bis] 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. The timing interval between the feedback packets is discussed in Section 7.

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. Figure 2 depicts the both the common packet format (the first 12 octets) and the feedback control information (FCI) for the TFRC-FB packet.

We note that the TFRC related feedback, is specific to one media stream sender, therefore all messages in the compound RTCP packet MUST share the same media source SSRC. In the case where a sender is sending multiple media streams to a receiver, each media flow will be allocated its own AVPF feedback flow.

We define four FCI fields for the TFRC-FB message as follows:

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. X_recv is computed per [RFC3448bis].

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.) The value of

the loss event rate is computed per [RFC3448bis] Section 5.

```
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 of media 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 [RFC4566].

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 re-signal 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 Usage

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
```

8.1. Usage with the SDP Offer/Answer Model

TBC

9. IANA Considerations

In this section we detail IANA registry values that need to be registered. Two new values must be reistered for the AVPF profile:

The new RTP/AVPF feedback packet, TFRC-FB. The following format (FMT) values must be registerd in the FMT sub-registry of the RTPFB payload type:

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

The new rtcp-fd-id "tfrc" must be registered with the "rtcp-fb" attribute registry:

Value name:	tfrc
Long name:	TFRC Feedback
Reference:	RFC XXXX

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, or applictions operating in environments that must strictly adhere to the TFRC send rate (and fear manipulation of the feedback messsages) can use the SAVPF [SAVPF] profile.

11. Acknowledgments

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