Framework for Real-time Media Congestion Avoidance Techniques
draft-zhu-rmcat-framework-00

Abstract

   Congestion control is an essential element in ensuring fair bandwidth
   usage and preventing congestion collapse for traffic sharing the
   Internet. For interactive real-time media traffic such as video
   conferencing, design of congestion control solution also needs to
   account for many other factors such as the requirement for low
   latency packet delivery and interactions with live video encoder.
   This document describes a common framework with the core functional
   building blocks for a real-time media congestion solutions.

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

   Internet-Drafts are working documents of the Internet Engineering
   Task Force (IETF). Note that other groups may also distribute
   working documents as Internet-Drafts. The list of current Internet-
   Drafts is at http://datatracker.ietf.org/drafts/current/.

   Internet-Drafts are draft documents valid for a maximum of six months
   and may be updated, replaced, or obsoleted by other documents at any
   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on January 8, 2017.

Copyright Notice

to this document. Code Components extracted from this document must
include Simplified BSD License text as described in Section 4.e of
the Trust Legal Provisions and are provided without warranty as
described in the Simplified BSD License.

Table of Contents

1. Introduction

   Given increasing amount of interactive real-time media traffic over
   the Internet, such as video conferencing, it is important that these
   applications employ proper congestion control mechanisms to avoid
   congestion collapse. [I-D.ietf-rmcat-cc-requirements] specifies the
   list of requirements of a viable solution.

   This document outlines a common framework for designing a congestion
   control mechanism for real-time interactive communication, so that
   individual drafts on specific solutions follow a consistent set of
   terminologies in describing their respective components. The next
   section (Section 3) describes common functional modules in this
   framework, whereas Section 4 provides examples on how these modules
   build together to support single and multiple media streams.

   [Editor's note : This document does not describe the interaction
   between application, codec and congestion control system. The
   interaction among application, codec and congestion control system
   are defined in other documents. There is a possibility to merge all
   the documents into one single document.]

2. Key Words for 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. Functional Modules

   A viable solution for real-time media congestion control needs to
   comprise of several common modules. This section provides a brief
   description of them and their respective functionalities. A
   congestion control solution for real-time media should comprise of
   the described functional modules. This should help understanding
   different congestion control solutions.

   o Network Congestion Controller : this is the core module for
      estimating available bandwidth over the network based on periodic
      RTCP feedback reports [RFC3550] from the receiver. This module
      contains key functions and calculations required to detect
      congestion and estimate available bandwidth on the transmission
      path based on the reception quality of the media traffic.
      Different congestion control solutions employ different algorithms
      in detecting congestion and estimating available bandwidth for its
      media flow. It also possible that multiple media streams are
      multiplexed over a single transport, hence share a common
      congestion control module in aggregation.

   o Transmission Queue : this module is needed to absorb the
      instantaneous mismatch between output from a live video encoder
      and regulated outgoing media flow. The transmission queue
      schedules outgoing traffic according to sending rate recommended
      by the rate controller module. It reports back its occupancy
      level to the rate controller module to assist future rate control
      decisions on target video rate, sending rate, and probing rate.

   o Rate Controller : this module takes the estimated available
      bandwidth from the network congestion controller, shared states of
      other flows, as well as occupancy level of the transmission queue
      as input. It makes holistic decisions on: a) target video rate
      for the live video encoder; b) sending rate for regulating
      outgoing media flow(s) for the transmission queue; and c) rate of
      probing packets when needed. In the case where multiple media
      streams share a single transport and a common network congestion
      controller (for estimating available bandwidth in aggregation),
      the rate controller is also responsible for distributing available
      bandwidth amongst different media streams according to their
      relative priorities as well as share state information. When
      losses occur over the network and some previous media packets need
      to be retransmitted, the rate controller should also account for
      the bandwidth needed for retransmission.

   o Network Probe Generator: A congestion control solution can
      actively probe to estimate the available bandwidth on the media
      transmission path by sending more than what the live video encoder

produces. Such an approach can be especially effective during the ramp up period of media and transmission rates, when no congestion has been observed over the network yet. The network probe generator is responsible for generating probing packets according to the probing rate specified by the rate controller. It can employ different techniques in doing so -- for example by generating simple dummy packets with unknown payload type or by generating Forward Error Correction (FEC) packets. While this document does not specify what probing technique to use or how those packets should be generated, a complete congestion control solution needs should specify total rate of the probe packets via the rate controller module.

o Live Video Encoder : the sender typically also contains a live video encoder, which adjusts the its encoding parameters according to the target video rate set by the rate controller. The output rate from the video encoder may deviate from this target due to uncertainty in the captured video content characteristics and the encoder rate control process. The output encoded media packets are fed to the transmission queue. Note that internal operations of the live video encoder (i.e., how video encoder rate control works) is out of scope for this document.

o Shared State: In the case of multiple media streams sharing a common sender hence a common network congestion controller, the sender should also contain a shared state module for storage and exchange of congestion control states [Editor's Note from Xiaoqing: examples of congestion control states??] amongst the multiple flows.

4. Example Configurations

4.1. Example Configurations for a Single Stream

```
                                                          RTCP Feedback
  +---------+                      +-------------+         Reports
  |  Live   |                      |  Network    |<---------------
  |  Video  |<----------------+    | Congestion  |
  | Encoder |                 |    | Controller  |
  +---------+                 |    +-------------+
     ||                       |           |(1)
     ||                       |           |
     ||       +-------------+ |   (4)     \|/
     ||       |  Network    | |  +-------------+
     ||       |  Probe      | +------|   Rate      |
     ||       | Generator   |<--------| Controller  |
     ||       +-------------+    (5)  +-------------+
     ||          ||                  (3)|    /|\
     ||          || Probing          \|/   |(2)
     ||          || Packets      +---------------+
     ||          \\============> | Transmission  |
  \\======================> |    Queue      |=============>
      Encoded Video Packets     +---------------+   Outgoing
                                                    Packets
```
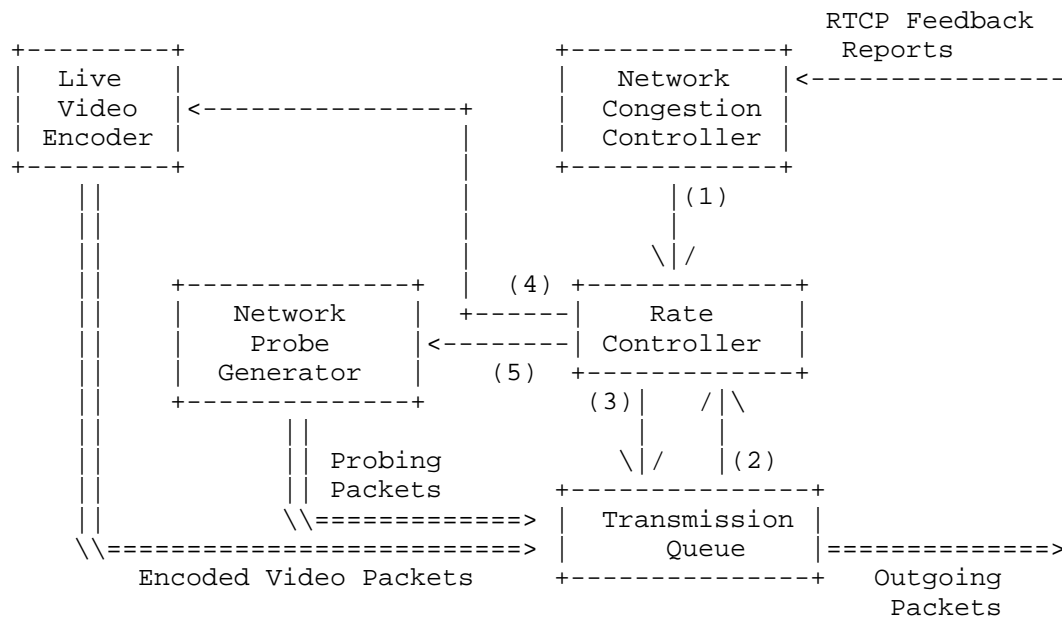
       Figure 1: RMCAT Solution Framework at the Sender: Single Stream

   Figure 1 shows an example configuration at the sender for supporting
   a single media stream. The Network Congestion Controller estimates
   available bandwidth based on periodic RTCP feedback reports. The
   Rate Controller takes as input the estimated available bandwidth (1)
   and the current occupancy level of the Transmission Queue (2). It
   calculates as output sending rate (3) for the Transmission Queue,
   video target rate (4) for the Live Video Encoder, and probing rate
   (5) -- if they are needed -- for the Network Probe Generator. The
   Transmission Queue holds packets generated by both the Live Video
   Encoder and the Network Probe Generator; it paces transmission of its
   outgoing packets according to the sending rate (3) specified by Rate
   Controller.

   Obviously, it is possible for a congestion control solution to
   contain alternative configurations between these functional modules.
   [TODO: add one quick example on alternative wiring.] It is required
   that the candidate solution draft specify how their internal
   functional modules align to this framework.

4.2. Example Configurations for Multiple Streams

```
                                                    RTCP Feedback
                                                     Reports
+---------+                          +-------------+
|  Live   |                          |  Network    |<----------------
|  Video  |<----------------+        | Congestion  |
| Encoder |                 |        | Controller  |
+---------+                 |        +-------------+
    ||                      |              |(1)
    ||                      |              |
    ||                      |             \|/
    ||                      |  (4) +-------------+    +--------+
    ||       +---------+    +------|   Rate      |<-----| Shared |
    ||       |  Live   |    |      | Controller  |      | States |
    ||       |  Video  |<----+     +-------------+      +--------+
    ||       | Encoder |          (3)|    /|\
    ||       +---------+             |     |
    ||          ||                  \|/    |(2)
    ||          ||               +--------------+
    ||          ||               | Transmission |
    \\==========================>|    Queue     |==============>
          Encoded Video Packets  +--------------+    Outgoing
                                                      Packets
```
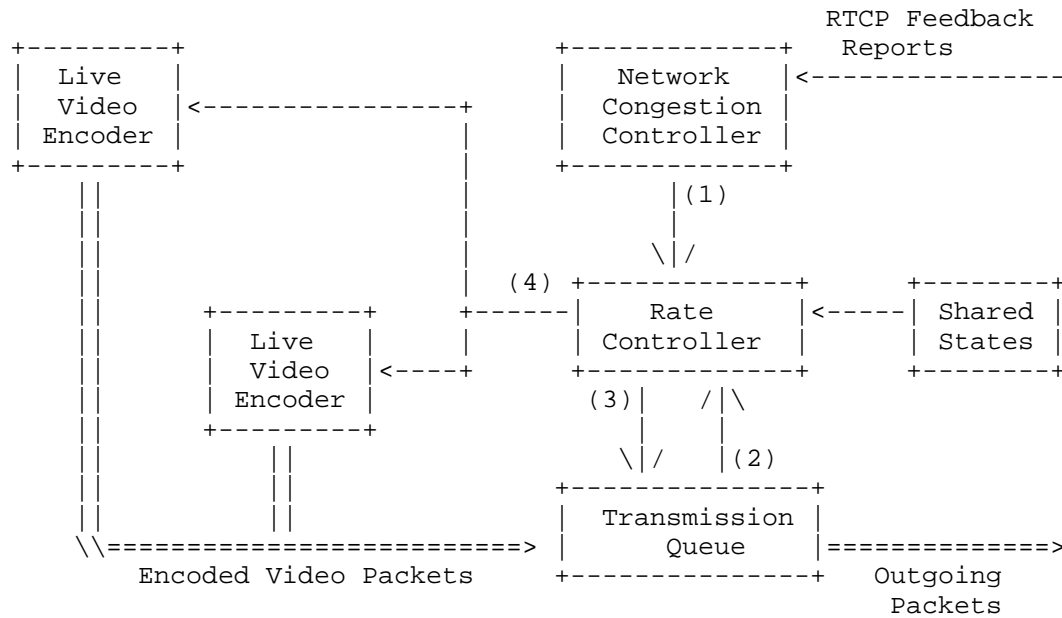
     Figure 2: RMCAT Solution Framework at the Sender: Multiple Streams

   Figure 2 shows an example configuration for multiple video streams
   sharing a common Network Congestion Controller. The Network
   Congestion Controller calculates an aggregated estimated available
   bandwidth (1) based on periodic RTCP feedback reports. The Rate
   Controller divides up the aggregate estimated bandwidth (1) from the
   Network Congestion Controller amongst sub-streams based on their
   relative priority levels, Shared States, as well as current occupancy
   level of the Transmission Queue. It subsequently determines the per-
   flow sending rate (3) as regulated by the Transmission Queue and
   target video rate (4) for each flow.

   In this specific example, the transmission queue is envisioned as a
   logical entity. For instance, this transmission queue can be
   implemented priority-based scheduling and one physical queue per
   stream. For sake of simplicity the role of Network Probe Generator
   is omitted in the above figure.

5. Acknowledgements

   The RMCAT design team discussions contributed to this memo.

6. IANA Considerations

   This memo includes no request to IANA.

7. Security Considerations

   TBD

8. References

8.1. Normative References

   [I-D.ietf-rmcat-cc-requirements]
             Jesup, R. and Z. Sarker, "Congestion Control Requirements
             for Interactive Real-Time Media", draft-ietf-rmcat-cc-
             requirements-09 (work in progress), December 2014.

   [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>.

   [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>.

   [RFC3551] Schulzrinne, H. and S. Casner, "RTP Profile for Audio and
             Video Conferences with Minimal Control", STD 65, RFC 3551,
             DOI 10.17487/RFC3551, July 2003,
             <http://www.rfc-editor.org/info/rfc3551>.

   [RFC4585] Ott, J., Wenger, S., Sato, N., Burmeister, C., and J. Rey,
             "Extended RTP Profile for Real-time Transport Control
             Protocol (RTCP)-Based Feedback (RTP/AVPF)", RFC 4585,
             DOI 10.17487/RFC4585, July 2006,
             <http://www.rfc-editor.org/info/rfc4585>.

   [RFC5104] Wenger, S., Chandra, U., Westerlund, M., and B. Burman,
             "Codec Control Messages in the RTP Audio-Visual Profile
             with Feedback (AVPF)", RFC 5104, DOI 10.17487/RFC5104,
             February 2008, <http://www.rfc-editor.org/info/rfc5104>.

8.2. Informative References

   [RFC0768] Postel, J., "User Datagram Protocol", STD 6, RFC 768,
              DOI 10.17487/RFC0768, August 1980,
              <http://www.rfc-editor.org/info/rfc768>.

Authors' Addresses

   Xianqing Zhu
   Cisco Systems
   12515 Research Blvd., Building 4
   Austin, TX 78759
   USA

   Email: xiaoqzhu@cisco.com

   Zaheduzzaman Sarker
   Ericsson AB
   Luleae
   Sweden

   Phone: 00 46 10 717 37 43
   Email: zaheduzzaman.sarker@ericsson.com