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Comparing One-way Delays in Multipath

Abstract

This document provides a solution for comparing one-way delays in
multipath quic. In this solution, through message interaction
between data receiver and data sender, the data sender can obtain
delay rankings of multiple specified uniflows, providing reference
for sending data packets.

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1. Introduction

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].

1.2. Overview

QUIC basic specifications have been released successively. As an extension of QUIC, multipath QUIC is being formulated. Currently,two multipath QUIC suggestions ([DECONINCK-MP] and [QUIC-MP-LIU]) are submitted to QUIC group. This document is based on [DECONINCK-MP].

[DECONINCK-MP] proposes a new design, that is, from a user perspective, the (multipath) QUIC is a collection of unidirectional flows ("all-uniflow"). Essentially, (multipath) QUIC consists of multiple client-to-server uniflows and server-to-client uniflows. When sending packets, endpoints perform data transmission scheduling independently. Referring to [DECONINCK-MP], Figure 1 illustrates the architecture of a multipath QUIC connection.

```
         +---------+                          +---------+
         | Client  |                          | Server  |
         +---------+                          +---------+
          | |   | |                            | |   | |
          +-+   +-+                            +-+   +-+
           |     |                              |     |
           |     |                              |     |
           |     |------CID A - Uniflow ID 1-------->|     |
           |     |                              |     |
           |     |------CID B - Uniflow ID 0--------------->|
           |     |                              |     |
           |     |<-----CID C - Uniflow ID 0---------|     |
           |     |                              |     |
           |<----------CID D - Uniflow ID 1---------|     |
           |     |                              |     |
           |     |<-----CID E - Uniflow ID 2---------------|
           |     |                              |     |
           |     |                              |     |
           |     |                              |     |
```
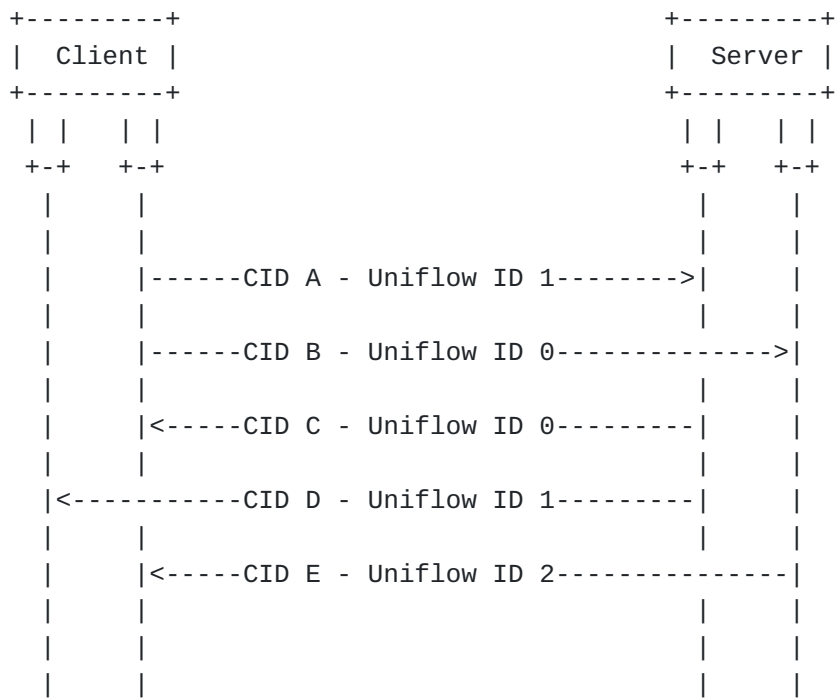
        Figure 1: An Example of Uniflow Distribution over a Multipath QUIC
                                Connection

In single-path QUIC, RTT is valuable in adjusting packet sending
window and congestion prevention and the algorithm of RTT
measurement is depicted in the Figure 2.

```
         +---------+                          +---------+
         | Client  |                          | Server  |
         +---------+                          +---------+
              |                                    |
              |                                    |
      T1  |------------------Tx------------------->|-
              |                                    |
              |                                    | Delay
              |                                    |
      T2  |<-----------------Ty--------------------|-
              |                                    |
              |        RTT(Tx+Ty)=(T2-T1-Delay)    |
              |                                    |
              |                                    |
```
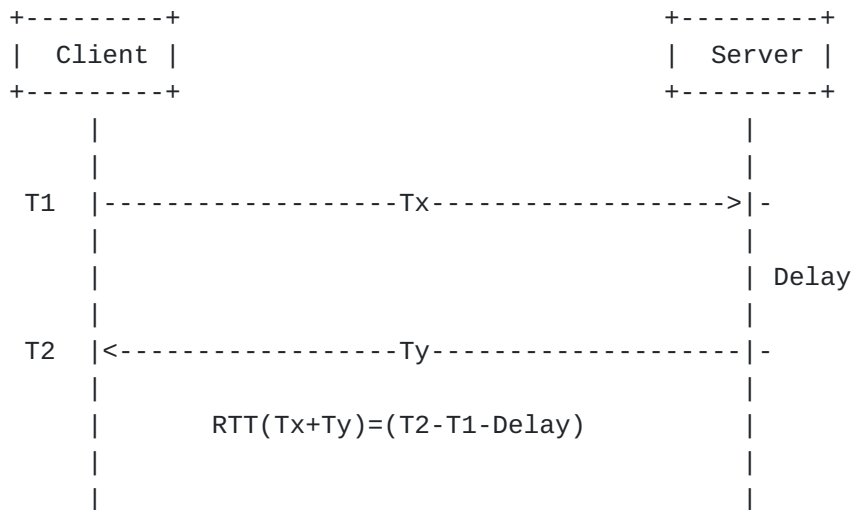
        Figure 2: RTT measurement Algorithm used in Single-path QUIC

In multipath QUIC scenarios, data/control packets and corresponding
ACKs are allowed to travel through different physical links to
decouple service flows (streams) and links (connections). Packets

(including ACKs) of the same stream may be transmitted through
different connections. Therefore, minRTT, as the common path
selection and scheduling algorithm for QUIC packets cannot be
implemented effectively. So, measurement of the minimum one-way
delay or calculation of the minimum delay of multiple uniflow in
multipath QUIC protocol is important and required.

2. One-way Delays Comparation in Multipath QUIC

Figure 3 shows the algorithm presented in this document that is used
by the data sender to determine the one-way delays of each uniflow
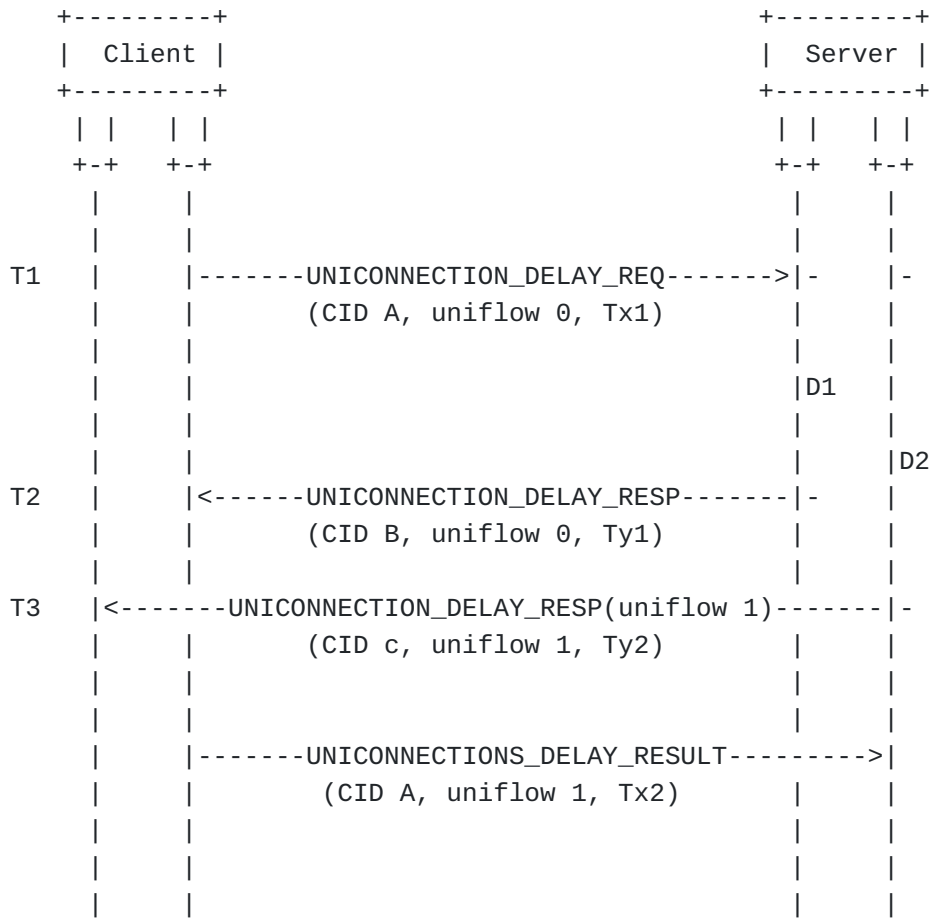or specified uniflows in a test period.

```
    +---------+                           +---------+
    | Client  |                           | Server  |
    +---------+                           +---------+
     | |   | |                             | |   | |
     +-+   +-+                             +-+   +-+
      |     |                               |     |
      |     |                               |     |
 T1   |     |-------UNICONNECTION_DELAY_REQ------->|-     |-
      |     |        (CID A, uniflow 0, Tx1)       |     |
      |     |                               |     |
      |     |                               |D1   |
      |     |                               |     |
      |     |                               |     |D2
 T2   |     |<------UNICONNECTION_DELAY_RESP-------|-     |
      |     |        (CID B, uniflow 0, Ty1)       |     |
      |     |                               |     |
 T3   |<-------UNICONNECTION_DELAY_RESP(uniflow 1)-------|-
      |     |        (CID c, uniflow 1, Ty2)       |     |
      |     |                               |     |
      |     |                               |     |
      |     |-------UNICONNECTIONS_DELAY_RESULT--------->|
      |     |        (CID A, uniflow 1, Tx2)       |     |
      |     |                               |     |
      |     |                               |     |
      |     |                               |     |
```

Figure 3: One-way Delays Comparation Algorithm

For example, the data sender is a server, and the data receiver is a
mobile phone client. If the server wants to obtain the one-way delay
information of each subflow, the server instructs the client to
create a measurement task and the client records the start time. The
client sends a delay test frame (UNICONNECTION_DELAY_REQ frame) to
the server through a client-to-server subflow. After receiving the
delay test frame (UNICONNECTION_DELAY_REQ frame) from the client,

the server returns the delay measurement responses
(UNICONNECTION_DELAY_RESP frame) on all candidate server-to-client
subflows. The client records the arrival time of each delay
measurement response (UNICONNECTION_DELAY_RESP frame). Then the
client can calculate the delay rankings for these candidate server-
to-client uniflows by the formulas below:

One-way Delay(uniflow 0): Ty1 = T2-T1-D1-Tx

One-way Delay(uniflow 1): Ty2 = T3-T1-D2-Tx

If Ty1 is greater than Ty2, uniflow 0's one-way delay is greater
than that of uniflow 0. If Ty1 is less than Ty2, uniflow 0's one-way
delay is less than that of uniflow 0.

Finally, the client sends the measurement result
(UNICONNECTIONS_DELAY_RESULT frame) to the server as a reference to
select a uniflow for data transmission in this test period.

3. Protocol Extension Considerations

In this solution, three new frames are introduced to complete the
interaction of the test between endpoints:

UNICONNECTION_DELAY_REQ Frame: triggering creation of a new
measurement task sent from the data sender to the data receiver.

UNICONNECTION_DELAY_RESP Frame: delay measurement response frame
sent from the data receiver to the data sender.

UNICONNECTIONS_DELAY_RESULT Frame: measurement result releasing
frame sent from the data receiver to the data sender.

4. IANA Considerations

Request to IANA will be added later.

5. Security Considerations

Security issues will be considered later in the design.

6. References

6.1. Normative References

[QUIC]   Iyengar, J. and M. Thomson, "QUIC: A UDP-Based
           Multiplexed and Secure Transport", RFC 9000, DOI
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6.2. Informative References

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Appendix A. Additional Stuff

This becomes an Appendix.

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