What To Do With Multiple Active Paths in QUIC
draft-dawkins-quic-what-to-do-with-multipath-00

Abstract

   The IETF QUIC working group has been chartered to produce extensions
   that would "enable ... multipath capabilities" since the working
   group was formed in 2016, but because multipath was an extension,
   work on multipath, and the other extensions named in the charter,
   waited while work proceeded on the core QUIC protocol specifications.

   After the QUIC working group chairs requested publication for the
   core QUIC protocol specifications, they scheduled a virtual interim
   meeting to understand the use cases that various groups inside and
   outside the IETF were envisioning for multipath with QUIC.

   As part of that discussion, it became obvious that people had a
   variety of ideas about how multiple paths would be used, because they
   weren't looking at the same use cases.

   This document is intended to capture that variety of ideas, to inform
   further discussion in the working group.

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 https://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 May 5, 2021.

Table of Contents

[1](#). Introduction

   The IETF QUIC working group has been chartered to produce extensions
   that would "enable ... multipath capabilities" ([[QUIC-charter](#)]) since
   the working group was formed in 2016, but because multipath was an

extension, work on multipath, and the other extensions named in the charter, waited while work proceeded on the core QUIC protocol specifications ([I-D.ietf-quic-transport] and related specifications).

After the QUIC working group chairs requested publication for the core QUIC protocol specifications, they scheduled a virtual interim meeting ([QUIC-interim-20-10]) to understand the use cases that various groups inside and outside the IETF were envisioning for multipath with QUIC.

As part of that discussion, it became obvious that people had a variety of ideas about how multiple paths would be used, because they weren't looking at the same use cases.

This document is intended to capture that variety of ideas, to inform further discussion in the working group.

For more details, please see the QUIC working group meeting minutes, at [QUIC-interim-20-10-minutes], which include pointers to the video recording from the meeting, pointers to each presentation given, questions and answers after each presentation, and overall discussion following the presentations.

1.1. Notes for Readers

This document is an informational Internet-Draft, not adopted by any IETF working group, and does not carry any special status within the IETF.

It reflects the author's understanding, and contributions that include improvements and clarifications are welcomed, as described in Section 1.2.

1.2. Contribution and Discussion Venues for this draft.

(Note to RFC Editor - if this document ever reaches you, please remove this section)

This document is under development in the Github repository at https://github.com/SpencerDawkins/draft-dawkins-quic-what-to-do-with-multipath. Readers are invited to open issues and send pull requests with contributed text for this document.

Substantial discussion of this document should take place on the QUIC working group mailing list (quic@ietf.org). Subscription and archive details are at https://www.ietf.org/mailman/listinfo/quic.

2. Multicast Modes of Operation

   For the purposes of this document, it's enough to consider two QUIC
   endpoints (QUIC Host X and QUIC Host Y) with two disjoint paths
   between them (Access Net A and Access Net B), as shown in Figure 1.

2.1. Reference Architecture

```
                     ------------
                    /            \
           +-------| Access Net A |--+
           |        \            /   |
           |         ------------    |
       +---+--+                      |       +------+
       | QUIC |                +--------| QUIC |
       } Host |                      | Host |
       |   X  |                +--------|  Y   |
       +---+--+                      |       +------+
           |         ------------    |
           |        /            \   |
           +-------| Access Net B |--+
                    \            /
                     ------------
```

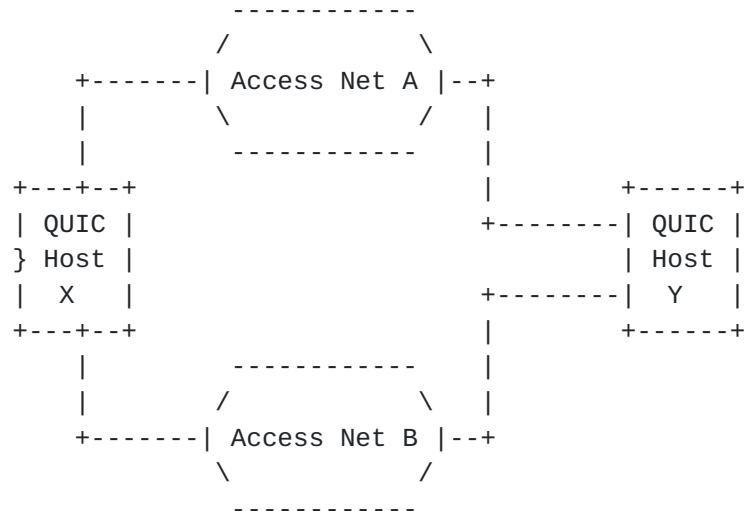   Figure 1: Simplified Reference Architecture for QUIC Multipath
                                  Operation

   More than two paths are certainly possible - for example, two hosts
   that are connected by a satellite uplink/downlink path, and two
   different landline paths from different network providers. But I
   believe this simplified architecture is sufficient for discussion
   purposes.

2.2. Forwarding When Multiple Paths Are Available

   This section uses terminology from 3GPP ATSSS {Access Traffic
   Steering, Switch and Splitting, [TS23501]) to describe three
   different patterns of packer forwarding that are applicable when
   multiple disjoint paths are available. Note that these terms
   describe concepts that are not ATSSS-specific, and could apply to any
   multipath environment. If terminology more accessible to IETF QUIC
   working group participants presents itself, I'll change it.

2.2.1. Traffic Steering

   When a sending host has more than one path available, a sending host
   will select a path to begin forwarding packets on. This can be
   described as Traffic Steering.

2.2.2. Traffic Switching

   When a sending host has more than one path available and is using a
   single path, the sending host can stop using this path, and start
   using another path. This can be described as Traffic Switching.

2.2.3. Traffic Splitting

   When a sending host has more than one path available, the sending
   host may wish to use both paths simultaneously. This can be
   described as Traffic Splitting.

2.2.4. Traffic Steering, Traffic Switching, and Traffic Splitting in
         the Core QUIC Transport Protocol

   [I-D.ietf-quic-transport] and related specifications support the
   selection and use of multiple paths between QUIC endpoints, as long
   as only one path is in active use at any given time.
   [I-D.ietf-quic-transport] and related specifications do not support
   forwarding traffic for a single connection on multiple paths between
   QUIC endpoints simultaneously.

   This level of support for multipath allows Traffic Steering - the
   selection of a specific path - and Traffic Switching - migration of
   traffic from one path to another, using QUIC connection migration.
   It does not allow "Traffic Splitting - the use of simultaneous paths
   for a single connection, except for unordered datagram traffic
   [I-D.ietf-quic-datagram].

   One important output from the QUIC interim meeting was the
   recognition that "Traffic Switching" can be accomplished with much
   more agility than some participants recognized - if you open and
   validate two or more connections, no additional setup or signaling is
   required for a sender to switch paths - that can begin with the next
   packet queued for transmission.

2.3. Forwarding Strategies with Multiple Paths

   During the QUIC virtual interim meeting, various presenters described
   various forwarding strategies that they have used in the past
   (especially with TCP [RFC0793] and Multipath TCP [RFC8684]). and that
   they expected to use in the future with some multipath QUIC
   extension.

   This section is an attempt to identify commonalities and gaps that
   may inform work on future multipath extensions for QUIC.

All of these forwarding strategies build on Traffic Steering -
opening one or more connections, and then proceeding to use one
connection, switch to another connection, or split traffic across
paths. For this reason, Traffic Steering isn't mentioned in the rest
of this section.

2.3.1. Bandwidth Aggregation

Some environment allow the use of multiple paths simultaneously for
significant periods of time, because none of the paths are metered,
so using all of the bandwidth on all of the paths simultaneously
makes sense. Traffic Splitting is required to support this strategy.
[Alibaba-MPQUIC] mentioned this strategy at the QUIC Interim Meeting.

2.3.2. Trading Latency Versus Bandwidth

Some applications require low latency, and others don't. So using a
network path with lower latency for some connections, and using a
different network path with higher bandwidth available for others.
allows this strategy. Traffic Switching is sufficient for this, if
measured path characteristics change enough to justify changing
paths. [Chromium-Multipath] mentioned this strategy at the QUIC
Interim Meeting. [Apple-Multipath] is actually switching paths at
sub-RTT rates.

2.3.3. RTT Difference

Not all multipath environments include paths with significant
differences between path characteristics, but several do. If two or
more paths have characteristics that are "sufficiently close" - for
example, they may have path RTTs that are equivalent, from the
application's point of view - a sender may wish to use both paths as
long as that's the case, and then adopt another forwarding strategy
when measured path characteristics diverge. Traffic Splitting is
required to support this strategy. [Apple-Multipath],
[Sat-Terr-Multipath].[Hybrid-Access-Multipath], and
[Multipath-3GPP-ATSSS] all mentioned this strategy at the QUIC
Interim Meeting.

2.3.4. Active-Standby

The traffic associated with a specific flow will be forwarded via a
specific path (the 'active path') and switched to another path
(called 'standby path') when the active access is unavailable.
Traffic Switching is sufficient to support this strategy.
[Multipath-3GPP-ATSSS] mentioned this strategy at the QUIC Interim
meeting.

2.3.5. Load-Balancing

The traffic associated with a specific connection will be distributed
among the available paths following a distribution ratio (e.g., 30%
via a first access, 70% via a second access). This distribution
ratio may be static, or may be adjusted over time, based on measured
path characteristics. Traffic Splitting is required to support this
strategy. [Multipath-3GPP-ATSSS] mentioned this strategy at the QUIC
Interim meeting.

2.3.6. Priority-based

Paths are assigned priority levels that indicate which path will be
used first. Concretely, the traffic associated with the matching
flow will be steered on the path with a high priority till congestion
is detected, then the overflow will be forwarded over a low priority
access. Traffic Splitting is required to support this strategy.
[Multipath-3GPP-ATSSS] mentioned this strategy at the QUIC Interim
meeting.

2.3.7. Redundant

Traffic is replicated over two or more paths to increase the
probability that the traffic will arrive at the other host undamaged
and usable. Redundant traffic may be used for all packets in a
connection, or may only be used when measured network conditions
indicate it should be used. Traffic Splitting is required to support
this strategy. [Multipath-3GPP-ATSSS] mentioned this strategy at the
QUIC Interim meeting.

3. IANA Considerations

This document does not make any request to IANA.

4. Security Considerations

QUIC-specific security considerations are discussed in Section 21 of
[I-D.ietf-quic-transport].

Section 6 of [I-D.ietf-quic-datagram] discusses security
considerations specific to the use of the Unreliable Datagram
Extension to QUIC.

Some multipath QUIC-specific security considerations can be found in
Section 8 of the individual draft [I-D.deconinck-quic-multipath].

5. Acknowledgements

   I'd like to thank Lars Eggert and Lucas Pardue, the QUIC working
   group chairs, who called the QUIC virtual interim meeting on
   multipath.

   I'd also like to thank the presenters at the QUIC virtual interim,
   who put together valuable presentations on short notice.

   Many thanks to (your name could easily appear here) for reviews and
   comments.

6. Document History

   (Note to RFC Editor - if this document ever reaches you, please
   remove this section)

   Version -00: initial submission

7. Normative References

   [Alibaba-MPQUIC]
              Yanmei Lei / Yunfei Ma, ., "MPQIIC Use Cases", October
              2020, <https://github.com/quicwg/wg-materials/blob/master/
              interim-20-10/MPQUIC%20use%20cases.pdf>.

   [Apple-Multipath]
              Christoph Paasch, ., "Multipath transports at Apple",
              October 2020, <https://github.com/quicwg/wg-
              materials/blob/master/interim-20-10/
              Multipath%20transports%20at%20Apple.pdf>.

   [Chromium-Multipath]
              Fan Yang/Jana Iyengar, ., "Multipath in Chromium", October
              2020, <https://github.com/quicwg/wg-materials/blob/master/
              interim-20-10/Multipath%20in%20Chromium.pdf>.

   [Hybrid-Access-Multipath]
              Olivier Bonaventure, ., "Hybrid access networks and
              requirements on MPQUIC", October 2020,
              <https://github.com/quicwg/wg-materials/blob/master/
              interim-20-10/Hybrid%20access%20networks%20and%20requireme
              nts%20on%20MPQUIC.pdf>.

   [I-D.deconinck-quic-multipath]
              Coninck, Q. and O. Bonaventure, "Multipath Extensions for
              QUIC (MP-QUIC)", draft-deconinck-quic-multipath-06 (work
              in progress), November 2020.

[I-D.ietf-quic-datagram]
          Pauly, T., Kinnear, E., and D. Schinazi, "An Unreliable
          Datagram Extension to QUIC", draft-ietf-quic-datagram-01
          (work in progress), August 2020.

[I-D.ietf-quic-transport]
          Iyengar, J. and M. Thomson, "QUIC: A UDP-Based Multiplexed
          and Secure Transport", draft-ietf-quic-transport-32 (work
          in progress), October 2020.

[Multipath-3GPP-ATSSS]
          Spencer Dawkins / Mirja Kuehlewind / Florin Baboescu /
          Hannu Flinck, ., "Multipath in 3GPP ATSSS", October 2020,
          <https://github.com/quicwg/wg-materials/blob/master/
          interim-20-10/Multipath%20in%203GPP%20ATSSS.pdf>.

[QUIC-charter]
          "IETF QUIC Working Group Charter", n.d.,
          <https://datatracker.ietf.org/wg/quic/about/>.

[QUIC-interim-20-10]
          "IETF QUIC Working Group Virtual Interim Meeting - October
          2020", October 2020, <https://github.com/quicwg/wg-
          materials/tree/master/interim-20-10>.

[QUIC-interim-20-10-minutes]
          "IETF QUIC Working Group Virtual Interim Meeting - October
          2020 - Minutes", October 2020, <https://github.com/quicwg/
          wg-materials/tree/master/interim-20-10>.

[RFC0793] Postel, J., "Transmission Control Protocol", STD 7,
          RFC 793, DOI 10.17487/RFC0793, September 1981,
          <https://www.rfc-editor.org/info/rfc793>.

[RFC8684] Ford, A., Raiciu, C., Handley, M., Bonaventure, O., and C.
          Paasch, "TCP Extensions for Multipath Operation with
          Multiple Addresses", RFC 8684, DOI 10.17487/RFC8684, March
          2020, <https://www.rfc-editor.org/info/rfc8684>.

[Sat-Terr-Multipath]
          Joerg Deutschmann, ., "Satellite/Terrestrial Multipath
          Communication", October 2020, <https://github.com/quicwg/
          wg-materials/blob/master/interim-20-10/Satellite-
          terrestrial%20multipath%20communication.pdf>.

   [TS23501] 3GPP (3rd Generation Partnership Project), ., "Technical
              Specification Group Services and System Aspects; System
              Architecture for the 5G System; Stage 2 (Release 16)",
              2019, <https://www.3gpp.org/ftp/Specs/
              archive/23_series/23.501/>.

Author's Address

   Spencer Dawkins (editor)
   Tencent America

   Email: spencerdawkins.ietf@gmail.com