An update on Path Selection Strategies

(“The Multipath Forward?”)

Two roads diverged in a wood, and I— I took the one less traveled by.

— Robert Frost
Mini-agenda

- “If you don’t have multipath, are you even a transport protocol?”
- RFC 9049 meets “Multipath Extension for QUIC”
- What Spencer thinks we could be looking at, in PANRG
- What Smarter People think we could be looking at, in PANRG
Multipath takes over the Internet? The IETF? TSV?

- SCTP Experimenting with Load Sharing since 2010
- We’ve had Multipath TCP as an Experimental RFC since 2013
- TSVWG adopted Multipath DCCP at IETF 111
- QUIC hummed to adopt Multipath QUIC yesterday (checking on list)

Becoming more common
More deployable
More ambitious
Mini-agenda

● “If you don’t have multipath, are you even a transport protocol?”

● RFC 9049 meets “Multipath Extension for QUIC”

● What Spencer thinks we could be looking at, in PANRG

● What Smarter People think we could be looking at, in PANRG
“Unifying the Multipath extensions”

- **Multipath Extension for QUIC** submitted before IETF 112
  - Roughly the *intersection* of three individual drafts
- **Presented** at IETF 112 QUIC session
- Focus on core components
  - Negotiation
  - Path management
  - Basic scheduling
  - Packet transmission/retransmission

*The draft authors are the experts - this is my summary*
Design Principles

- Reuse as much as possible from RFC 9000
- Path defined as a bidirectional 4-tuple
- Replace path “migration” by path “simultaneous use”
- Add signaling for removal of abandoned paths
- New transport parameter during handshake negotiation (enable_multipath)
- Two new frames (PATH_ABANDON and ACK_MP)
- One remaining decision - One or Multiple Packet Number Space?

The draft authors are the experts - this is my summary
Remember [RFC 9049 Lessons Learned]? 😎

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justifying Deployment ([Section 4.1])</td>
<td>Invariant</td>
</tr>
<tr>
<td>Providing Benefits for Early Adopters ([Section 4.2])</td>
<td>Invariant</td>
</tr>
<tr>
<td>Providing Benefits during Partial Deployment ([Section 4.3])</td>
<td>Invariant</td>
</tr>
<tr>
<td>Outperforming End-to-End Protocol Mechanisms ([Section 4.4])</td>
<td>Variable</td>
</tr>
<tr>
<td>Paying for Path Aware Techniques ([Section 4.5])</td>
<td>Invariant</td>
</tr>
<tr>
<td>Impact on Operational Practices ([Section 4.6])</td>
<td>Invariant</td>
</tr>
<tr>
<td>Per Connection State ([Section 4.7])</td>
<td>Variable</td>
</tr>
<tr>
<td>Keeping Traffic on Fast Paths ([Section 4.8])</td>
<td>Variable</td>
</tr>
<tr>
<td>Endpoints Trusting Intermediate Nodes ([Section 4.9])</td>
<td>Not Now</td>
</tr>
<tr>
<td>Intermediate Nodes Trusting Endpoints ([Section 4.10])</td>
<td>Not Now</td>
</tr>
<tr>
<td>Reacting to Distant Signals ([Section 4.11])</td>
<td>Variable</td>
</tr>
<tr>
<td>Support in Endpoint Protocol Stacks ([Section 4.12])</td>
<td>Variable</td>
</tr>
<tr>
<td>Planning for Failure ([Section 4.13])</td>
<td>Invariant</td>
</tr>
</tbody>
</table>

*Table 1*
How Multipath QUIC looks in RFC 9049 (1)

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Is Spencer concerned (yet)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justifying Deployment</td>
<td>Depends on path selection strategy</td>
</tr>
<tr>
<td>Benefits for Early Adopters</td>
<td>Adoption decision is at endpoints</td>
</tr>
<tr>
<td>Benefits during Partial Deployment</td>
<td>Only endpoints must be upgraded to deploy Multipath QUIC</td>
</tr>
<tr>
<td>Outperforming End-to-End Protocol</td>
<td>Signals used by QUIC, including Multipath QUIC, are E2E</td>
</tr>
<tr>
<td>Paying for Path Aware Techniques</td>
<td>Extensions to RFC 9000 are encrypted - not in invariant fields</td>
</tr>
<tr>
<td>Impact on Operational Practices</td>
<td>Minimal - QLOG may need to be enhanced for multipath</td>
</tr>
<tr>
<td>Per-Connection State</td>
<td>All connection state is in endpoints</td>
</tr>
</tbody>
</table>

**Risk Assessment:**
- **No Problem**
- **Think First**
- **Big Problem**
# How Multipath QUIC looks in RFC 9049 (2)

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Is Spencer concerned (yet)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keeping Traffic on Fast Paths</td>
<td>No impact on any IP header field/extension header field</td>
</tr>
<tr>
<td>Endpoints Trusting Midpoints</td>
<td>Additions to RFC 9000 are encrypted - not in invariant fields</td>
</tr>
<tr>
<td>Midpoints Trusting Endpoints</td>
<td>Additions to RFC 9000 are encrypted - not in invariant fields</td>
</tr>
<tr>
<td>Reacting to Distant Signals</td>
<td>Signals used by QUIC, including Multipath QUIC, are E2E</td>
</tr>
<tr>
<td>Support in Endpoint Stacks</td>
<td>Potential user space stack but scheduling is work in progress</td>
</tr>
<tr>
<td>Planning for Failure</td>
<td>Rich QUIC versioning but need to recognize dysfunction</td>
</tr>
</tbody>
</table>

**No Problem**  **Think First**  **Big Problem**
How Multipath QUIC looks to Spencer

- Really good (especially for a -00 individual draft!)
  - Out of 13 “lessons learned”, $1 + \frac{1}{2} + \frac{1}{2}$ are worth thinking about
  - Neither of the “trust” lessons are relevant - they are big problems
- “Justifying Deployment” does depend on path selection strategy
  - Bandwidth aggregation more motivating than some others
  - Redundancy might work just as well under application control
- “Support in Endpoint Stacks” depends on “advanced scheduling”
  - If “advanced scheduling” isn’t advanced enough, your app has to do it
- “Planning for Failure” depends on knowing when to discard paths

*We should pause for a moment of appreciation*
Mini-agenda

● “If you don’t have multipath, are you even a transport protocol?”

● RFC 9049 meets “Multipath Extension for QUIC”

● **What Spencer thinks we could be looking at, in PANRG**

● What Smarter People think we could be looking at, in PANRG
The Multipath Landscape

- Becoming more common - increasing number of multipath transports
- More deployable - multipath protocols in user space stacks
- More ambitious - not just active/standby or load sharing
- Multipath work in protocol groups (and that’s a good thing)
- Opportunity for common approaches to multipath problems
  - Identifying path failures, address discovery, etc.
- For some problems, that may happen in the IETF
- For other problems, that could happen in PANRG
  - Selecting paths for packets versus selecting paths to achieve a goal
Mini-agenda

- “If you don’t have multipath, are you even a transport protocol?”
- RFC 9049 meets “Multipath Extension for QUIC”
- What Spencer thinks we could be looking at, in PANRG
- What Smarter People think we could be looking at, in PANRG
So, what am I missing?

This is your time to ... have thoughts.
Thank you all!

And please, Make Good Choices

Found something new to say when I leave a room.