Multipath Extension for QUIC

draft-lmbdhk-quic-multipath-00

QUIC session @ IETF-112, Nov 10, 2021

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What happened so far

- QUIC interim meeting Oct 2020 on multipath QUIC use cases
  - [https://datatracker.ietf.org/meeting/interim-2020-quic-02/session/quic](https://datatracker.ietf.org/meeting/interim-2020-quic-02/session/quic)

- QUIC side meeting Oct 18, 2021 on unifying the proposed QUIC extension
  - [https://github.com/mirjak/draft-lmbdhk-quic-multipath/tree/master/presentations](https://github.com/mirjak/draft-lmbdhk-quic-multipath/tree/master/presentations)

- New draft submitted that unifies components of all three previous proposals:
  - draft-deconinck-quic-multipath-07
  - draft-liu-multipath-quic-04
  - draft-huitema-quic-mpath-option-01
Focus on core components
- Negotiation
- Path management (setup/closure)
- Basic scheduling
- Packet transmission and retransmission

Other drafts may cover
- Advanced Scheduling
- Multipath extensions, such as
  - Unidirectional paths
  - Address discovery and selection
Design Principles

● Re-use as much as possible from RFC9000
  ○ Path validation is unchanged
  ○ Per-path congestion control
  ○ Header format is unchanged
  ○ Multipath usage only for 1-RTT packets

● Path is defined as 4-tuple (bidirectional)
  ○ At most one active path/CID per 4-tuple
Changes from RFC9000

- Replace “migration” by “simultaneous use”
  - Sending of non-probing frames on multiple paths
  - Additional signaling for removal of abandoned paths
- Additional considerations on
  - Efficient loss recovery and RTT estimation
  - ACKing and Packet Numbers (see next slides)
Handshake negotiation

New transport parameter: 

<table>
<thead>
<tr>
<th>Option</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0</td>
<td>No multipath support</td>
</tr>
<tr>
<td>0x1</td>
<td>Only support for one PN space</td>
</tr>
<tr>
<td>0x2</td>
<td>Only support for multiple PN spaces</td>
</tr>
<tr>
<td>0x3</td>
<td>Support for both - multiple PN spaces is selected if both endpoint set 0x3</td>
</tr>
</tbody>
</table>

More evaluation and implementation experience needed to select on approach for final publication!
## Use of one or more Packet Number (PN) spaces

### Single PN Space

**Pros**
- Support of zero-length CID allows for minimal transmission overhead
- Implementation complexity: Fewer code changes
- Fewer crypto stack requirements: Does not require 96 bit nonce

**Cons**
- Potential increases ACK size, especially for paths with different latencies
- Higher complexity in packet scheduling and/or ACK logic

### Multiple PN Spaces

**Pros**
- Smaller ACK ranges: Works well, even with large CWND
- No ambiguity about per-path packet loss and RTTs
- Simple logic: Per path version of RFC 9002 algorithms

**Cons**
- Currently requires use of CIDs in both directions
- More code changes needed
Path Management

Path Initiation

- New paths are only initiated by the client
- Use of RFC9000 path validation before non-probing packets can be sent

Path Removal

- New PATH_ABANDON frame indicates to peer that path should not be used anymore
- RETIRE_CONNECTION_ID frames indicates that resources can be released
- Idle timeout also causes path closure and removal of resources
Two new frame types

PATH_ABANDON

- Carries path identifier, error code, and reason phrase
- Three path identifier types to indicate either use of source or destination CID as identifier, or to refer to the current path used
- If CID(s) are used this frame can be sent over any path

ACK_MP (for use with multiple PN spaces only)

- Like ACK frames but additional packet number space identifier
Ready for working group adoption?

- Draft focus on core components only
- Agreement on design principles of all draft authors
- Negotiation option for PN space selection enables experimentation
- Side meeting has indicated interest and planned implementation work