Multi-Path Quic over 5G

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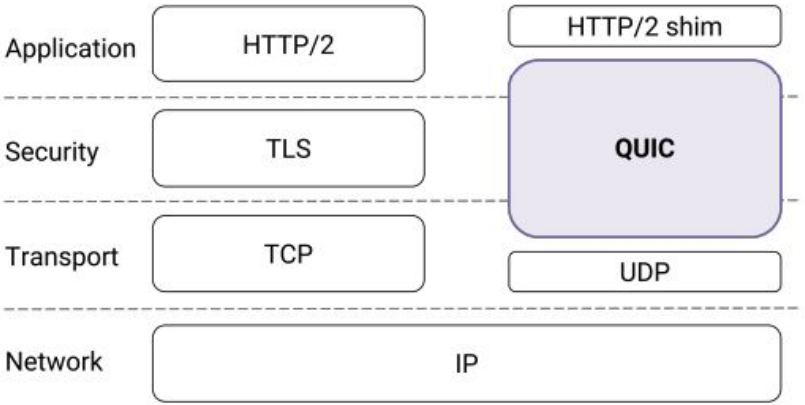
Outline

- What is QUIC
- What is Multi-Path?
- Current QUIC status in 5G
- Why need Multi-Path QUIC in 5G?
- Current Multi-Path QUIC design
- Conclusion

What is QUIC

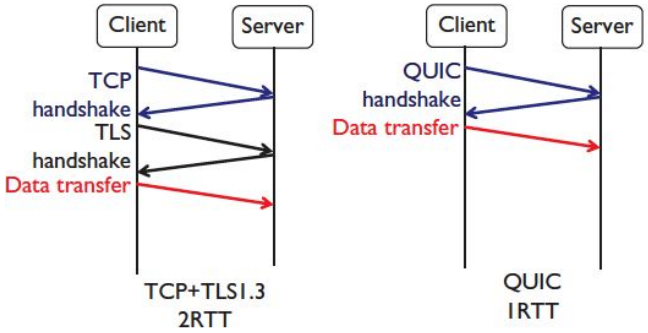
- QUIC is Quick UDP Internet Connections.
- The goal of QUIC:
  - Replaces most of the traditional HTTPS stack: HTTP/2 + TLS + TCP.
- The performance results from Google compare to traditional HTTPS stack
  - Reduces latency of Google Search responses by 8.0% for desktop users.
  - Reduces rebuffer rates of YouTube playbacks by 18.0% for desktop users.



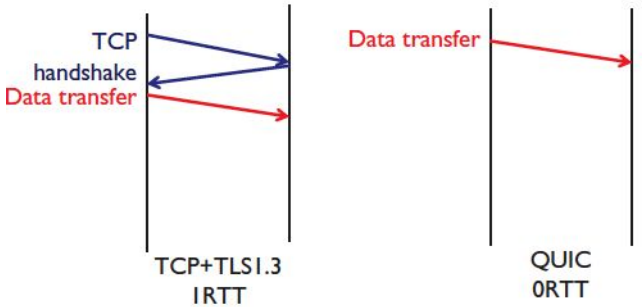
What is QUIC

- Key advantages of QUIC over TCP+TLS+HTTP2
  - Low latency of connection establishment
    - QUIC handshakes frequently require zero roundtrips before sending payload, as compared to 1-3 roundtrips for TCP+TLS

First time connection establishment

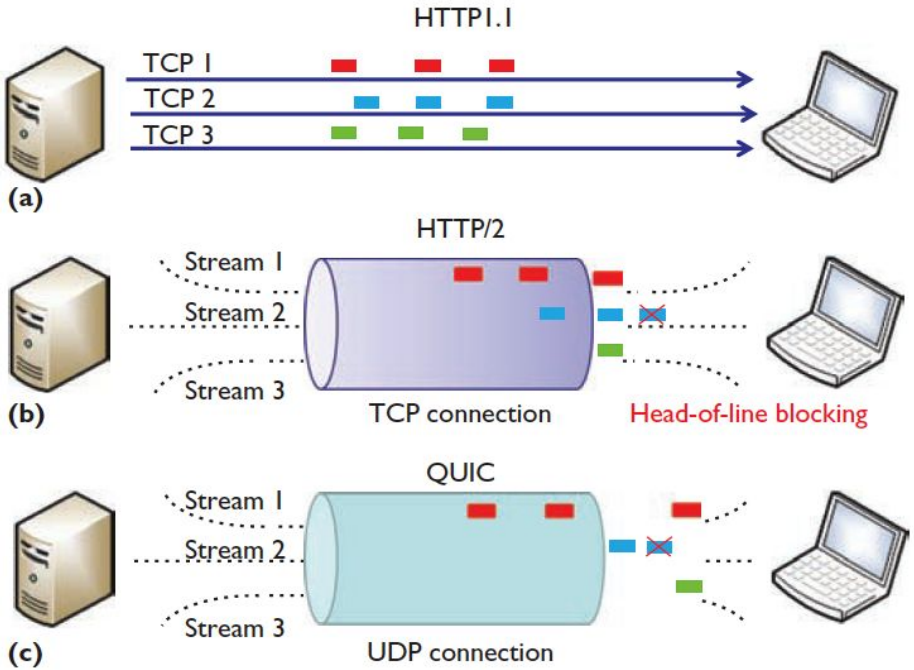


Subsequence connections



What is QUIC

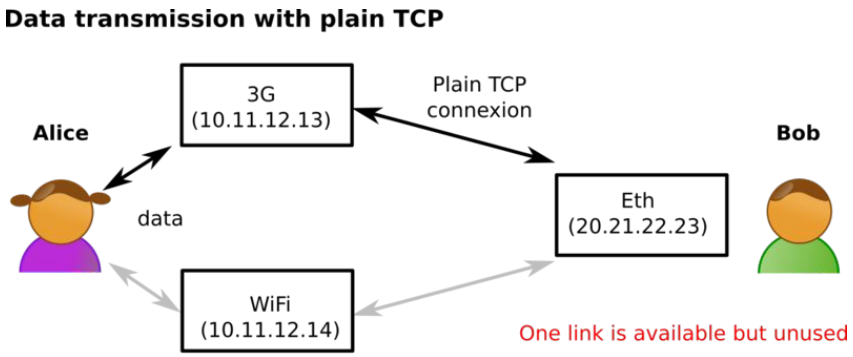
- Key advantages of QUIC over TCP+TLS+HTTP2
  - Support stream multiplexing without head-of-line blocking
    - QUIC use a lightweight data-structuring abstraction,streams, which are multiplexed within a single connection so that loss of a single packet blocks only streams with data in that packet.

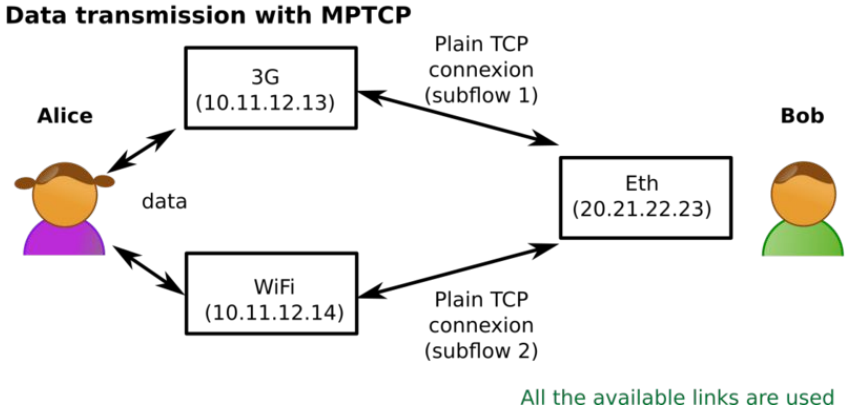


(a) HTTP1.1 (b) HTTP 2.0 (c) QUIC

What is Multipath TCP

- Allows multiple paths to be used simultaneously by a single transport connection.
- Transparently to the application.
  - Original TCP is a single-path protocol
    - When a TCP connection is established, the connection is bound to the IP addresses of the two communicating hosts.
  - Networks today is multipath
    - Mobile devices have multiple wireless interfaces.
    - Data centers have many redundant paths between servers





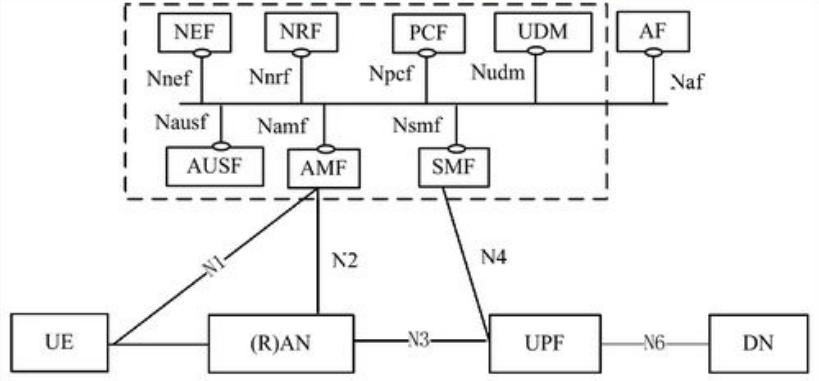
What is Multipath TCP

- Two key benefits of multipath transport
  - To increase the reliability of the connectivity by providing multiple paths, protecting end hosts from the failure of one (seamless handoff)
  - To increase the efficiency of the resource usage, and thus increase the network capacity available to end hosts (sharing load)

Current QUIC Status in 5G

In Technical Specification (TS) 23.501 -- known as System Architecture for the 5G System -- the 3GPP is currently standardizing what is known as the Service-Based Architecture (SBA) for 5G Core. It uses service-based interfaces between control-plane functions, while user-plane functions connect over point-to-point links. This is shown in the figure below. The service-based interfaces will use HTTP 2.0 over TCP in the initial release, with QUIC transport being considered for later releases.

Service-Based Architecture for 5G Core



Source: 3GPP TR 23.501, July 2017, Figure 4.2.3-1

Why need Multipath QUIC in 5G

- 5G has high throughput and low latency requirements.
  - HTTP will need to become more streamlined and lightweight.
- 5G wireless networks comprise a lot of Radio Access Technologies (RATs).
  - Seamless handoff can provide better user experience.
- Solution
  - Using Multipath TCP
    - Load sharing and seamless handoff
  - Using QUIC
    - Have better performance in traditional HTTPS stack.
    - UDP-based, stream-multiplexing, always-encrypted transport protocol focused on minimizing application latency.
    - Provide better end-user experience while accessing web-based services
  - Using Multipath QUIC

Multi-Path QUIC

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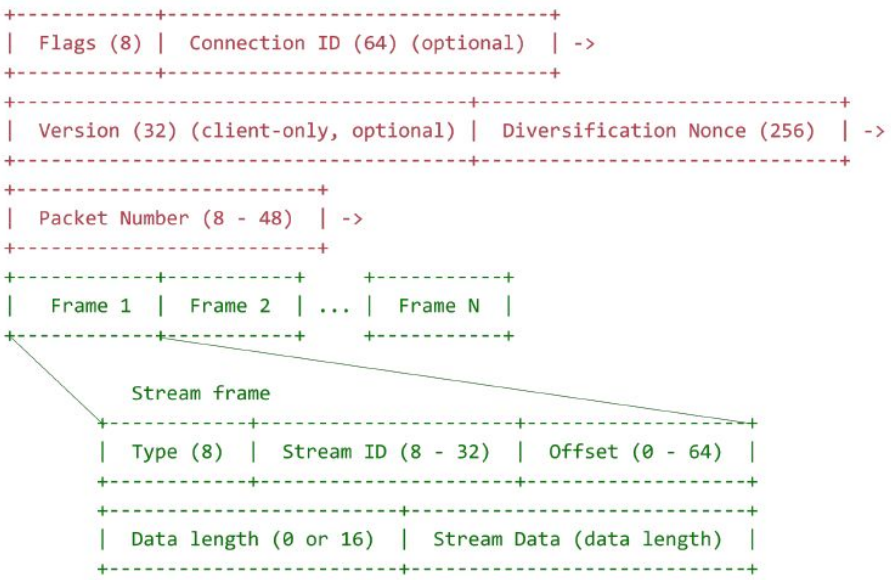
Olivier Bonaventure

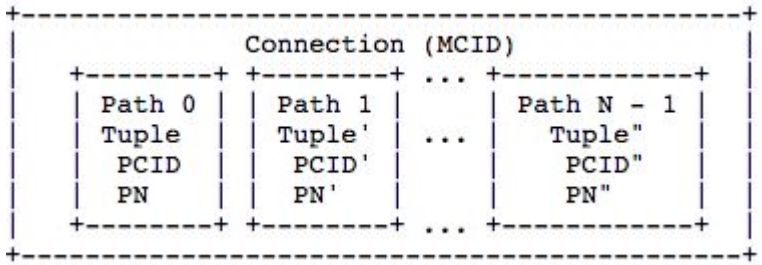
How Does Multi-Path QUIC Work

- How to define the packets belong to the same path
  - UDP : (src ip, src port, dst ip, dst port)
  - QUIC: (QUIC, connection ID)

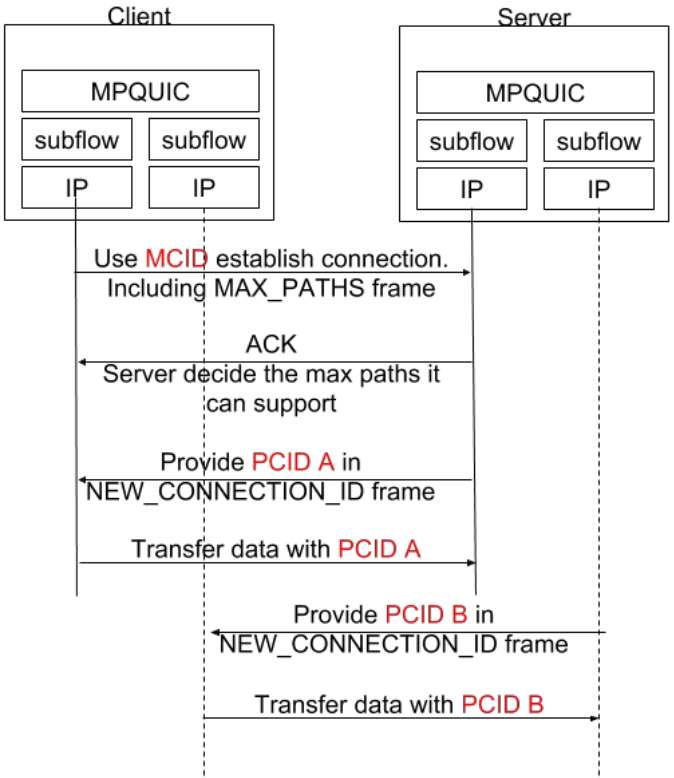


How Does Multi-Path QUIC Work

- Multi-Path QUIC:
  - A logical association between two hosts over which packets can be sent.
  - A path is identified by a Path ID.
- Connection ID
  - MCID: Master Connection ID
    - Uniquely identifies the connection.
  - PCID: Path Connection ID
    - Packets belongs to the same path has the same PCID



How Does Multi-Path QUIC Work



Notes:

1. No need to modify the header
2. Add new control frames, such as MAX_PATHS frame and NEW_CONNECTION_ID frame.

Performance Results

- Experimental design parameters

Figure 2: Simple network with two hosts and disjoint paths.

	Low-BDP		High-BDP	
Factor	Min.	Max.	Min.	Max.
Capacity [Mbps]	0.1	100	0.1	100
Round-Trip-Time [ms]	0	50	0	400
Queuing Delay [ms]	0	100	0	2000
Random Loss [%]	0	2.5	0	2.5

Table 1: Experimental design parameters [37].

Performance Results

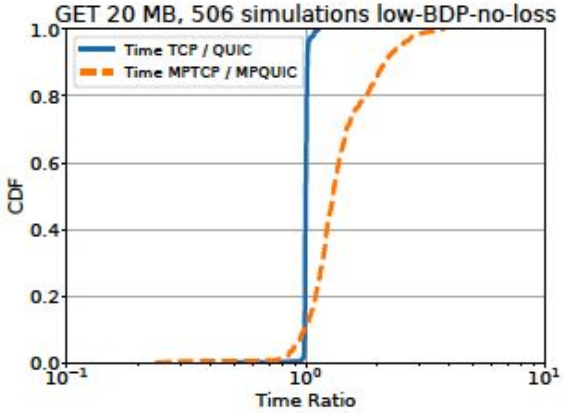


Figure 3: QUIC and TCP exhibit similar performances. On average, Multipath QUIC tends to be faster than Multipath TCP.

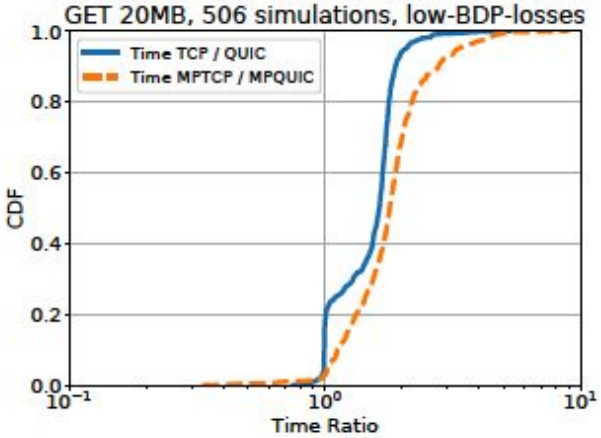


Figure 5: In low-BDP scenarios (Multipath) QUIC reacts faster than (Multipath) TCP to random losses.

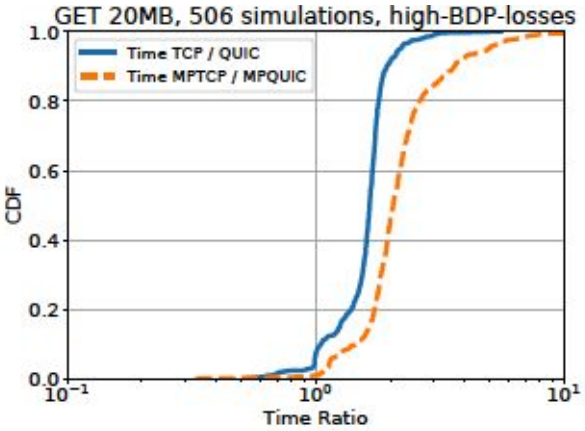
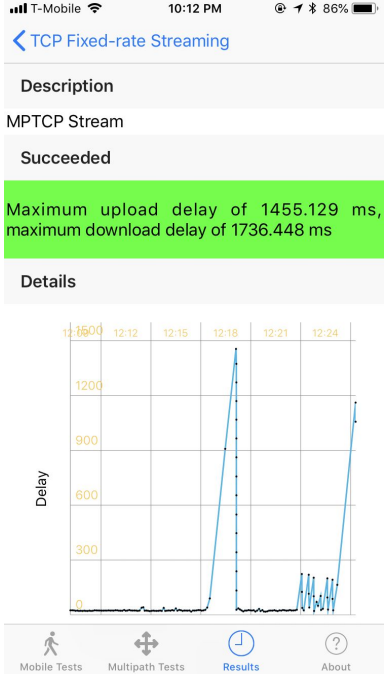
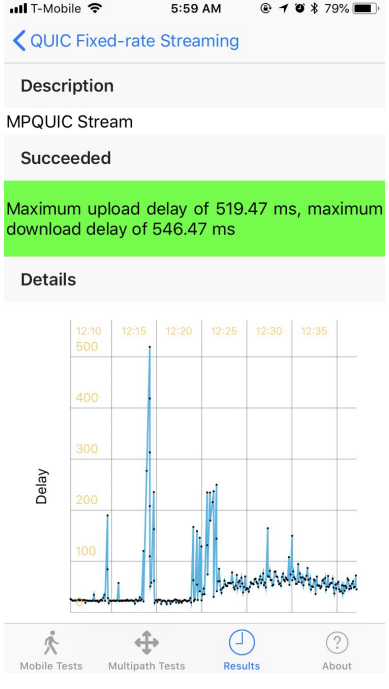


Figure 8: QUIC performs better than TCP in high-BDP environments when there are random losses.

Multi-Path Tester

- An iOS application that uses several network paths such as WiFi and cellular on the iPhone to evaluate MultiPath TCP and MultiPath QUIC





Conclusion

- QUIC is a protocol combines the functions of HTTP/2, TLS, and TCP over UDP, with the goal to reduce the latency of client-server communication.
- Multipath QUIC has better performance comparing to MultiPath TCP no matter in lossy or non-lossy scenarios.
- With Multipath QUIC, it’s more possible to achieve high throughput and low latency goals for web services in 5G environment.

Thank You

Reference

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