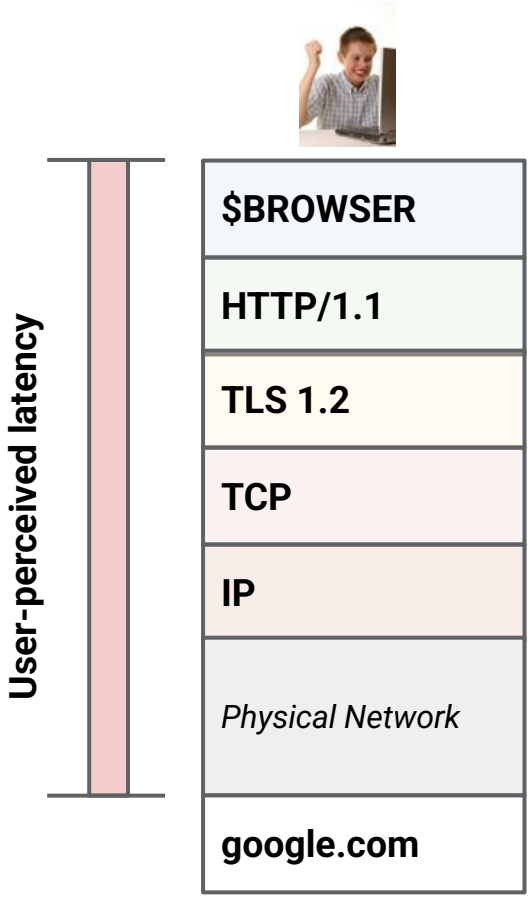
QUIC Protocol

Presenter: AmirMahdi Kousheshi (Dutchman)

How do you make the web faster?



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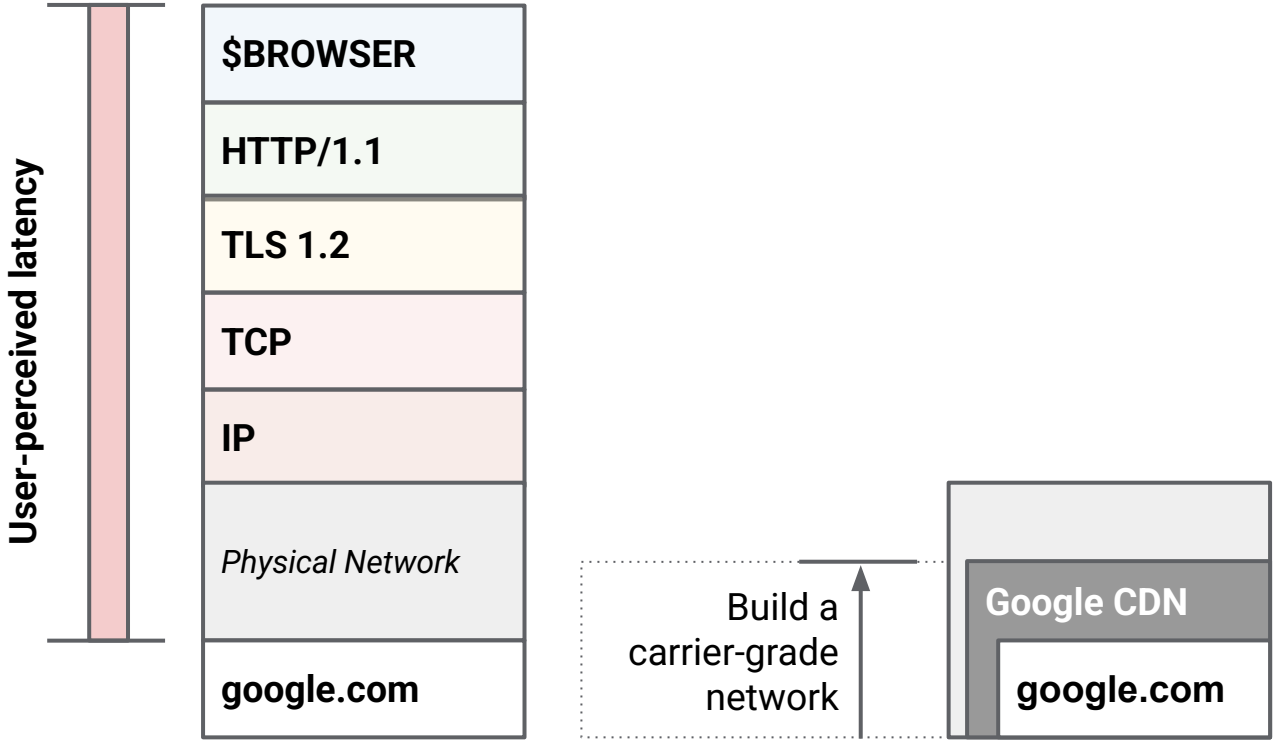

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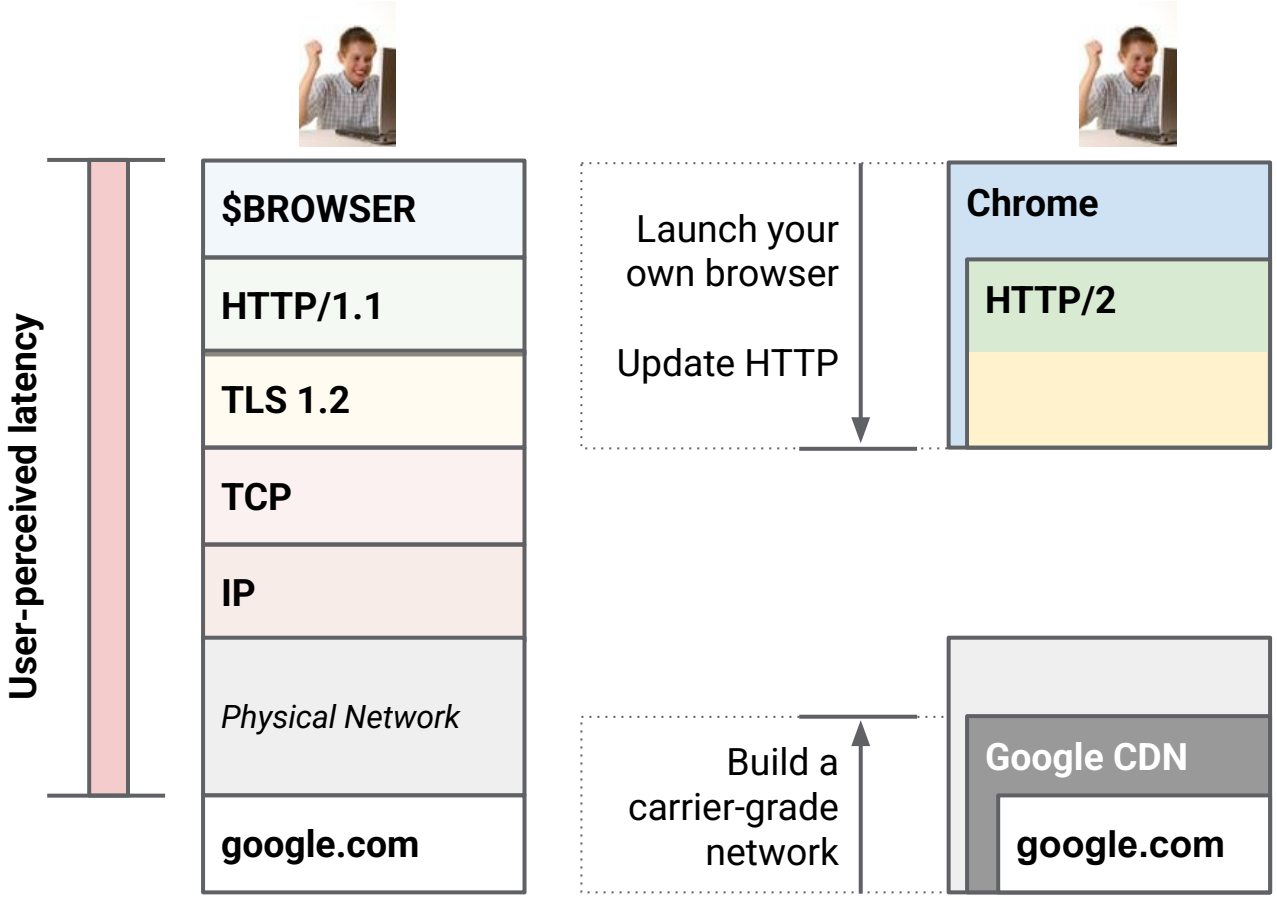

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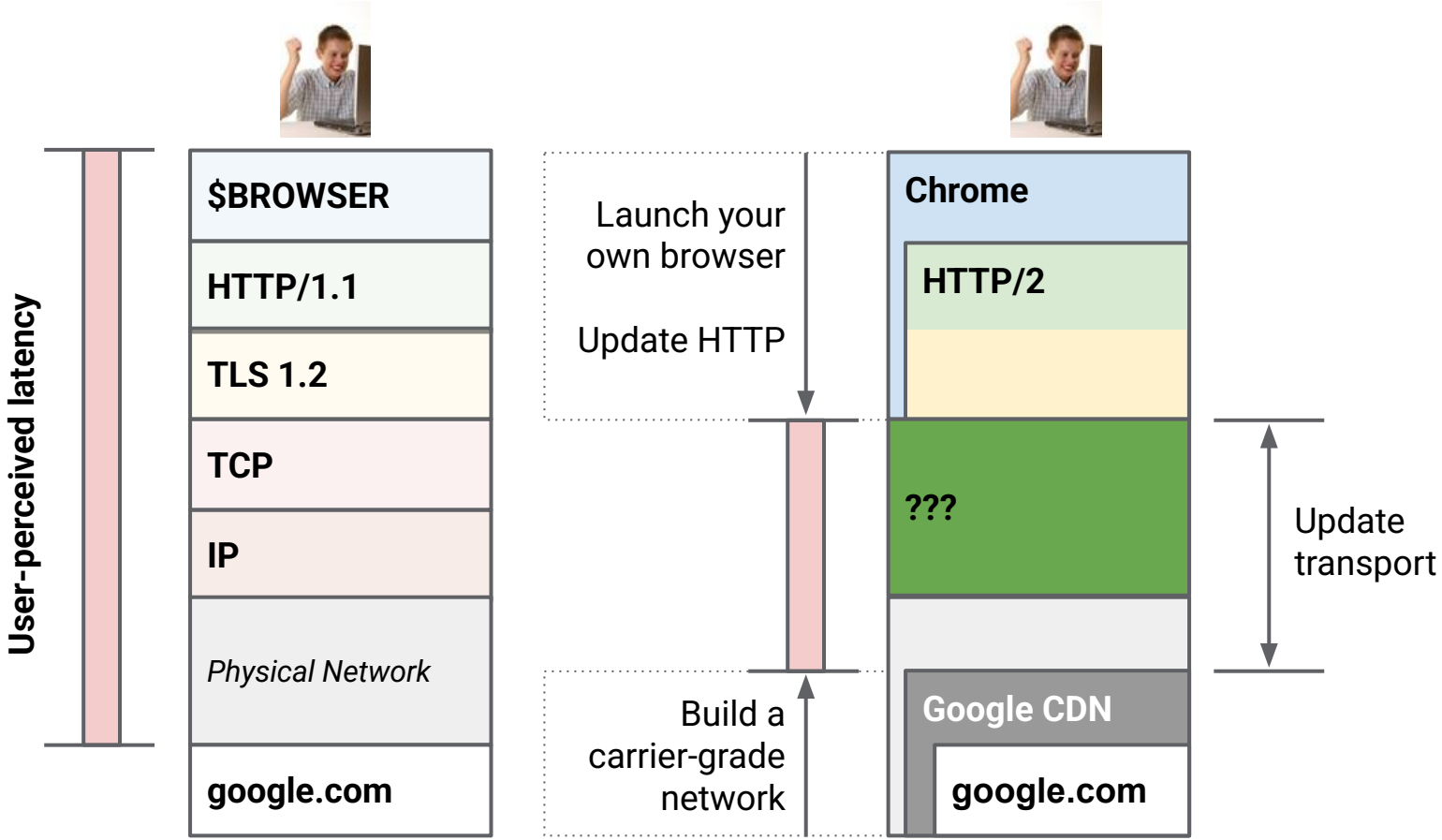


What is QUIC?

QUIC

Quick **U**DP **I**nternet **C**onnections

- A reliable, multiplexed transport over UDP
- Always encrypted
- Reduces latency
- Runs in user-space
- Open sourced in Chromium

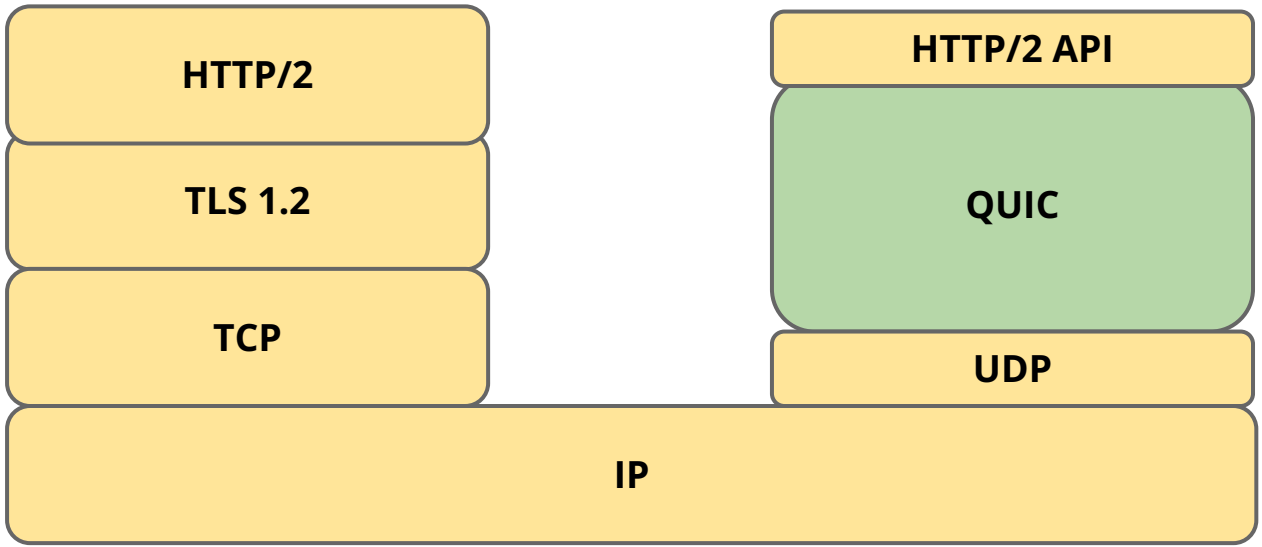
What is QUIC?

New transport designed to reduce web latency

- TCP + TLS + SPDY over UDP
- Faster connection establishment than TLS/TCP
  - 0-RTT usually, 1-RTT sometimes
- Deals better with packet loss than TCP
- Has Stream-level and Connection-level Flow Control
- FEC recovery
- Multipath

*except for HTTP/2 headers, which should be fixed as well.

Where does it fit?



Always encrypted

Comparable to TLS
Perfect forward secrecy, with more efficient handshake

IP spoofing protection
Signed proof of address

Inspired TLS 1.3's 0-RTT handshake
Plan to adopt TLS 1.3 when complete

Connection establishment

Connection identified by Connection ID

- As opposed to common 5-tuple
- 64 bits
- Chosen randomly by the client
- Enables connection mobility across IP, port

0-RTT connection establishment

TCP

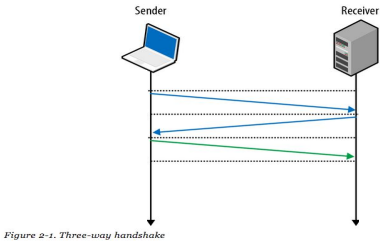
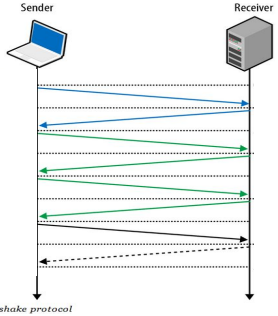


Figure 2-1. Three-way handshake

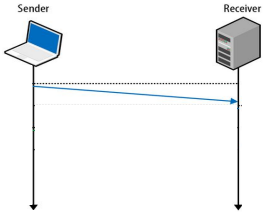
TCP + TLS



2 4-2. TLS handshake protocol

QUIC

(equivalent to TCP + TLS)



First-ever connection - 1 RTT

No cached information available

First CHLO is inchoate (empty)

- Simply includes version and server name

Server responds with REJ

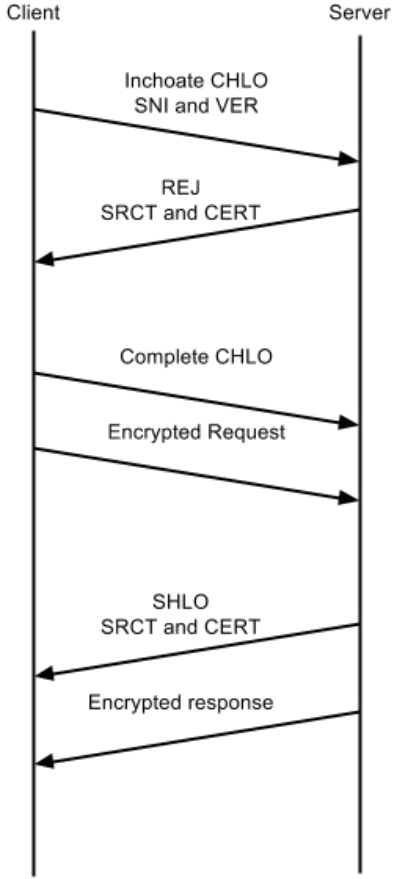
- Includes server config, certs, etc
- Allows client to make forward progress

Second CHLO is complete

- Followed by initially encrypted request data

Server responds with SHLO

- Followed immediately by forward-secure encrypted response data



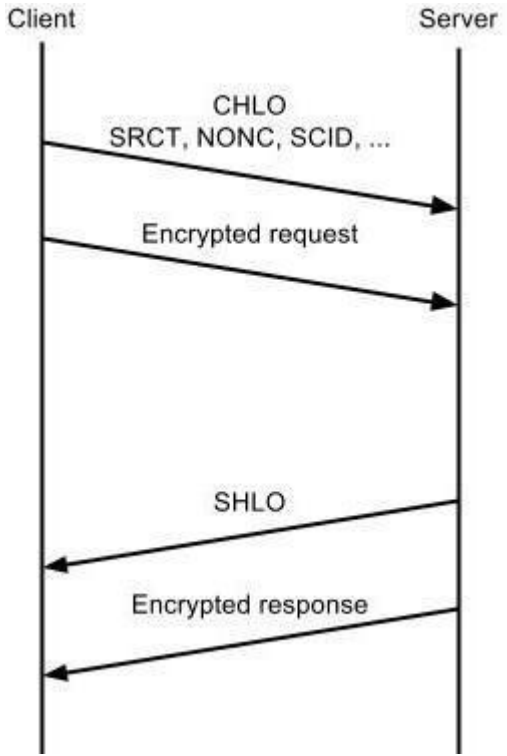
Subsequent connections - 0 RTT

First CHLO is complete

- Based on information from previous connection
- Followed by initially encrypted data.

Server responds with SHLO

- Followed immediately by forward-secure encrypted data



Congestion control & reliability

QUIC builds on decades of experience with TCP

Incorporates TCP best practices

TCP Cubic - fair with TCP

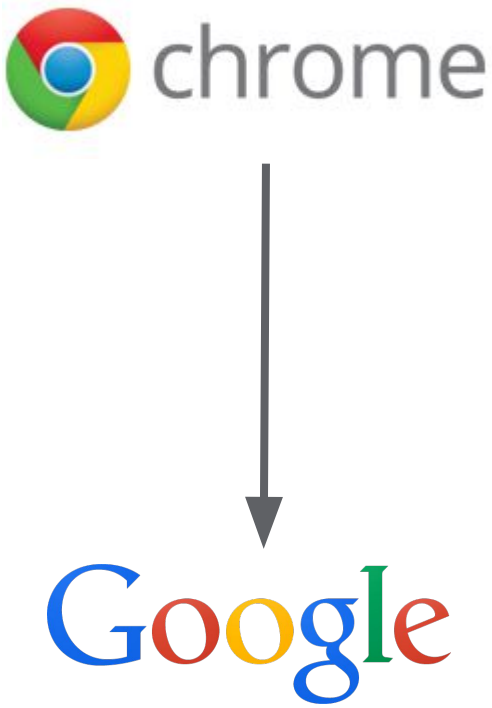
FACK, TLP, F-RTO, Early Retransmit...

More flexibility going forward

Improved congestion feedback, control over acking

Better signaling than TCP

Measuring performance



Controlled Experiments

Client Side
Latency, Bandwidth, Quality of Experience, Errors

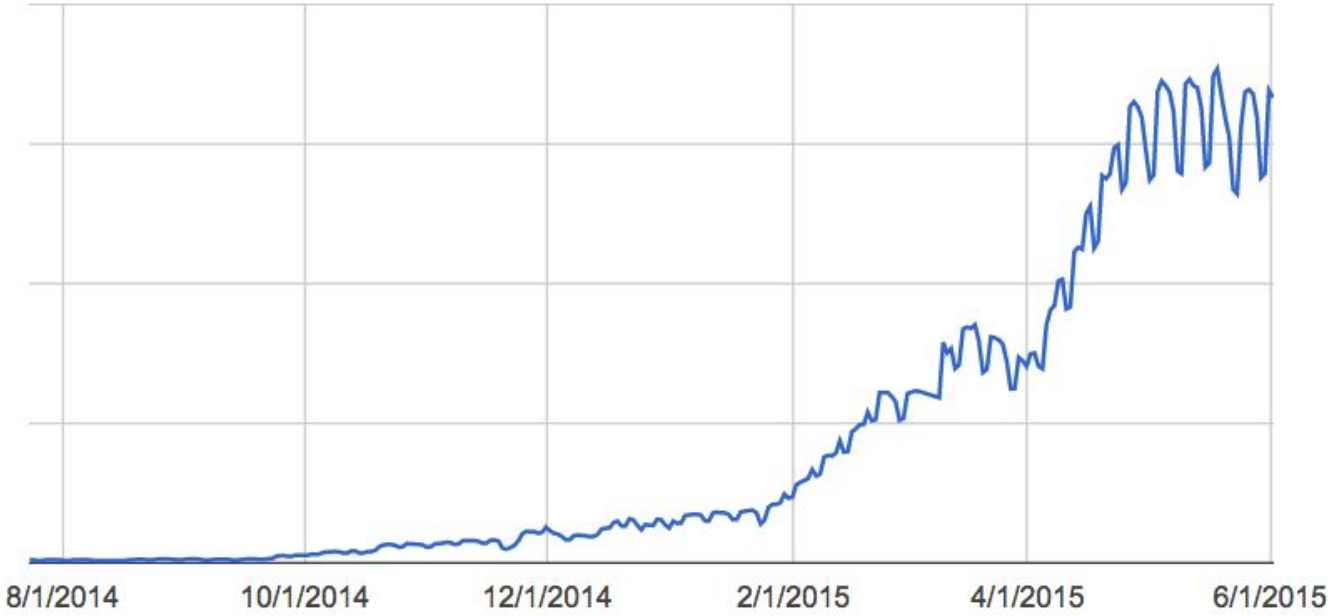
Server Side
Latency, Bandwidth, QUIC Success Rate

Fine Grained Analysis
By ASN, Server, OS, Version

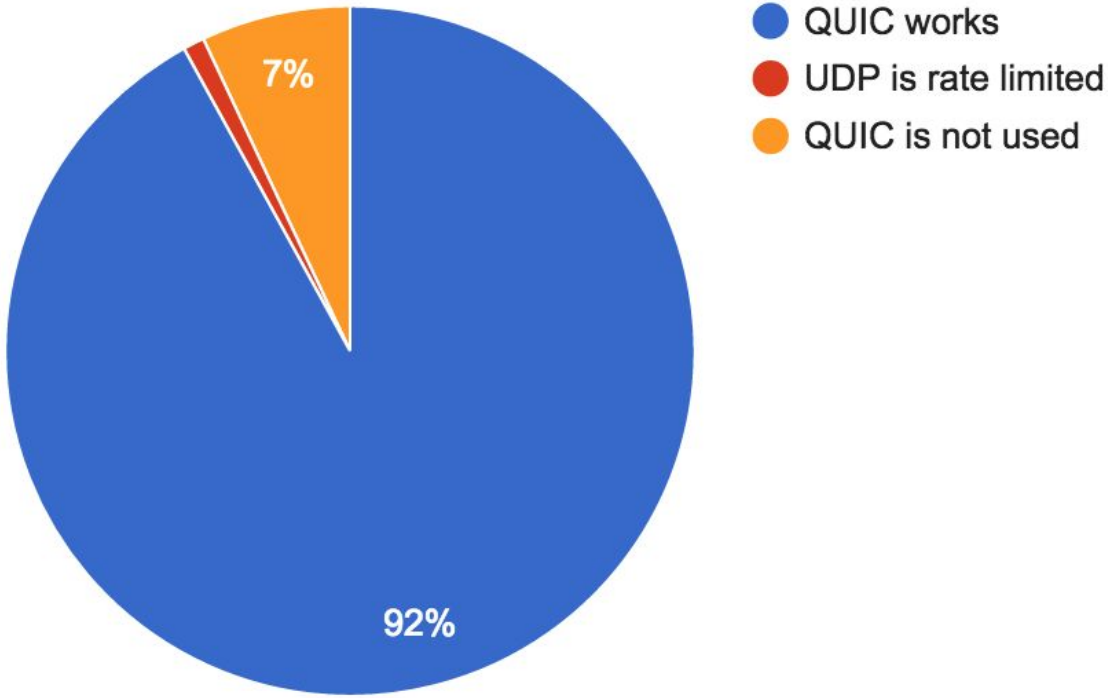
Deployment timeline

Tested at scale, with millions of users

- Chrome Canary: June, 2013
- Chrome Stable: April, 2014
- Ramped up for Google traffic in 2015



QUIC: Does it work?



QUIC handshakes fail when RTTs are greater than 2.5 seconds or when UDP is blocked

Performance on Google properties

Faster page loading times

- 5% faster on average
- 1 second faster for web search at 99th-percentile

Improved YouTube Quality of Experience

- 30% fewer rebuffers (video pauses)

Where are the gains from?

0-RTT

- Over 50% of the latency improvement (at median and 95th-percentile)

Improved loss recovery

- Over 10x fewer timeout based retransmissions improve tail latency and YouTube video rebuffer rates

Other, smaller benefits

- e.g. head of line blocking, more efficient framing

Client-side protection

What if UDP is blocked?

- Chrome seamlessly falls back to HTTP/TCP

What if the path MTU is too small?

- QUIC handshake fails, Chrome falls back to TCP

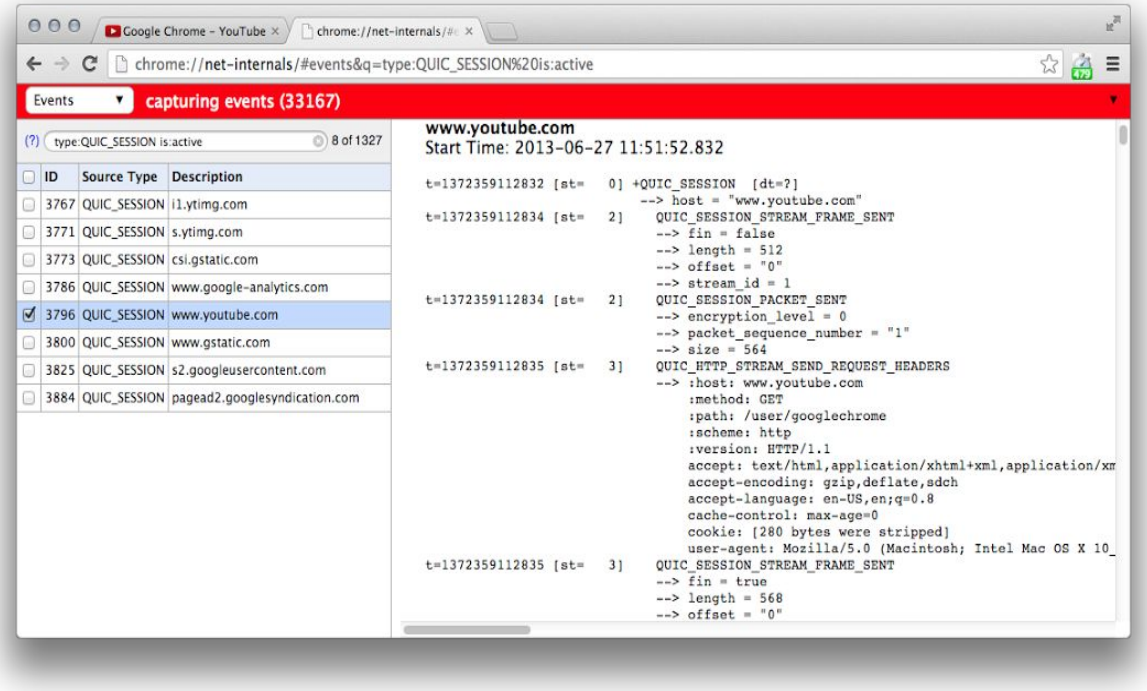
What if a client doesn’t want to use QUIC?

- Chrome flag / administrative policy to disable QUIC

Debugging Tools: Chrome

chrome://net-internals

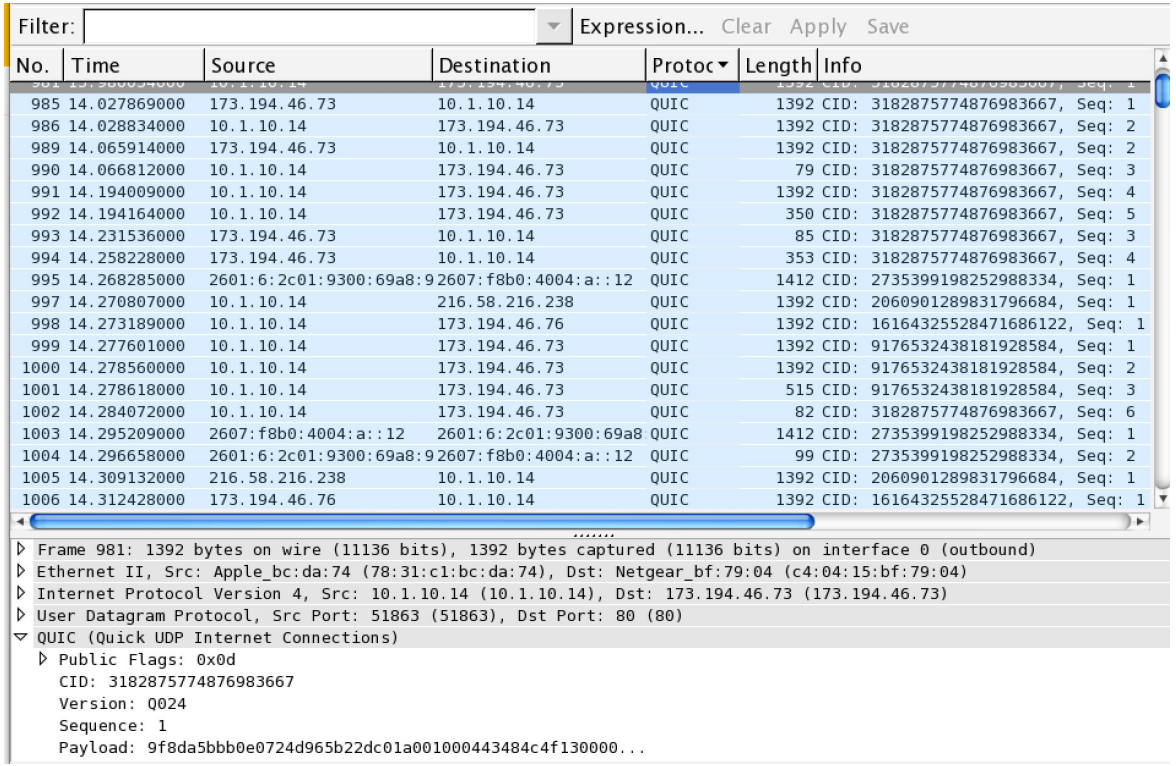
- Active QUIC sessions
- Captures all events
- Important for filing Chromium bugs



Debugging Tools: Wireshark

Parses

- Protocol: QUIC
- CID: Connection ID
- Seq: Sequence number
- Version: ie: Q024
- Public flags: 1 byte
- Payload: Encrypted



Future Improvements

- Forward Error Correction
- Connection Mobility
- Multipath
- More congestion control experiments

Open source implementations

Servers

- Open source test server included in Chromium
- Working with other server vendors

Clients

- Open source Chromium client library for desktop and mobile
- Google Chrome and some Google Android apps
- Working with other browsers

Review: QUIC Summary

- Reliable, multiplexed transport
- Runs over UDP
- Always encrypted
- Lower latency connection establishment
- Optional FEC
- Rapidly evolving user-space implementation
- Open source

QUIC

Source: QUIC in Chromium
Page: www.chromium.org/quic

Any Question?