# The sad reality of QUIC handshakes: How bad configuration leads to delay or DDoS.

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# Recap: RIPE 84 on Monday

# Design goals of QUIC handshakes.

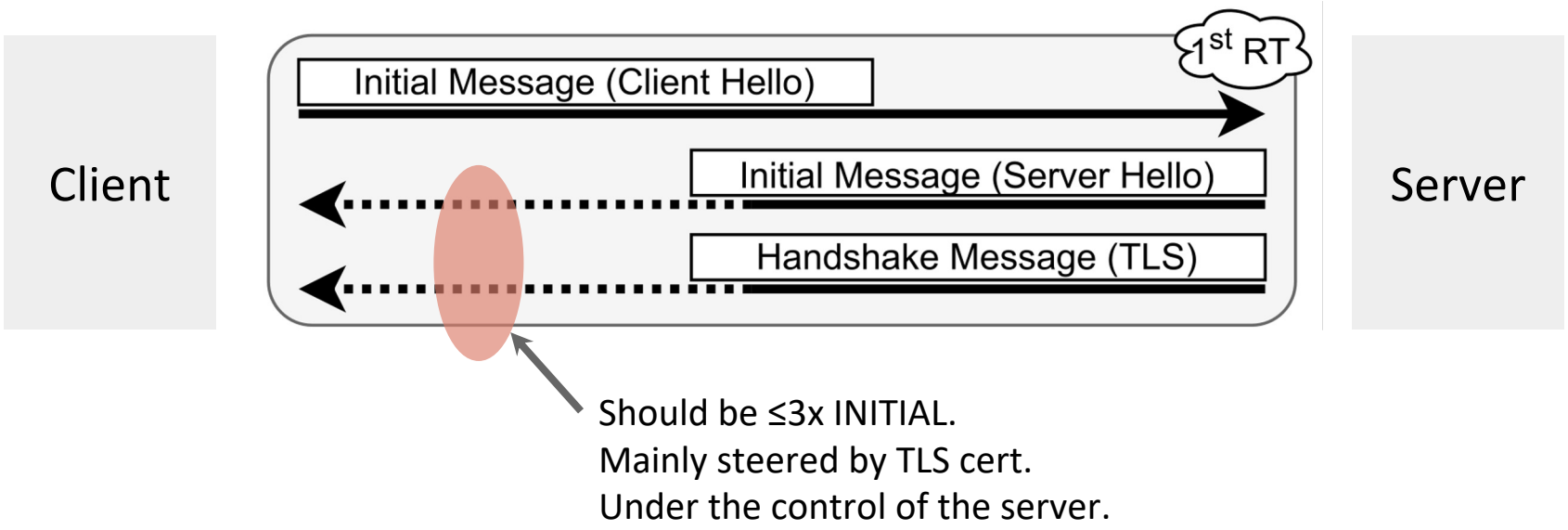
**Reduce round trip times.**

TCP/TLS/HTTP handshakes coalesced into 1RTT.

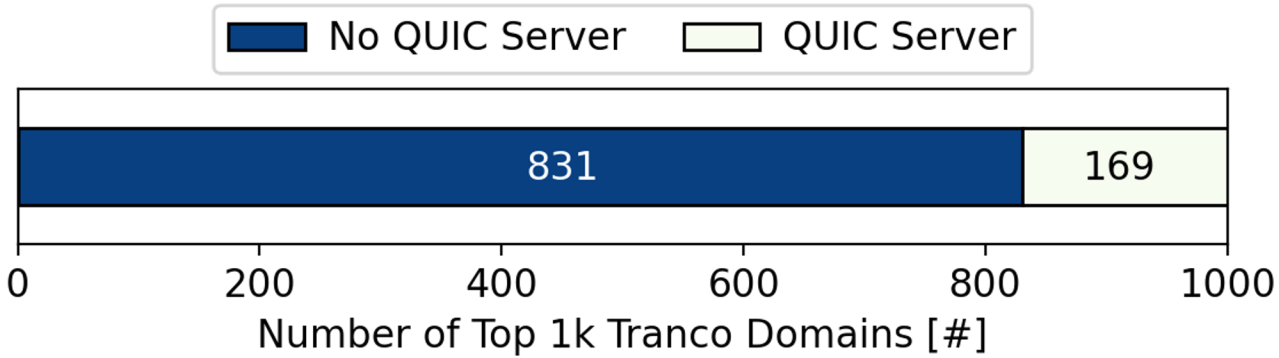
**Prevent UDP amplification attacks.**

RFC limits response size to 3x of an (unauthenticated) request.

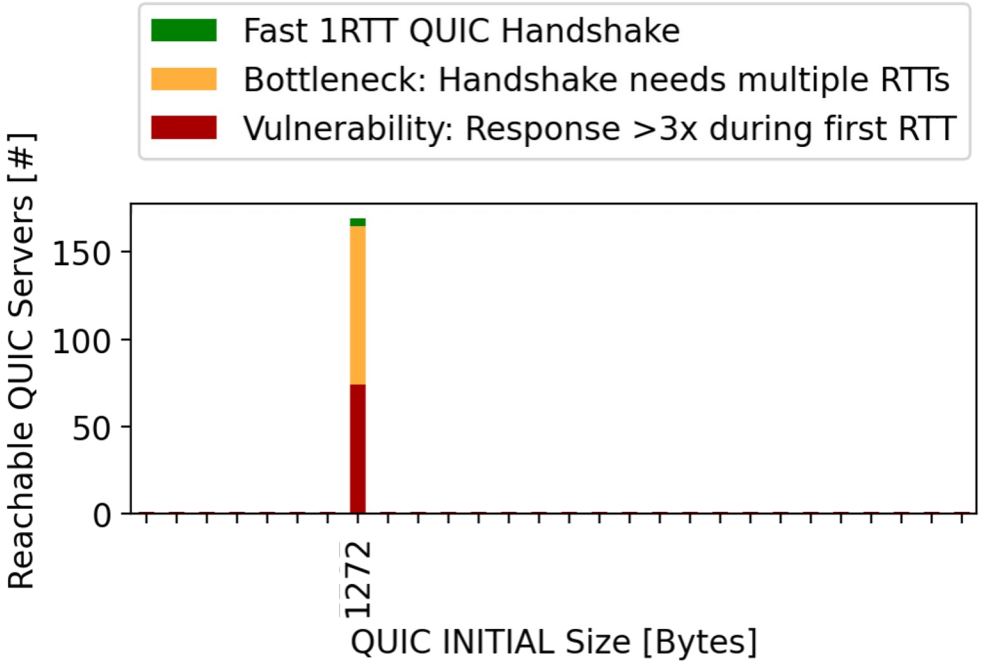
# In practice.


Client
1st RT
Initial Message (Client Hello)
Initial Message (Server Hello)
Handshake Message (TLS)
Server
Should be ≤3x INITIAL.
Mainly steered by TLS cert.
Under the control of the server.

# We actively scanned 1k top domains.



# Have the design goals been met? No!



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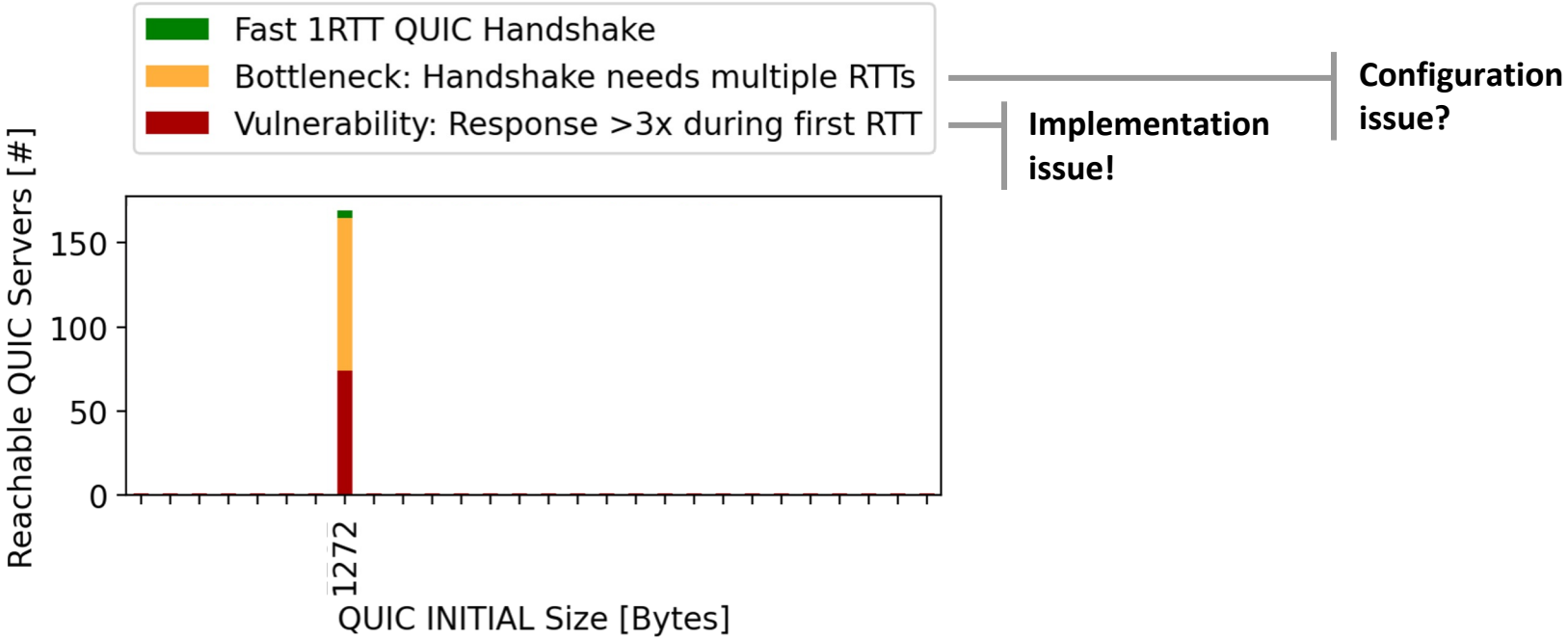
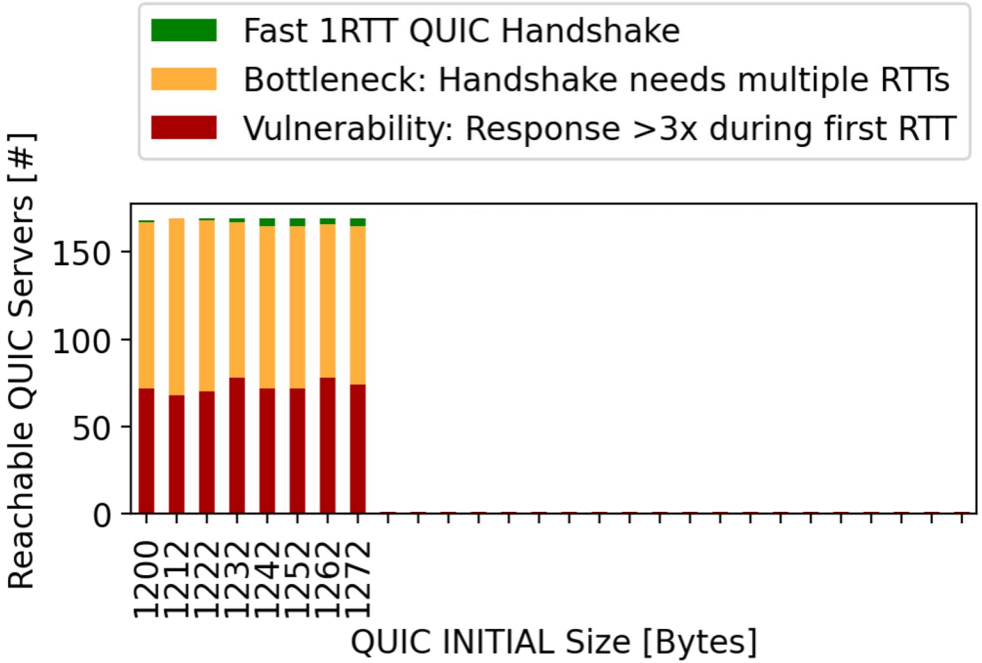
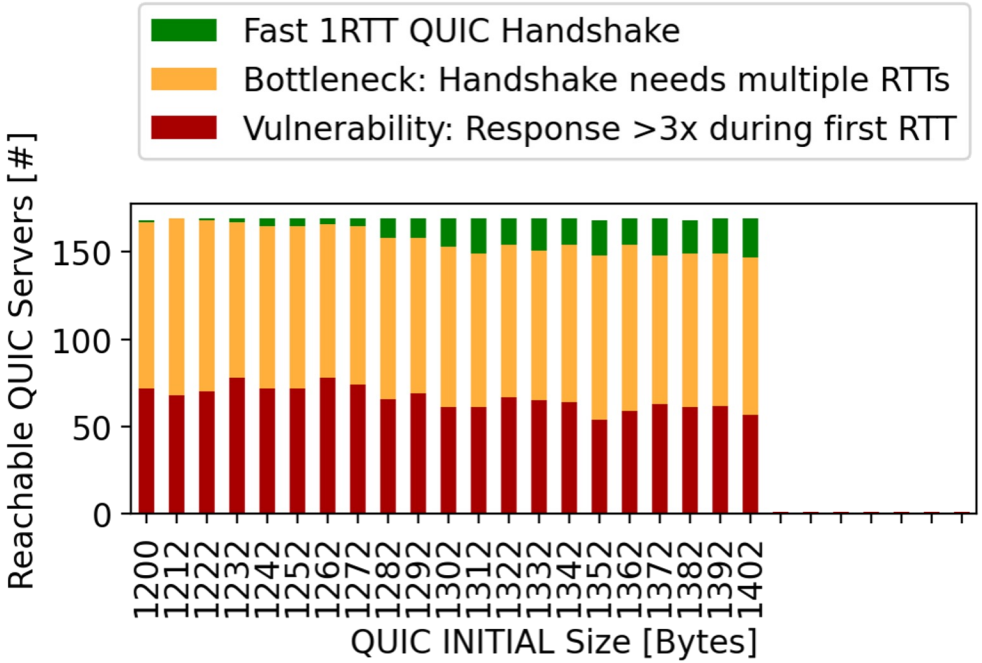


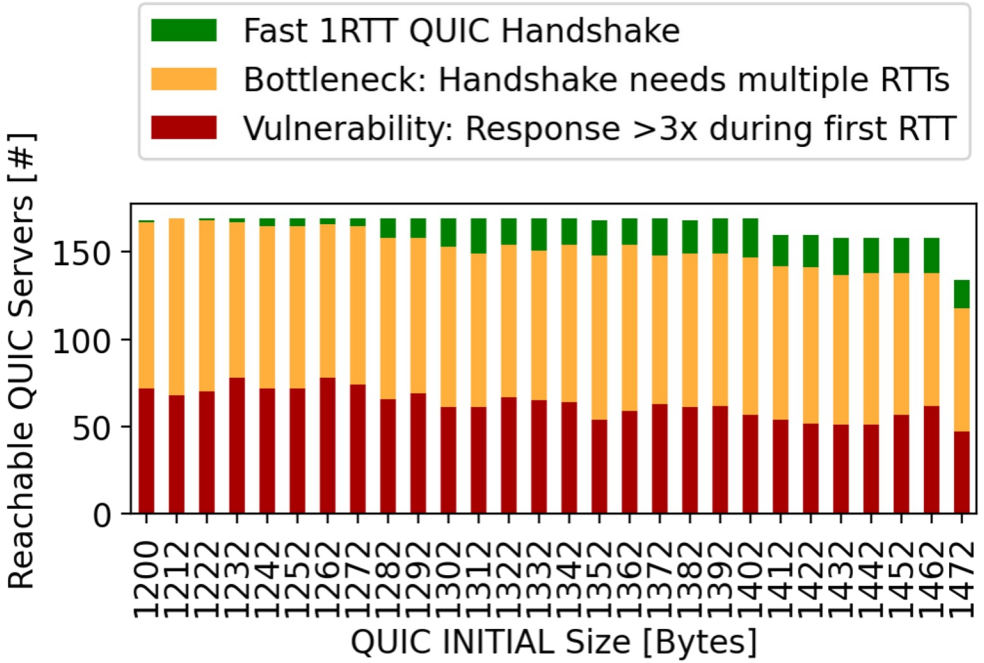
# Small QUIC INITIALs lead to multiple RTTs.



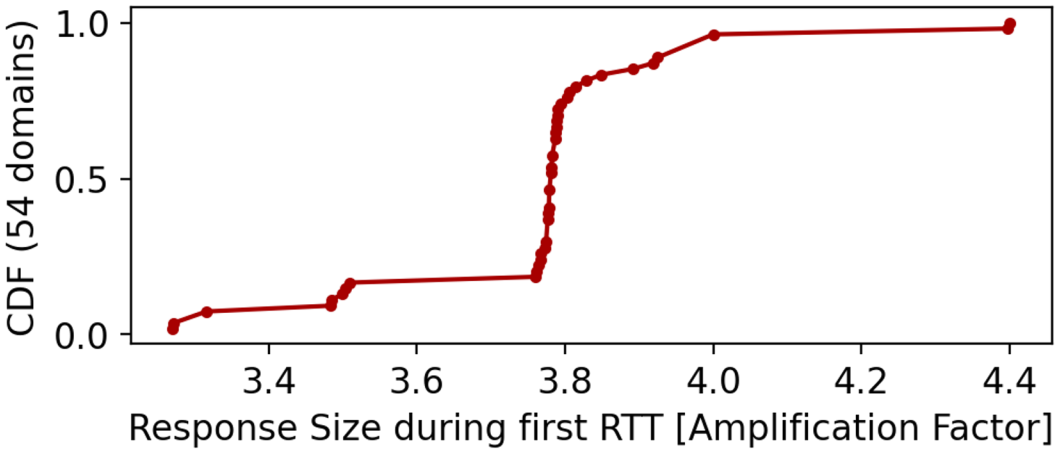
# ~1350 bytes are the sweet spot.



# Larger QUIC INITIALs reduce reachability.



# How bad is the amplification? Not bad.



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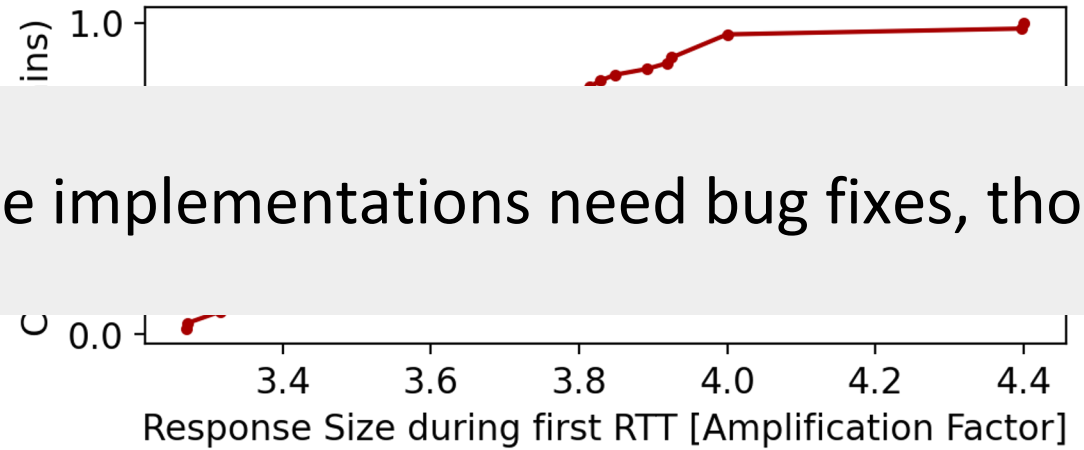



Some implementations need bug fixes, though!

# What causes **multiple RTTs**?

RETRY tokens
(DDoS prevention)

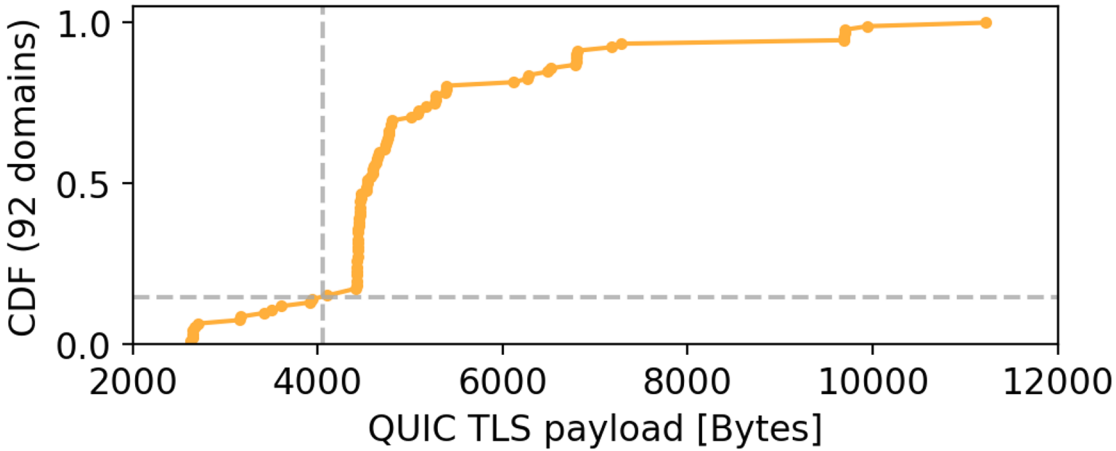
Only 2 domains.

Large TLS certificates
(in conflict with the 3x limit)

The majority!

# 85% of TLS data exceed the 3x threshold!

This causes multiple round trip times.



# What is the best-performing INITIAL size to not induce an additional RTT given current TLS certs?

**Currently, it is ~1350 bytes.**

Trade-off:

Small INITIALs trigger multiple RTTs due to large TLS certificates.

Large INITIALs reduce reachability because QUIC forbids IP fragmentation!

# Recommendations to operators

## if you care about delay and DDoS prevention

1. Reduce the size of your TLS data!
   Be below 3x of common requests to fit into the 1RTT handshake.

2. Activate `RETRY` tokens!
   QUIC INITIAL DDoS floods are a rising threat vector! [ACM IMC'21]
   `RETRY` enables DDoS prevention for ZERO additional cost compared to current deployments (with multiple RTTs).

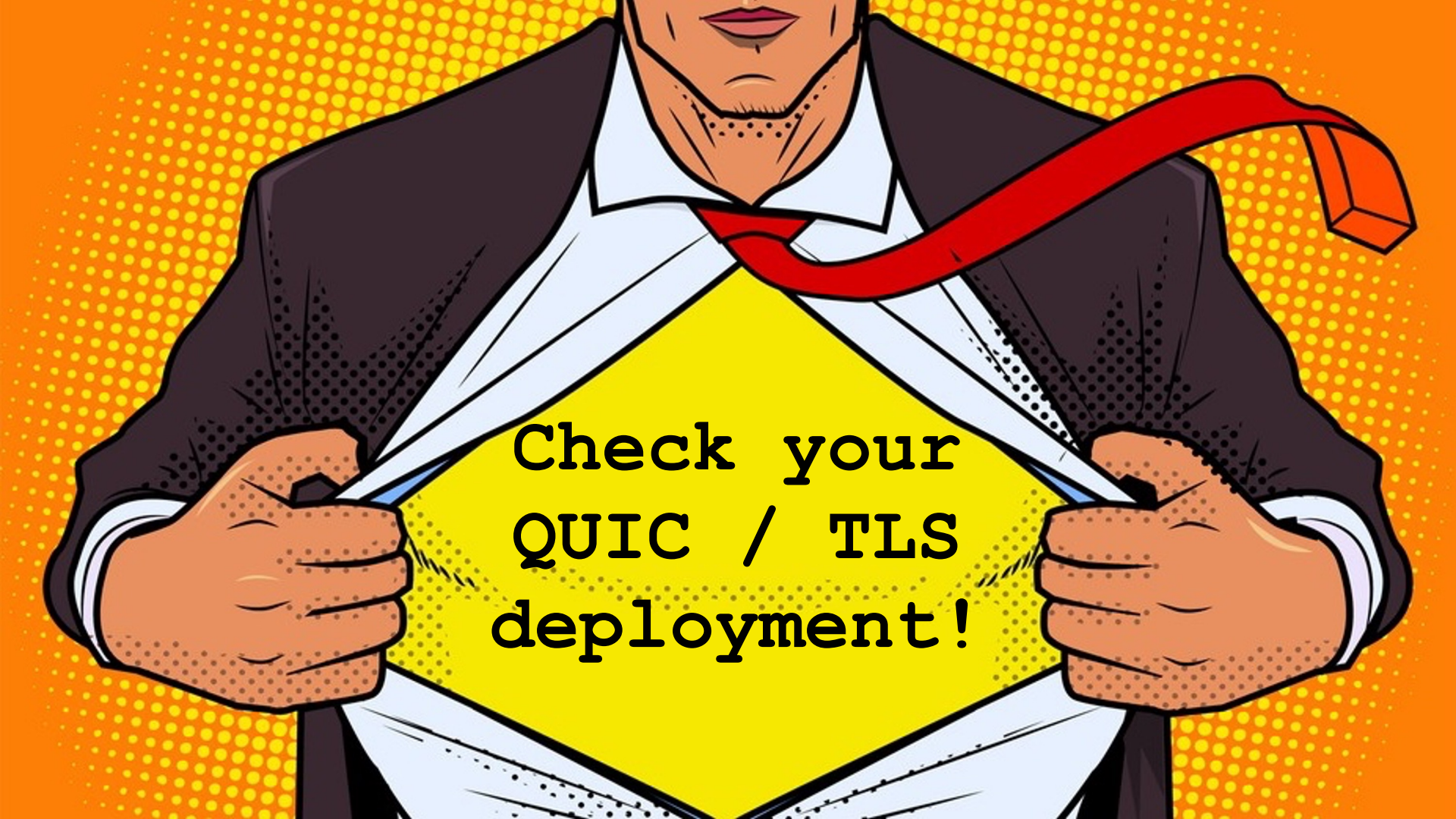
# Test your QUIC server today! An open source tool.

```
> quicreach google.com
Success
```

```
> quicreach example.com
Failure
```

```
> quicreach '*' --stats
                        SERVER          RTT        TIME_I        TIME_H              SEND:RECV
              quic.aiortc.org    102.082 ms    106.934 ms    240.379 ms    4:5 2523:4900 (1.9x)
             ietf.akaquic.com     98.277 ms    100.906 ms    201.243 ms    3:5 2480:5869 (2.4x)
                quic.ogre.com
```

https://github.com/microsoft/quicreach


Check your
QUIC / TLS
deployment!

# Backup

# Are you saying we should increase the 3x limit?

**No.**

Let’s first find out what a space-efficient but secure TLS config looks like.

The 3x limit could encourage optimal configs.

# How can you decrease your TLS data size?

1. Use algorithms with smaller signature footprint (elliptic instead of RSA).
2. We observe certificates with a long list of Subject Alt Names (SANs), reduce them!
3. This is a joint effort due to certificate chains.

# Load balancers also add bloat!

We are scanning top domains with a very large user base. → Load balancers.

Packet encapsulation is used between L4 and L7 load balancers (+20 bytes).

# RFC 9000 and the 3x threshold for unvalidated clients

**8.1. Address Validation during Connection Establishment**

*Prior to validating the client address, servers MUST NOT send more than three times as many bytes as the number of bytes they have received.*

**17.2.5. Retry Packet**

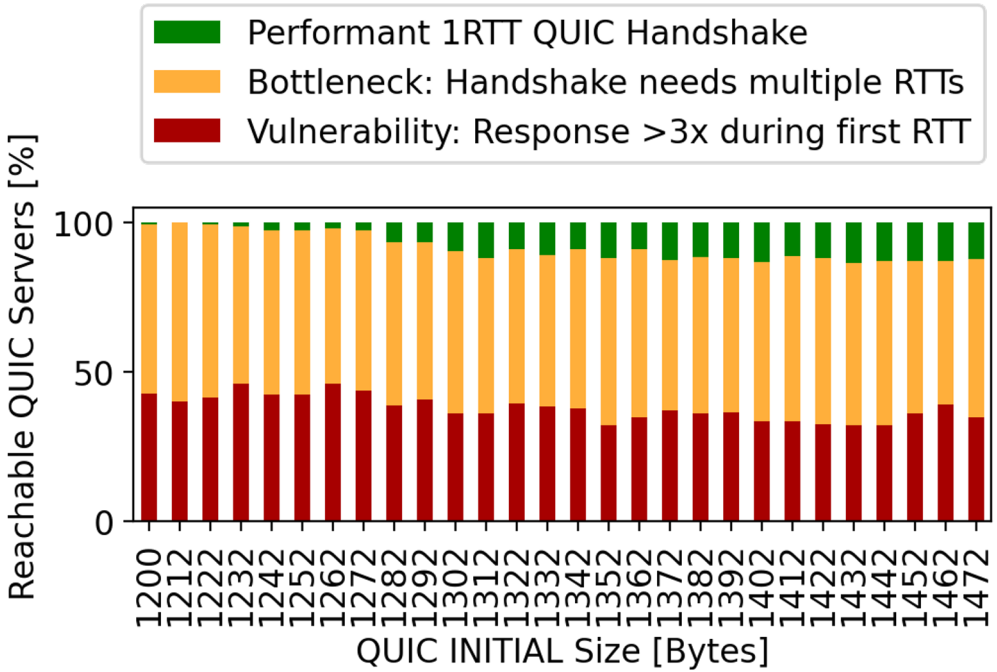
*An opaque token that the server can use to validate the client's address.*

# RFC 9000 and IP fragmentation

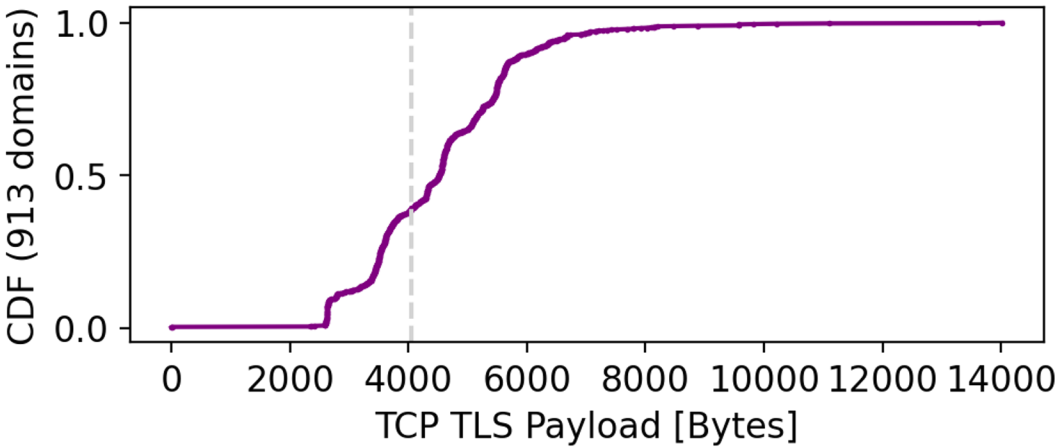
**14. Datagram Size**

*UDP datagrams MUST NOT be fragmented at the IP layer. In IPv4 [IPv4], the Don't Fragment (DF) bit MUST be set if possible, to prevent fragmentation on the path.*

# QUIC INITIALS (relative).



# >50% of 1k top domains have large TLS certificate data!



# QUIC vs TCP certificate data.

TLS data received over QUIC or TCP has roughly the same size.

We observe ~100 bytes more with QUIC.