QUIC und HTTP/2 — neue Internet Protokolle

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mami
measurement and architecture for a middleboxed internet

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Short Bio — Mirja Kühlewind

- Senior researcher at **Eidgenössische Technische Hochschule (ETH) Zürich** since 2014
  - PhD on TCP congestion control at University of Stuttgart in 2015
  - Dipl.-Ing. in Informations- und Kommunikationstechnik at Friedrich-Alexander-University Erlangen-Nürnberg in 2009
- **Internet Engineering Task Force (IETF)** Area Director for the transport area since 2015
  - Co-chair of the Internet Research Task Force (IRTF) Measurement and Analysis for Protocols Research Group (MAPRG)
  - Previously (till March 2015) co-chair IETF rmcat and tcpinc working groups
  - Author of multiple RFCs, e.g. LEDBAT (RFC6817) and ConEx (RFC7786, RFC7837)
- Project coordinator of the EU H2020 **Measurement and Architecture for a Middlebox'ed Internet (MAMI) project**
  - See mami-project.eu
  - Twitter: @mamiproject

Overview
QUIC

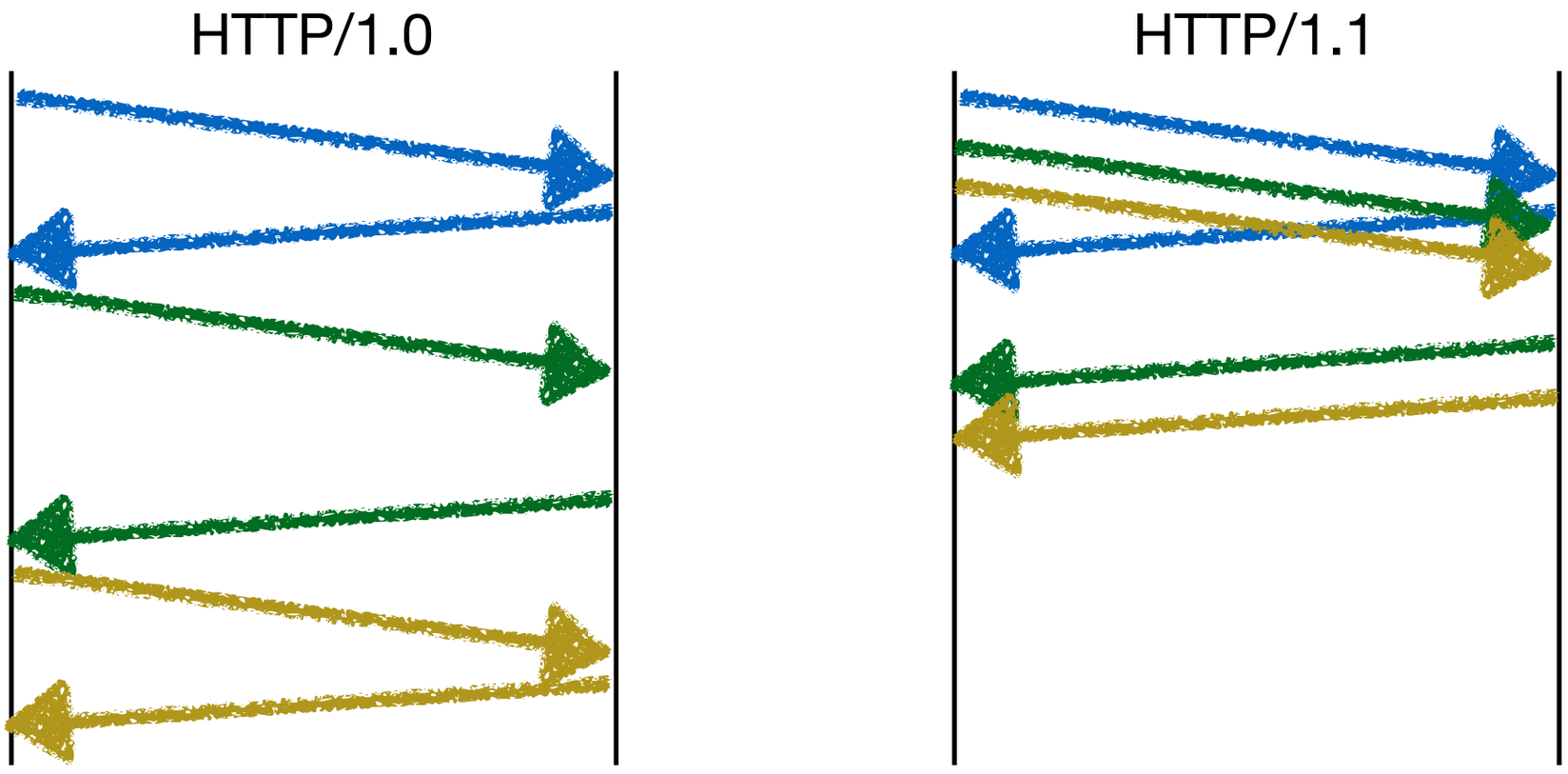
- New transport protocol, e.g. an alternative to TCP
- Currently under standardization in the IETF (since Nov’16)
- Optimized for HTTP and latency reductions
- Originally developed by Google together with SPDY
- Designed to be implemented in user space, e.g. in your browser

Overview HTTP/2

- Published as IETF RFC7540 in May 2015
- HTTP/2 is based on SPDY as originally proposed by Google
- About 250K domains support HTTP/2[1)]
  - Deployment driven by big hosting providers
- New features to reduce latency of page load time
  - Header compression (HPACK)
  - Server Push
  - Multiplexing of multiple requests over 1 TCP connection

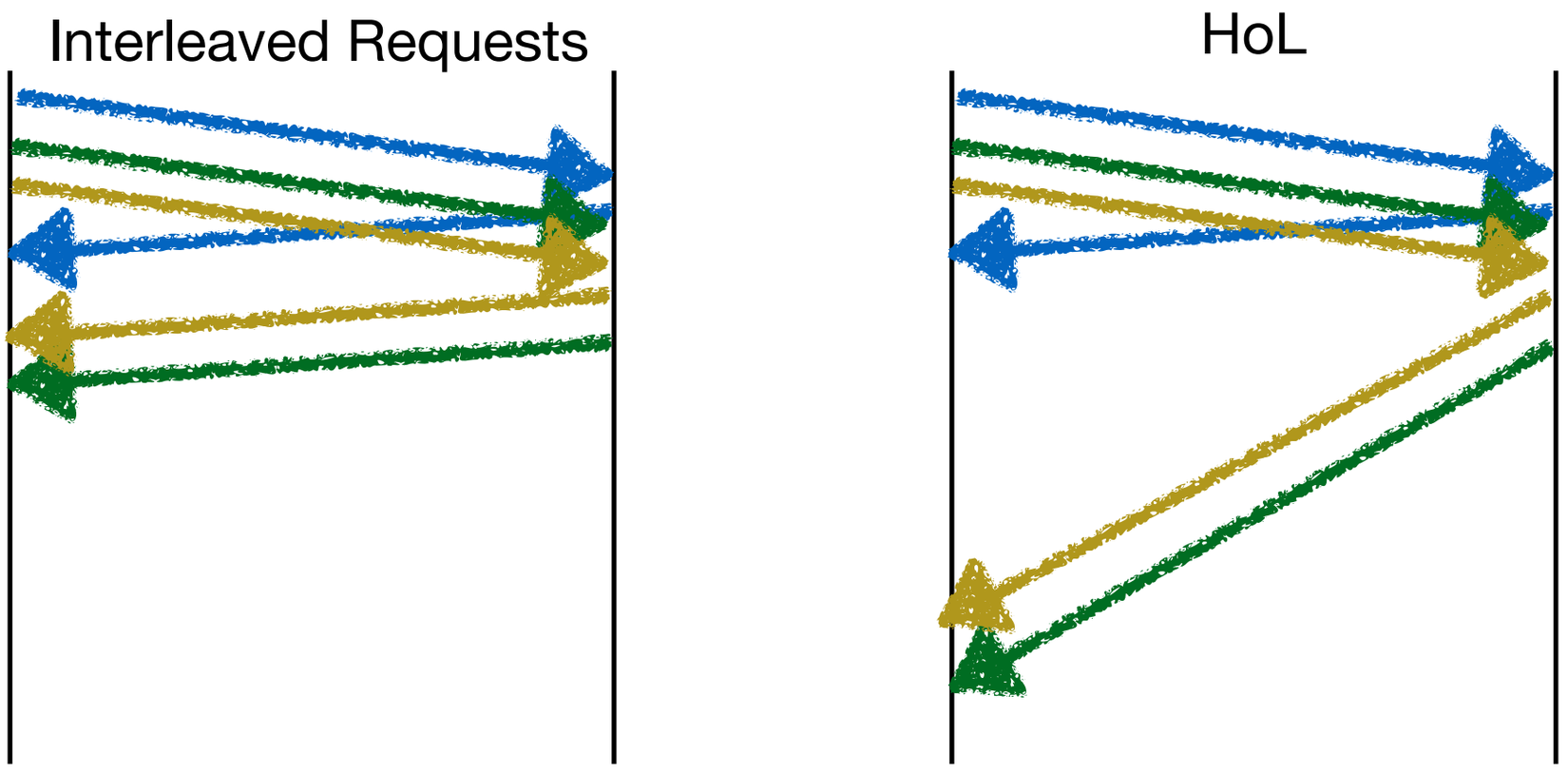
1) e.g. see isthewebhttp2yet.com

HTTP/1.1 — Pipelining



- With pipelining multiple requests can be sent at once
  - ➡ All requests and responses can be sent over the same TCP connection

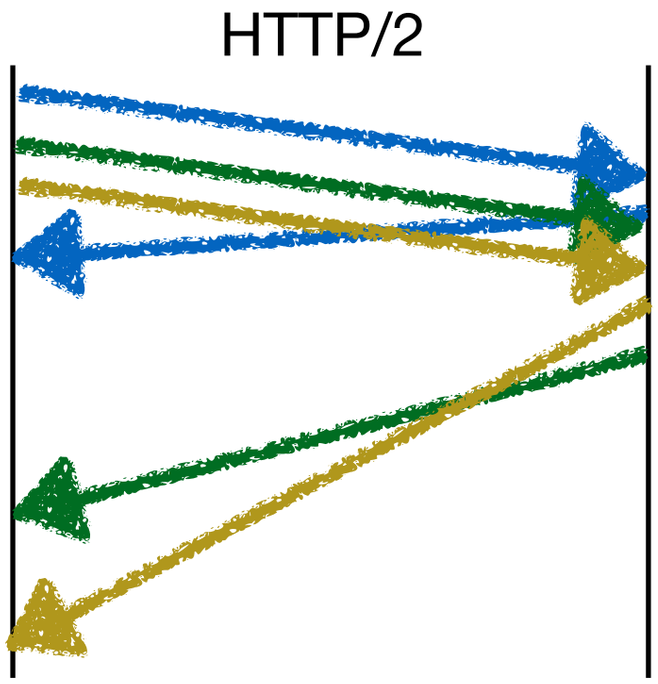
HTTP — Head of Line Blocking (HoL)



- Large resources can delay later, more important resources

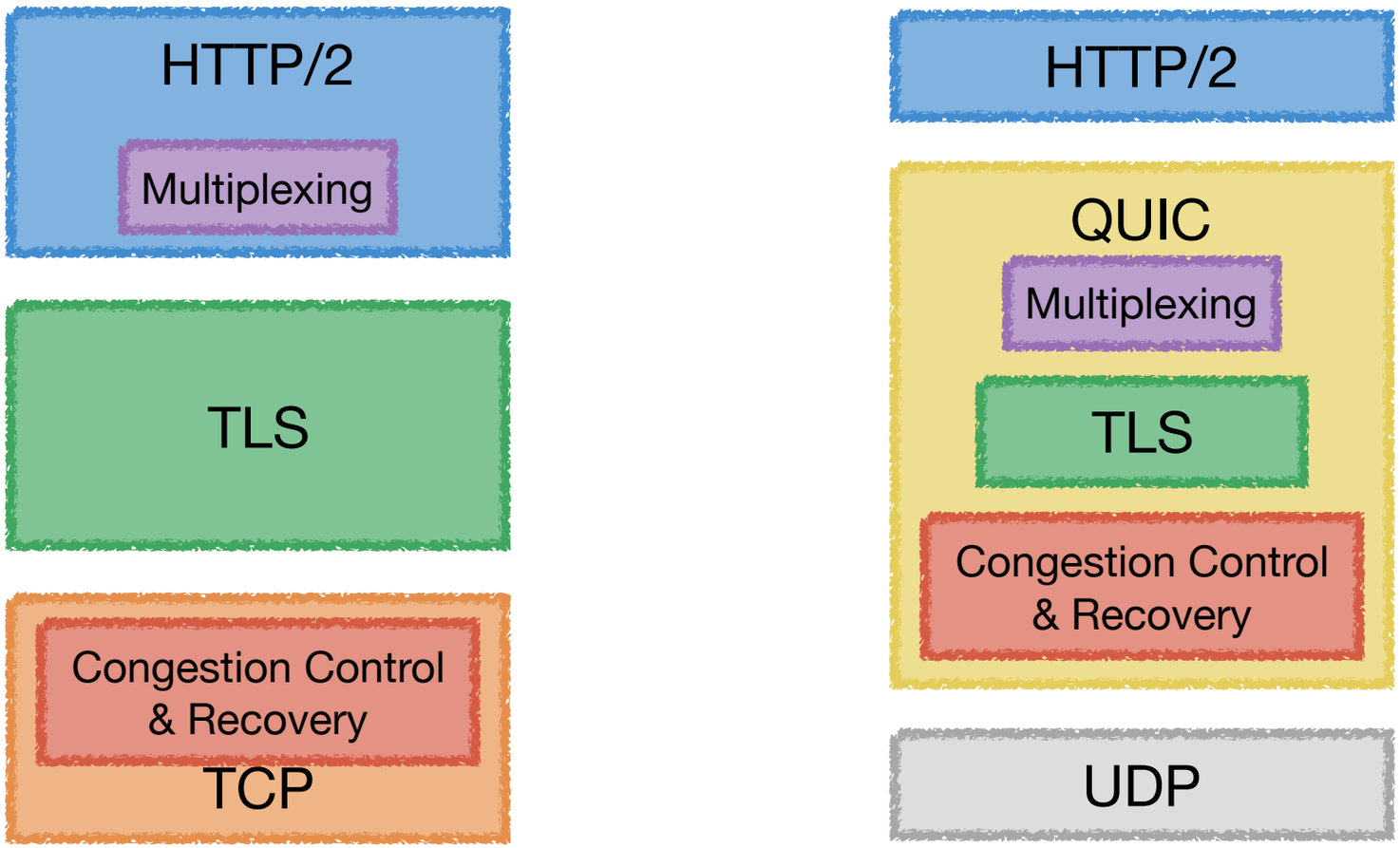
  ➡ Head-of-Line (HoL) blocking is still possible

HTTP/2 — Stream Multiplexing



- Requests are send on independent streams in frames
  - ➡ Loss or reordering can lead to Head-of-Line (HoL) blocking in the transport layer/TCP

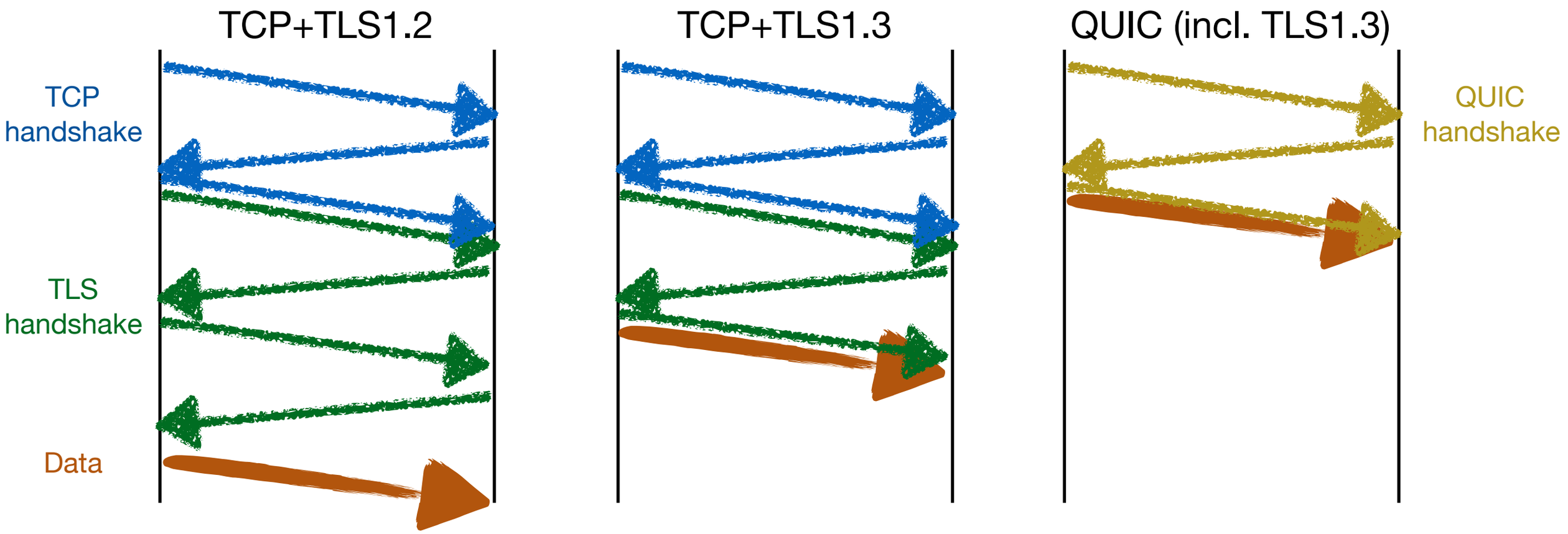
HTTP/2 over QUIC



- Stream multiplexing avoids HoL of independent data resources
- Always authenticated and payload is fully encrypted

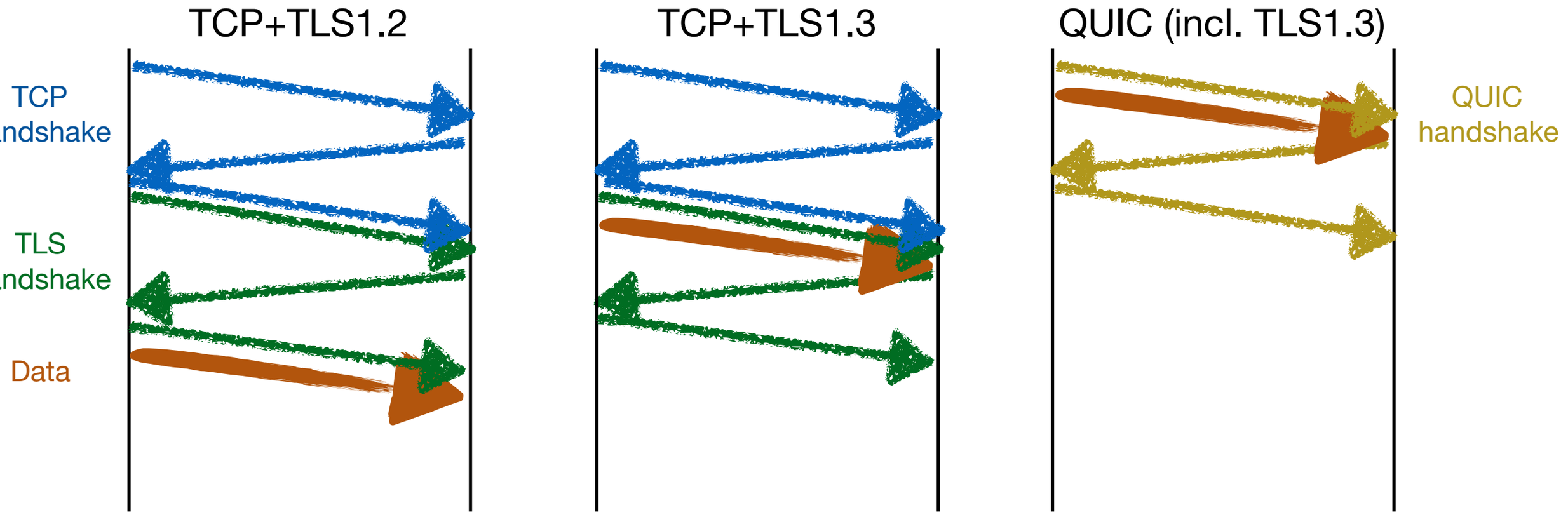
➡ **Stream & other control information (for e.g. recovery) is not visible to the network anymore!**

QUIC —
Low Latency Session Establishment



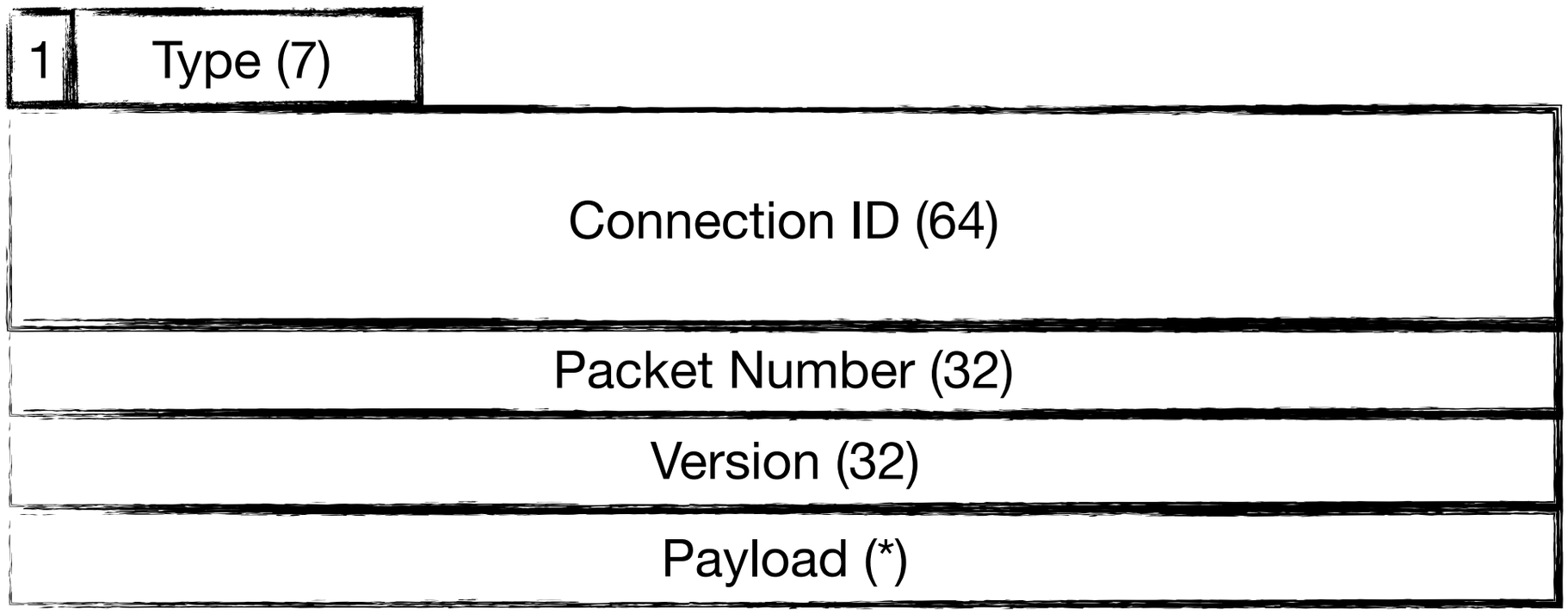
- QUIC combines the transport and crypto handshake
- Handshake packets are not encrypted but verified later

QUIC — 0-RTT Session Resumption



- QUIC can send encrypted payload data in the first RTT on session resumption to a previously connected server
- Care must be taken as QUIC/TLS1.3 0-RTT data are not protected against reply attacks

The QUIC wire image — Long header format (handshake & 0-RTT)



- Connection ID for migration and resilience to NAT rebinding
- Packet number is initiated to a random values and is unique within a connection
  - Packet Number also provides input to decryption

QUIC Long Header Types

Type	Name
0x01	Version Negotiation
0x02	Client Initial
0x03	Server Stateless Retry
0x04	Server Cleartext
0x05	Client Cleartext
0x06	0-RTT **Protected**
0x07	1-RTT **Protected** (key phase 0)
0x08	1-RTT **Protected** (key phase 1)

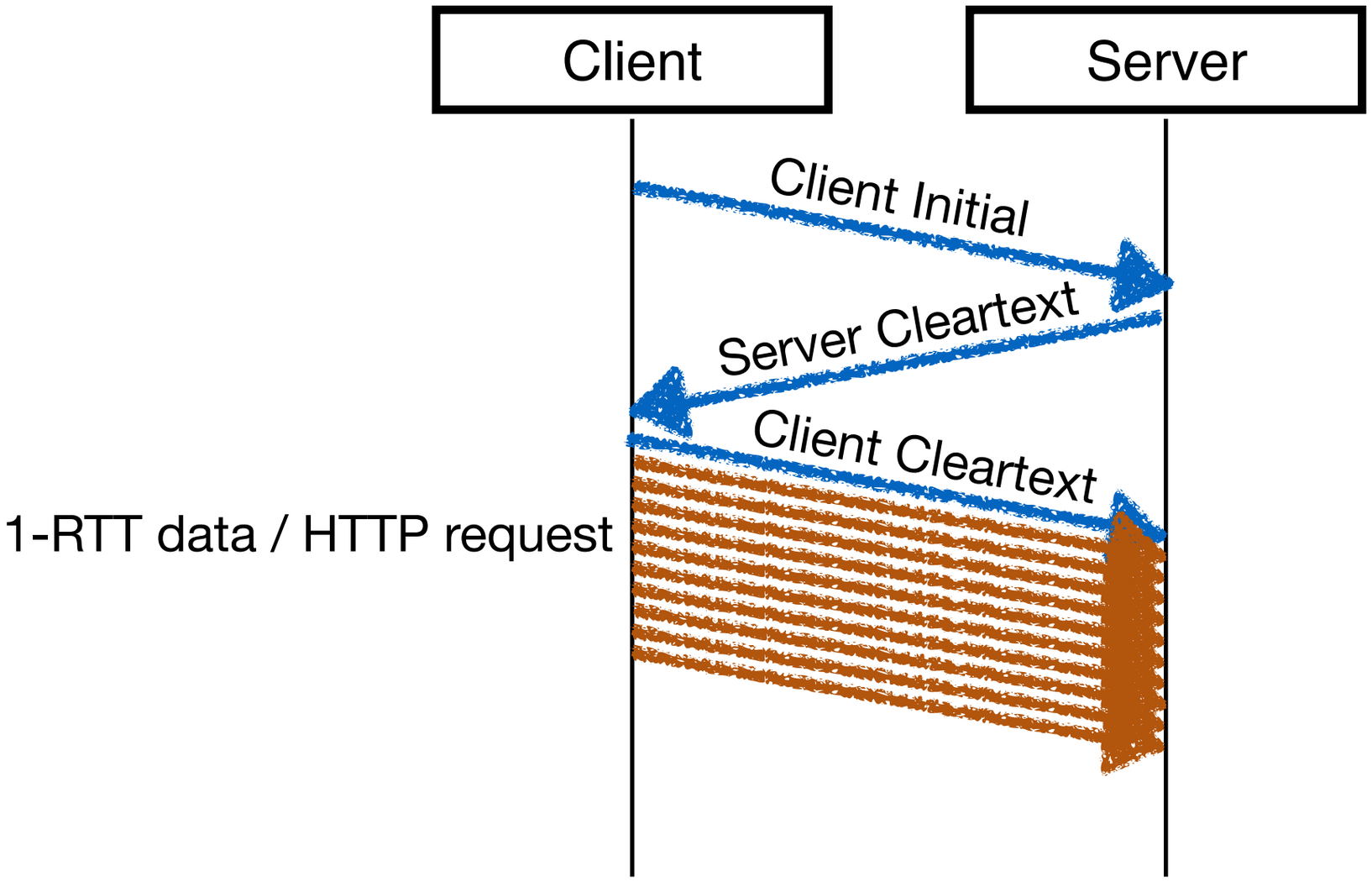
- Cleartext packets for Client Initial, Server Stateless Retry, and Server/Client handshake
- Encrypted payload for 0-RTT and 1-RTT data

QUIC
Version Negotiation

- Basically everything can change between QUIC version!

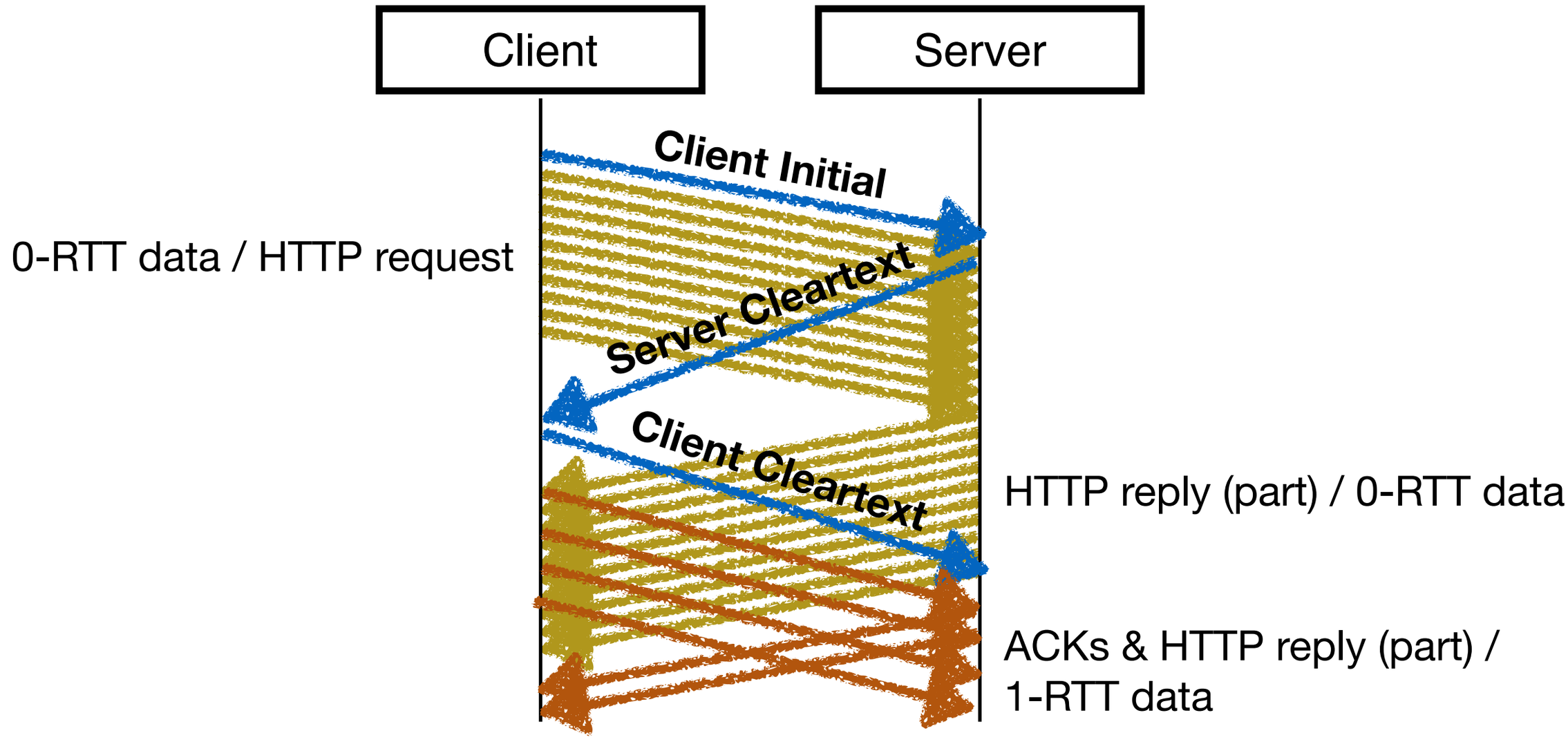
- Only to make version negotiation work, between different versions the following things need to remain the same:
  - the location of the header form flag,
  - the location of the Connection ID flag in short headers,
  - the location and size of the Connection ID field in both header forms,
  - the location and size of the Version field in long headers, and
  - the location and size of the Packet Number field in long headers.

QUIC Handshake



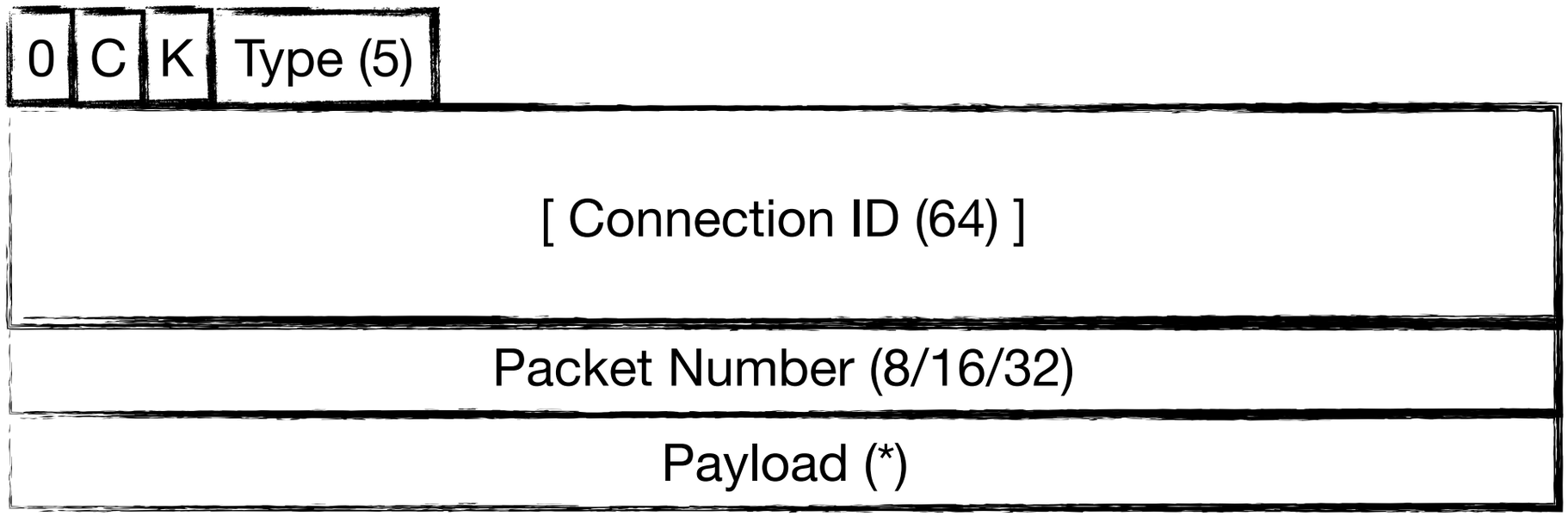
- Copy of the Client Initial and Server Cleartext are included in the encrypted part to verify content

QUIC Handshake — 0-RTT Session Resumption



- Client can send an initial window of data (10 packets) together with Client Initial

The QUIC wire image — Short header format (only 1-RTT)



- Connection ID is optional as indicated by the C flag
- Packet Number length is indicated by the header type
- K bit indications key phase for decryption
- Payload is always encrypted

QUIC wire image — Measurements and Monitoring

- Packet Number can be utilized to measure **packet loss (or reordering) so far** (from the sender to the observation point)
  - ➡ Packet number is monotonously increasing
  - ➡ But gap can also be introduced by the sender
  - ➡ Retransmissions and ECN congestion indications are not visible to the path (to estimate whole-path congestion)

- **Round-Trip Time (RTT)** can be estimated during the handshake
  - ➡ No easy was to correlate two packets in both direction during the rest of the connection

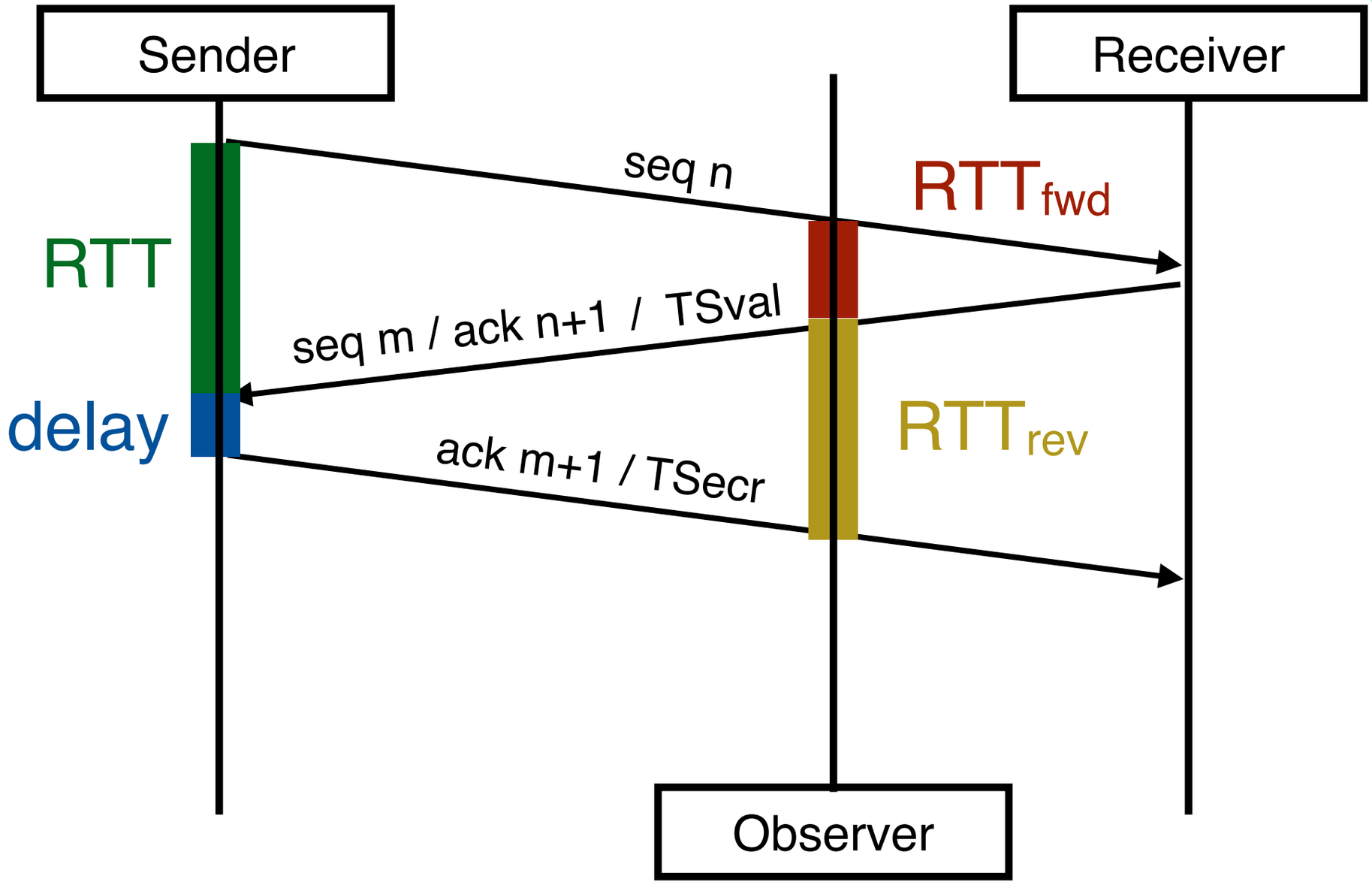
HTTP/2 and QUIC

- Both protocols are optimized for ***latency reductions*** by
  - multiplexing to avoid Head-of-line blocking,
  - overhead reduction (HPACK), and
  - optimizations in the in the handshake (QUIC and TLS).

- QUIC is currently ***still under development*** in the IETF
  - QUIC is a general purpose transport protocol optimized for HTTP/2
  - QUIC is always encrypted to enhance user privacy and avoid packet mangling
  - QUIC wire image is still under discussion to support basic monitoring support

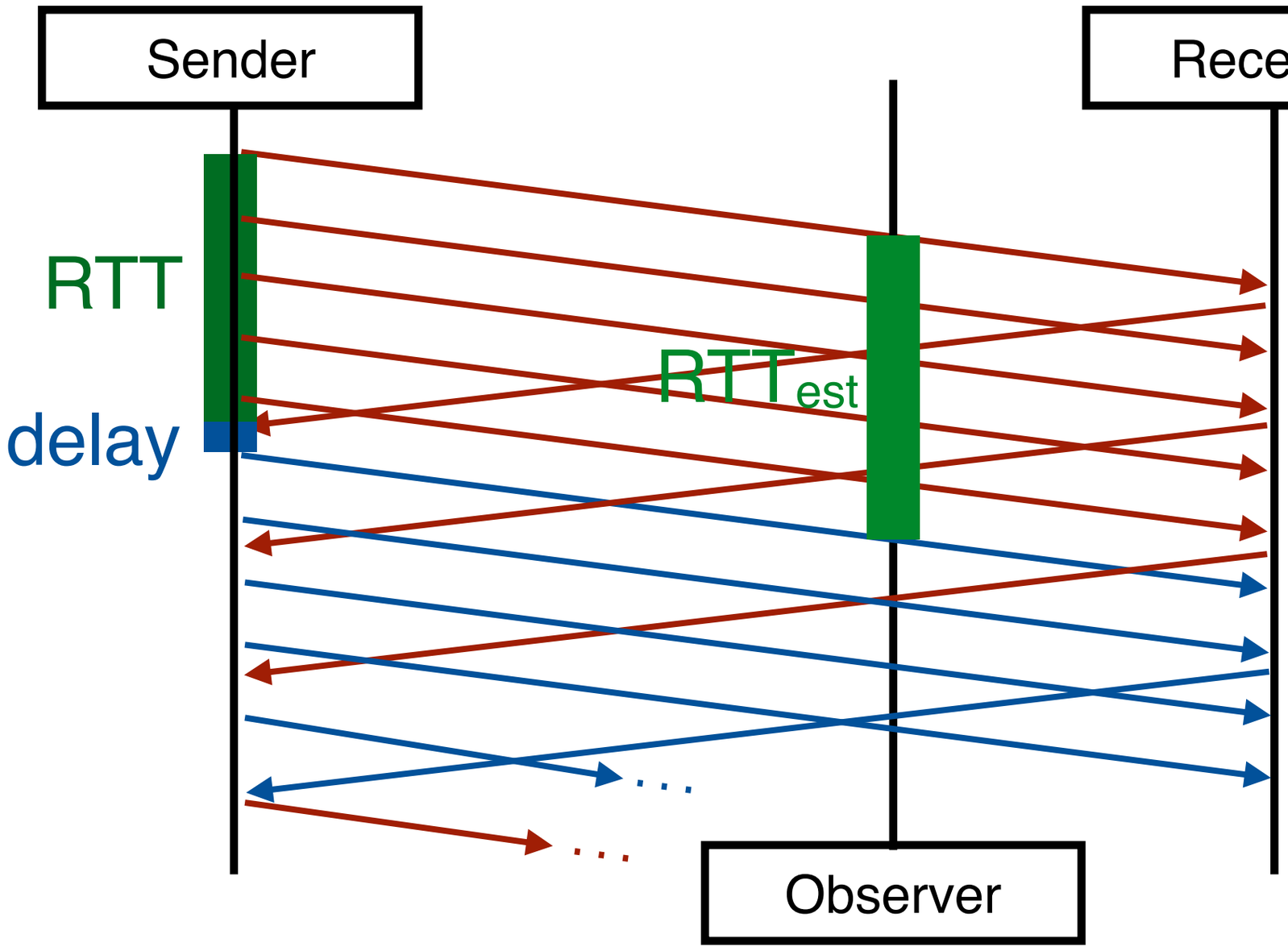
Backup

RTT estimation with TCP



- Use of SEQ# and ACK# and/or TCP Timestamp Option

Proposed Latency Spin Bit for QUIC



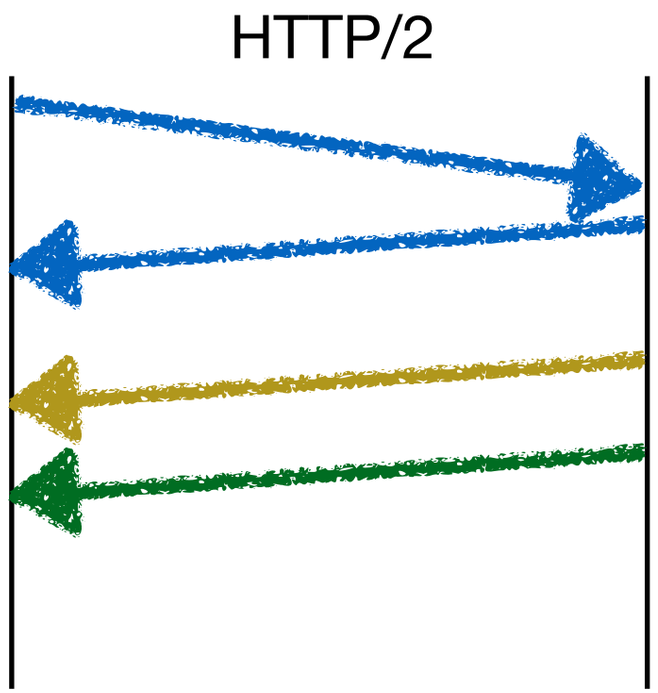
$t_{0\rightarrow1} - t_{1\rightarrow0}$

$t_{1\rightarrow0} - t_{0\rightarrow1}$

- Spin bit changes once per RTT

  ➡ enables observer in the network to take one RTT sample per RTT

HTTP/2 — Server Push



- Server can push resources with request