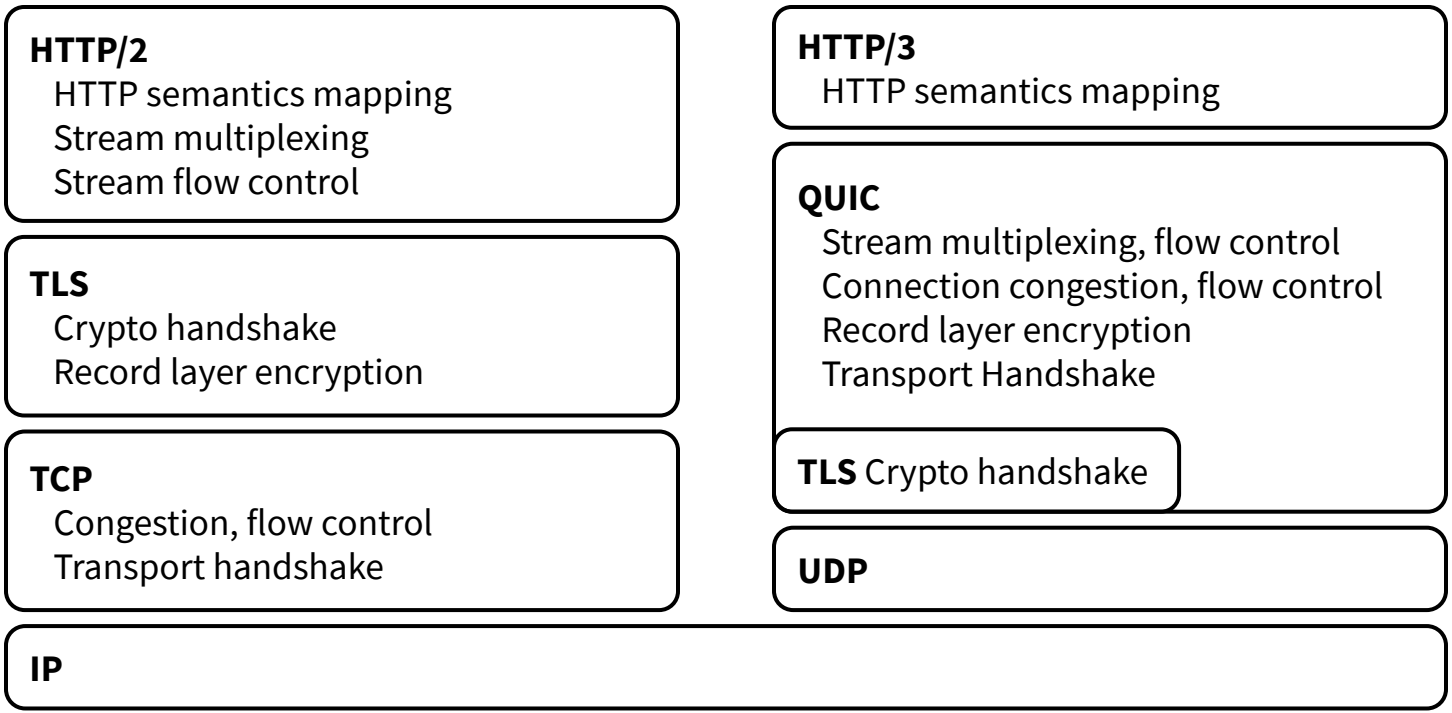
Securing the Next Version of HTTP

How QUIC and HTTP/3 Compare to HTTP/2


HTTP/2
HTTP semantics mapping
Stream multiplexing
Stream flow control
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Crypto handshake
Record layer encryption
TCP
Congestion, flow control
Transport handshake
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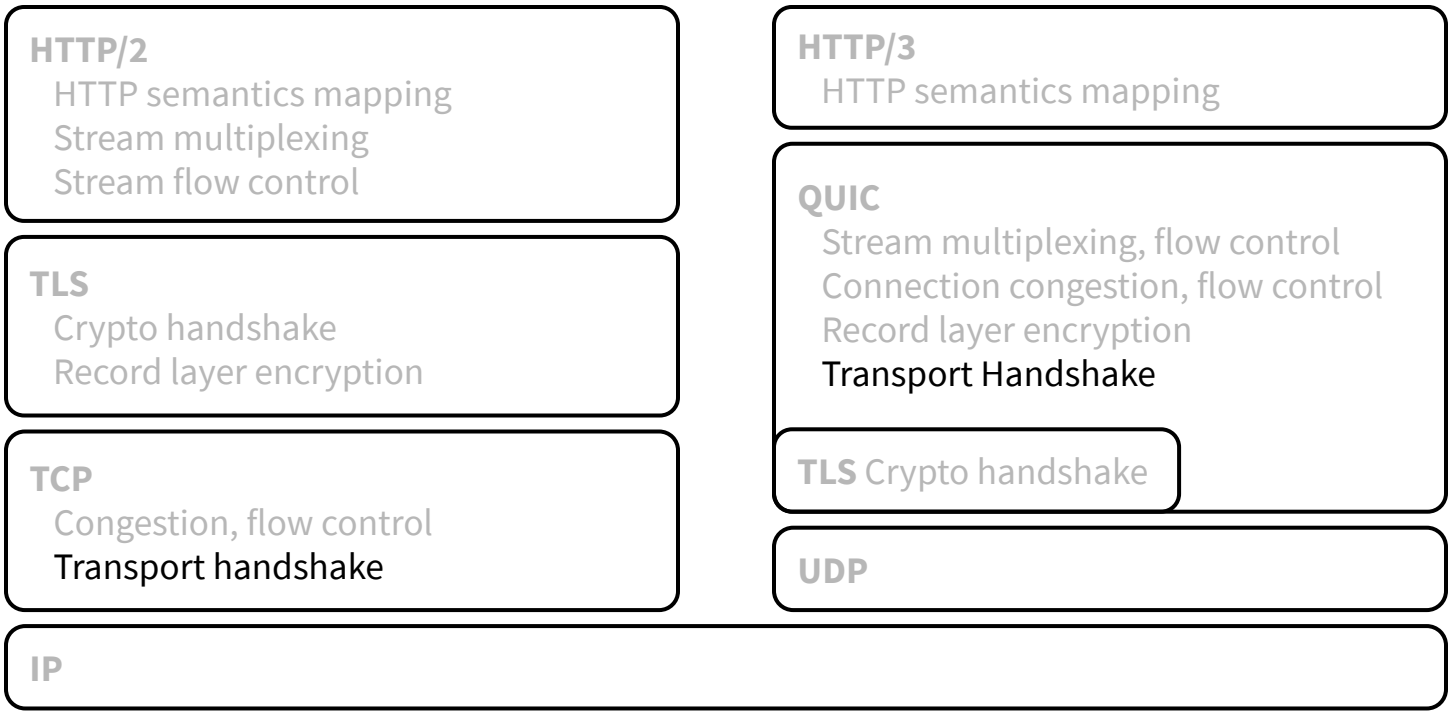
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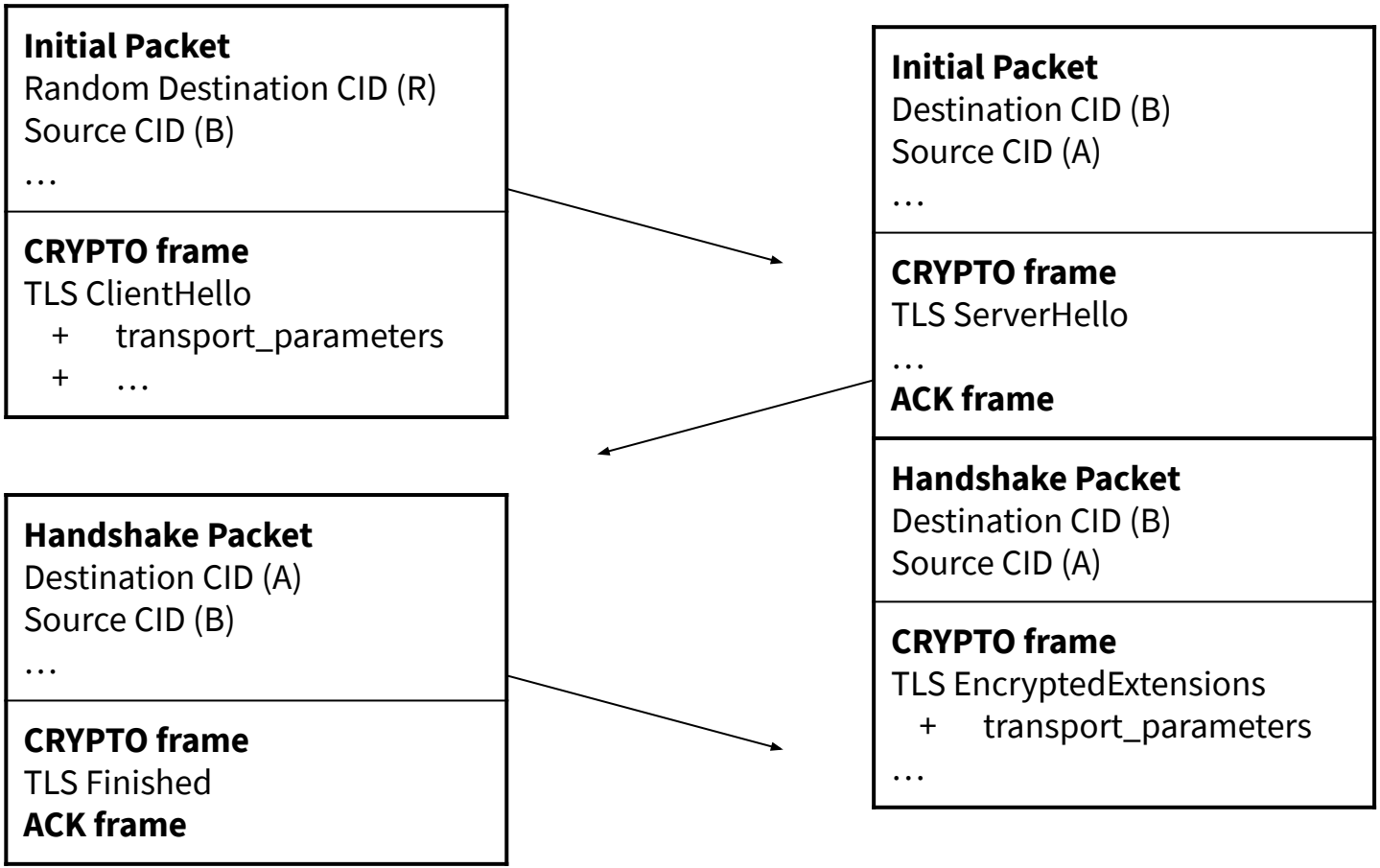
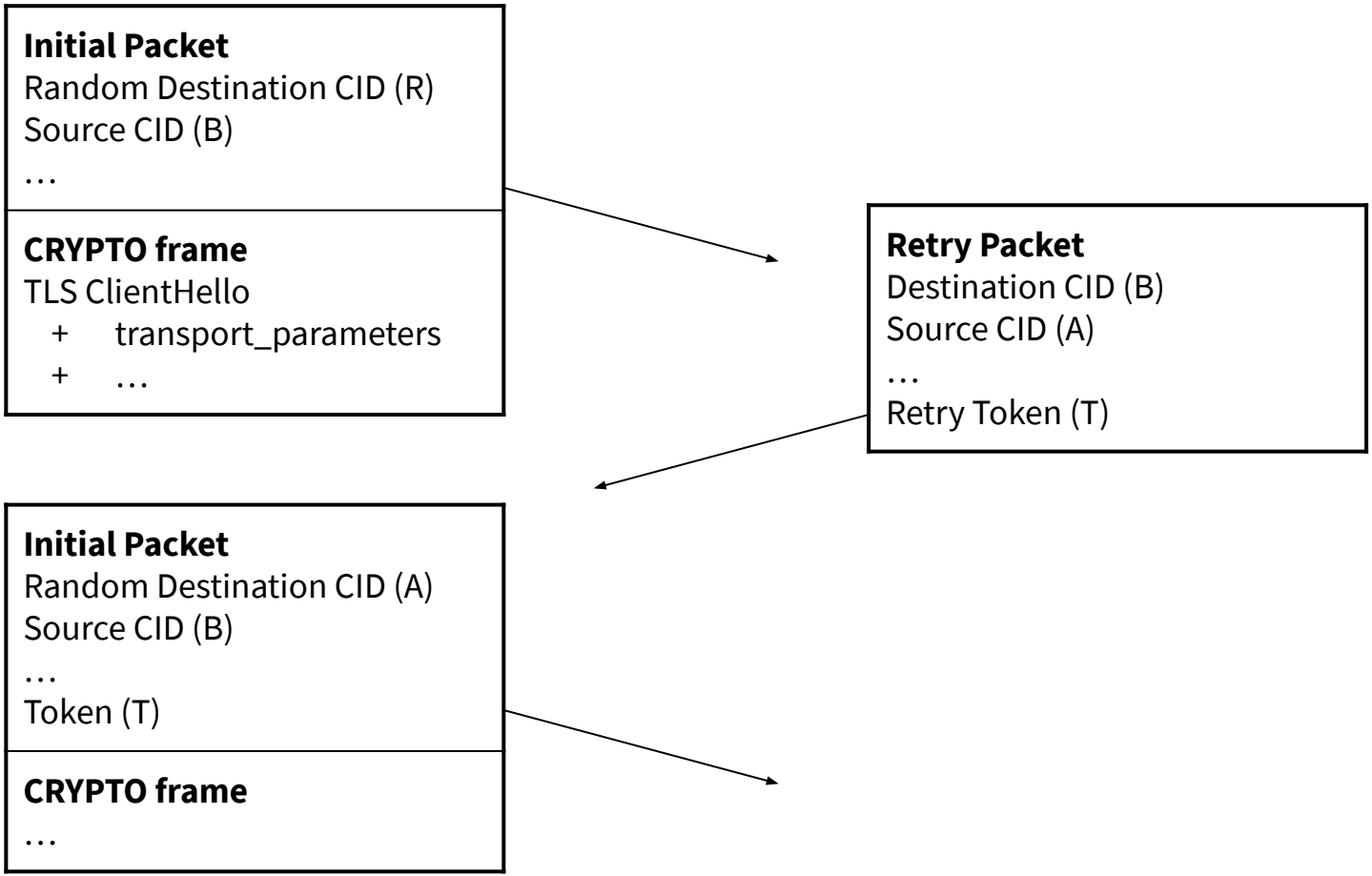

Initial Packet
Random Destination CID (R)
Source CID (B)
…
CRYPTO frame
TLS ClientHello
+ transport_parameters
+ …
Initial Packet
Destination CID (B)
Source CID (A)
…
CRYPTO frame
TLS ServerHello
…
ACK frame
Handshake Packet
Destination CID (B)
Source CID (A)
CRYPTO frame
TLS EncryptedExtensions
+ transport_parameters
…
Handshake Packet
Destination CID (A)
Source CID (B)
…
CRYPTO frame
TLS Finished
ACK frame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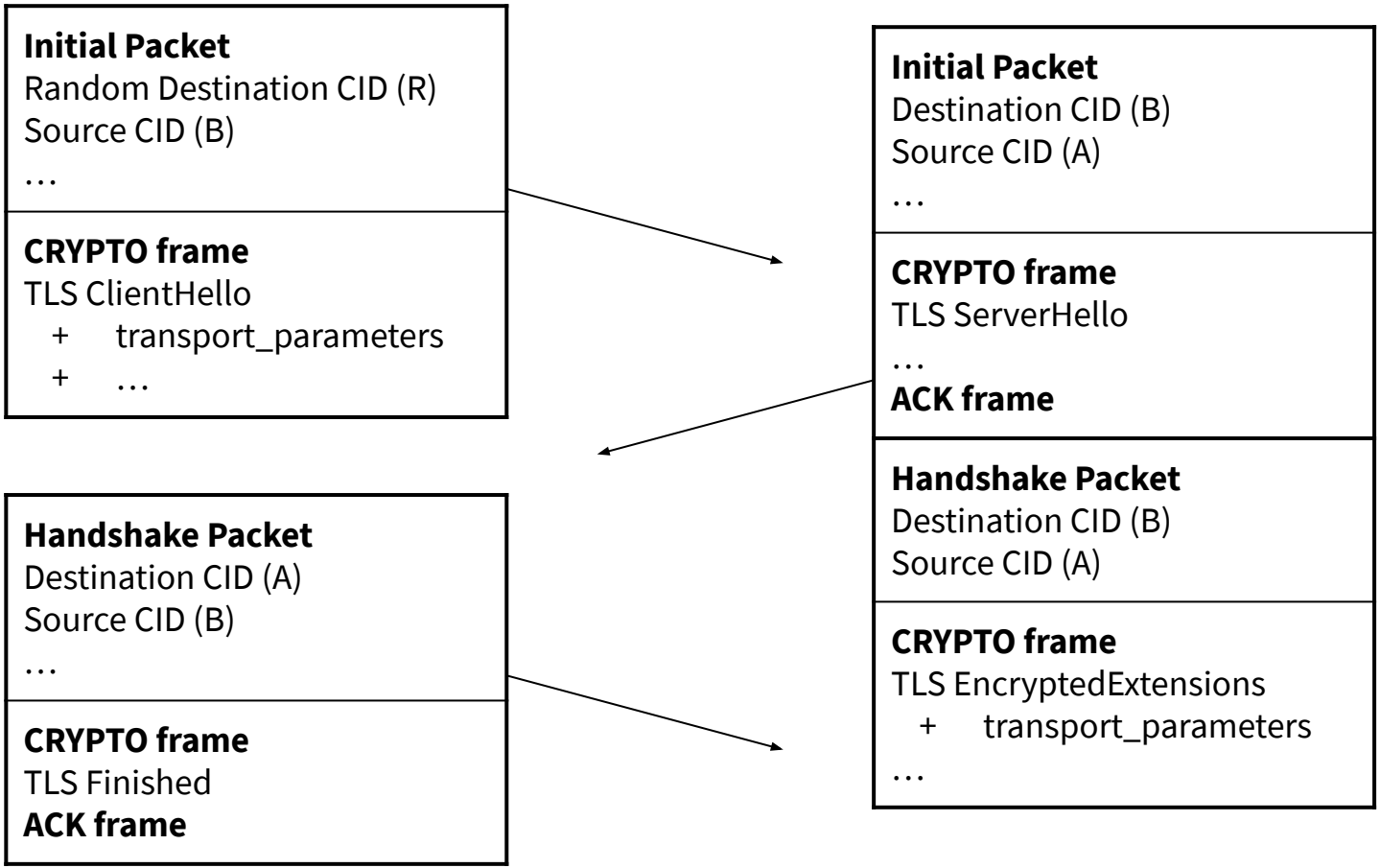
Source CID (B)
…
CRYPTO frame
TLS ClientHello
+ transport_parameters
+ …
Retry Packet
Destination CID (B)
Source CID (A)
…
Retry Token (T)
Initial Packet
Random Destination CID (A)
Source CID (B)
…
Token (T)
CRYPTO frame
…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CRYPTO frame
TLS EncryptedExtensions
+ transport_parameters
…
Handshake Packet
Destination CID (A)
Source CID (B)
…
CRYPTO frame
TLS Finished
ACK frame

Packet format invariants

```
Long Header Packet {
  Header Form (1) = 1,
  Version-Specific Bits (7),
  Version (32),
  Destination Connection ID Length (8),
  Destination Connection ID (0..2040),
  Source Connection ID Length (8),
  Source Connection ID (0..2040),
  Version-Specific Data (..),
}
```

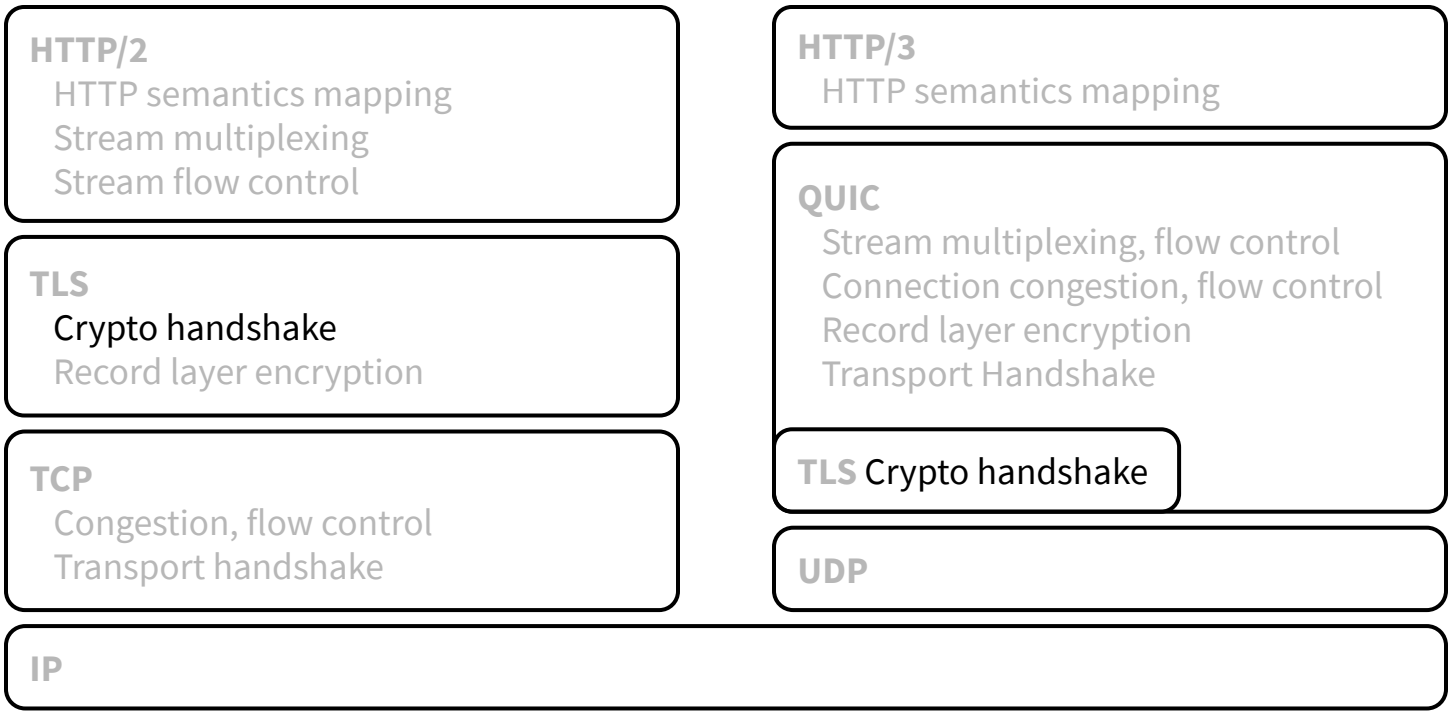
```
Short Header Packet {
  Header Form (1) = 0,
  Version-Specific Bits (7),
  Destination Connection ID (..),
  Version-Specific Data (..),
}
```

QUIC Connection IDs

Used in place of 5-tuple to identify a QUIC connection

Variable length, issued by endpoint

Should appear to be random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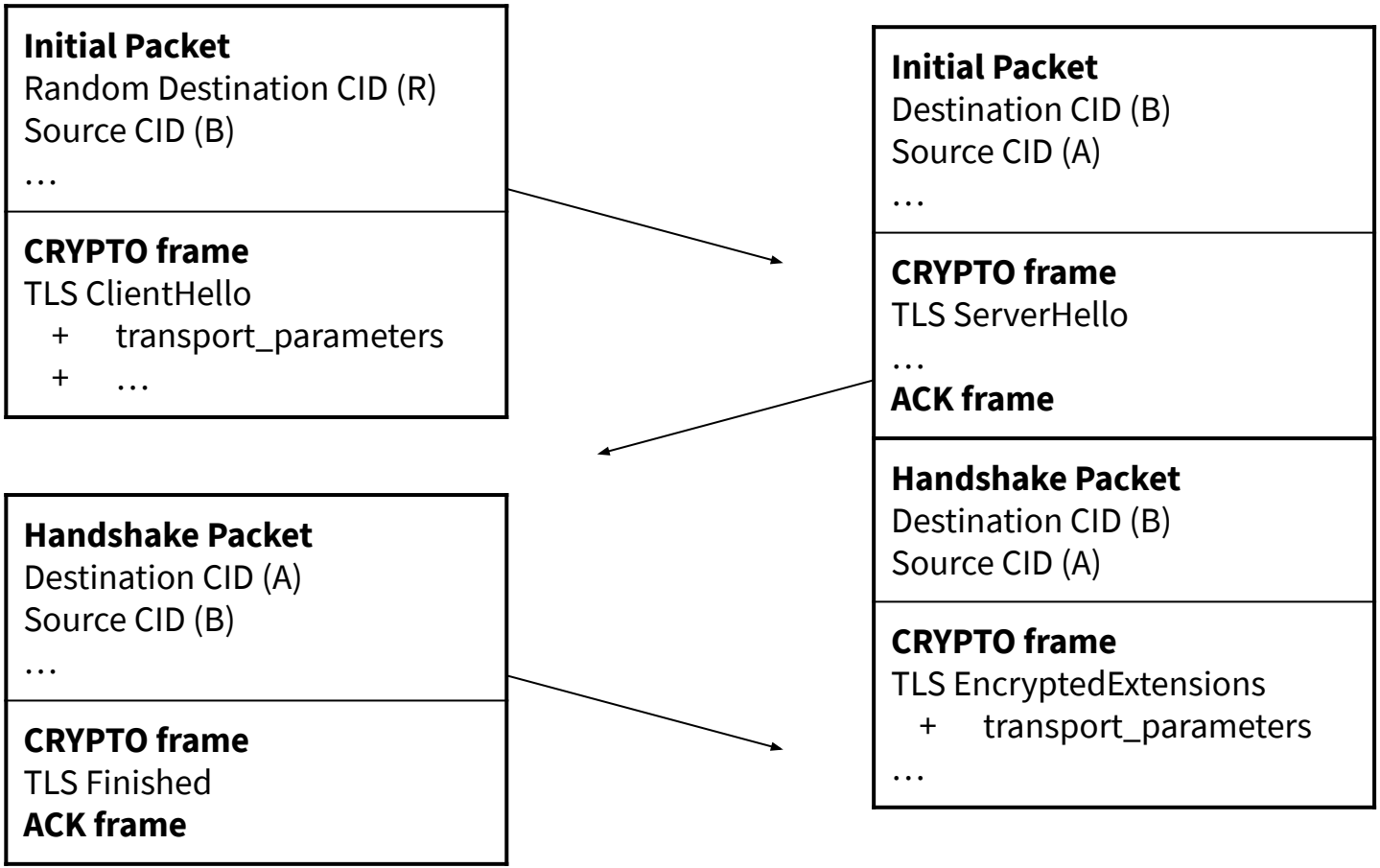
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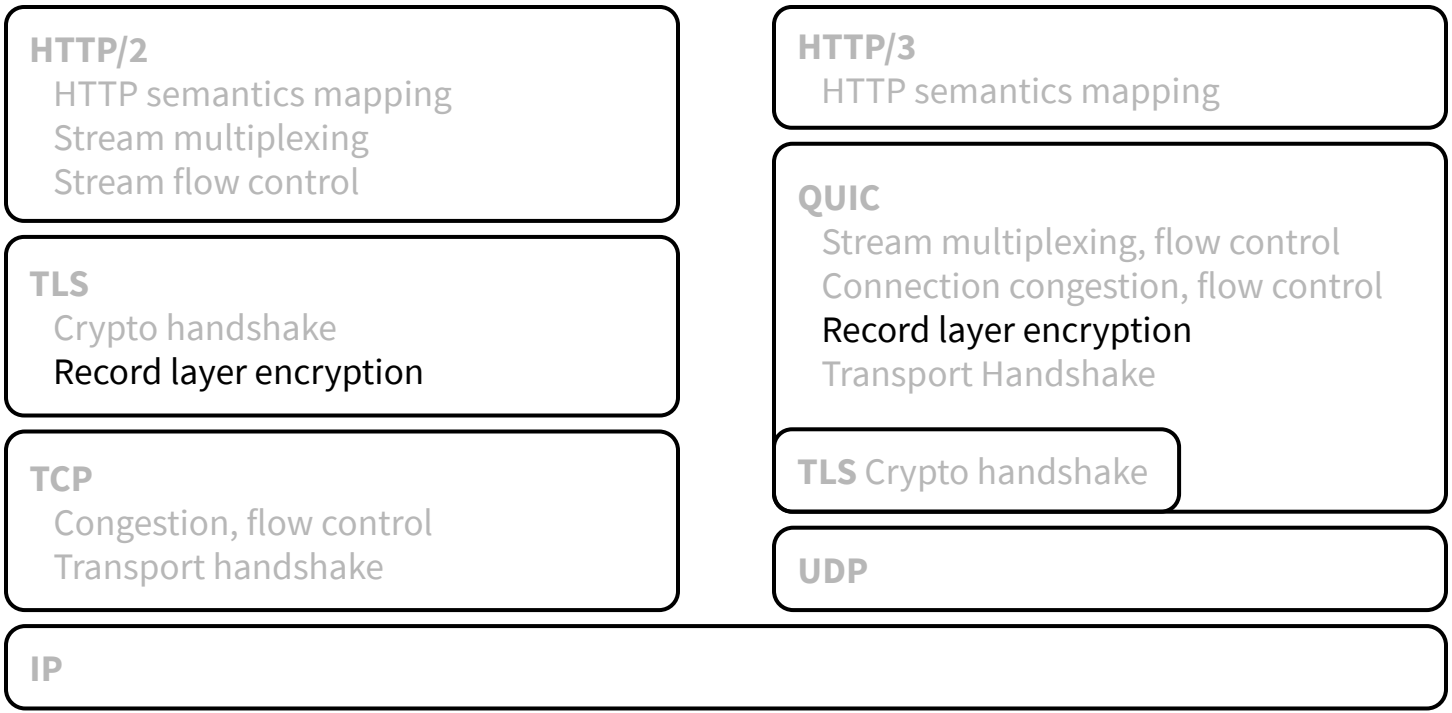
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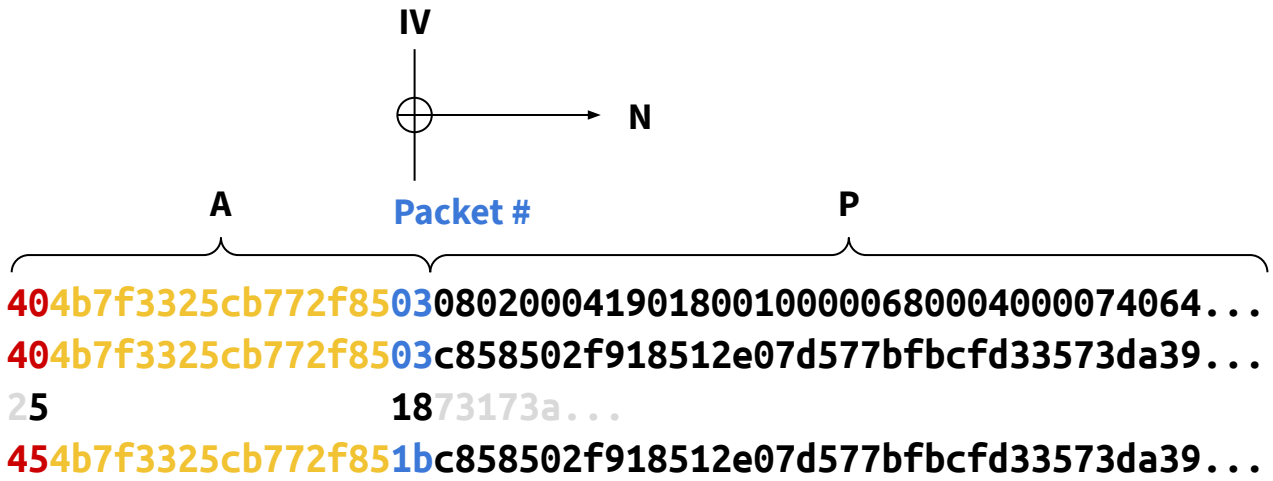
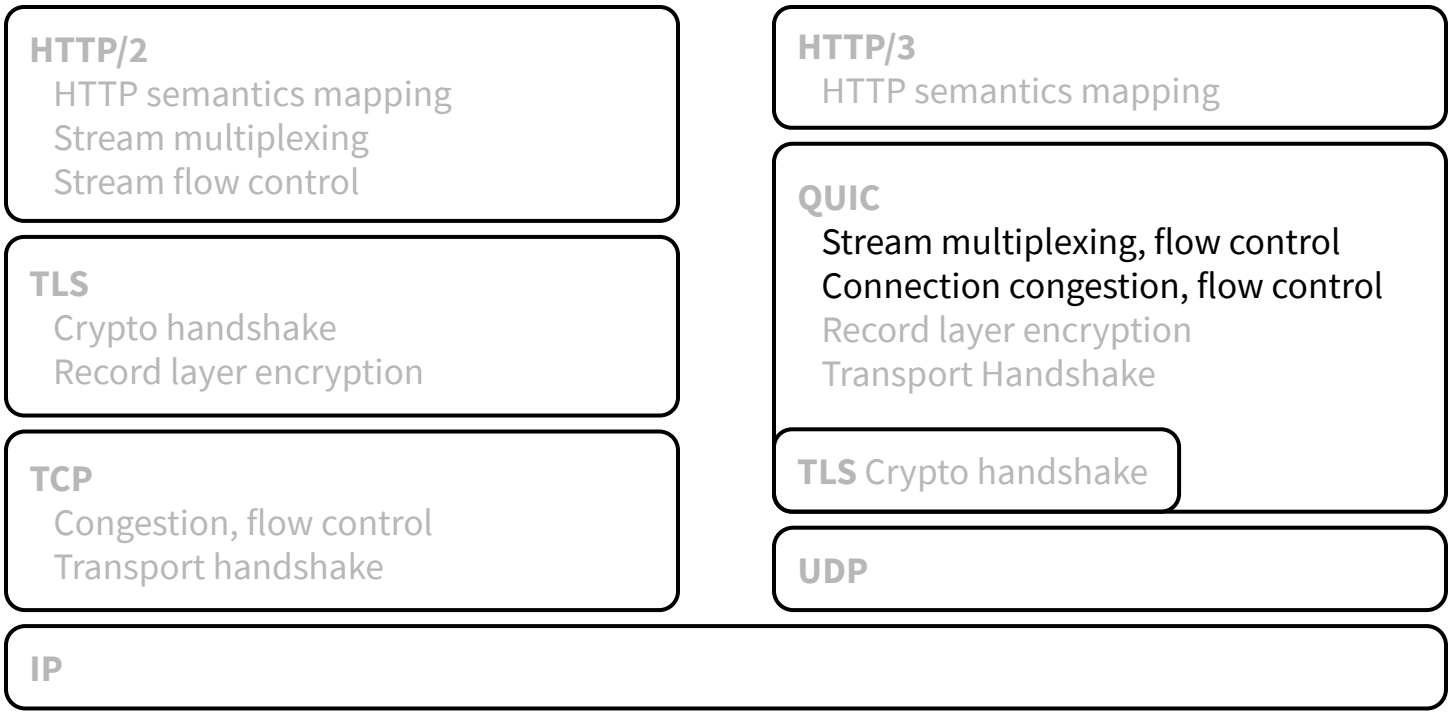
QUICv1 Record Protection

AEAD(K, N, P, A) = C

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Streams, flow control, and other frames

STREAM frames carry application data

Flow control updates sent in MAX_DATA (per connection), MAX_STREAM_DATA (per stream), and MAX_STREAMS frames

Packets acknowledged via ACK frames

PATH_CHALLENGE and PATH_RESPONSE used to validate new paths

Implementation considerations

Flow control

Path validation

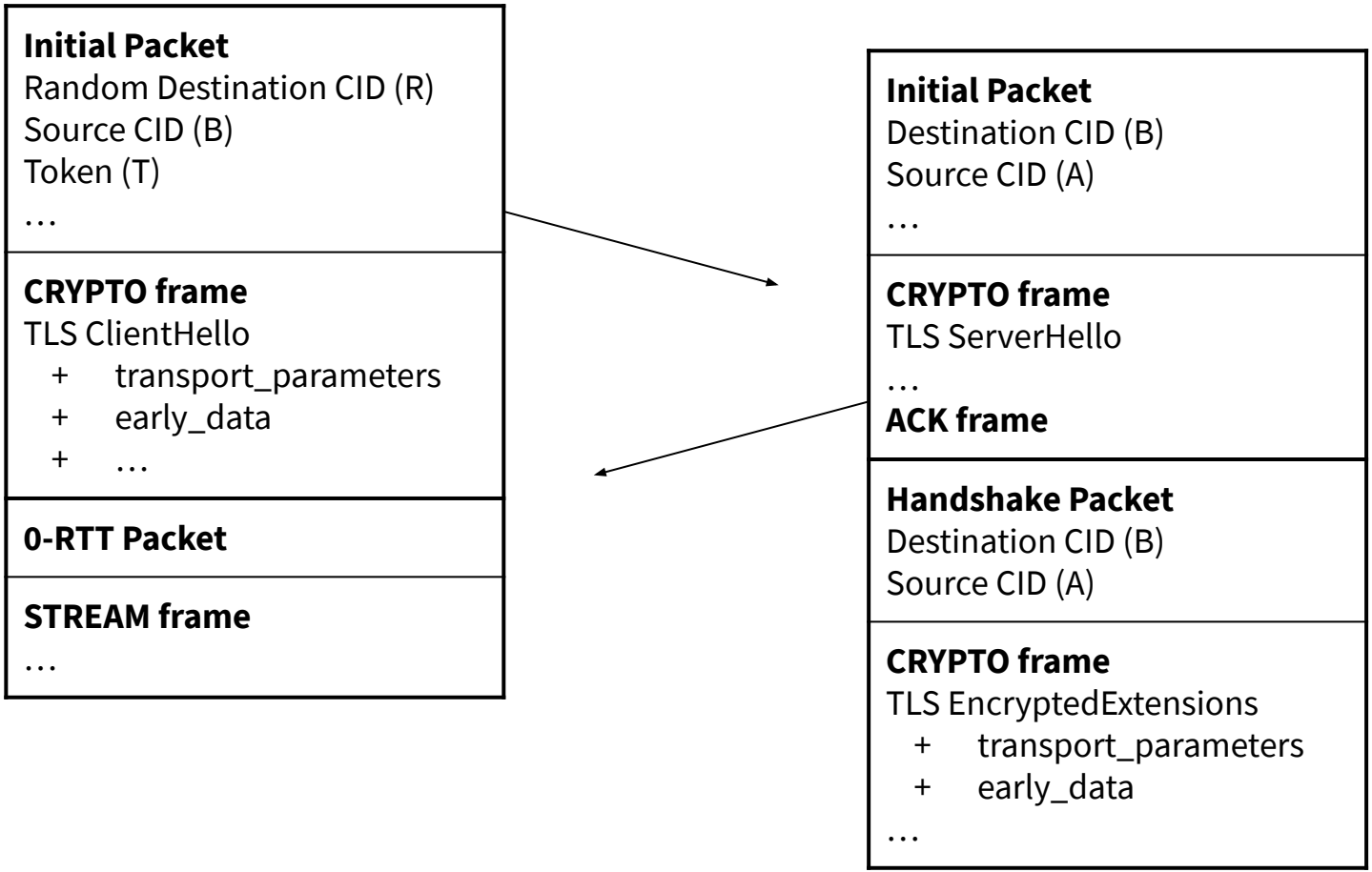
CVE-2019-9517 “Internal Data Buffering”

0-RTT Connection Resumption

Combines TLS 1.3 0-RTT resumption handshake with address validation token from QUIC transport

Server sends address validation token in NEW_TOKEN frame on previous connection

Server sends 0-RTT capable NewSessionTicket in TLS handshake on previous connection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Source CID (B)
Token (T)
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CRYPTO frame
TLS ClientHello
+ transport_parameters
+ early_data
+ …
0-RTT Packet
STREAM frame
…
Initial Packet
Destination CID (B)
Source CID (A)
…
CRYPTO frame
TLS ServerHello
…
ACK frame
Handshake Packet
Destination CID (B)
Source CID (A)
CRYPTO frame
TLS EncryptedExtensions
+ transport_parameters
+ early_data
…

Summary

The HTTP/3 protocol stack has equivalent security as HTTP/2

HTTP/3’s use of QUIC improves performance

QUIC improves privacy