Testing QUIC with packetdrill

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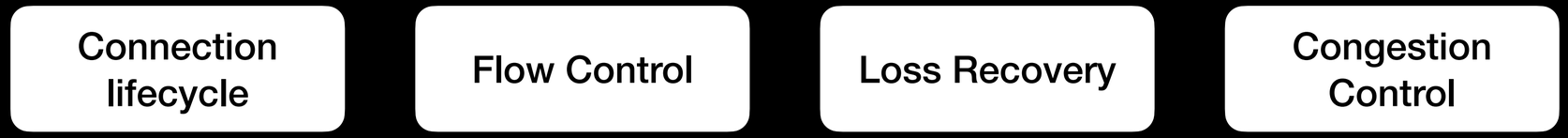
Is QUIC ready to ship?

- Unit testing
- Inter-op testing between ~20 implementations
- Performance sanity of HTTP/3 vs HTTP/2
- Initial deployment for experimentation
- Is the industry ready?

Transport protocols are complex



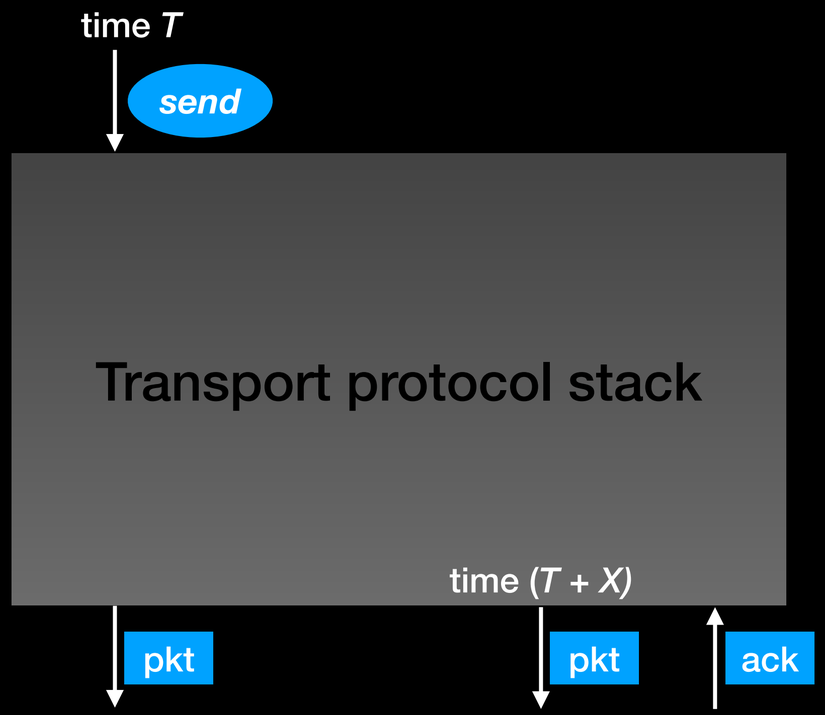
QUIC is even harder

- Header and packet protection
- Authenticated handshake
- Multiple streams within a connection
- Large set of transport parameters and frames
- Built-in mobility; and more …

Testing Methods

- Interoperability / Performance testing
- Protocol fuzzing
- Failure testing
- Conformance testing
- Longevity / Stress testing
- **Reproducible integration testing**

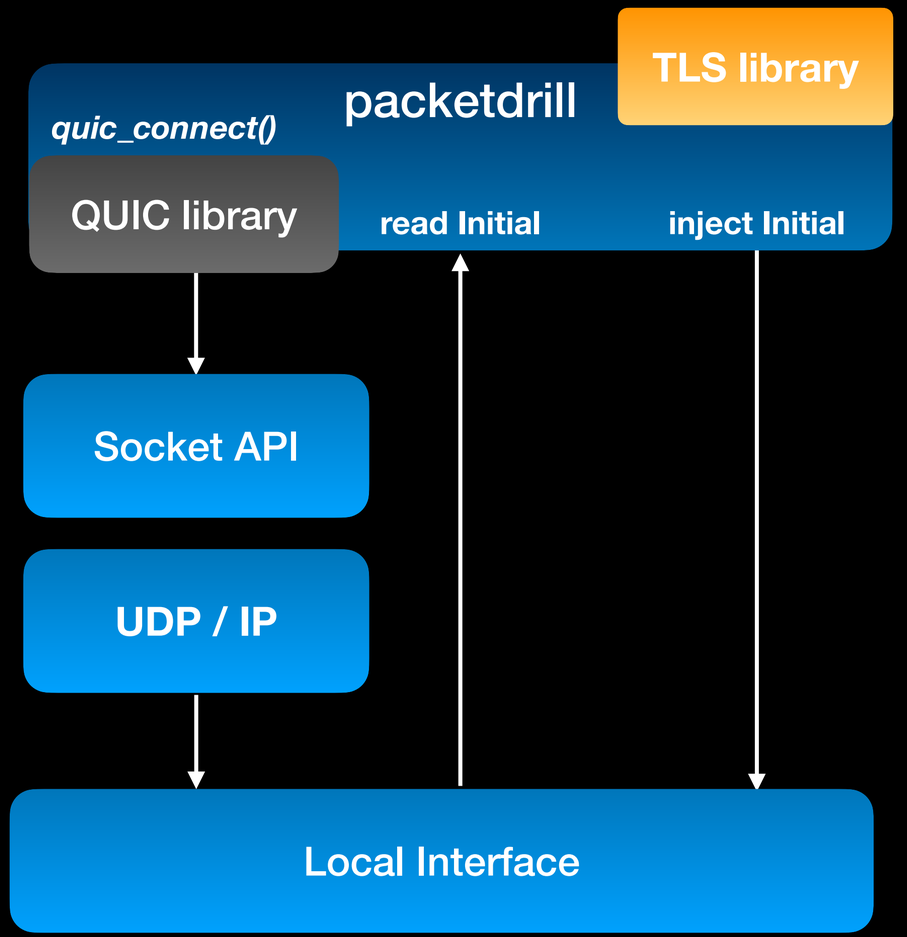
Reproducible & precise Integration testing



packetdrill

- Scripting tool developed by Google
- Specify a set of events with timestamps
  - system calls, packets, shell commands, python script
- Write precise, reproducible and automated scripts
- Easy integration of new protocol options

packetdrill for QUIC



Example script for QUIC handshake

+0 quic_create (…, IPPROTO_QUIC) = 3

+0 quic_connect (3, …, …) = 0

+0 > quic (initial, dcid=0x1, pn=0 [,…])

+0.1 < quic (initial, dcid=0x2, pn=0 [,…])

+0 < quic (handshake, dcid=0x02, pn = 0 [,…])

+0 < quic (handshake, dcid=0x02, pn = 1 [,…])

+0 > quic (handshake, dcid=0x1, pn=0 [,…])

+0 > quic (application, dcid=0x1, pn=0)

QUIC library

packetdrill

Integrating QUIC into packetdrill

- QUIC packet grammar
- TLS handshake
- Packet parsing and verification
- Packet injection

QUIC packet grammar

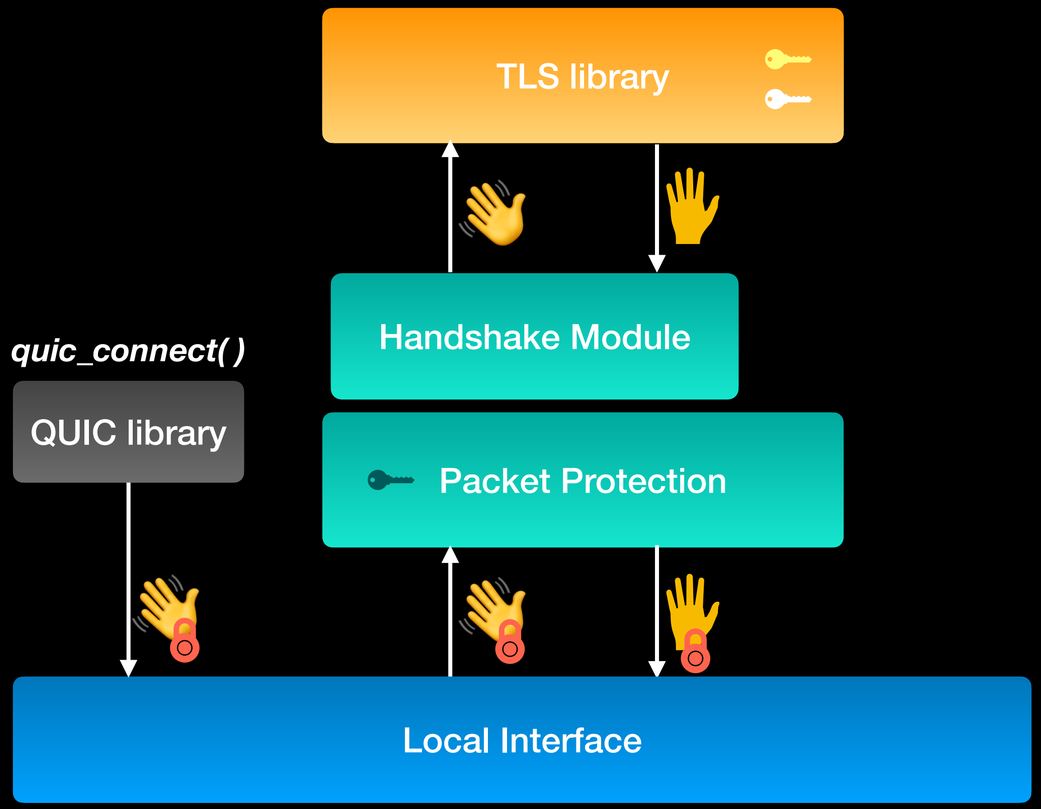
packet	packet_prefix **QUIC (** q_header **):** q_frame_list
q_header	q_packet_type**,** header_field1**=**<value> [,…]
q_frame_list	q_frame [; q_frame[…]]
q_frame	q_frame_type **[**field1**=**<value> [,…]**]**

QUIC packet examples

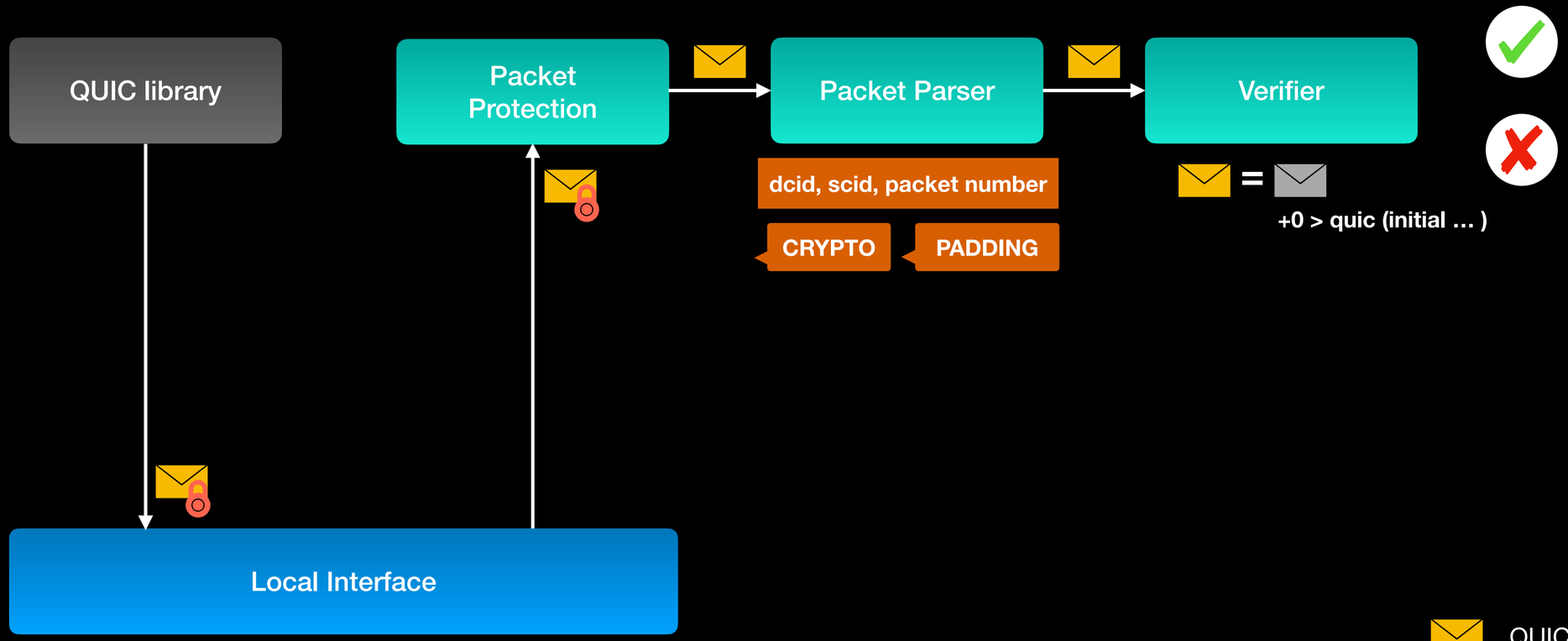
```
// Client Initial packet
+0 > quic (initial, dcid=0x1, scid=0x2, pn=0):
        CRYPTO[offset=0, length=512];
        PADDING[length=640]

// Injected server initial, transport params are specified in CRYPTO frame
+0.1 < quic (initial, dcid=0x2, scid=0x1, pn=0):
        CRYPTO[offset=0, length=122, initial_max_stream_data_bidi_remote=5000];
        ACK[largest=0, delay=10, range_count=0, range0=0]
```

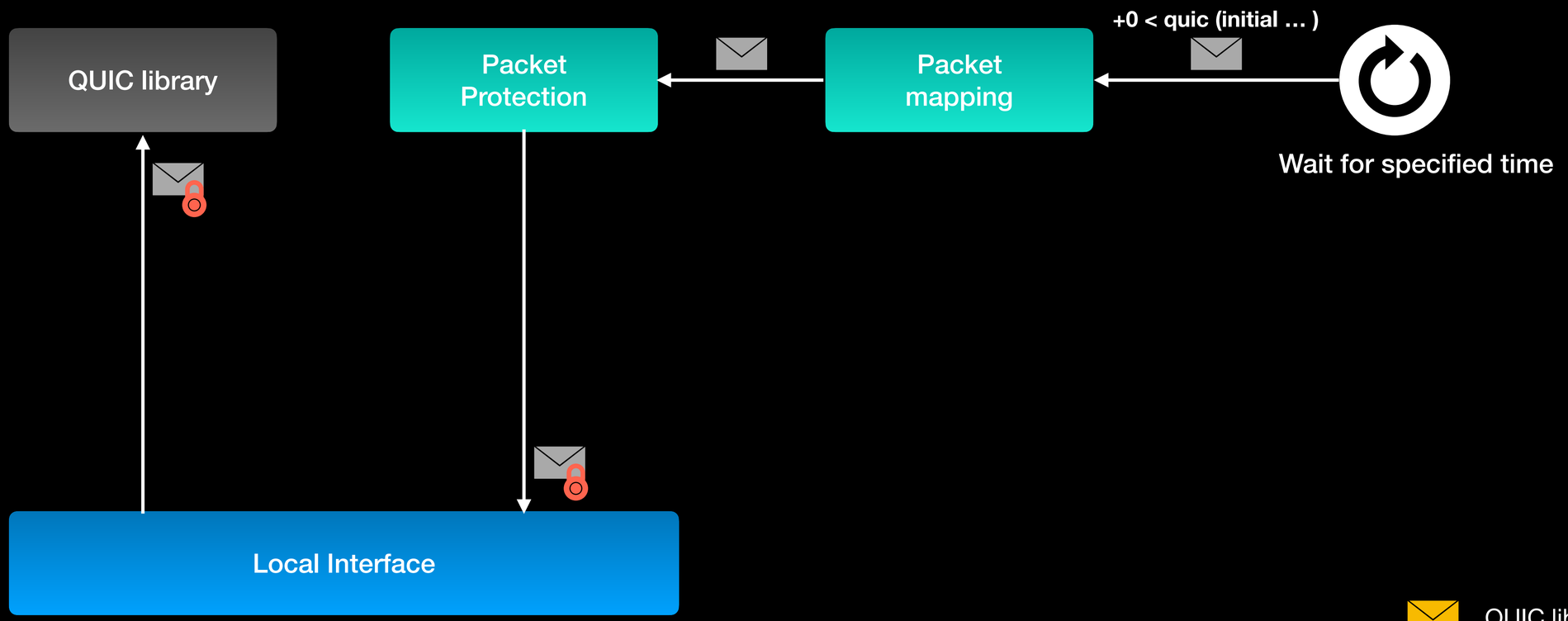
TLS handshake



Packet parsing and verification



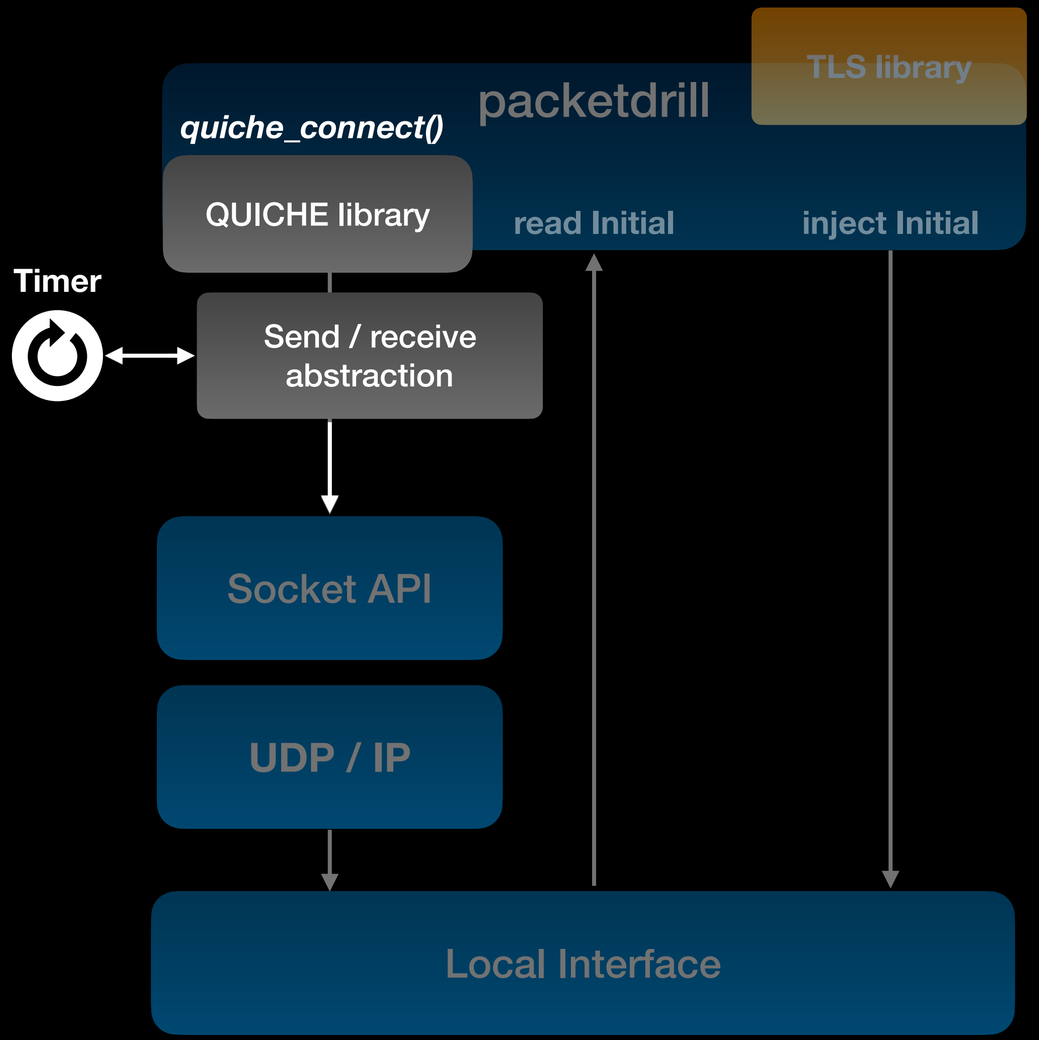
Packet injection



QUIC test scripts

- Over 50 scripts and growing
- Scripts for handshake, flow control, streams, loss recovery, congestion control, PMTU discovery…
- Continuous integration and automation testing
- Use during development, regression testing & troubleshooting

Adopting a second QUIC library



Experience with QUICHE

- Easy to integrate, less than 300 lines of source code
- Reuse same test scripts for a different library
- Found issues and worked with Cloudflare to fix them

Challenges

- **CPU time for TLS handshake may be variable**
  - Variance introduces instability in test results
  - Use tolerance and time intervals
- **Script MUST start with QUIC handshake**
  - QUIC handshake is lengthy to write - can create inconsistencies
  - Include a handshake template
- **Multiple draft versions**
  - Continue to add support for newer draft
  - Specify ALPN through QUIC library API to set client version

Conclusion

- Packetdrill provides us an opportunity to test the complex protocol state machines.
- Reuse code & scripts for any QUIC library
- Testing QUIC with packetdrill will help us achieve higher quality for our QUIC implementations

Thank You!

Any questions ?