asymptotic

State of QUIC in GStreamer

Sanchayan Maity

Who

asymptotic

- Open source consulting firm based out of Bangalore and Toronto.

Who

asymptotic

- Open source consulting firm based out of Bangalore and Toronto.
- Building high-quality, low-level systems software.

Who

asymptotic

- Open source consulting firm based out of Bangalore and Toronto.
- Building high-quality, low-level systems software.
- Providing services for audio/video using GStreamer and PipeWire.

Agenda

asymptotic

- Introduction to QUIC

Agenda

asymptotic

- Introduction to QUIC
- QUIC elements

Agenda

asympt⁄tic

- Introduction to QUIC
- QUIC elements
  - review of the current state

Agenda

asymptotic

- Introduction to QUIC
- QUIC elements
  - review of the current state
  - challenges

Agenda

asymptotic

- Introduction to QUIC
- QUIC elements
  - review of the current state
  - challenges
- Overview of media related protocols

Agenda

asympt·tic

- Introduction to QUIC
- QUIC elements
  - review of the current state
  - challenges
- Overview of media related protocols
  - RTP over QUIC (RoQ)

Agenda

asymptotic

- Introduction to QUIC
- QUIC elements
  - review of the current state
  - challenges
- Overview of media related protocols
  - RTP over QUIC (RoQ)
  - Media over QUIC (MoQ)

Agenda

asymptotic

- Introduction to QUIC
- QUIC elements
  - review of the current state
  - challenges
- Overview of media related protocols
  - RTP over QUIC (RoQ)
  - Media over QUIC (MoQ)
- Potential future work

QUIC

- Pronounced exactly like the English word “quick”

QUIC

- Pronounced exactly like the English word “quick”
- Not an acronym

QUIC

asymptotic

- Pronounced exactly like the English word “quick”
- Not an acronym
- Standardized in RFC 9000

QUIC

- Pronounced exactly like the English word “quick”
- Not an acronym
- Standardized in RFC 9000
- Supported by

QUIC

asymptotic

- Pronounced exactly like the English word “quick”
- Not an acronym
- Standardized in RFC 9000
- Supported by
  - RFC 8999 - Version independent properties of QUIC

QUIC

asymptotic

- Pronounced exactly like the English word “quick”
- Not an acronym
- Standardized in RFC 9000
- Supported by
  - RFC 8999 - Version independent properties of QUIC
  - RFC 9001 - Using TLS to secure QUIC

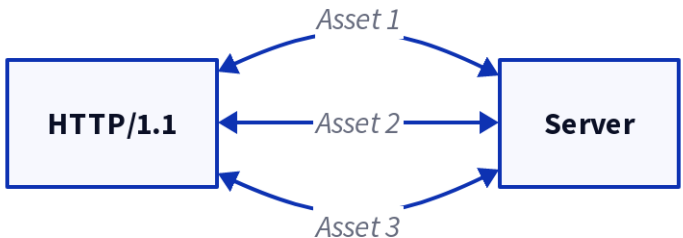
QUIC

asymptotic

- Pronounced exactly like the English word “quick”
- Not an acronym
- Standardized in RFC 9000
- Supported by
  - RFC 8999 - Version independent properties of QUIC
  - RFC 9001 - Using TLS to secure QUIC
  - RFC 9002 - QUIC loss detection & congestion control

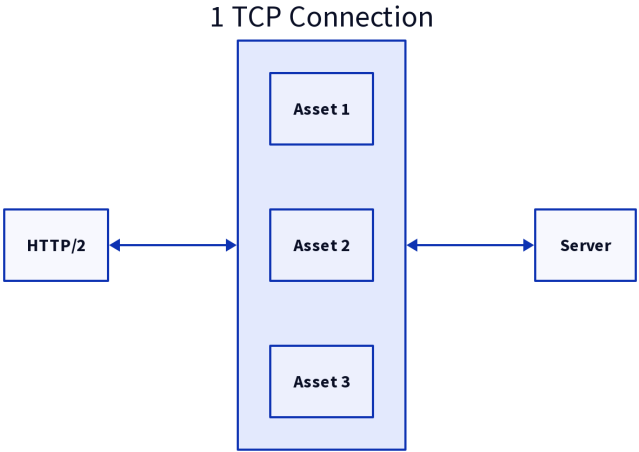
HTTP/1.1

asymptotic



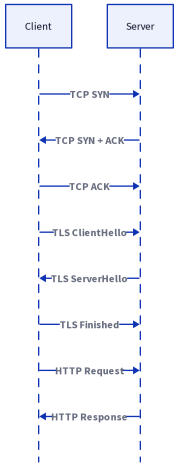
HTTP/2

asymptotic



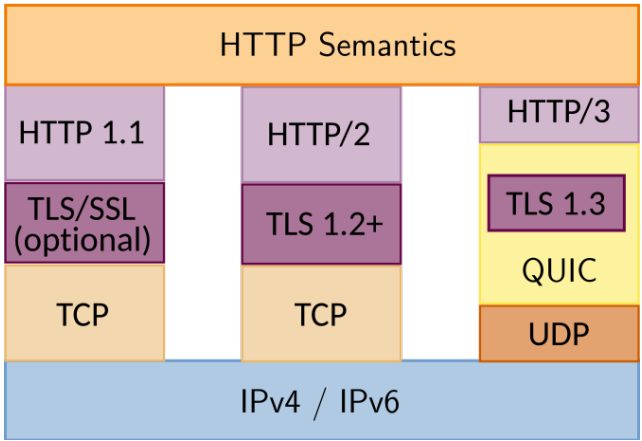
HTTP + TCP + TLS[1]

asymptotic



[1] Cloudflare: The road to QUIC

Stack[2]



[2] HTTP/3 - Wikipedia

QUIC

asymptotic

- Implemented on top of UDP

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable
  - Different streams can be out-of-order

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable
  - Different streams can be out-of-order
  - Independent/no head of line blocking

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable
  - Different streams can be out-of-order
  - Independent/no head of line blocking
- Unreliable datagrams

QUIC

asymptotic

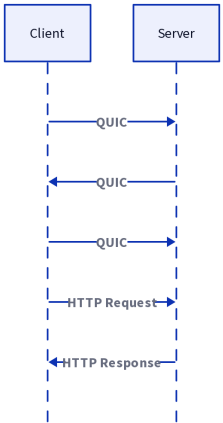
- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable
  - Different streams can be out-of-order
  - Independent/no head of line blocking
- Unreliable datagrams
- Connection migration

QUIC

asymptotic

- Implemented on top of UDP
- Multiplexed over a single UDP port
- Fully encrypted
- Logical streams similar to HTTP/2
  - In-order and Reliable
  - Different streams can be out-of-order
  - Independent/no head of line blocking
- Unreliable datagrams
- Connection migration
- RFC 7301 - TLS/Application-Layer Protocol Negotiation Extension

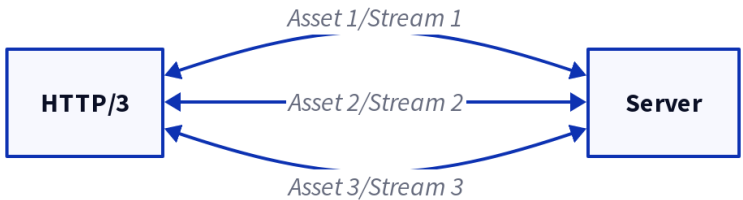
HTTP + QUIC[3]



[3] Cloudflare: The road to QUIC

HTTP/3

asymptotic



- Limits based Flow control scheme[4]

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level
- Congestion control for both streams & datagrams

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level
- Congestion control for both streams & datagrams
  - Bottleneck Bandwidth and Round-trip propagation (BBR)

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level
- Congestion control for both streams & datagrams
  - Bottleneck Bandwidth and Round-trip propagation (BBR)
  - Cubic RFC 8312

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level
- Congestion control for both streams & datagrams
  - Bottleneck Bandwidth and Round-trip propagation (BBR)
  - Cubic RFC 8312
  - Reno

[4] RFC 9000 - Flow Control

- Limits based Flow control scheme[4]
  - Stream level
  - Connection level
- Congestion control for both streams & datagrams
  - Bottleneck Bandwidth and Round-trip propagation (BBR)
  - Cubic RFC 8312
  - Reno
  - SCReAM

[4] RFC 9000 - Flow Control

Implementations

asympt⟋tic

- QUIC

Implementations

asymptotic

- QUIC
  - quinn-rs

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic

Implementations

asympt⁄tic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2
  - net: implement the QUIC protocol in linux kernel

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2
  - net: implement the QUIC protocol in linux kernel
- Prior work by British Broadcasting Corporation

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2
  - net: implement the QUIC protocol in linux kernel
- Prior work by British Broadcasting Corporation
  - gst-quic-transport

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2
  - net: implement the QUIC protocol in linux kernel
- Prior work by British Broadcasting Corporation
  - gst-quic-transport
  - gst-roq

Implementations

asymptotic

- QUIC
  - quinn-rs
  - quiche
  - s2n-quic
  - neqo
  - quic
  - msquic
  - ngtcp2
  - net: implement the QUIC protocol in linux kernel
- Prior work by British Broadcasting Corporation
  - gst-quic-transport
  - gst-roq
  - Uses ngtcp2

- New elements in `gst-plugins-rs`

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing
  - `quinnroqmux` and `quinnroqdemux` for RTP over QUIC

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing
  - `quinnroqmux` and `quinnroqdemux` for RTP over QUIC
  - Uses quinn-rs

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing
  - `quinnroqmux` and `quinnroqdemux` for RTP over QUIC
  - Uses quinn-rs
- Related merge requests

GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing
  - `quinnroqmux` and `quinnroqdemux` for RTP over QUIC
  - Uses quinn-rs
- Related merge requests
  - !1634 - Stream multiplexing

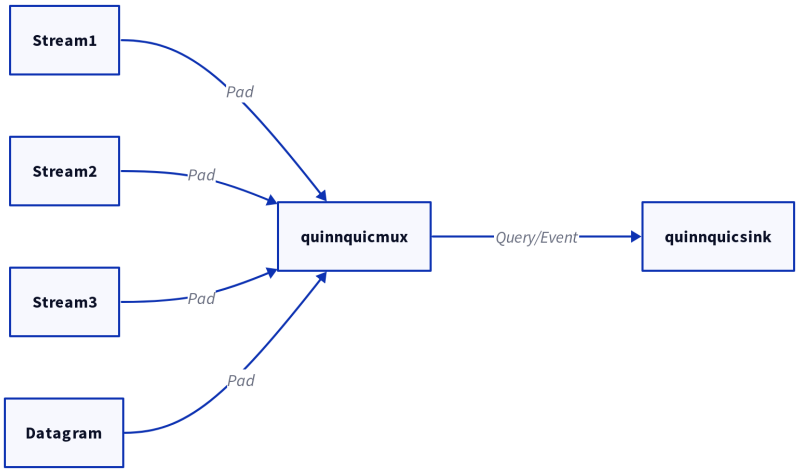
GStreamer

asymptotic

- New elements in `gst-plugins-rs`
  - `quinnquicsink` and `quinnquicsrc`
  - `quinnquicmux` and `quinnquicdemux` for stream multiplexing
  - `quinnroqmux` and `quinnroqdemux` for RTP over QUIC
  - Uses quinn-rs
- Related merge requests
  - !1634 - Stream multiplexing
  - !1775 - RTP over QUIC

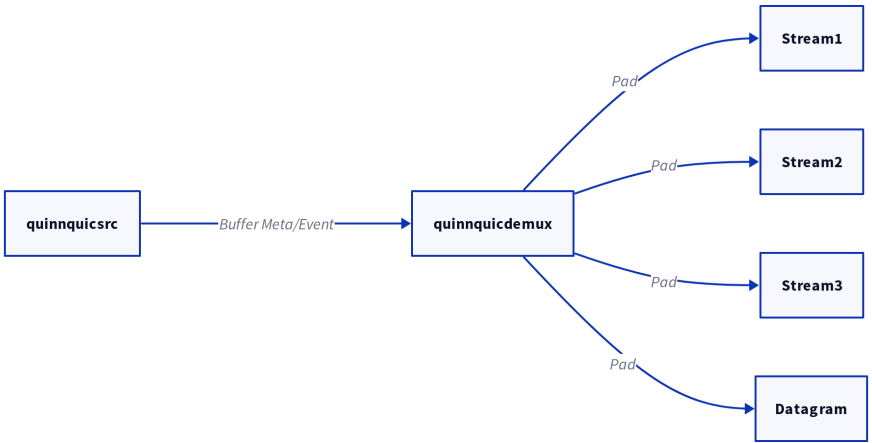
Stream multiplexing

asymptotic



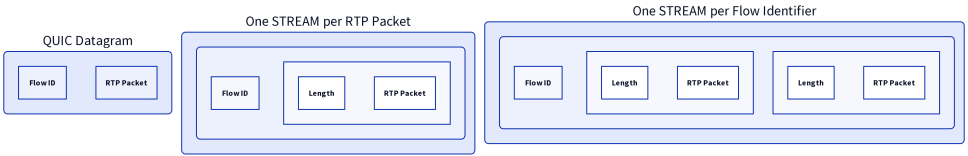
Stream de-multiplexing

asymptotic



RoQ[5]

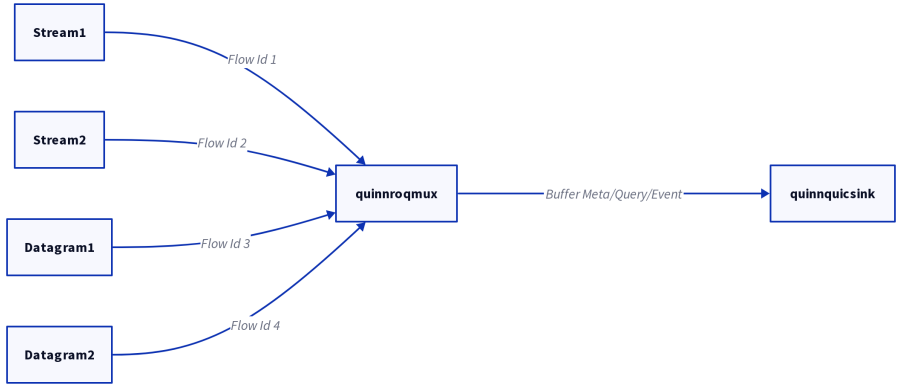
asymptotic



[5] RFC draft - RTP over QUIC

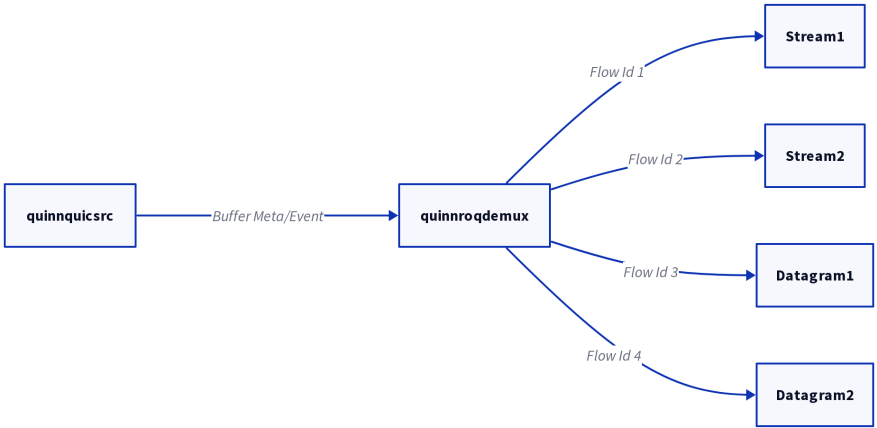
RoQ multiplexing

asymptotic



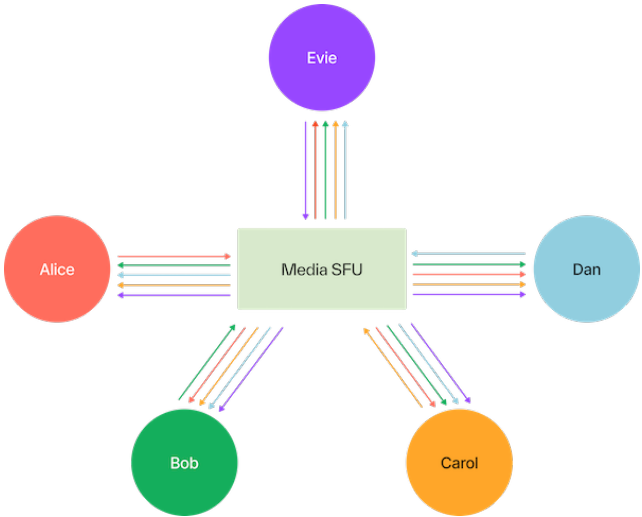
RoQ de-multiplexing

asymptotic



WebRTC[6]

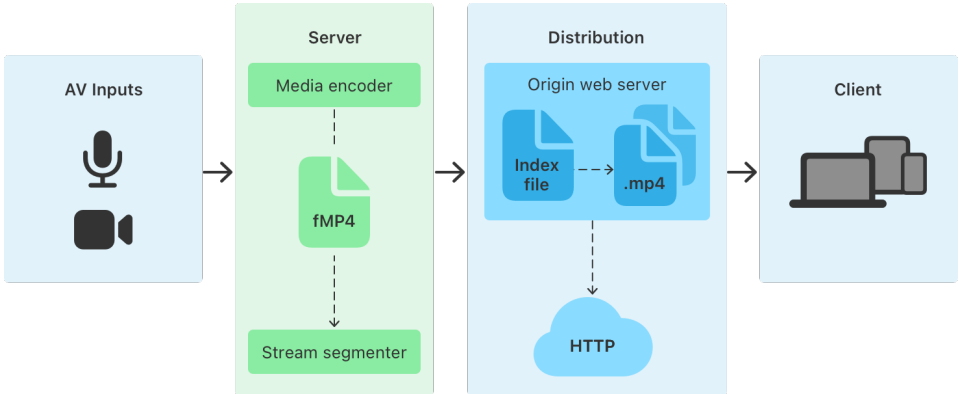
asymptotic



[6] quic.video - Replacing WebRTC

HTTP Live Streaming (HLS)[7]

asymptotic



[7] HTTP Live Streaming

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency
- WebRTC

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency
- WebRTC
  - Optimized for playback at the live-edge only

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency
- WebRTC
  - Optimized for playback at the live-edge only
  - Difficult to use for near-live and VOD playback

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency
- WebRTC
  - Optimized for playback at the live-edge only
  - Difficult to use for near-live and VOD playback
- HLS

WebRTC vs HLS[8]

asymptotic

- Scale vs Latency
- WebRTC
  - Optimized for playback at the live-edge only
  - Difficult to use for near-live and VOD playback
- HLS
  - Can operate at scale in the one-to-few-seconds latency range

WebRTC vs HLS[8]

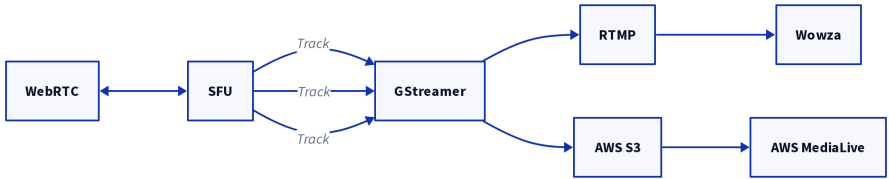
asymptotic

- Scale vs Latency
- WebRTC
  - Optimized for playback at the live-edge only
  - Difficult to use for near-live and VOD playback
- HLS
  - Can operate at scale in the one-to-few-seconds latency range
  - Not for real-time

[8] quic.video - Replacing WebRTC

Bridging WebRTC & HLS

asymptotic



Media over QUIC[9]

asymptotic

- **Simple low-latency media delivery solution for ingest and distribution of media**

Media over QUIC[9]

asymptotic

- **Simple low-latency media delivery solution for ingest and distribution of media**
- Application-level multicast overlay/application layer Named Data Networking

Media over QUIC[9]

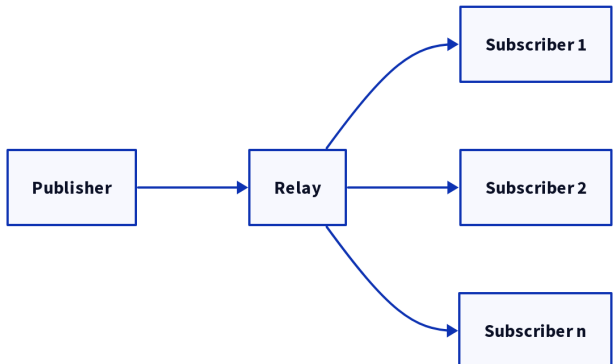
asymptotic

- **Simple low-latency media delivery solution for ingest and distribution of media**
- Application-level multicast overlay/application layer Named Data Networking
- Designed considering all three latency regimes: real-time, interactive, and VOD

[9] What's the deal with Media over QUIC

MoQ topology - Example I[10]

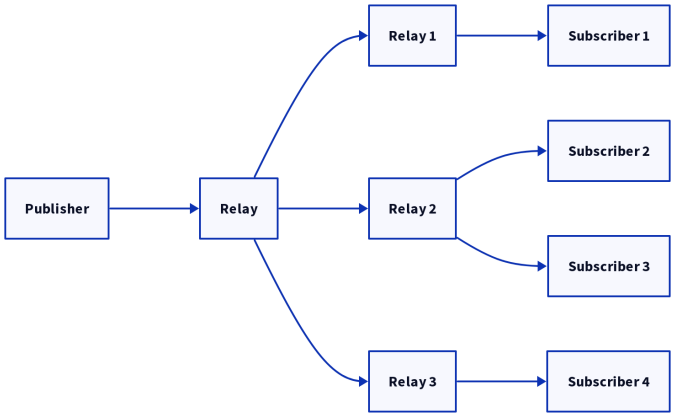
asymptotic



[10] Getting Media Over QUIC (MoQ) and WebRTC to like each other

MoQ topology - Example II[11]

asymptotic



[11] Getting Media Over QUIC (MoQ) and WebRTC to like each other

MoQ implementations[12]

asymptotic

- moq-rs

MoQ implementations[1][2]

asymptotic

- moq-rs
- moxygen

MoQ implementations[12]

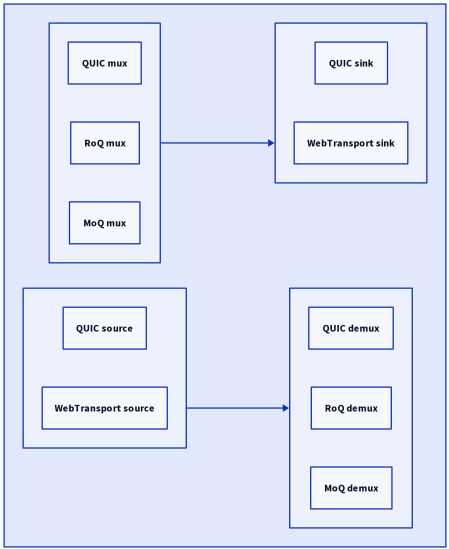
asymptotic

- moq-rs
- moxygen
- moqtransport

[12] MoQ RFCs

QUIC toolbox

asymptotic



Future work

asympt⟋tic

- Support for WebTransport

Future work

asympt⁄tic

- Support for WebTransport
- Handling flow and congestion control

Future work

asymptotic

- Support for WebTransport
- Handling flow and congestion control
- Improvements to RTP over QUIC (stream per GOP and RTCP)

Future work

asymptotic

- Support for WebTransport
- Handling flow and congestion control
- Improvements to RTP over QUIC (stream per GOP and RTCP)
- Media over QUIC elements - Publisher & Subscriber

Future work

asymptotic

- Support for WebTransport
- Handling flow and congestion control
- Improvements to RTP over QUIC (stream per GOP and RTCP)
- Media over QUIC elements - Publisher & Subscriber
- Interoperability between `gst-quic-transport`, `gst-roq`, `moq-rs` & `moxygen`

Future work

asymptotic

- Support for WebTransport
- Handling flow and congestion control
- Improvements to RTP over QUIC (stream per GOP and RTCP)
- Media over QUIC elements - Publisher & Subscriber
- Interoperability between `gst-quic-transport`, `gst-roq`, `moq-rs` & `moxygen`
- Re-usability of queries, metas and events with other implementations

Questions

asymptotic

- Reach out on

Questions

asymptotic

- Reach out on
  - email:
    - hello@asymptotic.io
    - sanchayan@asymptotic.io

Questions

asymptotic

- Reach out on
  - email:
    - `hello@asymptotic.io`
    - `sanchayan@asymptotic.io`
  - Mastodon: sanchayanmaity.com

Questions

asymptotic

- Reach out on
  - email:
    - `hello@asymptotic.io`
    - `sanchayan@asymptotic.io`
  - Mastodon: sanchayanmaity.com
  - Blog: sanchayanmaity.net