[qlog] structured event logging

The philosophical update

Robin Marx robin.marx@kuleuven.be

IETF 111

The story so far

[qlog] = QUIC Logging

Log events directly inside the endpoint implementations

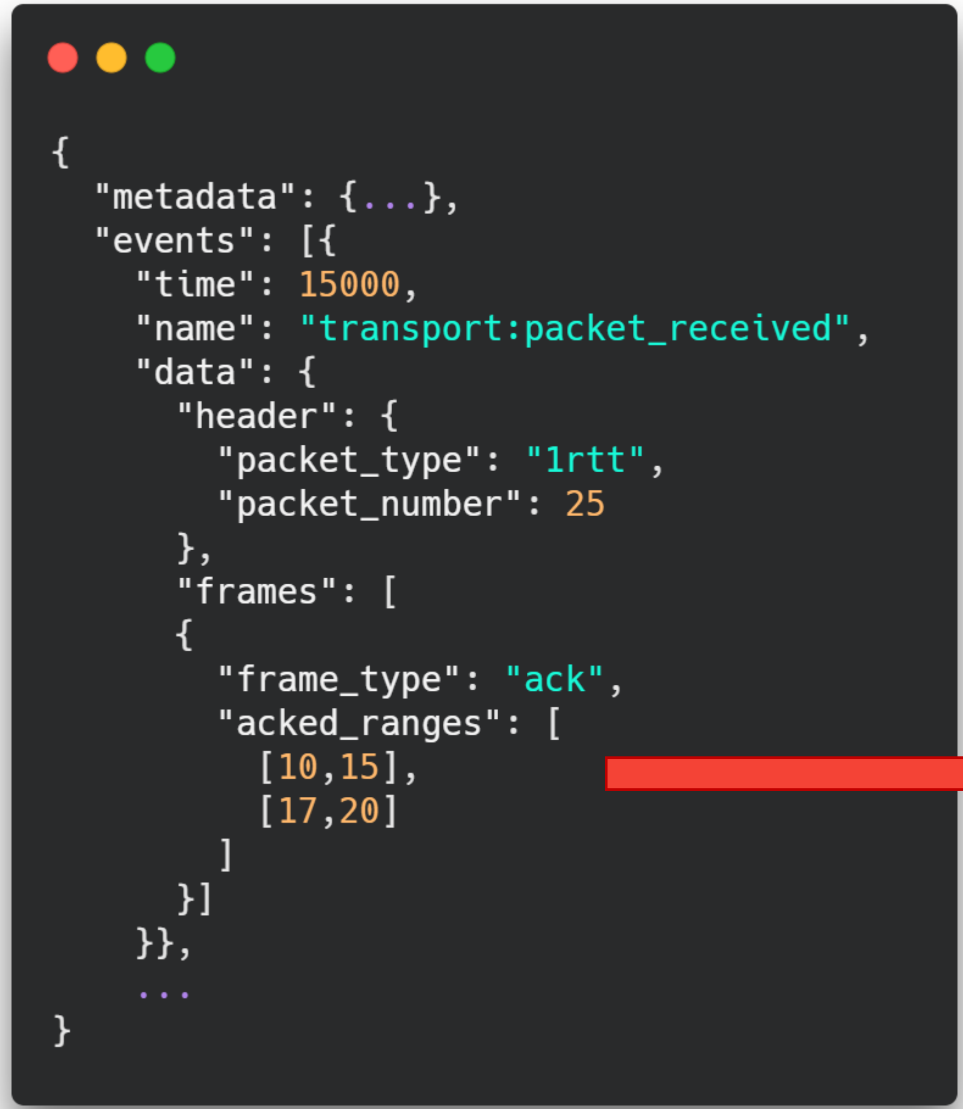
- Packet captures require full decryption → worse for privacy/security
- Can add additional information (e.g., congestion window)

3 separate documents:

- Main schema → metadata schema + serialization format
- QUIC and TLS events } → event schema
- HTTP/3 and QPACK events

https://github.com/quicwg/qlog

Schema vs Serialization Format

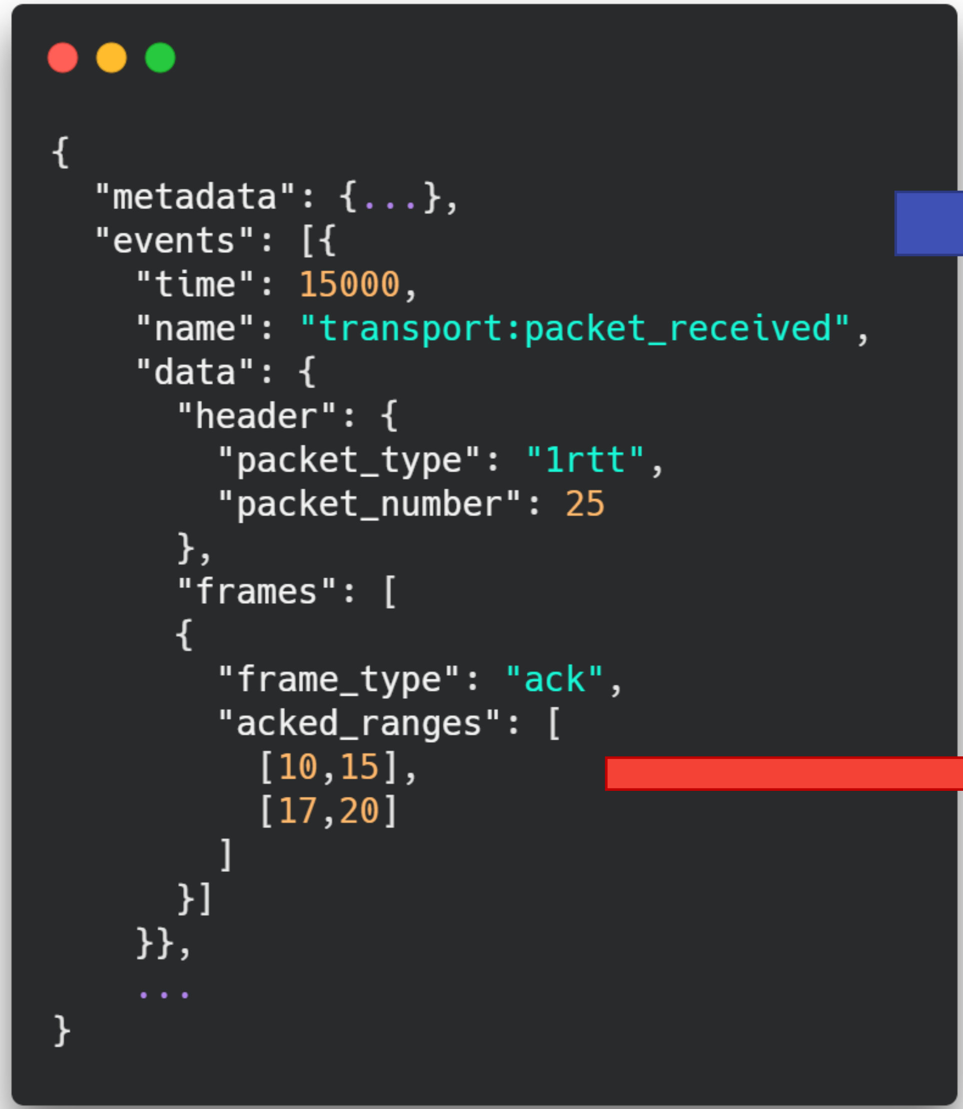


```
{
  "metadata": {...},
  "events": [{
    "time": 15000,
    "name": "transport:packet_received",
    "data": {
      "header": {
        "packet_type": "1rtt",
        "packet_number": 25
      },
      "frames": [
      {
        "frame_type": "ack",
        "acked_ranges": [
          [10,15],
          [17,20]
        ]
      }]
    }},
    ...
}
```

```
class AckFrame{
    frame_type:string = "ack";

    ack_delay?:float; // in ms

    acked_ranges?:Array<[uint64, uint64]|[uint64]>;

    ect1?:uint64;
    ect0?:uint64;
    ce?:uint64;
}
```

https://github.com/quicwg/qlog

Schema vs Serialization Format



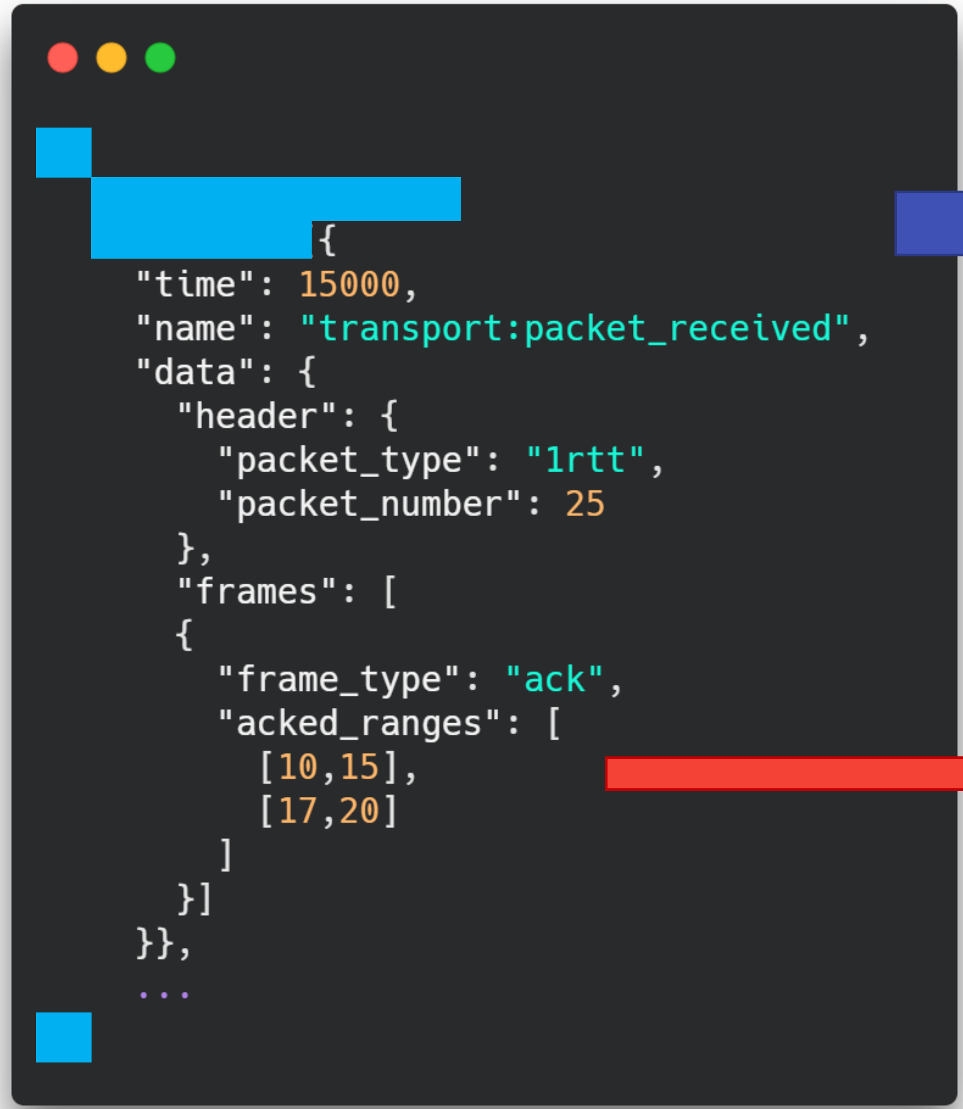
```
{
  "metadata": {...},
  "events": [{
    "time": 15000,
    "name": "transport:packet_received",
    "data": {
      "header": {
        "packet_type": "1rtt",
        "packet_number": 25
      },
      "frames": [
      {
        "frame_type": "ack",
        "acked_ranges": [
          [10,15],
          [17,20]
        ]
      }]
    }},
    ...
}
```

JSON

```
class AckFrame{
    frame_type:string = "ack";

    ack_delay?:float; // in ms

    acked_ranges?:Array<[uint64, uint64]|[uint64]>;

    ect1?:uint64;
    ect0?:uint64;
    ce?:uint64;
}
```

https://github.com/quicwg/qlog

Schema vs Serialization Format



```
[redacted]
  [redacted]{
    "time": 15000,
    "name": "transport:packet_received",
    "data": {
      "header": {
        "packet_type": "1rtt",
        "packet_number": 25
      },
      "frames": [
      {
        "frame_type": "ack",
        "acked_ranges": [
          [10,15],
          [17,20]
        ]
      }]
    }},
    ...
[redacted]
```

JSON and NDJSON

qlog_format?:string = "JSON" | "NDJSON";

```
class AckFrame{
    frame_type:string = "ack";

    ack_delay?:float; // in ms

    acked_ranges?:Array<[uint64, uint64]|[uint64]>;

    ect1?:uint64;
    ect0?:uint64;
    ce?:uint64;
}
```

https://github.com/quicwg/qlog

Today

What do we actually standardize and why?

Part 1: The JSON in the room

JSON pros:

- Broadly supported → browser-based tooling, scripting libraries
- Plaintext → re-use existing tools (jq, sed/awk/grep/…, YOU), fprintf("%s")

JSON cons:

- Slow
- Verbose
- *NDJSON isn't actually standardized anywhere yet… need to define our own "Streaming JSON"*

Alternatives:

- CBOR
- Protobuffers/flatbuffers/…
- PCAPNG
- …

Binary format - https://github.com/quicwg/qlog/issues/30
Revisit serialization format - https://github.com/quicwg/qlog/issues/144

Part 1: What is the goal for qlog?

Optimize for interoperable/reusable tools?

VS

Optimize for direct output/storage/transfer?

https://github.com/quicwg/qlog/issues/85#issuecomment-721232467
https://github.com/quicwg/qlog/issues/144#issuecomment-815018003

Part 1: What is the goal for qlog?

Optimize for interoperable/reusable tools?

VS

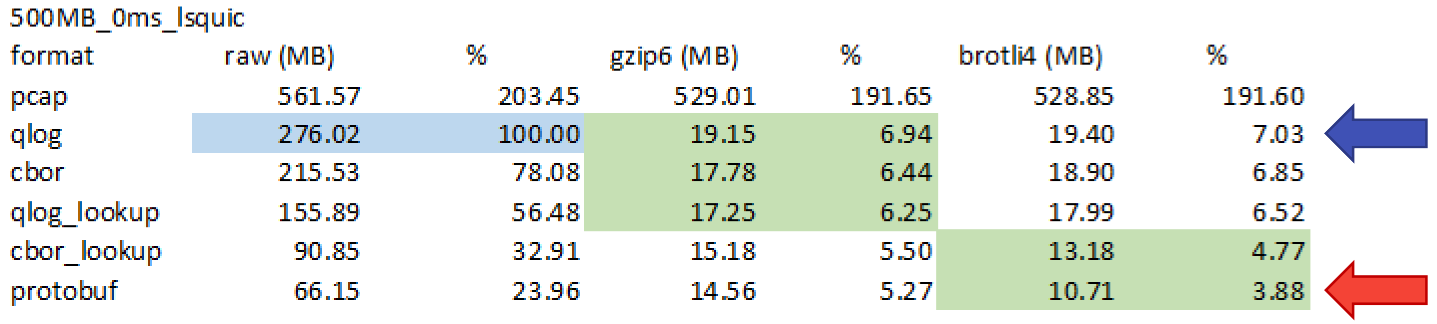
Optimize for direct output/storage/transfer?

Is this even needed?

- Direct JSON is feasible
  - mvfst, quic-go

- Log optimized, **convert**
  - quicly, picoquic
  - chromium (kind of)

- **Compress**



500MB_0ms_lsquic

format	raw (MB)	%	gzip6 (MB)	%	brotli4 (MB)	%
pcap	561.57	203.45	529.01	191.65	528.85	191.60
qlog	276.02	100.00	19.15	6.94	19.40	7.03
cbor	215.53	78.08	17.78	6.44	18.90	6.85
qlog_lookup	155.89	56.48	17.25	6.25	17.99	6.52
cbor_lookup	90.85	32.91	15.18	5.50	13.18	4.77
protobuf	66.15	23.96	14.56	5.27	10.71	3.88

https://crates.io/crates/qlog
https://github.com/quicwg/qlog/issues/30
https://github.com/quicwg/qlog/issues/144#issuecomment-815018003

Part 1: Proposal

Stick to JSON + "Streaming JSON"

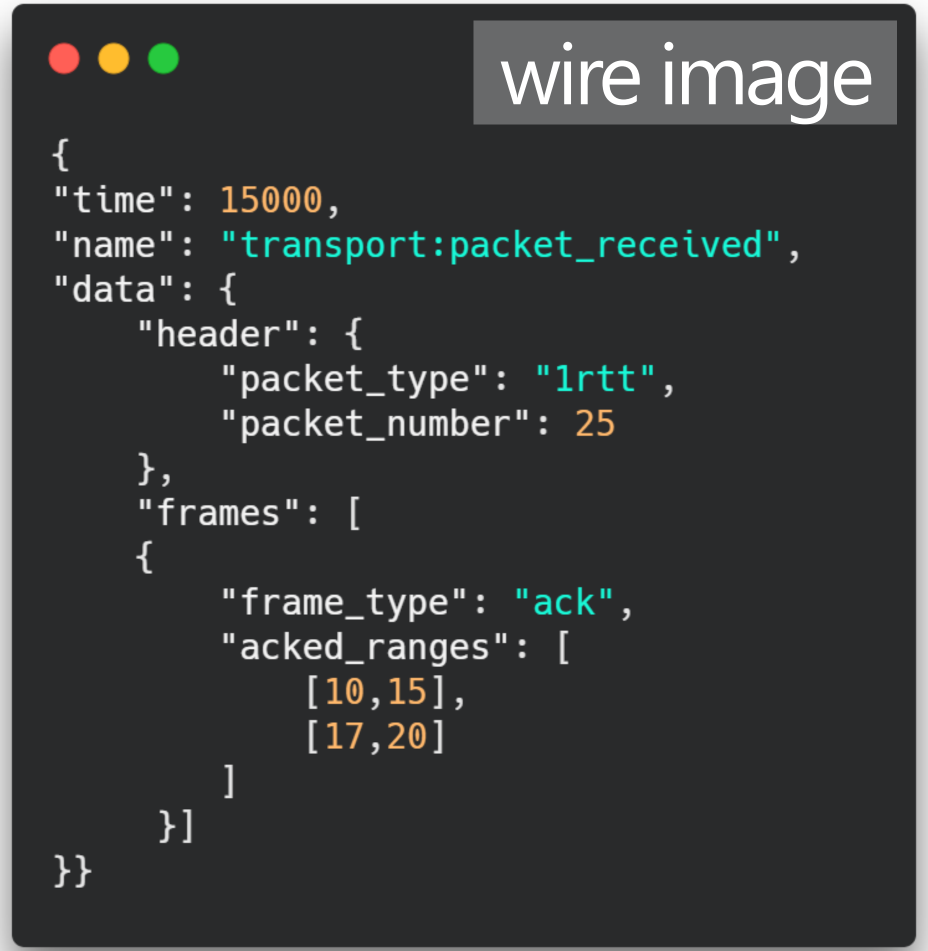
- Optimize for text-based and browser-based processing

- Even loading large JSON files should be feasible
    - Not in qvis/browser, but surely in native apps

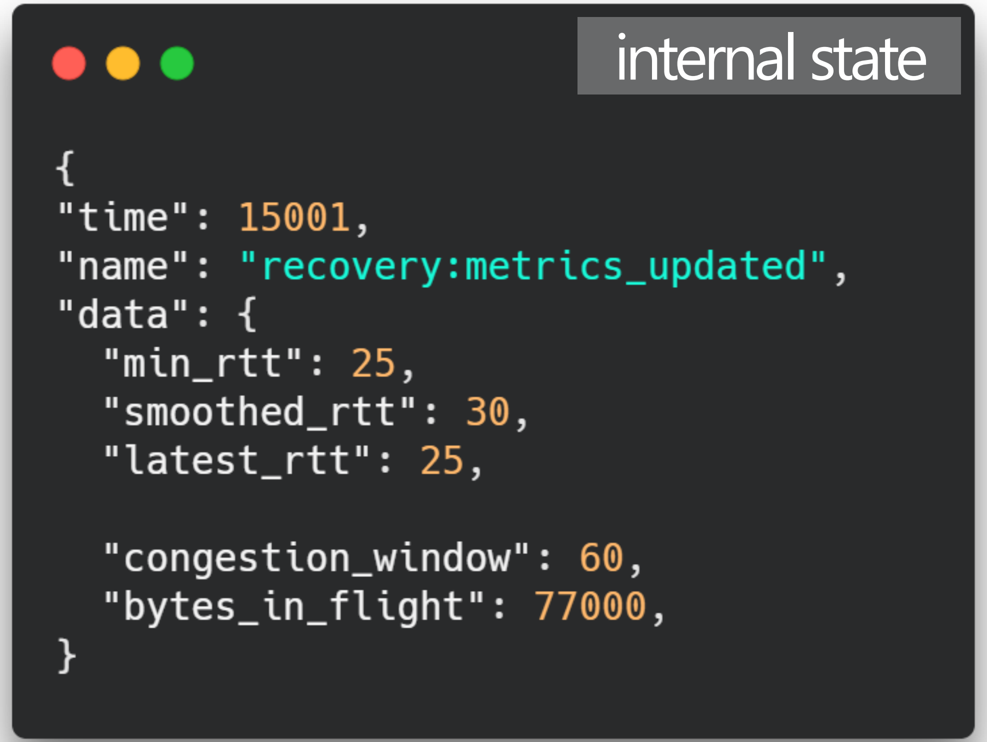
- Other documents can later define CBOR/PCAPNG/Protobuf/… *if needed*
    - *Take care to make schema as generic as possible to allow easy mapping*
    - *You're free to use another format in your implementation (duh) and then write converter*

- *We do need to define Streaming JSON properly ourselves then…*
    - *Can still be identical to NDJSON's format! Or use another delimiter or …*

Part 2: which events do we include?


wire image

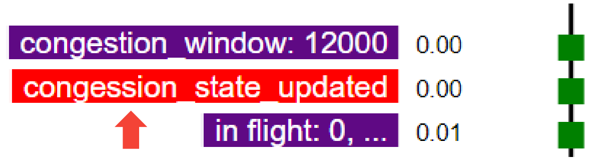
```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_type": "1rtt",
        "packet_number": 25
    },
    "frames": [
    {
        "frame_type": "ack",
        "acked_ranges": [
            [10,15],
            [17,20]
        ]
     }]
}}
```


internal state

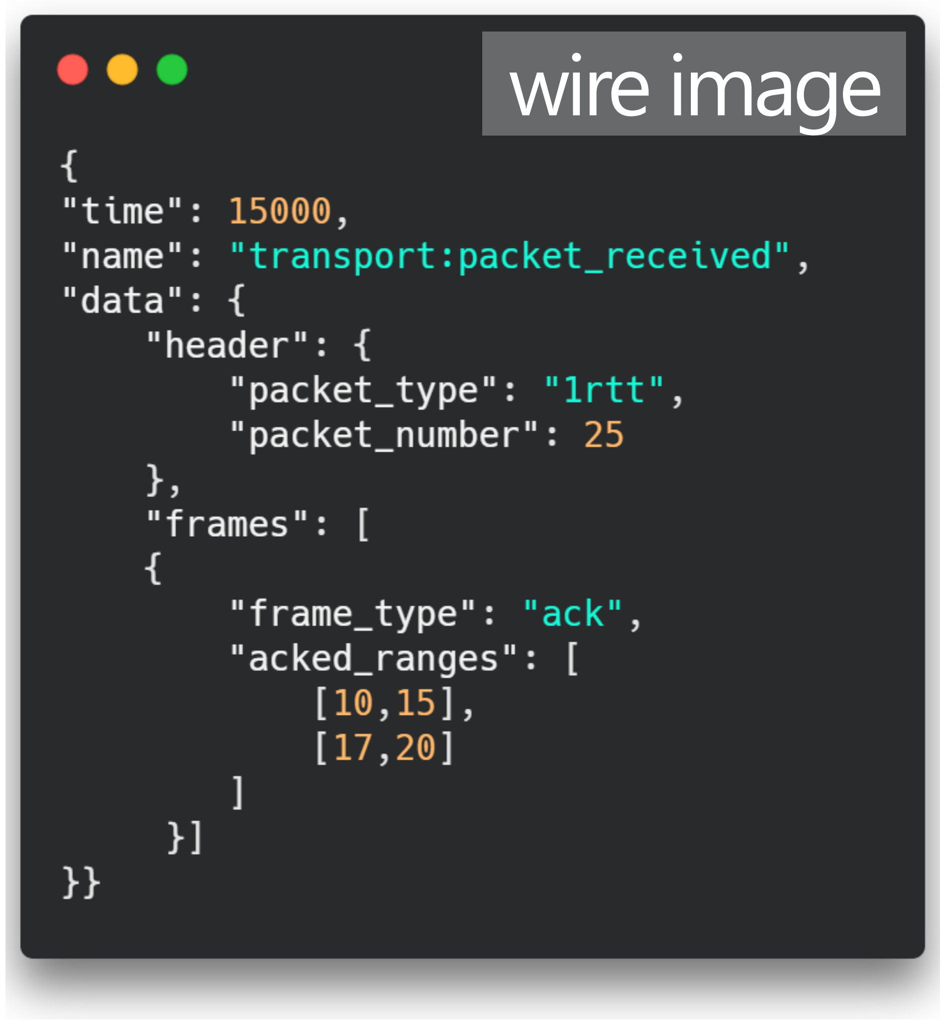
```
{
"time": 15001,
"name": "recovery:metrics_updated",
"data": {
  "min_rtt": 25,
  "smoothed_rtt": 30,
  "latest_rtt": 25,

  "congestion_window": 60,
  "bytes_in_flight": 77000,
}
```

+ Custom events!

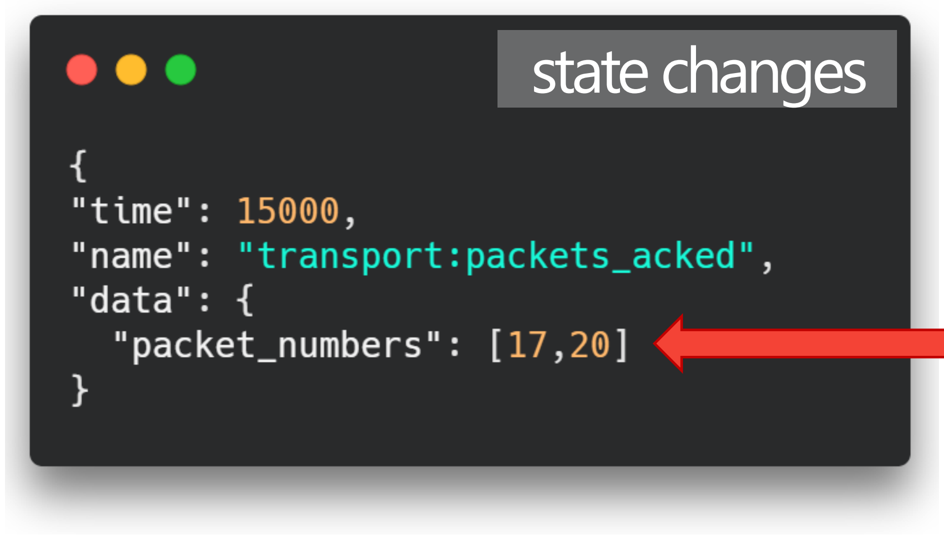
Tools MUST deal with unknown events



Part 2: 2 sides of the same coin


wire image

```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_type": "1rtt",
        "packet_number": 25
    },
    "frames": [
    {
        "frame_type": "ack",
        "acked_ranges": [
            [10,15],
            [17,20]
        ]
     }]
}}
```

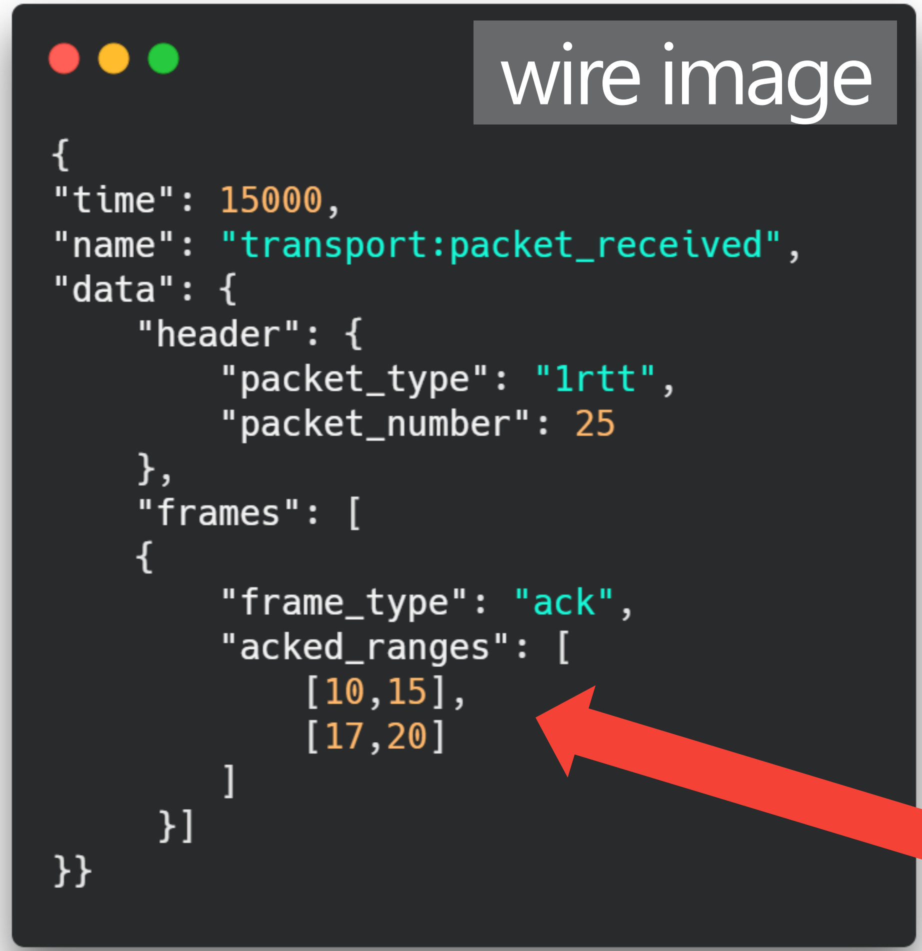

state changes

```
{
"time": 15000,
"name": "transport:packets_acked",
"data": {
  "packet_numbers": [17,20]
}
```

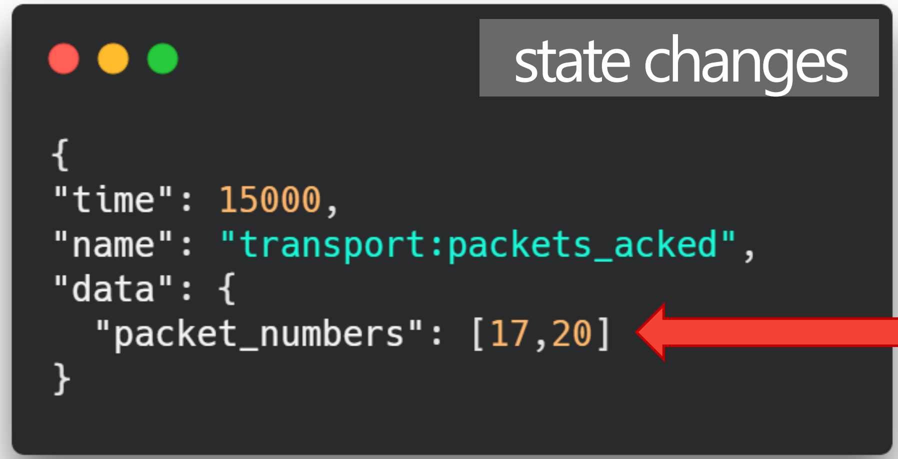
Only newly ACKed

Note: we also have a separate packet_lost event

Part 2: 3 sides of the same... triangle?

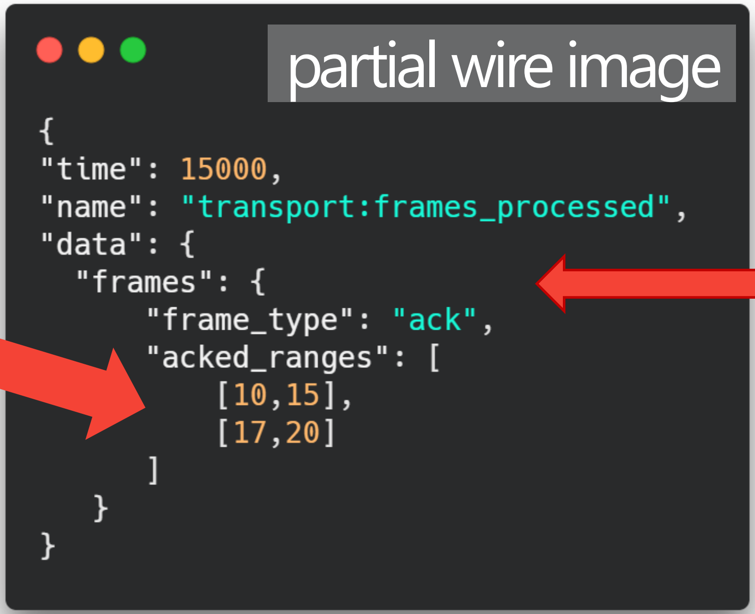


```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_type": "1rtt",
        "packet_number": 25
    },
    "frames": [
    {
        "frame_type": "ack",
        "acked_ranges": [
            [10,15],
            [17,20]
        ]
     }]
}}
```



```
{
"time": 15000,
"name": "transport:packets_acked",
"data": {
   "packet_numbers": [17,20]
}
```

Only newly ACKed

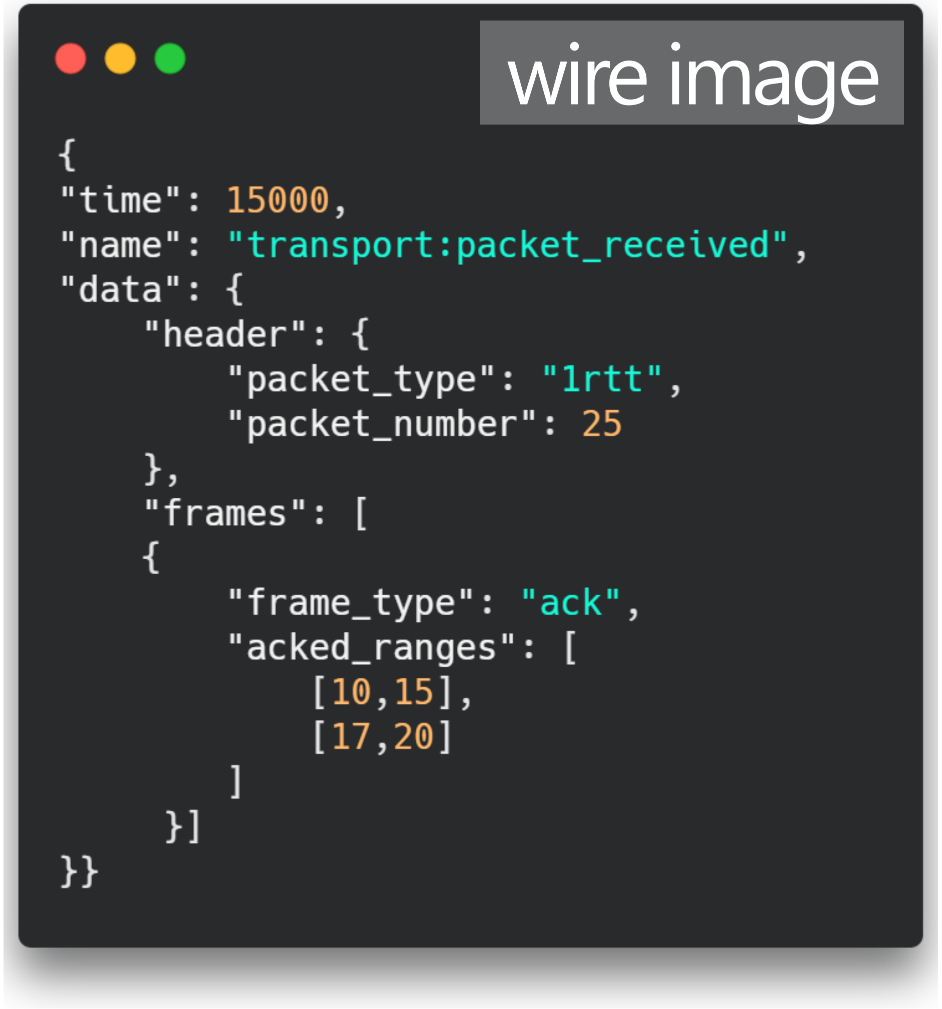


```
{
"time": 15000,
"name": "transport:frames_processed",
"data": {
  "frames": {
      "frame_type": "ack",
      "acked_ranges": [
          [10,15],
          [17,20]
      ]
   }
}
```

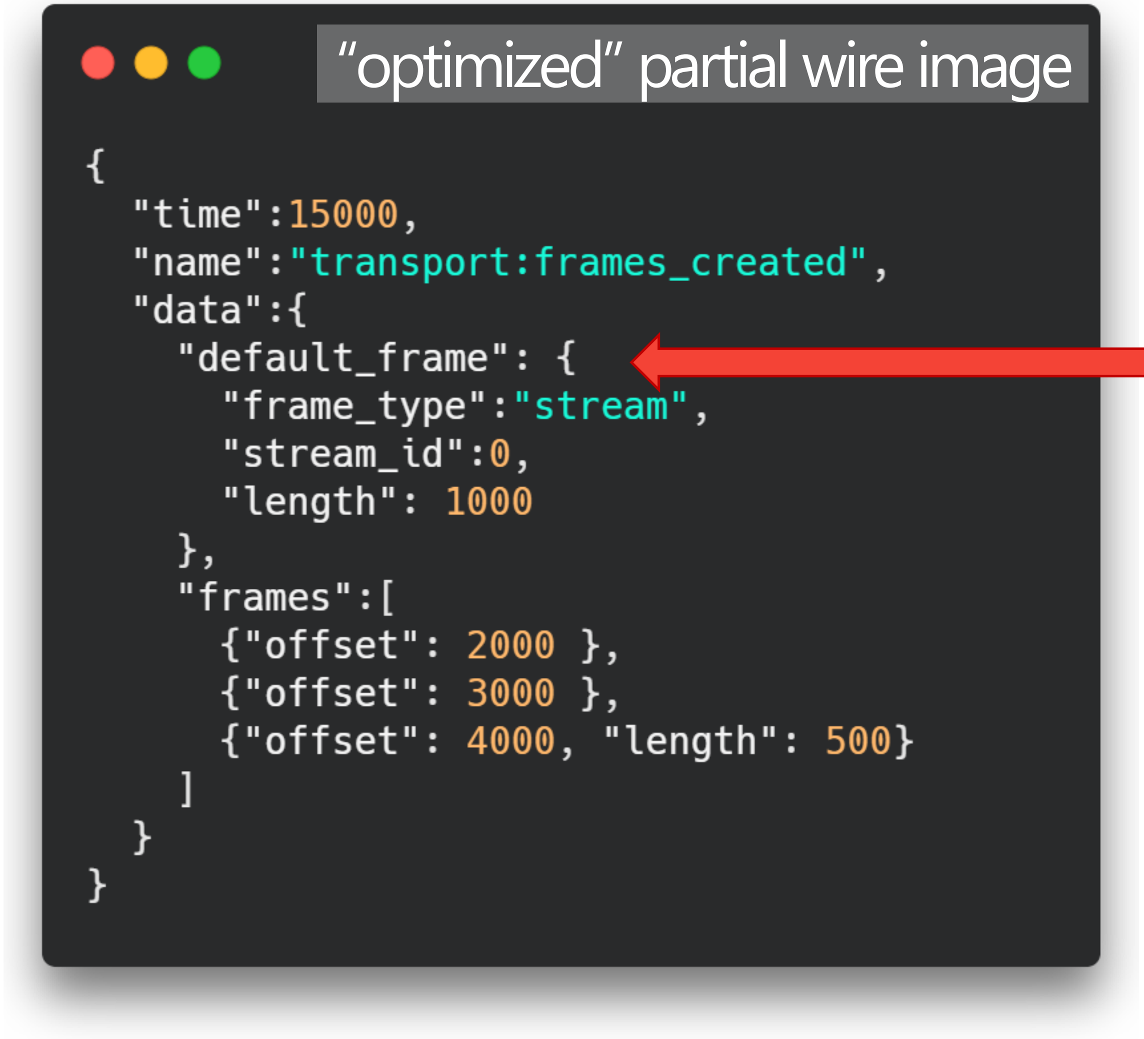
No packet header

Is this too tied to implementation specifics?

Part 2: 4 sides of … I give up


wire image

```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_type": "1rtt",
        "packet_number": 25
    },
    "frames": [
    {
        "frame_type": "ack",
        "acked_ranges": [
            [10,15],
            [17,20]
        ]
     }]
}}
```


“optimized” partial wire image

```
{
   "time":15000,
   "name":"transport:frames_created",
   "data":{
     "default_frame": {
       "frame_type":"stream",
       "stream_id":0,
       "length": 1000
     },
     "frames":[
       {"offset": 2000 },
       {"offset": 3000 },
       {"offset": 4000, "length": 500}
     ]
   }
}
```

Often sending similar STREAM frames

Aggregating stream_frame - https://github.com/quicwg/qlog/issues/163

Part 2: Explosion of events

All useful, but confusing

- qlog implementers: what to log when/where?
- Tool creators: which events to use? What if contradictions?

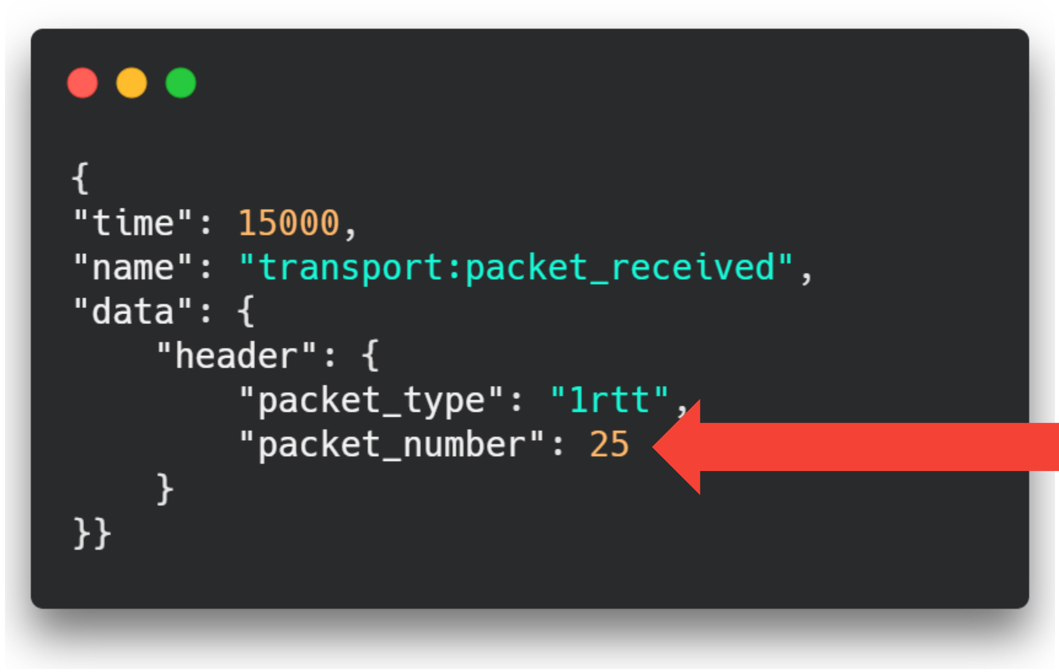
    - *If tools only support a subset, what's the use of standardizing more?*

We need guidelines/design philosphy

When should something be a new event / re-use event / be custom event?

provide clearer usage advice - https://github.com/quicwg/qlog/issues/53
frames_processed fails to capture - https://github.com/quicwg/qlog/issues/154

Part 2: Re-use event types

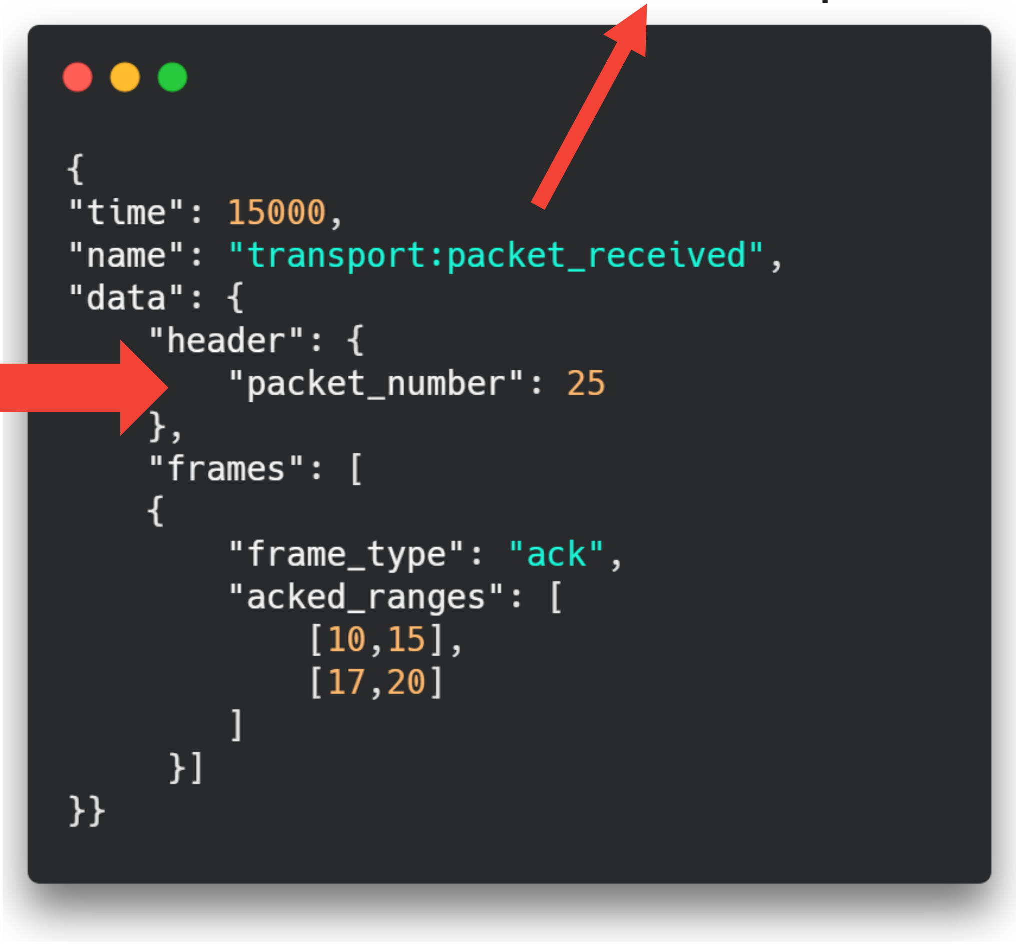


```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_type": "1rtt",
        "packet_number": 25
    }
}}
```

When handling header

Tool couples based on PN

instead of frames_processed



```
{
"time": 15000,
"name": "transport:packet_received",
"data": {
    "header": {
        "packet_number": 25
    },
    "frames": [
    {
        "frame_type": "ack",
        "acked_ranges": [
            [10,15],
            [17,20]
        ]
     }]
}}
```

When handling payload

frames_processed fails to capture - https://github.com/quicwg/qlog/issues/154

Part 2: Proposal

Pragmatism: rules with exceptions

1. Stay as close to wire image as possible
   - Only deviate for internal state
     - *Makes tools mostly usable on pcaps as well*

packet_sent + congestion_metrics_updated

Part 2: Proposal

Pragmatism: rules with exceptions

1. Stay as close to wire image as possible
   - Only deviate for <u>internal state</u>
     - *Makes tools mostly usable on pcaps as well*

packet_sent + congestion_metrics_updated

2. Prevent duplicate info logging
   - Only deviate for non-trivial <u>internal state</u> changes
     - *packets_acked would be a good "exception to the rule"*
     - *QPACK wire image vs "dynamic_table_contents"*

packets_acked

Part 2: Proposal

Pragmatism: rules with exceptions

1. Stay as close to wire image as possible
   - Only deviate for internal state
     - *Makes tools mostly usable on pcaps as well*

packet_sent +
congestion_metrics_updated

2. Prevent duplicate info logging
   - Only deviate for non-trivial internal state changes
     - *packets_acked would be a good "exception to the rule"*
     - *QPACK wire image vs "dynamic_table_contents"*

packets_acked

~~= no more frames_processed~~

If implementations need split (re-used) events/other logic:
→ Write custom converter to "proper" qlog for tools that don't support those

What do we actually standardize?

Proposal 1: JSON + “Streaming JSON”

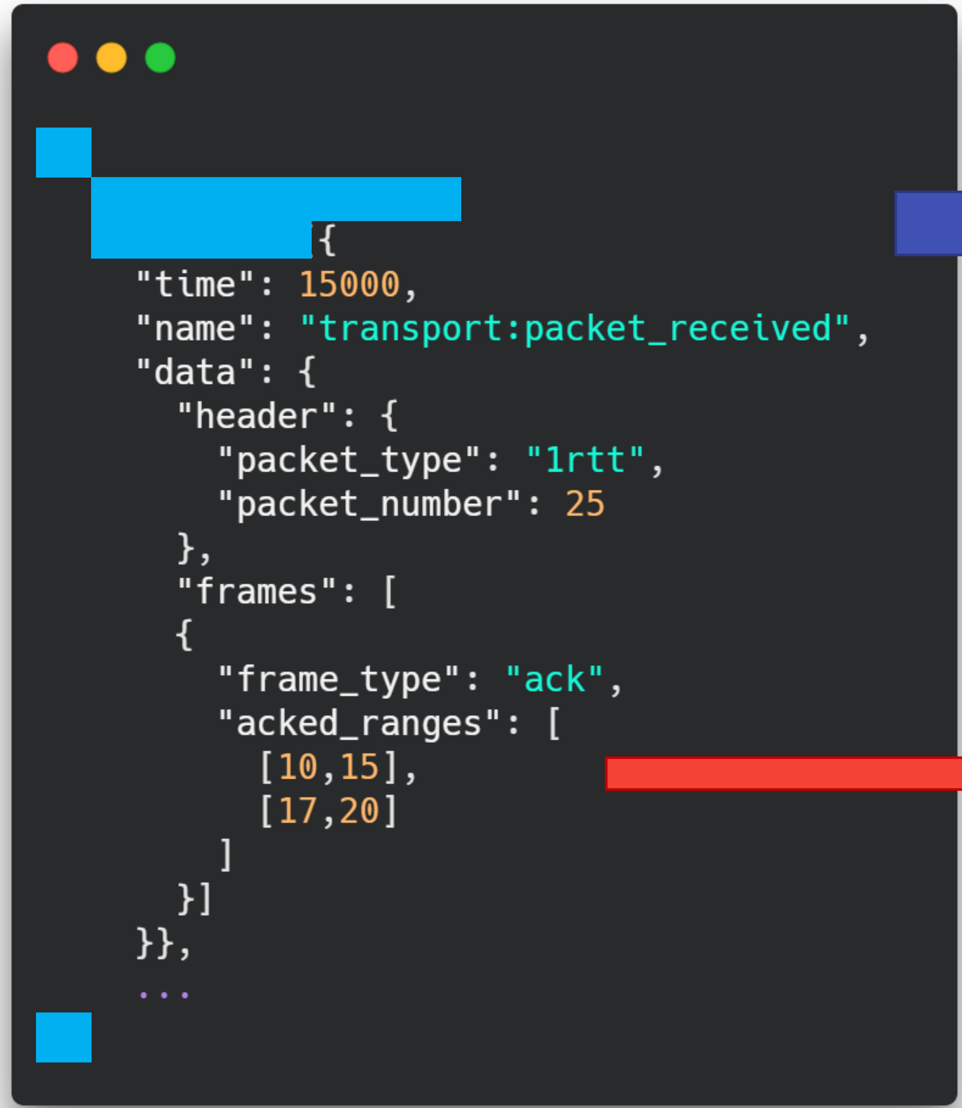
Proposal 2: limit event options, similar to draft-01

getting rough consensus on these impacts ~75% of open issues

provide clearer usage advice - https://github.com/quicwg/qlog/issues/53
frames_processed fails to capture - https://github.com/quicwg/qlog/issues/154

EXTRA

Schema vs Serialization Format



```
[redacted]
[redacted]{
    "time": 15000,
    "name": "transport:packet_received",
    "data": {
      "header": {
        "packet_type": "1rtt",
        "packet_number": 25
      },
      "frames": [
      {
        "frame_type": "ack",
        "acked_ranges": [
          [10,15],
          [17,20]
        ]
      }]
    }},
    ...
[redacted]
```

JSON and NDJSON

qlog_format?:string = "JSON" | "NDJSON";

```
class AckFrame{
    frame_type:string = "ack";

    ack_delay?:float; // in ms

    acked_ranges?:Array<[uint64, uint64]|[uint64]>;

    ect1?:uint64;
    ect0?:uint64;
    ce?:uint64;
}
```

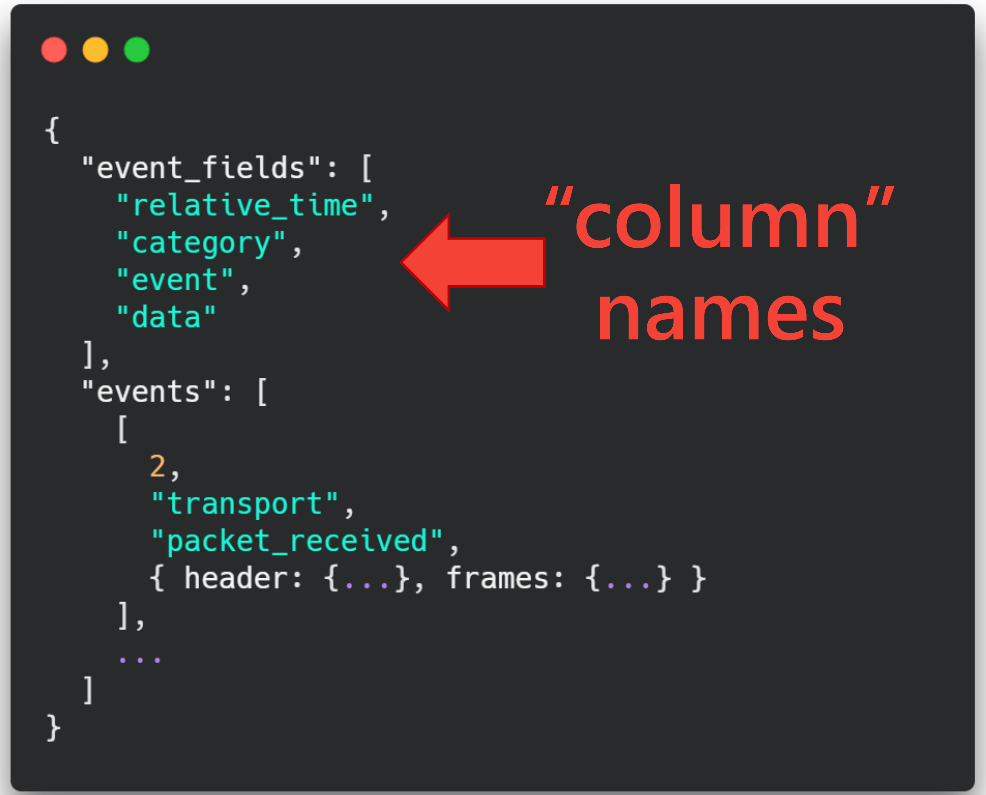
Data Definition Language

not for today ;)

https://github.com/quicwg/qlog

Part 1: what does it look like?

draft-01: csv + JSON

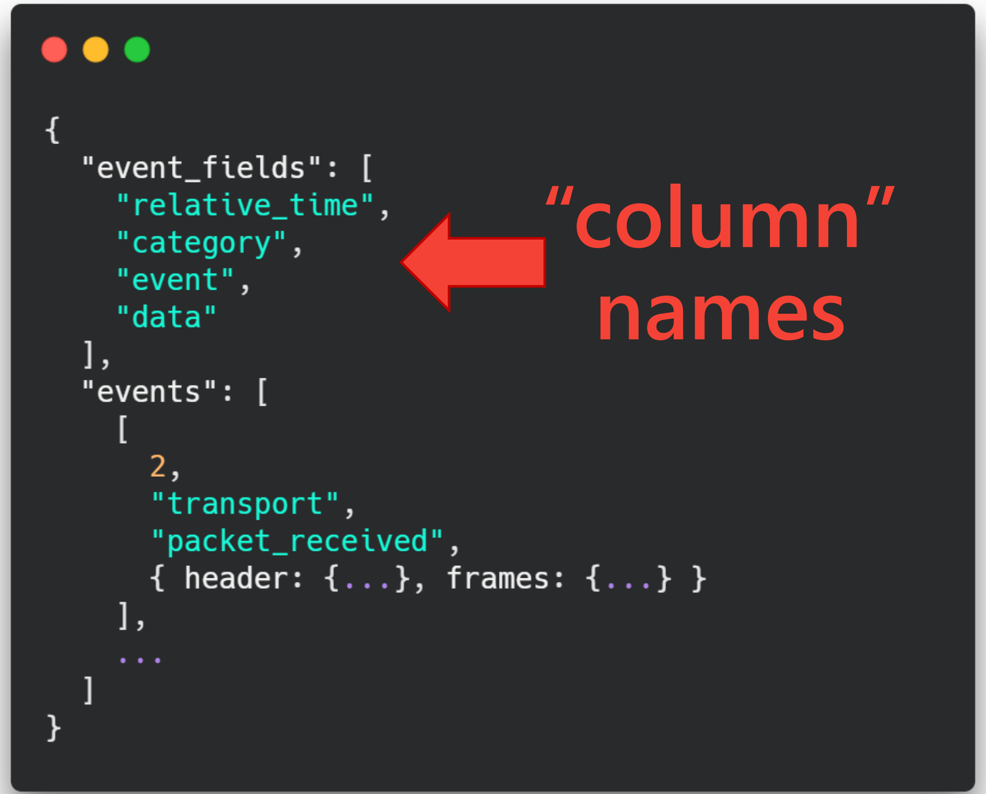


```
{
  "event_fields": [
    "relative_time",
    "category",
    "event",
    "data"
  ],
  "events": [
    [
      2,
      "transport",
      "packet_received",
      { header: {...}, frames: {...} }
    ],
    ...
  ]
}
```

- mvfst
- aioquic
- quicly / H2O
- f5
- neqo
- picoquic
- ats
- applequic
- ...

Part 1: what does it look like?

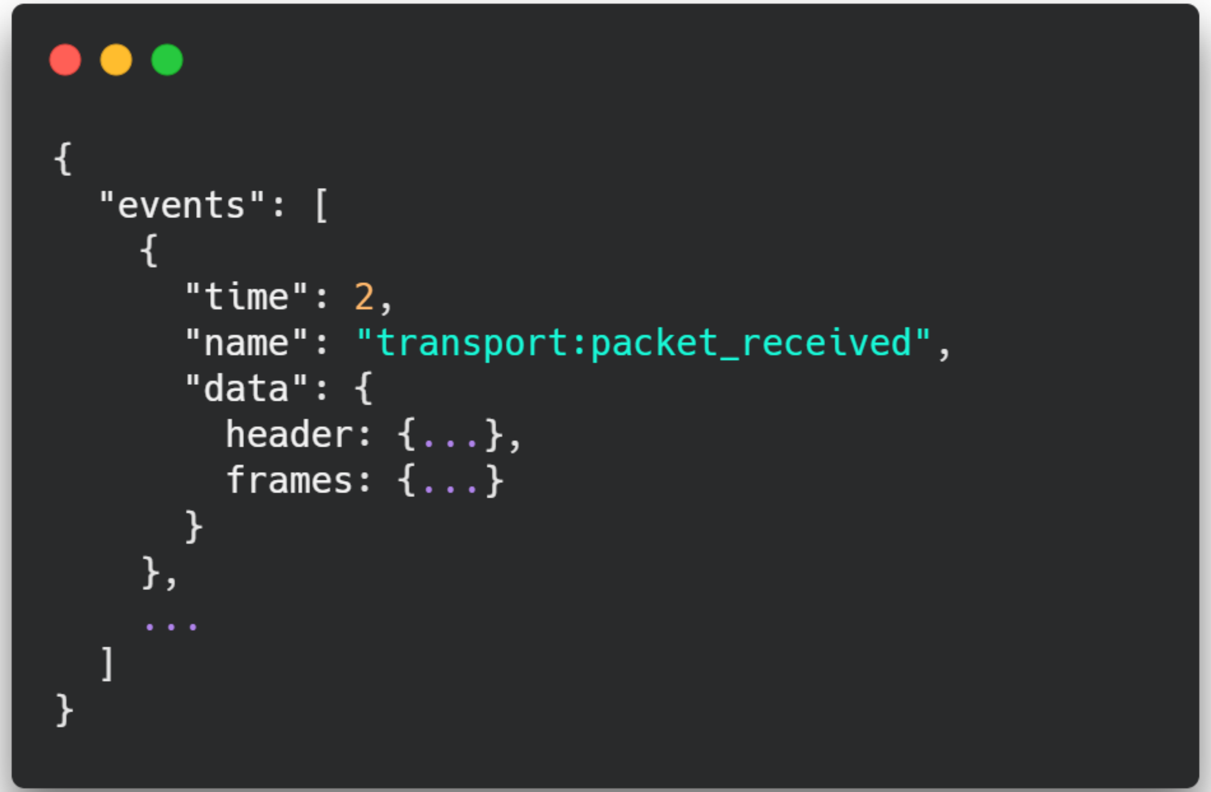
draft-01: csv + JSON



```
{
  "event_fields": [
    "relative_time",
    "category",
    "event",
    "data"
  ],
  "events": [
    [
      2,
      "transport",
      "packet_received",
      { header: {...}, frames: {...} }
    ],
    ...
  ]
}
```

- mvfst
- aioquic
- quicly / H2O
- f5
- neqo
- picoquic
- ats
- applequic
- ...

draft-02: JSON



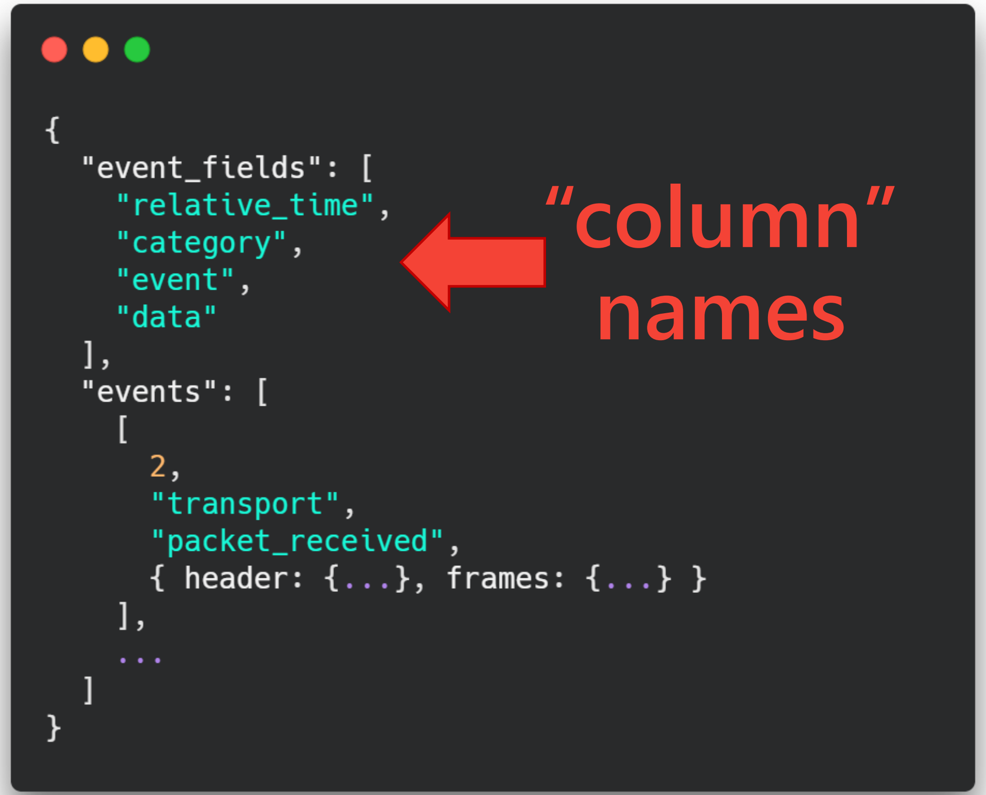
```
{
  "events": [
    {
      "time": 2,
      "name": "transport:packet_received",
      "data": {
        header: {...},
        frames: {...}
      }
    },
    ...
  ]
}
```

- quic-go
- ngtcp2
- quiche
- haskell
- kwik

https://github.com/quicwg/qlog

Part 1: what does it look like?

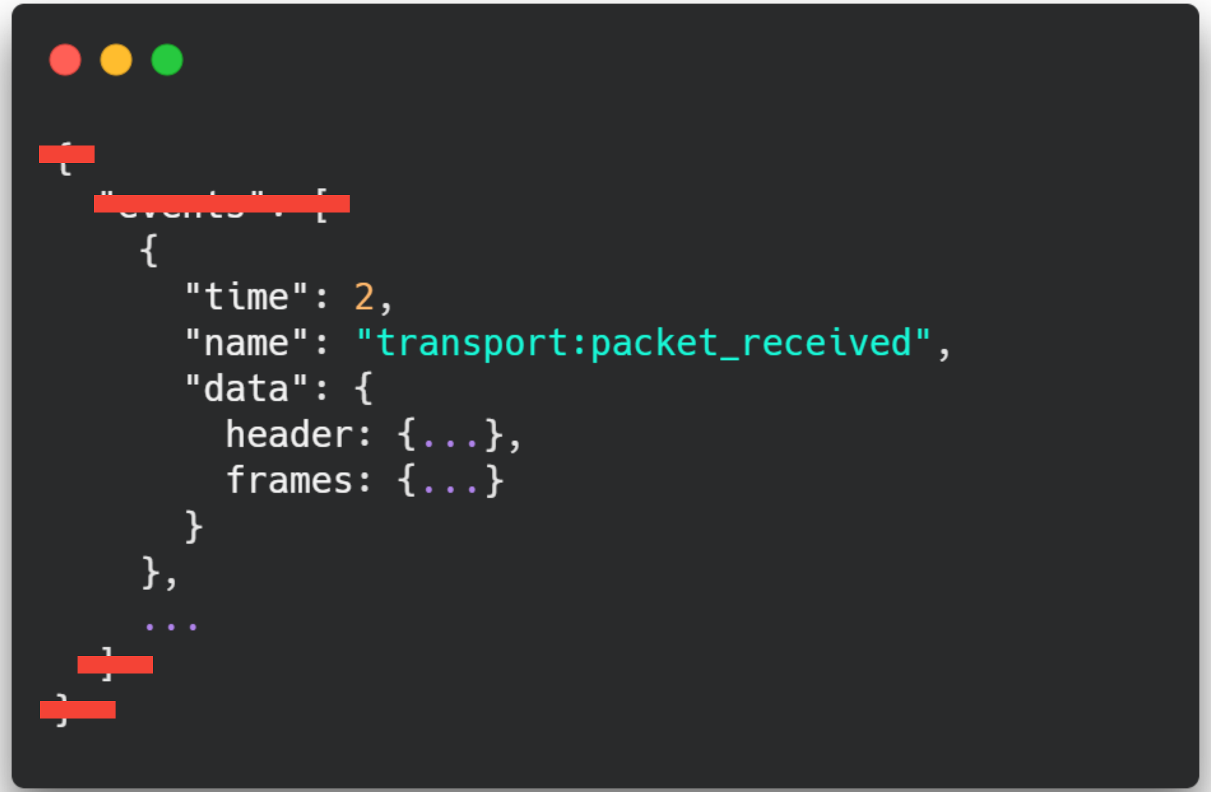
draft-01: csv + JSON



```
{
  "event_fields": [
    "relative_time",
    "category",
    "event",
    "data"
  ],
  "events": [
    [
      2,
      "transport",
      "packet_received",
      { header: {...}, frames: {...} }
    ],
    ...
  ]
}
```

- mvfst
- aioquic
- quicly / H2O
- f5
- neqo
- picoquic
- ats
- applequic
- ...

draft-02: JSON + NDJSON



```
~~{~~
  ~~"events": [~~
    {
      "time": 2,
      "name": "transport:packet_received",
      "data": {
        header: {...},
        frames: {...}
      }
    },
    ...
  ~~]~~
~~}~~
```

- quic-go
- ngtcp2
- quiche
- haskell
- kwik

https://github.com/quicwg/qlog