QUIC
Internet-Draft
Intended status: Standards Track
Expires: November 18, 2021

R. Marx
KU Leuven
L. Niccolini, Ed.
Facebook
M. Seemann, Ed.
Protocol Labs
May 17, 2021

HTTP/3 and QPACK event definitions for qlog
draft-marx-quic-qlog-h3-events-00

Abstract

This document describes concrete qlog event definitions and their metadata for HTTP/3 and QPACK-related events. These events can then be embedded in the higher level schema defined in [QLOG-MAIN].

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on November 18, 2021.

Table of Contents

1. Introduction

This document describes the values of the qlog name ("category" + "event") and "data" fields and their semantics for the HTTP/3 and QPACK protocols. This document is based on draft-34 of the HTTP/3 I-D [QUIC-HTTP] and draft-21 of the QPACK I-D [QUIC-QPACK]. QUIC events are defined in a separate document [QLOG-QUIC].

Feedback and discussion are welcome at https://github.com/quiclog/internet-drafts [1]. Readers are advised to refer to the "editor's draft" at that URL for an up-to-date version of this document.

Concrete examples of integrations of this schema in various programming languages can be found at https://github.com/quiclog/qlog/ [2].

1.1. Notational Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

The examples and data definitions in ths document are expressed in a custom data definition language, inspired by JSON and TypeScript, and described in [QLOG-MAIN].

2. Overview

This document describes the values of the qlog "name" ("category" + "event") and "data" fields and their semantics for the HTTP/3 and QPACK protocols.

This document assumes the usage of the encompassing main qlog schema defined in [QLOG-MAIN]. Each subsection below defines a separate category (for example http, qpack) and each subsubsection is an event type (for example "frame_created").

For each event type, its importance and data definition is laid out, often accompanied by possible values for the optional "trigger" field. For the definition and semantics of "importance" and "trigger", see the main schema document.

Most of the complex datastructures, enums and re-usable definitions are grouped together on the bottom of this document for clarity.

2.1. Usage with QUIC

The events described in this document can be used with or without logging the related QUIC events defined in [QLOG-QUIC]. If used with QUIC events, the QUIC document takes precedence in terms of recommended filenames and trace separation setups.

If used without QUIC events, it is recommended that the implementation assign a globally unique identifier to each HTTP/3 connection. This ID can then be used as the value of the qlog "group_id" field, as well as the qlog filename or file identifier, potentially suffixed by the vantagepoint type (For example, abcd1234_server.qlog would contain the server-side trace of the connection with GUID abcd1234).

2.2. Links to the main schema

This document re-uses all the fields defined in the main qlog schema (e.g., name, category, type, data, group_id, protocol_type, the time-related fields, importance, RawInfo, etc.).

One entry in the "protocol_type" qlog array field MUST be "HTTP3" if events from this document are included in a qlog trace.

2.2.1. Raw packet and frame information

This document re-uses the definition of the RawInfo data class from [QLOG-MAIN].

Note: As HTTP/3 does not use trailers in frames, each HTTP/3 frame header_length can be calculated as header_length = RawInfo:length - RawInfo:payload_length

Note: In some cases, the length fields are also explicitly reflected inside of frame headers. For example, all HTTP/3 frames include their explicit payload lengths in the frame header. In these cases, those fields are intentionally preserved in the event definitions. Even though this can lead to duplicate data when the full RawInfo is logged, it allows a more direct mapping of the HTTP/3 specifications to qlog, making it easier for users to interpret. In this case, both fields MUST have the same value.

3. HTTP/3 and QPACK event definitions

Each subheading in this section is a qlog event category, while each sub-subheading is a qlog event type.

For example, for the following two items, we have the category "http" and event type "parameters_set", resulting in a concatenated qlog "name" field value of "http:parameters_set".

3.1. http

Note: like all category values, the "http" category is written in lowercase.

3.1.1. parameters_set

Importance: Base

This event contains HTTP/3 and QPACK-level settings, mostly those received from the HTTP/3 SETTINGS frame. All these parameters are typically set once and never change. However, they are typically set at different times during the connection, so there can be several instances of this event with different fields set.

Note that some settings have two variations (one set locally, one requested by the remote peer). This is reflected in the "owner" field. As such, this field MUST be correct for all settings included a single event instance. If you need to log settings from two sides, you MUST emit two separate event instances.

Data:

```
{
    owner?:"local" | "remote",

    max_header_list_size?:uint64, // from SETTINGS_MAX_HEADER_LIST_SIZE
    max_table_capacity?:uint64, // from SETTINGS_QPACK_MAX_TABLE_CAPACITY
    blocked_streams_count?:uint64, // from SETTINGS_QPACK_BLOCKED_STREAMS

    // qlog-defined
    waits_for_settings?:boolean // indicates whether this implementation waits
for a SETTINGS frame before processing requests
}
```

Note: enabling server push is not explicitly done in HTTP/3 by use of a setting or parameter. Instead, it is communicated by use of the MAX_PUSH_ID frame, which should be logged using the frame_created and frame_parsed events below.

Additionally, this event can contain any number of unspecified fields. This is to reflect setting of for example unknown (greased) settings or parameters of (proprietary) extensions.

3.1.2. parameters_restored

Importance: Base

When using QUIC 0-RTT, HTTP/3 clients are expected to remember and reuse the server's SETTINGs from the previous connection. This event is used to indicate which HTTP/3 settings were restored and to which values when utilizing 0-RTT.

Data:

```
{
    max_header_list_size?:uint64,
    max_table_capacity?:uint64,
    blocked_streams_count?:uint64
}
```

Note that, like for parameters_set above, this event can contain any number of unspecified fields to allow for additional and custom settings.

3.1.3. stream_type_set

Importance: Base

Emitted when a stream's type becomes known. This is typically when a stream is opened and the stream's type indicator is sent or received.

Note: most of this information can also be inferred by looking at a stream's id, since id's are strictly partitioned at the QUIC level. Even so, this event has a "Base" importance because it helps a lot in debugging to have this information clearly spelled out.

Data:

```
{
    stream_id:uint64,

    owner?:"local"|"remote"

    old?:StreamType,
    new:StreamType,

    associated_push_id?:uint64 // only when new == "push"
}

enum StreamType {
    data, // bidirectional request-response streams
    control,
    push,
    reserved,
    qpack_encode,
    qpack_decode
}
```

3.1.4. frame_created

Importance: Core

HTTP equivalent to the packet_sent event. This event is emitted when the HTTP/3 framing actually happens. Note: this is not necessarily the same as when the HTTP/3 data is passed on to the QUIC layer. For that, see the "data_moved" event in [QLOG-QUIC].

Data:

```
{
    stream_id:uint64,
    length?:uint64, // payload byte length of the frame
    frame:HTTP3Frame, // see appendix for the definitions,

    raw?:RawInfo
}
```

Note: in HTTP/3, DATA frames can have arbitrarily large lengths to reduce frame header overhead. As such, DATA frames can span many

QUIC packets and can be created in a streaming fashion. In this case, the frame_created event is emitted once for the frame header, and further streamed data is indicated using the data_moved event.

3.1.5. frame_parsed

Importance: Core

HTTP equivalent to the packet_received event. This event is emitted when we actually parse the HTTP/3 frame. Note: this is not necessarily the same as when the HTTP/3 data is actually received on the QUIC layer. For that, see the "data_moved" event in [QLOG-QUIC].

Data:

```
{
    stream_id:uint64,
    length?:uint64, // payload byte length of the frame
    frame:HTTP3Frame, // see appendix for the definitions,

    raw?:RawInfo
}
```

Note: in HTTP/3, DATA frames can have arbitrarily large lengths to reduce frame header overhead. As such, DATA frames can span many QUIC packets and can be processed in a streaming fashion. In this case, the frame_parsed event is emitted once for the frame header, and further streamed data is indicated using the data_moved event.

3.1.6. push_resolved

Importance: Extra

This event is emitted when a pushed resource is successfully claimed (used) or, conversely, abandoned (rejected) by the application on top of HTTP/3 (e.g., the web browser). This event is added to help debug problems with unexpected PUSH behaviour, which is commonplace with HTTP/2.

```
{
    push_id?:uint64,
    stream_id?:uint64, // in case this is logged from a place that does not
have access to the push_id

    decision:"claimed"|"abandoned"
}
```

3.2. qpack

Note: like all category values, the "qpack" category is written in lowercase.

The QPACK events mainly serve as an aid to debug low-level QPACK issues. The higher-level, plaintext header values SHOULD (also) be logged in the http.frame_created and http.frame_parsed event data (instead).

Note: qpack does not have its own parameters_set event. This was merged with http.parameters_set for brevity, since qpack is a required extension for HTTP/3 anyway. Other HTTP/3 extensions MAY also log their SETTINGS fields in http.parameters_set or MAY define their own events.

3.2.1. state_updated

Importance: Base

This event is emitted when one or more of the internal QPACK variables changes value. Note that some variables have two variations (one set locally, one requested by the remote peer). This is reflected in the "owner" field. As such, this field MUST be correct for all variables included a single event instance. If you need to log settings from two sides, you MUST emit two separate event instances.

Data:

```
{
    owner:"local" | "remote",

    dynamic_table_capacity?:uint64,
    dynamic_table_size?:uint64, // effective current size, sum of all the
entries

    known_received_count?:uint64,
    current_insert_count?:uint64
}
```

3.2.2. stream_state_updated

Importance: Core

This event is emitted when a stream becomes blocked or unblocked by header decoding requests or QPACK instructions.

Note: This event is of "Core" importance, as it might have a large impact on HTTP/3's observed performance.

Data:

```
{
    stream_id:uint64,

    state:"blocked"|"unblocked" // streams are assumed to start "unblocked"
until they become "blocked"
}
```

3.2.3. dynamic_table_updated

Importance: Extra

This event is emitted when one or more entries are inserted or evicted from QPACK's dynamic table.

Data:

```
{
    owner:"local" | "remote", // local = the encoder's dynamic table. remote =
the decoder's dynamic table

    update_type:"inserted"|"evicted",

    entries:Array<DynamicTableEntry>
}

class DynamicTableEntry {
    index:uint64;
    name?:string | bytes;
    value?:string | bytes;
}
```

3.2.4. headers_encoded

Importance: Base

This event is emitted when an uncompressed header block is encoded successfully.

Note: this event has overlap with http.frame_created for the HeadersFrame type. When outputting both events, implementers MAY omit the "headers" field in this event.

Data:

```
{
    stream_id?:uint64,

    headers?:Array<HTTPHeader>,

    block_prefix:QPackHeaderBlockPrefix,
    header_block:Array<QPackHeaderBlockRepresentation>,

    length?:uint32,
    raw?:bytes
}
```

3.2.5. headers_decoded

Importance: Base

This event is emitted when a compressed header block is decoded successfully.

Note: this event has overlap with http.frame_parsed for the HeadersFrame type. When outputting both events, implementers MAY omit the "headers" field in this event.

Data:

```
{
    stream_id?:uint64,

    headers?:Array<HTTPHeader>,

    block_prefix:QPackHeaderBlockPrefix,
    header_block:Array<QPackHeaderBlockRepresentation>,

    length?:uint32,
    raw?:bytes
}
```

3.2.6. instruction_created

Importance: Base

This event is emitted when a QPACK instruction (both decoder and encoder) is created and added to the encoder/decoder stream.

Data:

```
{
    instruction:QPackInstruction // see appendix for the definitions,

    length?:uint32,
    raw?:bytes
}
```

Note: encoder/decoder semantics and stream_id's are implicit in either the instruction types or can be logged via other events (e.g., http.stream_type_set)

3.2.7. instruction_parsed

Importance: Base

This event is emitted when a QPACK instruction (both decoder and encoder) is read from the encoder/decoder stream.

Data:

```
{
    instruction:QPackInstruction // see appendix for the definitions,

    length?:uint32,
    raw?:bytes
}
```

Note: encoder/decoder semantics and stream_id's are implicit in either the instruction types or can be logged via other events (e.g., http.stream_type_set)

4. Security Considerations

TBD

5. IANA Considerations

TBD

6. References

6.1. Normative References

[QLOG-MAIN] Marx, R., Ed., Niccolini, L., Ed., and M. Seemann, Ed., "Main logging schema for qlog", draft-marx-qlog-main-schema-04 (work in progress).

[QLOG-QUIC]
Marx, R., Ed., Niccolini, L., Ed., and M. Seemann, Ed., "QUIC event definitions for qlog", draft-marx-quic-qlog-quic-events-00 (work in progress).

[QUIC-HTTP]
Bishop, M., Ed., "Hypertext Transfer Protocol Version 3 (HTTP/3)", draft-ietf-quic-http-latest (work in progress).

[QUIC-QPACK]
Krasic, C., Bishop, M., and A. Frindell, Ed., "QPACK: Header Compression for HTTP over QUIC", draft-ietf-quic-qpack-latest (work in progress).

6.2. Informative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

6.3. URIs

[1] https://github.com/quiclog/internet-drafts

[2] https://github.com/quiclog/qlog/

Appendix A. HTTP/3 data field definitions

A.1. HTTP/3 Frames

```
type HTTP3Frame = DataFrame | HeadersFrame | PriorityFrame | CancelPushFrame |
SettingsFrame | PushPromiseFrame | GoAwayFrame | MaxPushIDFrame |
DuplicatePushFrame | ReservedFrame | UnknownFrame;
```

A.1.1. DataFrame

```
class DataFrame{
    frame_type:string = "data";

    raw?:bytes;
}
```

A.1.2. HeadersFrame

This represents an _uncompressed_, plaintext HTTP Headers frame (e.g., no QPACK compression is applied).

For example:

```
headers: [{"name":":path","value":"/"},{"name":":method","value":"GET"},
{"name":":authority","value":"127.0.0.1:4433"},
{"name":":scheme","value":"https"}]
```

```
class HeadersFrame{
    frame_type:string = "header";
    headers:Array<HTTPHeader>;
}

class HTTPHeader {
    name:string;
    value:string;
}
```

A.1.3. CancelPushFrame

```
class CancelPushFrame{
    frame_type:string = "cancel_push";
    push_id:uint64;
}
```

A.1.4. SettingsFrame

```
class SettingsFrame{
    frame_type:string = "settings";
    settings:Array<Setting>;
}

class Setting{
    name:string;
    value:string;
}
```

A.1.5. PushPromiseFrame

```
class PushPromiseFrame{
    frame_type:string = "push_promise";
    push_id:uint64;

    headers:Array<HTTPHeader>;
}
```

A.1.6. GoAwayFrame

```
class GoAwayFrame{
    frame_type:string = "goaway";
    stream_id:uint64;
}
```

A.1.7. MaxPushIDFrame

```
class MaxPushIDFrame{
    frame_type:string = "max_push_id";
    push_id:uint64;
}
```

A.1.8. DuplicatePushFrame

```
class DuplicatePushFrame{
    frame_type:string = "duplicate_push";
    push_id:uint64;
}
```

A.1.9. ReservedFrame

```
class ReservedFrame{
    frame_type:string = "reserved";
}
```

A.1.10. UnknownFrame

HTTP/3 re-uses QUIC's UnknownFrame definition, since their values and usage overlaps. See [QLOG-QUIC].

A.2. ApplicationError

```
enum ApplicationError{
    http_no_error,
    http_general_protocol_error,
    http_internal_error,
    http_stream_creation_error,
    http_closed_critical_stream,
    http_frame_unexpected,
    http_frame_error,
    http_excessive_load,
    http_id_error,
    http_settings_error,
    http_missing_settings,
    http_request_rejected,
    http_request_cancelled,
    http_request_incomplete,
    http_early_response,
    http_connect_error,
    http_version_fallback
}
```

Appendix B. QPACK DATA type definitions

B.1. QPACK Instructions

Note: the instructions do not have explicit encoder/decoder types, since there is no overlap between the insturctions of both types in neither name nor function.

```
type QPackInstruction = SetDynamicTableCapacityInstruction |
InsertWithNameReferenceInstruction | InsertWithoutNameReferenceInstruction |
DuplicateInstruction | HeaderAcknowledgementInstruction |
StreamCancellationInstruction | InsertCountIncrementInstruction;
```

B.1.1. SetDynamicTableCapacityInstruction

```
class SetDynamicTableCapacityInstruction {
    instruction_type:string = "set_dynamic_table_capacity";

    capacity:uint32;
}
```

B.1.2. InsertWithNameReferenceInstruction

```
class InsertWithNameReferenceInstruction {
    instruction_type:string = "insert_with_name_reference";

    table_type:"static"|"dynamic";

    name_index:uint32;

    huffman_encoded_value:boolean;

    value_length?:uint32;
    value?:string;
}
```

B.1.3. InsertWithoutNameReferenceInstruction

```
class InsertWithoutNameReferenceInstruction {
    instruction_type:string = "insert_without_name_reference";

    huffman_encoded_name:boolean;

    name_length?:uint32;
    name?:string;

    huffman_encoded_value:boolean;

    value_length?:uint32;
    value?:string;
```

```
}
```

B.1.4. DuplicateInstruction

```
   class DuplicateInstruction {
       instruction_type:string = "duplicate";

       index:uint32;
   }
```

B.1.5. HeaderAcknowledgementInstruction

```
   class HeaderAcknowledgementInstruction {
       instruction_type:string = "header_acknowledgement";

       stream_id:uint64;
   }
```

B.1.6. StreamCancellationInstruction

```
   class StreamCancellationInstruction {
       instruction_type:string = "stream_cancellation";

       stream_id:uint64;
   }
```

B.1.7. InsertCountIncrementInstruction

```
   class InsertCountIncrementInstruction {
       instruction_type:string = "insert_count_increment";

       increment:uint32;
   }
```

B.2. QPACK Header compression

```
type QPackHeaderBlockRepresentation = IndexedHeaderField |
LiteralHeaderFieldWithName | LiteralHeaderFieldWithoutName;
```

B.2.1. IndexedHeaderField

```
   Note: also used for "indexed header field with post-base index"

class IndexedHeaderField {
    header_field_type:string = "indexed_header";

    table_type:"static"|"dynamic"; // MUST be "dynamic" if is_post_base is true
    index:uint32;

    is_post_base:boolean = false; // to represent the "indexed header field
with post-base index" header field type
}
```

B.2.2. LiteralHeaderFieldWithName

Note: also used for "Literal header field with post-base name reference"

```
class LiteralHeaderFieldWithName {
    header_field_type:string = "literal_with_name";

    preserve_literal:boolean; // the 3rd "N" bit
    table_type:"static"|"dynamic"; // MUST be "dynamic" if is_post_base is true
    name_index:uint32;

    huffman_encoded_value:boolean;
    value_length?:uint32;
    value?:string;

    is_post_base:boolean = false; // to represent the "Literal header field
with post-base name reference" header field type
}
```

B.2.3. LiteralHeaderFieldWithoutName

```
class LiteralHeaderFieldWithoutName {
    header_field_type:string = "literal_without_name";

    preserve_literal:boolean; // the 3rd "N" bit

    huffman_encoded_name:boolean;
    name_length?:uint32;
    name?:string;

    huffman_encoded_value:boolean;
    value_length?:uint32;
    value?:string;
}
```

B.2.4. QPackHeaderBlockPrefix

```
class QPackHeaderBlockPrefix {
    required_insert_count:uint32;
    sign_bit:boolean;
    delta_base:uint32;
}
```

Appendix C. Change Log

C.1. Since draft-marx-qlog-event-definitions-quic-h3-02:

- These changes were done in preparation of the adoption of the drafts by the QUIC working group (#137)
- Split QUIC and HTTP/3 events into two separate documents
- Moved RawInfo, Importance, Generic events and Simulation events to the main schema document.

C.2. Since draft-marx-qlog-event-definitions-quic-h3-01:

Major changes:

- Moved data_moved from http to transport. Also made the "from" and "to" fields flexible strings instead of an enum (#111,#65)
- Moved packet_type fields to PacketHeader. Moved packet_size field out of PacketHeader to RawInfo:length (#40)
- Made events that need to log packet_type and packet_number use a header field instead of logging these fields individually
- Added support for logging retry, stateless reset and initial tokens (#94,#86,#117)
- Moved separate general event categories into a single category "generic" (#47)
- Added "transport:connection_closed" event (#43,#85,#78,#49)
- Added version_information and alpn_information events (#85,#75,#28)
- Added parameters_restored events to help clarify 0-RTT behaviour (#88)

Smaller changes:

- Merged loss_timer events into one loss_timer_updated event
- Field data types are now strongly defined (#10,#39,#36,#115)
- Renamed qpack instruction_received and instruction_sent to instruction_created and instruction_parsed (#114)
- Updated qpack:dynamic_table_updated.update_type. It now has the value "inserted" instead of "added" (#113)

- Updated qpack:dynamic_table_updated. It now has an "owner" field to differentiate encoder vs decoder state (#112)
- Removed push_allowed from http:parameters_set (#110)
- Removed explicit trigger field indications from events, since this was moved to be a generic property of the "data" field (#80)
- Updated transport:connection_id_updated to be more in line with other similar events. Also dropped importance from Core to Base (#45)
- Added length property to PaddingFrame (#34)
- Added packet_number field to transport:frames_processed (#74)
- Added a way to generically log packet header flags (first 8 bits) to PacketHeader
- Added additional guidance on which events to log in which situations (#53)
- Added "simulation:scenario" event to help indicate simulation details
- Added "packets_acked" event (#107)
- Added "datagram_ids" to the datagram_X and packet_X events to allow tracking of coalesced QUIC packets (#91)
- Extended connection_state_updated with more fine-grained states (#49)

C.3. Since draft-marx-qlog-event-definitions-quic-h3-00:

- Event and category names are now all lowercase
- Added many new events and their definitions
- "type" fields have been made more specific (especially important for PacketType fields, which are now called packet_type instead of type)
- Events are given an importance indicator (issue #22)
- Event names are more consistent and use past tense (issue #21)

- Triggers have been redefined as properties of the "data" field and updated for most events (issue #23)

Appendix D. Design Variations

TBD

Appendix E. Acknowledgements

Much of the initial work by Robin Marx was done at Hasselt University.

Thanks to Marten Seemann, Jana Iyengar, Brian Trammell, Dmitri Tikhonov, Stephen Petrides, Jari Arkko, Marcus Ihlar, Victor Vasiliev, Mirja Kuehlewind, Jeremy Laine, Kazu Yamamoto, Christian Huitema, and Lucas Pardue for their feedback and suggestions.

Authors' Addresses

Robin Marx
KU Leuven

Email: robin.marx@kuleuven.be

Luca Niccolini (editor)
Facebook

Email: lniccolini@fb.com

Marten Seemann (editor)
Protocol Labs

Email: marten@protocol.ai