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Using QUIC Datagrams with HTTP/3

Abstract

The QUIC DATAGRAM extension provides application protocols running over QUIC with a mechanism to send unreliable data while leveraging the security and congestion-control properties of QUIC. However, QUIC DATAGRAM frames do not provide a means to demultiplex application contexts. This document defines how to use QUIC DATAGRAM frames when the application protocol running over QUIC is HTTP/3 by adding an identifier at the start of the frame payload. This allows HTTP messages to convey related information using unreliable DATAGRAM frames, ensuring those frames are properly associated with an HTTP message.

Discussion of this work is encouraged to happen on the MASQUE IETF mailing list (masque@ietf.org) or on the GitHub repository which contains the draft: <https://github.com/DavidSchinazi/draft-h3-datagram>.

Status of This Memo

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1. Introduction

The QUIC DATAGRAM extension [[DGRAM](#)] provides application protocols running over QUIC [[QUIC](#)] with a mechanism to send unreliable data while leveraging the security and congestion-control properties of QUIC. However, QUIC DATAGRAM frames do not provide a means to demultiplex application contexts. This document defines how to use QUIC DATAGRAM frames when the application protocol running over QUIC is HTTP/3 [[H3](#)] by adding an identifier at the start of the frame payload. This allows HTTP messages to convey related information using unreliable DATAGRAM frames, ensuring those frames are properly associated with an HTTP message.

This design mimics the use of Stream Types in HTTP/3, which provide a demultiplexing identifier at the start of each unidirectional stream.

Discussion of this work is encouraged to happen on the MASQUE IETF mailing list (masque@ietf.org) or on the GitHub repository which contains the draft: <https://github.com/DavidSchinazi/draft-h3-datagram>.

1.1. Conventions and Definitions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

2. Flow Identifiers

Flow identifiers represent bidirectional flows of datagrams within a single QUIC connection. These are conceptually similar to streams in the sense that they allow multiplexing of application data. Flows lack any of the ordering or reliability guarantees of streams.

Beyond this, a sender SHOULD ensure that DATAGRAM frames within a single flow are transmitted in order relative to one another. If multiple DATAGRAM frames can be packed into a single QUIC packet, the sender SHOULD group them by flow identifier to promote fate-sharing within a specific flow and improve the ability to process batches of datagram messages efficiently on the receiver.

3. Flow Identifier Allocation

Implementations of HTTP/3 that support the DATAGRAM extension MUST provide a flow identifier allocation service. That service will allow applications co-located with HTTP/3 to request a unique flow identifier that they can subsequently use for their own purposes. The HTTP/3 implementation will then parse the flow identifier of incoming DATAGRAM frames and use it to deliver the frame to the appropriate application.

Even-numbered flow identifiers are client-initiated, while odd-numbered flow identifiers are server-initiated. This means that an HTTP/3 client implementation of the flow identifier allocation service MUST only provide even-numbered identifiers, while a server implementation MUST only provide odd-numbered identifiers. Note that, once allocated, any flow identifier can be used by both client and server - only allocation carries separate namespaces to avoid requiring synchronization.

4. HTTP/3 DATAGRAM Frame Format

When used with HTTP/3, the Datagram Data field of QUIC DATAGRAM frames uses the following format (using the notation from the "Notational Conventions" section of [[QUIC](#)]):

```
HTTP/3 DATAGRAM Frame {  
  Flow Identifier (i),  
  HTTP/3 Datagram Payload (...),  
}
```

Figure 1: HTTP/3 DATAGRAM Frame Format

Flow Identifier: A variable-length integer indicating the Flow Identifier of the datagram (see [Section 2](#)).

HTTP/3 Datagram Payload: The payload of the datagram, whose semantics are defined by individual applications. Note that this field can be empty.

Endpoints MUST treat receipt of a DATAGRAM frame whose payload is too short to parse the flow identifier as a connection error of type `PROTOCOL_VIOLATION`.

5. The `H3_DATAGRAM HTTP/3 SETTINGS` Parameter

Implementations of HTTP/3 that support this mechanism can indicate that to their peer by sending the `H3_DATAGRAM SETTINGS` parameter with a value of 1. The value of the `H3_DATAGRAM SETTINGS` parameter MUST be either 0 or 1. A value of 0 indicates that this mechanism is not supported. An endpoint that receives the `H3_DATAGRAM SETTINGS` parameter with a value that is neither 0 or 1 MUST terminate the connection with error `H3_SETTINGS_ERROR`.

An endpoint that sends the `H3_DATAGRAM SETTINGS` parameter with a value of 1 MUST send the `max_datagram_frame_size` QUIC Transport Parameter [[DGRAM](#)]. An endpoint that receives the `H3_DATAGRAM SETTINGS` parameter with a value of 1 on a QUIC connection that did not also receive the `max_datagram_frame_size` QUIC Transport Parameter MUST terminate the connection with error `H3_SETTINGS_ERROR`.

When clients use 0-RTT, they MAY store the value of the server's `H3_DATAGRAM SETTINGS` parameter. Doing so allows the client to use HTTP/3 datagrams in 0-RTT packets. When servers decide to accept 0-RTT data, they MUST send a `H3_DATAGRAM SETTINGS` parameter greater or equal to the value they sent to the client in the connection where they sent them the `NewSessionTicket` message. If a client stores the value of the `H3_DATAGRAM SETTINGS` parameter with their 0-RTT state, they MUST validate that the new value of the `H3_DATAGRAM SETTINGS` parameter sent by the server in the handshake is greater or equal to the stored value; if not, the client MUST terminate the connection with error `H3_SETTINGS_ERROR`.

6. Datagram-Flow-Id Header Field Definition

"Datagram-Flow-Id" is a Item Structured Field [[STRUCT-FIELD](#)]. Its value MUST be an Integer. Its ABNF is:

```
Datagram-Flow-Id = sf-integer
```

The "Datagram-Flow-Id" header field is used to associate a datagram flow identifier with an HTTP message. For example, the definition of an HTTP method could instruct the client to use its flow identifier allocation service to allocate a new flow identifier, and then the client will add the "Datagram-Flow-Id" header field to its request to communicate that value to the server. For example, the resulting header field could look like:

```
Datagram-Flow-Id = 2
```

Definitions of HTTP features that use the "Datagram-Flow-Id" header field MAY define their own parameters (parameters are defined in Section 3.1.2 of [[STRUCT-FIELD](#)]). For example, an HTTP method that wishes to use two datagram flow identifiers for the lifetime of its request stream could encode the second flow identifier as a parameter, which could look like this:

```
Datagram-Flow-Id = 42; alternate=44
```

The "Datagram-Flow-Id" header field MUST NOT be present more than once on a given HTTP message; any HTTP message containing more than one "Datagram-Flow-Id" header field is malformed.

Since the QUIC STREAM frame that contains the "Datagram-Flow-Id" header field could be lost or reordered, it is possible that an endpoint will receive an HTTP/3 datagram with a flow identifier that it does not know as it has not yet received the corresponding "Datagram-Flow-Id" header field. Endpoints MUST NOT treat that as an error; they MUST either silently discard the datagram or buffer it until they receive the "Datagram-Flow-Id" header field.

Note that integer structured fields can only encode values up to $10^{15}-1$, therefore the maximum possible value of the "Datagram-Flow-Id" header field is lower than the theoretical maximum value of a flow identifier which is $2^{62}-1$ due to the QUIC variable length integer encoding. If the flow identifier allocation service of an endpoint runs out of values lower than $10^{15}-1$, the endpoint MUST treat it as a connection error of type H3_ID_ERROR.

7. HTTP Intermediaries

HTTP/3 DATAGRAM flow identifiers are specific to a given HTTP/3 connection. However, in some cases, an HTTP request may travel

across multiple HTTP connections if there are HTTP intermediaries involved; see Section 2.3 of [[RFC7230](#)].

If an intermediary has sent the H3_DATAGRAM SETTINGS parameter with a value of 1 on its client-facing connection, it MUST inspect all HTTP requests from that connection and check for the presence of the "Datagram-Flow-Id" header field. If the HTTP method of the request is not supported by the intermediary, it MUST remove the "Datagram-Flow-Id" header field before forwarding the request. If the intermediary supports the method, it MUST either remove the header field or adhere to the requirements leveraged by that method on intermediaries.

If an intermediary has sent the H3_DATAGRAM SETTINGS parameter with a value of 1 on its server-facing connection, it MUST inspect all HTTP responses from that connection and check for the presence of the "Datagram-Flow-Id" header field. If the HTTP method of the request is not supported by the intermediary, it MUST remove the "Datagram-Flow-Id" header field before forwarding the response. If the intermediary supports the method, it MUST either remove the header field or adhere to the requirements leveraged by that method on intermediaries.

8. Security Considerations

This document does not have additional security considerations beyond those defined in [[QUIC](#)] and [[DGRAM](#)].

9. IANA Considerations

9.1. HTTP SETTINGS Parameter

This document will request IANA to register the following entry in the "HTTP/3 Settings" registry:

+-----+-----+-----+-----+
Setting Name Value Specification Default
+-----+-----+-----+-----+
H3_DATAGRAM 0x276 This Document 0
+-----+-----+-----+-----+

9.2. HTTP Header Field

This document will request IANA to register the "Datagram-Flow-Id" header field in the "Permanent Message Header Field Names" registry maintained at <<https://www.iana.org/assignments/message-headers>>.

Header Field Name	Protocol	Status	Reference
Datagram-Flow-Id	http	std	This document

10. Normative References

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