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An Unreliable Datagram Extension to QUIC
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Abstract

This document defines an extension to the QUIC transport protocol to add support for sending and receiving unreliable datagrams over a QUIC connection.

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[1.](#) Introduction

The QUIC Transport Protocol [[I-D.ietf-quic-transport](#)] provides a secure, multiplexed connection for transmitting reliable streams of application data. Reliability within QUIC is performed on a per-stream basis, so some frame types are not eligible for retransmission.

Some applications, particularly those that need to transmit real-time data, prefer to transmit data unreliably. These applications can build directly upon UDP [[RFC0768](#)] as a transport, and can add security with DTLS [[RFC6347](#)]. Extending QUIC to support transmitting unreliable application data would provide another option for secure datagrams, with the added benefit of sharing a cryptographic and authentication context used for reliable streams.

This document defines four new DATAGRAM QUIC frame types, which carry application data without requiring retransmissions.

[1.1.](#) Specification of Requirements

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. Motivation

Transmitting unreliable data over QUIC provides benefits over existing solutions:

- o Applications that open both a reliable TLS stream and an unreliable DTLS flow to the same peer can benefit by sharing a single handshake and authentication context between a reliable QUIC stream and flow of unreliable QUIC datagrams. This can reduce the latency required for handshakes.
- o QUIC uses a more nuanced loss recovery mechanism than the DTLS handshake, which has a basic packet loss retransmission timer. This may allow loss recovery to occur more quickly for QUIC data.
- o QUIC datagrams, while unreliable, can support acknowledgements, allowing applications to be aware of whether a datagram was successfully received.

These reductions in connection latency, and application insight into the delivery of datagrams, can be useful for optimizing audio/video streaming applications, gaming applications, and other real-time network applications.

Unreliable QUIC datagrams can also be used to implement an IP packet tunnel over QUIC, such as for a Virtual Private Network (VPN). Internet-layer tunneling protocols generally require a reliable and authenticated handshake, followed by unreliable secure transmission of IP packets. This can, for example, require a TLS connection for the control data, and DTLS for tunneling IP packets. A single QUIC connection could support both parts with the use of unreliable datagrams.

3. Transport Parameter

Support for receiving the DATAGRAM frame types is advertised by means of a QUIC Transport Parameter (name=max_datagram_frame_size, value=0x0020). The max_datagram_frame_size transport parameter is an integer value (represented as a variable-length integer) that represents the maximum size of a DATAGRAM frame (including the frame type, flow identifier, length and payload) the endpoint is willing to receive, in bytes. An endpoint that includes this parameter supports the DATAGRAM frame types and is willing to receive such frames on this connection. Endpoints MUST NOT send DATAGRAM frames until they have sent and received the max_datagram_frame_size transport parameter. Endpoints MUST NOT send DATAGRAM frames of size strictly larger than the value of max_datagram_frame_size the endpoint has received from its peer. An endpoint that receives a DATAGRAM frame

when it has not sent the `max_datagram_frame_size` transport parameter MUST terminate the connection with error `PROTOCOL_VIOLATION`. An endpoint that receives a DATAGRAM frame that is strictly larger than the value it sent in its `max_datagram_frame_size` transport parameter MUST terminate the connection with error `PROTOCOL_VIOLATION`.

4. Datagram Frame Type

DATAGRAM frames are used to transmit application data in an unreliable manner. The DATAGRAM frame type takes the form `0b001100XX` (or the set of values from `0x30` to `0x33`). The least significant bit of the DATAGRAM frame type is the `LEN` bit (`0x01`). It indicates that there is a Length field present. If this bit is set to 0, the Length field is absent and the Datagram Data field extends to the end of the packet. If this bit is set to 1, the Length field is present. The second least significant bit of the DATAGRAM frame type is the `FLOW_ID` bit (`0x02`). It indicates that there is a Flow ID field present. If this bit is set to 0, the Flow ID field is absent and the Flow ID is assumed to be zero. If this bit is set to 1, the Flow ID field is present.

The DATAGRAM frame is structured as follows:

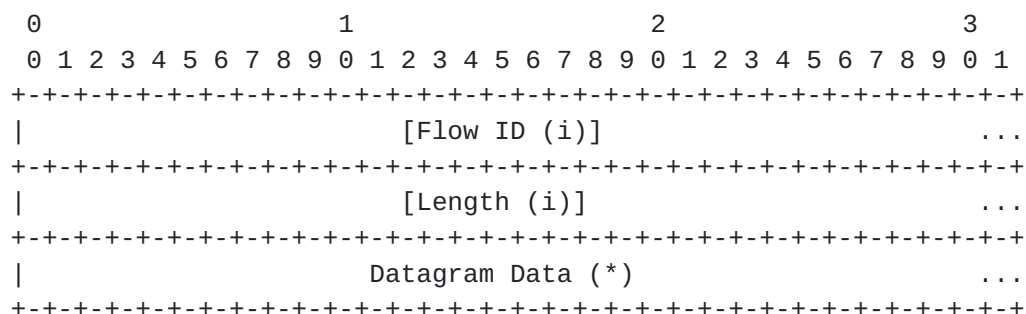


Figure 1: DATAGRAM Frame Format

DATAGRAM frames contain the following fields:

Flow ID: A variable-length integer indicating the Flow ID of the datagram (see [Section 5.1](#)). This field is present when the `FLOW_ID` bit is set, and is assumed to be zero otherwise.

Length: A variable-length integer specifying the length of the datagram in bytes. This field is present only when the `LEN` bit is set. If the `LEN` bit is not set, the datagram data extends to the end of the QUIC packet.

Datagram Data: The bytes of the datagram to be delivered.

5. Behavior and Usage

When an application sends an unreliable datagram over a QUIC connection, QUIC will generate a new DATAGRAM frame and send it in the first available packet. This frame SHOULD be sent as soon as possible, and MAY be coalesced with other frames.

When a QUIC endpoint receives a valid DATAGRAM frame, it SHOULD deliver the data to the application immediately, as long as it is able to process the frame and can store the contents in memory.

DATAGRAM frames MUST be protected with either 0-RTT or 1-RTT keys.

5.1. Flow Identifiers

Flow identifiers represent bidirectional flows of datagrams within a single QUIC connection. These are effectively equivalent to UDP ports, that allow basic demultiplexing of application data. Whenever one side of a connection receives a frame with a Flow ID was not previously known, it MAY represent this to the application as a new flow of datagrams.

The primary role of the QUIC transport towards the flow identifier is to provide a standard mechanism for demultiplexing application data flows, which may be destined for different processing threads in the application, akin to UDP sockets.

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 packet, the sender SHOULD group them by Flow ID to promote fate-sharing within a specific flow and improve the ability to process batches of datagram messages efficiently on the receiver.

Applications that do not have a need for the Flow ID can use the value zero on their DATAGRAM frames and clear the FLOW_ID bit to omit sending the identifier over the wire. If an application uses a mixture of DATAGRAM frames with and without the FLOW_ID bit set, the frames without it are assumed to be part of the application-level flow with Flow ID zero.

5.2. Acknowledgement Handling

Although DATAGRAM frames are not retransmitted upon loss detection, they are ack-eliciting ([[I-D.ietf-quic-recovery](#)]). Receivers SHOULD support delaying ACK frames (within the limits specified by `max_ack_delay`) in response to receiving packets that only contain

DATAGRAM frames, since the timing of these acknowledgements is not used for loss recovery.

If a sender detects that a packet containing a specific DATAGRAM frame has been lost, the implementation MAY notify the application that the datagram was lost. Similarly, if a packet containing a DATAGRAM frame is acknowledged, the implementation MAY notify the application that the datagram was successfully transmitted and received.

5.3. Flow Control

DATAGRAM frames do not provide any explicit flow control signaling, and do not contribute to any per-flow or connection-wide data limit.

The risk associated with not providing flow control for DATAGRAM frames is that a receiver may not be able to commit the necessary resources to process the frames. For example, it may not be able to store the frame contents in memory. However, since DATAGRAM frames are inherently unreliable, they MAY be dropped by the receiver if the receiver cannot process them.

5.4. Congestion Control

DATAGRAM frames are subject to a QUIC connection's congestion control. Specifically, if a DATAGRAM frame is enqueued to be sent by the application, but sending a packet with this frame is not allowed by the congestion control window as specified in [\[I-D.ietf-quic-recovery\]](#), the packet cannot be sent. The sender implementation MUST either drop the frame without sending it (at which point it MAY notify the application) or else delay sending the frame until the window opens.

Implementations can optionally support allowing the application to specify a sending expiration time, beyond which a congestion-controlled DATAGRAM frame ought to be dropped without transmission.

6. Security Considerations

The DATAGRAM frame shares the same security properties as the rest of the data transmitted within a QUIC connection. All application data transmitted with the DATAGRAM frame, like the STREAM frame, MUST be protected either by 0-RTT or 1-RTT keys.

7. IANA Considerations

This document registers a new value in the QUIC Transport Parameter Registry:

Value: 0x0020 (if this document is approved)

Parameter Name: max_datagram_frame_size

Specification: Indicates that the connection should enable support for unreliable DATAGRAM frames. An endpoint that advertises this transport parameter can receive datagrams frames from the other endpoint, up to and including the length in bytes provided in the transport parameter.

This document also registers a new value in the QUIC Frame Type registry:

Value: 0x30 - 0x33 (if this document is approved)

Frame Name: DATAGRAM

Specification: Unreliable application data

8. Acknowledgments

Thanks to Ian Swett, who inspired this proposal.

9. References

9.1. Normative References

[I-D.ietf-quic-recovery]

Iyengar, J. and I. Swett, "QUIC Loss Detection and Congestion Control", [draft-ietf-quic-recovery-20](#) (work in progress), April 2019.

[I-D.ietf-quic-transport]

Iyengar, J. and M. Thomson, "QUIC: A UDP-Based Multiplexed and Secure Transport", [draft-ietf-quic-transport-20](#) (work in progress), April 2019.

9.2. Informative References

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