Abstract

Network Address Translators (NATs) are widely deployed to share scarce public IPv4 addresses among multiple end hosts. They overwrite IP addresses and ports in IP packets to do so. QUIC is a protocol on top of UDP that provides transport-like services. QUIC is better-behaved in the presence of NATs than older protocols, and existing UDP NATs should operate without incident if unmodified. QUIC offers additional features that may tempt NAT implementers as potential optimizations. However, in practice, leveraging these features will lead to new connection failure modes and security vulnerabilities.

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Network Address Translators (NATs) are a widely deployed means of multiplexing multiple private IP addresses over scarce IPv4 public address space by replacing those addresses and using ports to distinguish those connections. The new address can also guarantee that packets move through a proxy throughout the life of a connection, so that the connection can continue with the required state at that proxy.

QUIC [QUIC-TRANSPORT] is a protocol, operating over UDP, that provides many transport-like services to the application layer. Among these services is the mapping of multiple endpoint IP addresses to a single connection through use of a Connection ID (CID). Connection IDs are opaque byte fields that are expressed consistently across all QUIC versions [QUIC-INVARIANTS]. This feature may appear to present opportunities to optimize NAT port usage and simplify the work of the QUIC server. In fact, NAT behavior that relies on CID may instead cause connection failure when endpoints change Connection ID, and disable important protocol security features.

The remainder of this document explains how QUIC supports NATs better than other connection-oriented protocols, why NAT use of Connection ID might appear attractive, and how NAT use of CID can create serious problems for the endpoints. The conclusion of this document is that NATs should retain their existing 4-tuple-based operation and refrain from parsing or otherwise using QUIC connection IDs.
2. 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 RFC 2119 [RFC2119].

3. QUIC and NAT Rebinding

An explicit goal of QUIC is to be robust to NAT rebinding. When a connection is idle for a long time, the NAT may guess it has terminated and assign the client port to a new connection. If either endpoint attempts to resume communication, the packet will be assigned a new IP and/or port. As TCP defines a connection by its address and port 4-tuple, the packet will not appear to belong to any existing connection at the receiver.

As QUIC endpoints identify their connections using a CID that is encoded in every packet, new IP addresses and ports will not affect delivery as long as no routing function in the path is dependent on source IP address and port.

4. The Lure of the Connection ID

There are a few reasons that CID-aware NATs may appear attractive.

4.1. Resource Conservation

NATs sometimes hit an operational limit where they exhaust available public IP addresses and ports, and must evict flows from their address/port mapping. CIDs offer a way to multiplex many connections over a single address and port.

However, QUIC endpoints may negotiate new connection IDs inside cryptographically protected packets, and begin using them at will. Therefore, leveraging Connection IDs will cause sudden connection breakage when an incoming packet uses CIDs with no clear mapping.

4.2. "Helping" with routing infrastructure issues

One problem in QUIC deployment is router and switch server infrastructures that direct traffic based on address-port 4-tuple rather than connection ID. The use of source IP address means that a NAT rebinding or address migration will deliver packets to the wrong server. For the reasons described above, routers and switches will not have access to negotiated CIDs. This is a particular problem for low-state load balancers, and a QUIC extension exists [QUIC-LB] to allow some server-load balancer coordination for routable CIDs.
A NAT at the front of this infrastructure might save the effort of converting all these devices by decoding routable connection IDs and rewriting the packet IP addresses to allow consistent routing by legacy devices.

Unfortunately, the change of IP address or port is an important signal to QUIC endpoints. It requires a review of path-dependent variables like congestion control parameters. It can also signify various attacks that mislead one endpoint about the best peer address for the connection (see section 9 of [QUIC-TRANSPORT]). The QUIC PATH_CHALLENGE and PATH_RESPONSE frames are intended to detect and mitigate these attacks and verify connectivity to the new address. Obviously, this mechanism cannot work if the NAT is bleaching peer address changes.

5. Security Considerations

This document proposes no change in behavior in the internet, so there are no new security implications. Note, however, that ignoring the recommendations here could prevent existing security mechanisms in QUIC from working properly.

6. IANA Considerations

There are no IANA requirements.

7. Informative References


Appendix A. Acknowledgments

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