TLS
Internet-Draft
Updates: 6347 (if approved)
Intended status: Standards Track
Expires: September 12, 2019

E. Rescorla, Ed.
RTFM, Inc.
H. Tschofenig, Ed.
T. Fossati
Arm Limited

March 11, 2019

# Connection Identifiers for DTLS 1.2
# draft-ietf-tls-dtls-connection-id-04

Abstract

This document specifies the Connection ID (CID) construct for the Datagram Transport Layer Security (DTLS) protocol version 1.2.

A CID is an identifier carried in the record layer header that gives the recipient additional information for selecting the appropriate security association. In "classical" DTLS, selecting a security association of an incoming DTLS record is accomplished with the help of the 5-tuple. If the source IP address and/or source port changes during the lifetime of an ongoing DTLS session then the receiver will be unable to locate the correct security context.

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 September 12, 2019.

Table of Contents



## 1. Introduction

The Datagram Transport Layer Security (DTLS) protocol was designed for securing connection-less transports, like UDP. DTLS, like TLS, starts with a handshake, which can be computationally demanding (particularly when public key cryptography is used). After a successful handshake, symmetric key cryptography is used to apply data origin authentication, integrity and confidentiality protection. This two-step approach allows endpoints to amortize the cost of the

initial handshake across subsequent application data protection. Ideally, the second phase where application data is protected lasts over a longer period of time since the established keys will only need to be updated once the key lifetime expires.

In the current version of DTLS, the IP address and port of the peer are used to identify the DTLS association. Unfortunately, in some cases, such as NAT rebinding, these values are insufficient. This is a particular issue in the Internet of Things when devices enter extended sleep periods to increase their battery lifetime. The NAT rebinding leads to connection failure, with the resulting cost of a new handshake.

This document defines an extension to DTLS 1.2 to add a CID to the DTLS record layer. The presence of the CID is negotiated via a DTLS extension.

## 2. Conventions and Terminology

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 RFC 2119 [RFC2119].

This document assumes familiarity with DTLS 1.2 [RFC6347].

## 3. The "connection_id" Extension

This document defines the "connection_id" extension, which is used in ClientHello and ServerHello messages.

The extension type is specified as follows.

```
enum {
   connection_id(TBD), (65535)
} ExtensionType;
```

The extension_data field of this extension, when included in the ClientHello, MUST contain the ConnectionId structure. This structure contains the CID value the client wishes the server to use when sending messages to the client. A zero-length CID value indicates that the client is prepared to send with a CID but does not wish the server to use one when sending. Alternatively, this can be interpreted as the client wishes the server to use a zero-length CID; the result is the same.

```
struct {
    opaque cid<0..2^8-1>;
} ConnectionId;
```

A server willing to use CIDs will respond with a "connection_id" extension in the ServerHello, containing the CID it wishes the client to use when sending messages towards it. A zero-length value indicates that the server will send with the client's CID but does not wish the client to include a CID (or again, alternately, to use a zero-length CID).

Because each party sends the value in the "connection_id" extension it wants to receive as a CID in encrypted records, it is possible for an endpoint to use a globally constant length for such connection identifiers. This can in turn ease parsing and connection lookup, for example by having the length in question be a compile-time constant. Implementations, which want to use variable-length CIDs, are responsible for constructing the CID in such a way that its length can be determined on reception. Such implementations must still be able to send CIDs of different length to other parties. Note that there is no CID length information included in the record itself.

In DTLS 1.2, CIDs are exchanged at the beginning of the DTLS session only. There is no dedicated "CID update" message that allows new CIDs to be established mid-session, because DTLS 1.2 in general does not allow TLS 1.3-style post-handshake messages that do not themselves begin other handshakes. When a DTLS session is resumed or renegotiated, the "connection_id" extension is negotiated afresh.

If DTLS peers have not negotiated the use of CIDs then the RFC 6347-defined record format and content type MUST be used.

If DTLS peers have negotiated the use of a CIDs using the ClientHello and the ServerHello messages then the peers need to take the following steps.

The DTLS peers determine whether incoming and outgoing messages need to use the new record format, i.e., the record format containing the CID. The new record format with the the tls12_cid content type is only used once encryption is enabled. Plaintext payloads never use the new record type and the CID content type.

For sending, if a zero-length CID has been negotiated then the RFC 6347-defined record format and content type MUST be used (see Section 4.1 of [RFC6347]) else the new record layer format with the tls12_cid content type defined in Figure 1 MUST be used.

When transmitting a datagram with the tls12_cid content type, the new MAC computation defined in Section 5 MUST be used.

For receiving, if the tls12_cid content type is set, then the CID is used to look up the connection and the security association. If the tls12_cid content type is not set, then the connection and security association is looked up by the 5-tuple and a check MUST be made to determine whether the expected CID value is indeed zero length. If the check fails, then the datagram MUST be dropped.

When receiving a datagram with the tls12_cid content type, the new MAC computation defined in Section 5 MUST be used. When receiving a datagram with the RFC 6347-defined record format the MAC calculation defined in Section 4.1.2 of [RFC6347] MUST be used.

## 4. Record Layer Extensions

This specification defines the DTLS 1.2 record layer format and [I-D.ietf-tls-dtls13] specifies how to carry the CID in DTLS 1.3.

To allow a receiver to determine whether a record has a CID or not, connections which have negotiated this extension use a distinguished record type tls12_cid(25). Use of this content type has the following three implications:

- The CID field is present and contains one or more bytes.

- The MAC calculation follows the process described in Section 5.

- The true content type is inside the encryption envelope, as described below.

When CIDs are being used, the content to be sent is first wrapped along with its content type and optional padding into a DTLSInnerPlaintext:

```
      struct {
          ContentType type;
          ProtocolVersion version;
          uint16 epoch;
          uint48 sequence_number;
          uint16 length;
          opaque fragment[DTLSPlaintext.length];
      } DTLSPlaintext;

      struct {
          opaque content[DTLSPlaintext.length];
          ContentType real_type;
          uint8 zeros[length_of_padding];
      } DTLSInnerPlaintext;
```

content A copy of DTLSPlaintext.fragment

real_type A copy of DTLSPlaintext.type

zeros An arbitrary-length run of zero-valued bytes may appear in the cleartext after the type field. This provides an opportunity for senders to pad any DTLS record by a chosen amount as long as the total stays within record size limits. See Section 5.4 of [RFC8446] for more details. (Note that the term TLSInnerPlaintext in RFC 8446 refers to DTLSInnerPlaintext in this specification.)

The DTLSInnerPlaintext value is then encrypted and the CID added to produce the final DTLSCiphertext.

```
      struct {
          ContentType special_type = tls12_cid; /* 25 */
          ProtocolVersion version;
          uint16 epoch;
          uint48 sequence_number;
          opaque cid[cid_length];               // New field
          uint16 length;
          opaque enc_content[DTLSCiphertext.length];
      } DTLSCiphertext;
```

Figure 1: DTLSCiphertext with CID

special_type The outer content type of a DTLSCiphertext record carrying a CID is always set to the value 25 (tls12_cid). The actual content type of the record is found in DTLSInnerPlaintext.real_type after decryption.

cid The CID value, cid_length bytes long, as agreed at the time the extension has been negotiated.

enc_content The encrypted form of the serialized DTLSInnerPlaintext structure.

All other fields are as defined in RFC 6347.

## 5. Record Payload Protection

This specification modifies the MAC calculation defined in [RFC6347] and [RFC7366] as well as the definition of the additional data used with AEAD ciphers provided in [RFC6347] for records with content type tls12_cid. The modified algorithm MUST NOT be applied to records that do not carry a CID, i.e., records with content type other than tls12_cid.

- Block Ciphers:

```
MAC(MAC_write_key, seq_num +
    tls12_cid +                      // New input
    DTLSPlaintext.version +
    cid +                            // New input
    cid_length +                     // New input
    length_of_DTLSInnerPlaintext +   // New input
    DTLSInnerPlaintext.content +     // New input
    DTLSInnerPlaintext.real_type +   // New input
    DTLSInnerPlaintext.zeros         // New input
)
```

- Block Ciphers with Encrypt-then-MAC processing:

```
MAC(MAC_write_key, seq_num +
    DTLSCipherText.type +
    DTLSCipherText.version +
    DTLSPlaintext.version +
    cid +                    // New input
    cid_length +             // New input
    length of (IV + DTLSCiphertext.enc_content) +
    IV +
    DTLSCiphertext.enc_content);
```

- AEAD Ciphers:

```
additional_data = seq_num + DTLSPlaintext.type +
                  DTLSPlaintext.version +
                  cid +                    // New input
                  cid_length +             // New input
                  length_of_DTLSInnerPlaintext;
```

Where:

cid Value of the negotiated CID.

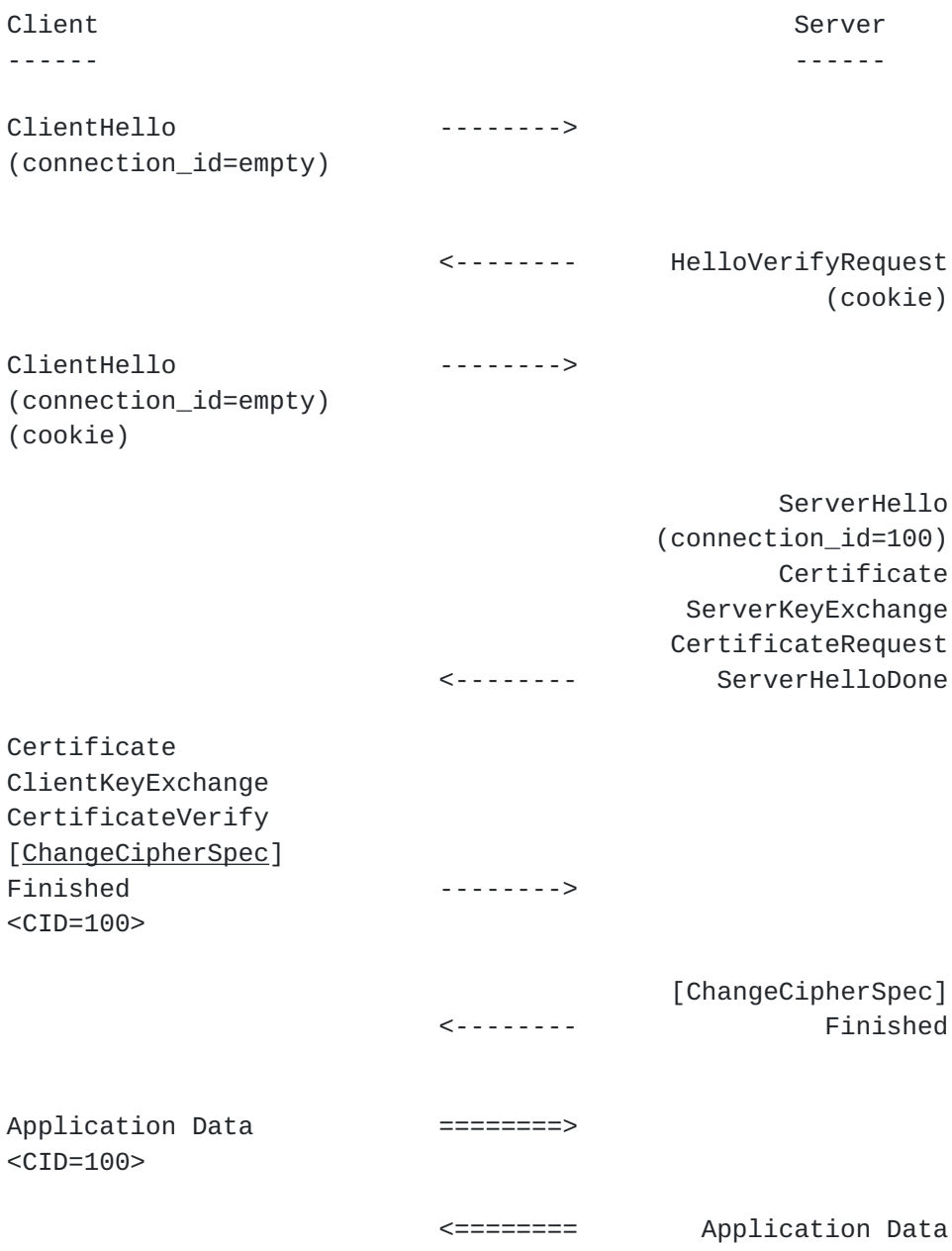
cid_length 1 byte field indicating the length of the negotiated CID.

All other fields are as defined in the cited documents.

length_of_DTLSInnerPlaintext The length (in bytes) of the serialised DTLSInnerPlaintext. The length MUST NOT exceed 2^14.

## 6. Examples

Figure 2 shows an example exchange where a CID is used uni-directionally from the client to the server. To indicate that a zero-length CID we use the term 'connection_id=empty'.




Legend:

<...> indicates that a connection id is used in the record layer
(...) indicates an extension
[...] indicates a payload other than a handshake message

Figure 2: Example DTLS 1.2 Exchange with CID

Note: In the example exchange the CID is included in the record layer once encryption is enabled. In DTLS 1.2 only one handshake message is encrypted, namely the Finished message. Since the example shows

how to use the CID for payloads sent from the client to the server only the record layer payload containing the Finished messagen contains a CID. Application data payloads sent from the client to the server contain a CID in this example as well.

## 7. Security and Privacy Considerations

The CID replaces the previously used 5-tuple and, as such, introduces an identifier that remains persistent during the lifetime of a DTLS connection. Every identifier introduces the risk of linkability, as explained in [RFC6973].

In addition, endpoints can use the CID to attach arbitrary metadata to each record they receive. This may be used as a mechanism to communicate per-connection information to on-path observers. There is no straightforward way to address this with CIDs that contain arbitrary values; implementations concerned about this SHOULD refuse to use connection ids.

An on-path adversary, who is able to observe the DTLS protocol exchanges between the DTLS client and the DTLS server, is able to link the observed payloads to all subsequent payloads carrying the same connection id pair (for bi-directional communication). Without multi-homing or mobility, the use of the CID is not different to the use of the 5-tuple.

With multi-homing, an adversary is able to correlate the communication interaction over the two paths, which adds further privacy concerns.

Importantly, the sequence number makes it possible for a passive attacker to correlate packets across CID changes. Thus, even if a client/server pair do a rehandshake to change CID, that does not provide much privacy benefit.

The CID-enhanced record layer introduces record padding; a privacy feature not available with the original DTLS 1.2 RFC. Padding allows to inflate the size of the ciphertext making traffic analysis more difficult. More details about the padding can be found in Section 5.4 and Appendix E.3 of RFC 8446.

## 8. IANA Considerations

IANA is requested to allocate an entry to the existing TLS "ExtensionType Values" registry, defined in [RFC5246], for connection_id(TBD) defined in this document.

IANA is requested to allocate tls12_cid(25) in the "TLS ContentType Registry".

## 9. References

### 9.1. Normative 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>.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, DOI 10.17487/RFC5246, August 2008, <https://www.rfc-editor.org/info/rfc5246>.

[RFC6347] Rescorla, E. and N. Modadugu, "Datagram Transport Layer Security Version 1.2", RFC 6347, DOI 10.17487/RFC6347, January 2012, <https://www.rfc-editor.org/info/rfc6347>.

[RFC7366] Gutmann, P., "Encrypt-then-MAC for Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)", RFC 7366, DOI 10.17487/RFC7366, September 2014, <https://www.rfc-editor.org/info/rfc7366>.

[RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <https://www.rfc-editor.org/info/rfc8446>.

### 9.2. Informative References

[I-D.ietf-tls-dtls13] Rescorla, E., Tschofenig, H., and N. Modadugu, "The Datagram Transport Layer Security (DTLS) Protocol Version 1.3", draft-ietf-tls-dtls13-30 (work in progress), November 2018.

[RFC6973] Cooper, A., Tschofenig, H., Aboba, B., Peterson, J., Morris, J., Hansen, M., and R. Smith, "Privacy Considerations for Internet Protocols", RFC 6973, DOI 10.17487/RFC6973, July 2013, <https://www.rfc-editor.org/info/rfc6973>.

### 9.3. URIs

[1] mailto:tls@ietf.org

[2] https://www1.ietf.org/mailman/listinfo/tls

[3] https://www.ietf.org/mail-archive/web/tls/current/index.html

## Appendix A. History

RFC EDITOR: PLEASE REMOVE THE THIS SECTION

draft-ietf-tls-dtls-connection-id-03

- Updated list of contributors
- Updated list of contributors and acknowledgements
- Updated example
- Changed record layer design
- Changed record payload protection
- Updated introduction and security consideration section
- Author- and affiliation changes

draft-ietf-tls-dtls-connection-id-02

- Move to internal content types a la DTLS 1.3.

draft-ietf-tls-dtls-connection-id-01

- Remove 1.3 based on the WG consensus at IETF 101

draft-ietf-tls-dtls-connection-id-00

- Initial working group version (containing a solution for DTLS 1.2 and 1.3)

draft-rescorla-tls-dtls-connection-id-00

- Initial version

## Appendix B. Working Group Information

RFC EDITOR: PLEASE REMOVE THE THIS SECTION

The discussion list for the IETF TLS working group is located at the e-mail address tls@ietf.org [1]. Information on the group and information on how to subscribe to the list is at https://www1.ietf.org/mailman/listinfo/tls [2]

Archives of the list can be found at: https://www.ietf.org/mail-archive/web/tls/current/index.html [3]

## Appendix C. Contributors

Many people have contributed to this specification and we would like to thank the following individuals for their contributions:

* Yin Xinxing
  Huawei
  yinxinxing@huawei.com

* Nikos Mavrogiannopoulos
  RedHat
  nmav@redhat.com

* Tobias Gondrom
  tobias.gondrom@gondrom.org

Additionally, we would like to thank the Connection ID task force team members:

- Martin Thomson (Mozilla)

- Christian Huitema (Private Octopus Inc.)

- Jana Iyengar (Google)

- Daniel Kahn Gillmor (ACLU)

- Patrick McManus (Mozilla)

- Ian Swett (Google)

- Mark Nottingham (Fastly)

The task force team discussed various design ideas, including cryptographically generated session
ids using hash chains and public key encryption, but dismissed them due to their inefficiency. The approach described in this specification is the simplest possible design that works given the limitations of DTLS 1.2. DTLS 1.3 provides better privacy features and developers are encouraged to switch to the new version of DTLS, if these privacy properties are important in a given deployment.

Finally, we want to thank the IETF TLS working group chairs, Chris Wood, Joseph Salowey, and Sean Turner, for their patience, support and feedback.

## Appendix D. Acknowledgements

We would like to thank Achim Kraus for his review feedback.

## Authors' Addresses

Eric Rescorla (editor)
RTFM, Inc.

EMail: ekr@rtfm.com

Hannes Tschofenig (editor)
Arm Limited

EMail: hannes.tschofenig@arm.com

Thomas Fossati
Arm Limited

EMail: thomas.fossati@arm.com