TLS
Internet-Draft
Updates: 6347 (if approved)
Intended status: Standards Track
Expires: June 24, 2022

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December 21, 2021

Return Routability Check for DTLS 1.2 and DTLS 1.3
draft-ietf-tls-dtls-rrc-04

Abstract

This document specifies a return routability check for use in context of the Connection ID (CID) construct for the Datagram Transport Layer Security (DTLS) protocol versions 1.2 and 1.3.

Status of This Memo

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

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This Internet-Draft will expire on June 24, 2022.

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1. Introduction

In "classical" DTLS, selecting a security context of an incoming DTLS record is accomplished with the help of the 5-tuple, i.e. source IP address, source port, transport protocol, destination IP address, and destination port. Changes to this 5 tuple can happen for a variety reasons over the lifetime of the DTLS session. In the IoT context, NAT rebinding is common with sleepy devices. Other examples include end host mobility and multi-homing. Without CID, 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. As a result, the DTLS handshake has to be re-run. Of course, it is not necessary to re-run the full handshake if session resumption is supported and negotiated.

A CID is an identifier carried in the record layer header of a DTLS datagram that gives the receiver additional information for selecting the appropriate security context. The CID mechanism has been specified in [I-D.ietf-tls-dtls-connection-id] for DTLS 1.2 and in [I-D.ietf-tls-dtls13] for DTLS 1.3.

Section 6 of [I-D.ietf-tls-dtls-connection-id] describes how the use of CID increases the attack surface by providing both on-path and off-path attackers an opportunity for (D)DoS. It then goes on describing the steps a DTLS principal must take when a record with a CID is received that has a source address (and/or port) different from the one currently associated with the DTLS connection. However, the actual mechanism for ensuring that the new peer address is willing to receive and process DTLS records is left open. This document standardizes a return routability check (RRC) as part of the DTLS protocol itself.

The return routability check is performed by the receiving peer before the CID-to-IP address/port binding is updated in that peer's session state database. This is done in order to provide more confidence to the receiving peer that the sending peer is reachable at the indicated address and port.

Note however that, irrespective of CID, if RRC has been successfully negotiated by the peers, path validation can be used at any time by either endpoint. For instance, an endpoint might use RRC to check that a peer is still in possession of its address after a period of quiescence.

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 BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

This document assumes familiarity with the CID format and protocol defined for DTLS 1.2 [I-D.ietf-tls-dtls-connection-id] and for DTLS 1.3 [I-D.ietf-tls-dtls13]. The presentation language used in this document is described in Section 4 of [RFC8446].

This document reuses the definition of "anti-amplification limit" from [RFC9000] to mean three times the amount of data received from an unvalidated address. This includes all DTLS records originating from that source address, excluding discarded ones.

3. RRC Extension

The use of RRC is negotiated via the "rrc" DTLS-only extension. On connecting, the client includes the "rrc" extension in its ClientHello if it wishes to use RRC. If the server is capable of meeting this requirement, it responds with a "rrc" extension in its ServerHello. The "extension_type" value for this extension is TBD1 and the "extension_data" field of this extension is empty. The client and server MUST NOT use RRC unless both sides have successfully exchanged "rrc" extensions.

Note that the RRC extension applies to both DTLS 1.2 and DTLS 1.3.

4. The Return Routability Check Message

When a record with CID is received that has the source address of the enclosing UDP datagram different from the one previously associated with that CID, the receiver MUST NOT update its view of the peer's IP address and port number with the source specified in the UDP datagram before cryptographically validating the enclosed record(s) but instead perform a return routability check.

```
enum {
    invalid(0),
    change_cipher_spec(20),
    alert(21),
    handshake(22),
    application_data(23),
    heartbeat(24),  /* RFC 6520 */
```

```
    return_routability_check(TBD2), /* NEW */
    (255)
} ContentType;

uint64 Cookie;

enum {
    path_challenge(0),
    path_response(1),
    reserved(2..255)
} rrc_msg_type;

struct {
    rrc_msg_type msg_type;
    select (return_routability_check.msg_type) {
        case path_challenge: Cookie;
        case path_response:  Cookie;
    };
} return_routability_check;
```


The newly introduced "return_routability_check" message contains a cookie. The cookie is a 8-byte field containing arbitrary data.

The "return_routability_check" message MUST be authenticated and encrypted using the currently active security context.

5. Path Validation Procedure

The receiver that observes the peer's address or port update MUST stop sending any buffered application data (or limit the data sent to the unvalidated address to the anti-amplification limit) and initiate the return routability check that proceeds as follows:

1. An unpredictable cookie is placed in a "return_routability_check" message of type path_challenge;

2. The message is sent to the observed new address and a timer T (see Section 5.3) is started;

3. The peer endpoint, after successfully verifying the received "return_routability_check" message responds by echoing the cookie value in a "return_routability_check" message of type

path_response;

4. When the initiator receives and verifies the "return_routability_check" message contains the sent cookie, it updates the peer address binding;

5. If T expires, or the address confirmation fails, the peer address binding is not updated.

After this point, any pending send operation is resumed to the bound peer address.

Section 5.1 and Section 5.2 contain the requirements for the initiator and responder roles, broken down per protocol phase.

5.1. Path Challenge Requirements

- The initiator MAY send multiple "return_routability_check" messages of type path_challenge to cater for packet loss on the probed path.
    - Each path_challenge SHOULD go into different transport packets. (Note that the DTLS implementation may not have control over the packetization done by the transport layer.)

    - The transmission of subsequent path_challenge messages SHOULD be paced to decrease the chance of loss.
    - Each path_challenge message MUST contain random data.
- The initiator MAY use padding using the record padding mechanism available in DTLS 1.3 (and in DTLS 1.2, when CID is enabled on the sending direction) up to the anti-amplification limit to probe if the path MTU (PMTU) for the new path is still acceptable.

5.2. Path Response Requirements

- The responder MUST NOT delay sending an elicited path_response message.

- The responder MUST send exactly one path_response messages for each received path_request.

- The responder MUST send the path_response on the network path where the corresponding path_challenge has been received, so that validation succeeds only if the path is functional in both directions.

  o The initiator MUST NOT enforce this behaviour

- The initiator MUST silently discard any invalid path_response it receives.

Note that RRC does not cater for PMTU discovery on the reverse path. If the responder wants to do PMTU discovery using RRC, it should initiate a new path validation procedure.

5.3. Timer Choice

When setting T, implementations are cautioned that the new path could have a longer round-trip time (RTT) than the original.

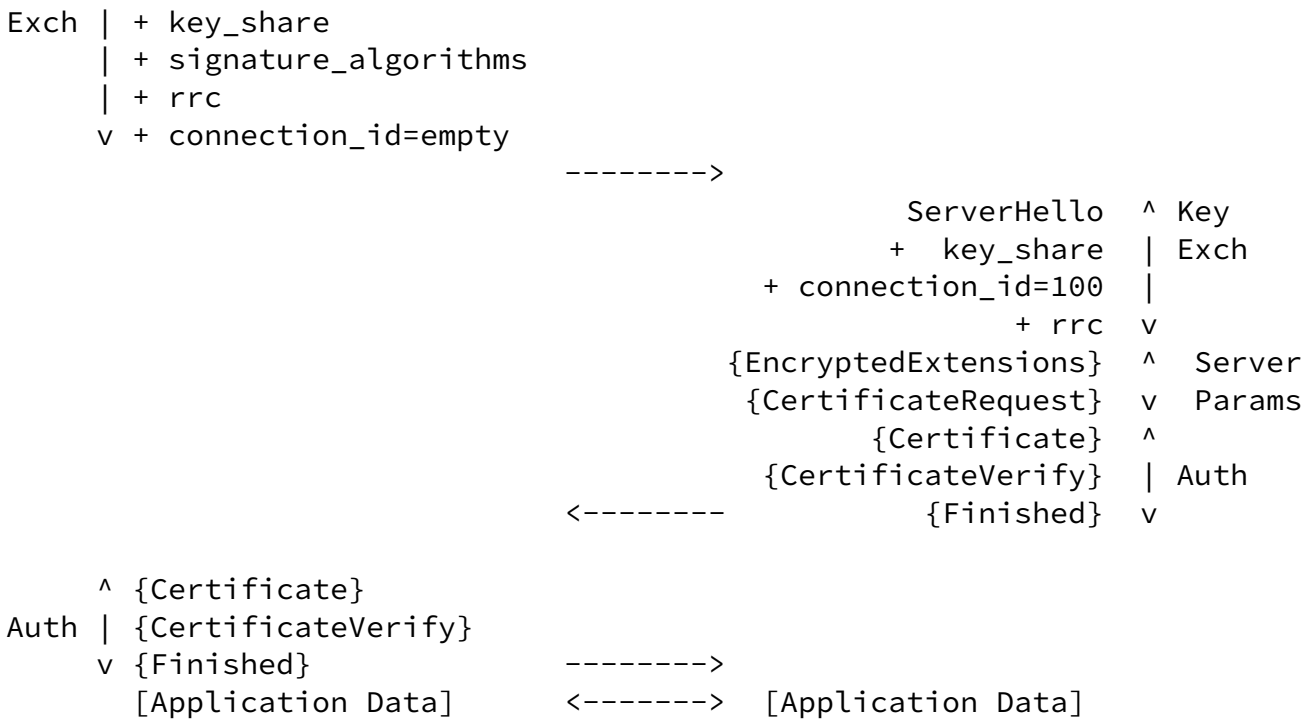
In settings where there is external information about the RTT of the active path, implementations SHOULD use T = 3xRTT.

If an implementation has no way to obtain information regarding the RTT of the active path, a value of 1s SHOULD be used.

Profiles for specific deployment environments - for example, constrained networks [I-D.ietf-uta-tls13-iot-profile] - MAY specify a different, more suitable value.

6. Example

The example TLS 1.3 handshake shown in Figure 1 shows a client and a server negotiating the support for CID and for the RRC extension.



+ Indicates noteworthy extensions sent in the previously noted message.

* Indicates optional or situation-dependent messages/extensions that are not always sent.

{} Indicates messages protected using keys derived from a [sender]_handshake_traffic_secret.

[] Indicates messages protected using keys derived from [sender]_application_traffic_secret_N.

Figure 1: Message Flow for Full TLS Handshake

Once a connection has been established the client and the server exchange application payloads protected by DTLS with an unilaterally used CIDs. In our case, the client is requested to use CID 100 for records sent to the server.

At some point in the communication interaction the IP address used by

the client changes and, thanks to the CID usage, the security context to interpret the record is successfully located by the server. However, the server wants to test the reachability of the client at his new IP address.

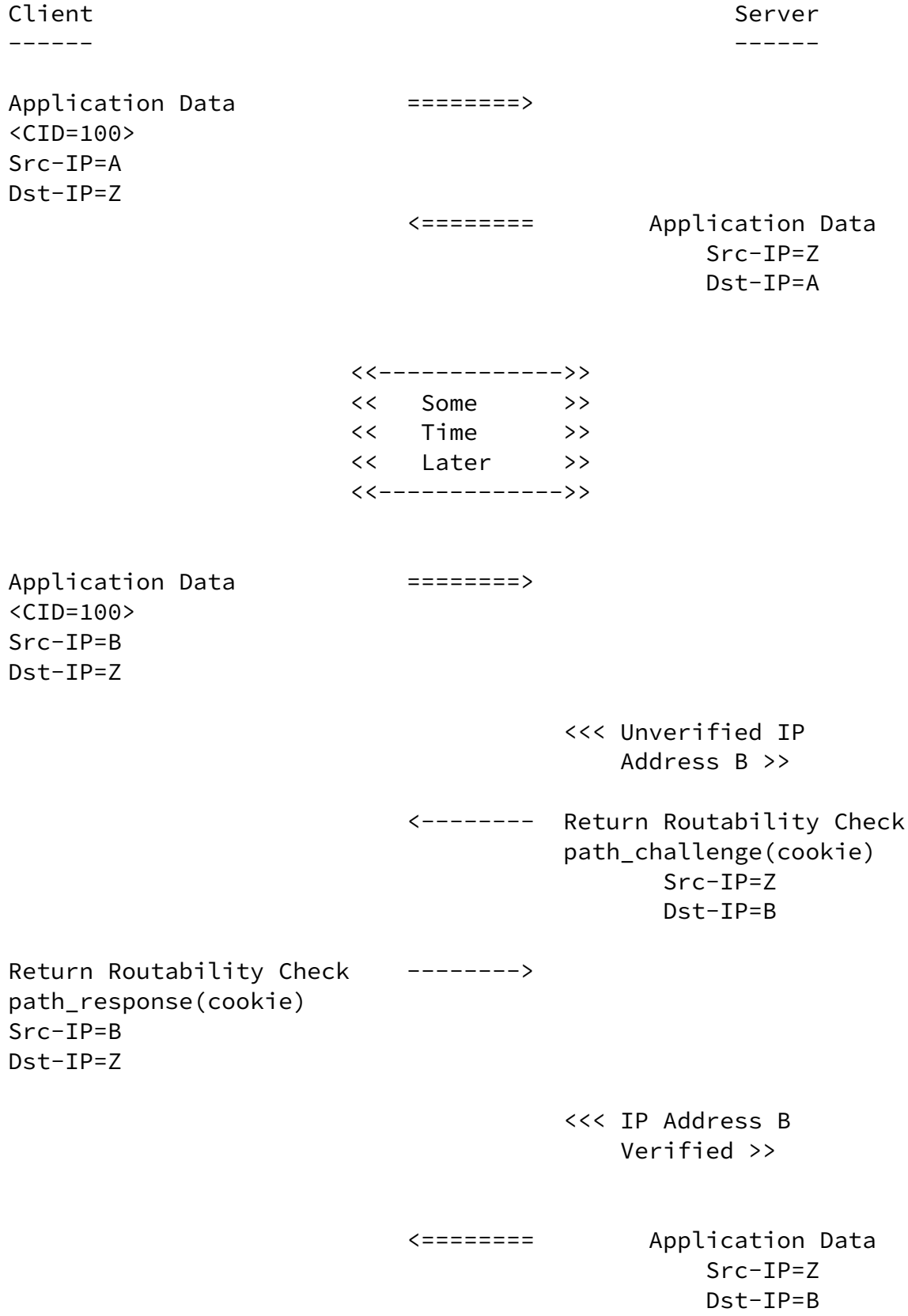


Figure 2: Return Routability Example

7. Security and Privacy Considerations

Note that the return routability checks do not protect against flooding of third-parties if the attacker is on-path, as the attacker can redirect the return routability checks to the real peer (even if those datagrams are cryptographically authenticated). On-path adversaries can, in general, pose a harm to connectivity.

8. IANA Considerations

IANA is requested to allocate an entry to the TLS "ContentType" registry, for the "return_routability_check(TBD2)" defined in this document. The "return_routability_check" content type is only applicable to DTLS 1.2 and 1.3.

IANA is requested to allocate the extension code point (TBD1) for the "rrc" extension to the "TLS ExtensionType Values" registry as described in Table 1.

Value	Extension Name	TLS 1.3	DTLS-Only	Recommended	Reference
TBD1	rrc	CH, SH	Y	N	RFC-THIS

Table 1: rrc entry in the TLS ExtensionType Values registry

9. Open Issues

Issues against this document are tracked at https://github.com/tlswg/dtls-rrc/issues

10. Acknowledgments

We would like to thank Achim Kraus, Hanno Becker, Hanno Boeck, Manuel Pegourie-Gonnard, Mohit Sahni and Rich Salz for their input to this document.

11. References

11.1. Normative References

[I-D.ietf-tls-dtls-connection-id]
RTFM, Inc., Arm Limited, Arm Limited, and Bosch.IO GmbH, "Connection Identifiers for DTLS 1.2", draft-ietf-tls-dtls-connection-id-13 (work in progress), June 2021.

[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-dtls13-43 (work in progress), April 2021.

[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>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[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>.

11.2. Informative References

[I-D.ietf-uta-tls13-iot-profile]
Arm Limited and Arm Limited, "TLS/DTLS 1.3 Profiles for the Internet of Things", draft-ietf-uta-tls13-iot-profile-03 (work in progress), October 2021.

[RFC9000] Iyengar, J., Ed. and M. Thomson, Ed., "QUIC: A UDP-Based Multiplexed and Secure Transport", RFC 9000, DOI 10.17487/RFC9000, May 2021, <https://www.rfc-editor.org/info/rfc9000>.

Appendix A. History

[[CREF1: RFC EDITOR: PLEASE REMOVE THIS SECTION]]

draft-ietf-tls-dtls-rrc-04

- Re-submitted draft to fix references

draft-ietf-tls-dtls-rrc-03

- Added details for challenge-response exchange

draft-ietf-tls-dtls-rrc-02

- Undo the TLS flags extension for negotiating RRC, use a new extension type

draft-ietf-tls-dtls-rrc-01

- Use the TLS flags extension for negotiating RRC
- Enhanced IANA consideration section
- Expanded example section

- Revamp message layout:

  - Use 8-byte fixed size cookies

  - Explicitly separate path challenge from response

draft-ietf-tls-dtls-rrc-00

- Draft name changed after WG adoption

draft-tschofenig-tls-dtls-rrc-01

- Removed text that overlapped with draft-ietf-tls-dtls-connection-id

draft-tschofenig-tls-dtls-rrc-00

- Initial version

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