

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: June 4, 2012

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December 2, 2011

Transport Layer Security (TLS) and Datagram Transport Layer Security
(DTLS) Heartbeat Extension
draft-ietf-tls-dtls-heartbeat-04.txt

Abstract

This document describes the Heartbeat Extension for the Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) protocol.

The Heartbeat Extension provides a new protocol for TLS/DTLS allowing the usage of keep-alive functionality without performing a renegotiation and a basis for path maximum transmission unit (PMTU) discovery for DTLS.

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TLS/DTLS Heartbeat Extension

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1. Introduction

1.1. Overview

This document describes the Heartbeat Extension for the Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) protocols, as defined in [\[RFC5246\]](#) and [\[I-D.ietf-tls-rfc4347-bis\]](#) and their adaptations to specific transport protocols described in [\[RFC3436\]](#), [\[RFC5238\]](#), and [\[RFC6083\]](#).

DTLS is designed to secure traffic running on top of unreliable transport protocols. Usually such protocols have no session management. The only mechanism available at the DTLS layer to figure out if a peer is still alive is performing a costly renegotiation. If the application uses unidirectional traffic there is no other way. Furthermore, DTLS needs to perform path maximum transmission unit (PMTU) discovery but has no specific message type to realize it without affecting user message transfer.

TLS is based on reliable protocols but there is not necessarily a feature available to keep the connection alive without continuous data transfer.

The Heartbeat Extension as described in this document overcomes these limitations. The user can use the new HeartbeatRequest message which has to be answered by the peer with a HeartbeatResponse immediately. To perform PMTU discovery, HeartbeatRequest messages containing padding can be used as probe packets as described in [\[RFC4821\]](#).

1.2. 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 [\[RFC2119\]](#).

[2.](#) Heartbeat Hello Extension

The support of Heartbeats is indicated with Hello Extensions. A peer can not only indicate that its implementation supports Heartbeats, it can also choose whether it is willing to receive HeartbeatRequest messages and respond with HeartbeatResponse messages or only to send HeartbeatRequest messages. The former is indicated by using `peer_allowed_to_send` as the HeartbeatMode, the latter is indicated by using `peer_not_allowed_to_send` as the Heartbeat mode. This decision can be changed with every renegotiation. HeartbeatRequest messages MUST NOT be sent to a peer indicating `peer_not_allowed_to_send`. If an endpoint that has indicated `peer_not_allowed_to_send` receives a

HeartbeatRequest message, the endpoint SHOULD drop the message silently and MAY send an unexpected_message Alert message.

The format of the Heartbeat Hello Extension is defined by:

```
enum {  
    peer_allowed_to_send(1),  
    peer_not_allowed_to_send(2),  
    (255)  
} HeartbeatMode;  
  
struct {  
    HeartbeatMode mode;  
} HeartbeatExtension;
```

Upon reception of an unknown mode, an error Alert message using `illegal_parameter` as its AlertDescription MUST be sent in response.

[3.](#) Heartbeat Protocol

The Heartbeat protocol is a new protocol on top of the Record Layer. The protocol itself consists of two message types: HeartbeatRequest and HeartbeatResponse.

```
enum {  
    heartbeat_request(1),  
    heartbeat_response(2),  
    (255)
```

} HeartbeatMessageType;

A HeartbeatRequest message can arrive almost at any time during the lifetime of a connection. Whenever a HeartbeatRequest message is received, it SHOULD be answered with a corresponding HeartbeatResponse message.

However, a HeartbeatRequest message SHOULD NOT be sent during handshakes. If a handshake is initiated while a HeartbeatRequest is still in flight, the sending peer MUST stop the DTLS retransmission timer for it. The receiving peer SHOULD discard it silently, if it arrives during the handshake. In case of DTLS, HeartbeatRequest messages from older epochs SHOULD be discarded.

There MUST NOT be more than one HeartbeatRequest message in flight at a time. A HeartbeatRequest message is considered to be in flight until the corresponding HeartbeatResponse message is received, or until the retransmit timer expires.

When using an unreliable transport protocol like DCCP or UDP, HeartbeatRequest messages MUST be retransmitted using the simple timeout and retransmission scheme DTLS uses for flights as described in Section 4.2.4 of [[I-D.ietf-tls-rfc4347-bis](#)]. In particular, after a number of retransmissions without receiving a corresponding HeartbeatResponse message having the expected payload the DTLS connection SHOULD be terminated. The threshold used for this SHOULD be the same as for DTLS handshake messages. Please note, that after the timer supervising a HeartbeatRequest messages expires, this message is no longer considered in flight. Therefore the HeartbeatRequest message is eligible for retransmission. The retransmission scheme in combination with the restriction that only one HeartbeatRequest is allowed to be in flight ensures that the congestion control is handled appropriately in case of the transport protocol not providing one, like in the case of DTLS over UDP.

When using a reliable transport protocol like SCTP or TCP, HeartbeatRequest messages only need to be sent once. The transport layer will handle retransmissions. If no corresponding HeartbeatResponse message has been received after some amount of time, the DTLS/TLS connection MAY be terminated by the application that initiated the sending of the HeartbeatRequest message.

4. Heartbeat Request and Response Messages

The Heartbeat protocol messages consist of their type and an arbitrary payload and padding.

```
struct {  
    HeartbeatMessageType type;  
    uint16 payload_length;  
    opaque payload[HeartbeatMessage.payload_length];  
    opaque padding[padding_length];  
} HeartbeatMessage;
```

The length of a HeartbeatMessage in total MUST NOT exceed 2^{14} or max_fragment_length when negotiated as defined in [\[RFC6066\]](#).

type: The message type, either heartbeat_request or heartbeat_response.

payload_length: The length of the payload.

payload: The payload consists of arbitrary content.

padding: The padding is random content which MUST be ignored by the receiver. The length of a HeartbeatMessage is TLSPlaintext.length for TLS and DTLSPlaintext.length for DTLS. Furthermore the length of the type field is 1 byte and the length of the payload_length is 2. Therefore, the padding_length is TLSPlaintext.length - payload_length - 3 for TLS and DTLSPlaintext.length - payload_length - 3 for DTLS. The padding_length MUST be at least 16.

The sender of a HeartbeatMessage MUST use a random padding of at least 16 bytes. The padding of a received HeartbeatMessage message MUST be ignored.

If the payload_length of a received HeartbeatMessage is too large, the received HeartbeatMessage MUST be discarded silently.

When a HeartbeatRequest message is received and sending a HeartbeatResponse is not prohibited as described elsewhere in this document, the receiver MUST send a corresponding HeartbeatResponse message carrying an exact copy of the payload of the received HeartbeatRequest.

If a received HeartbeatResponse message does not contain the expected payload the message MUST be discarded silently. If it does contain the expected payload the retransmission timer MUST be stopped.

[5.](#) Use Cases

Each endpoint sends HeartbeatRequest messages at a rate and with the padding required for the particular use case. The endpoint should not expect its peer to send HeartbeatRequests. The directions are independent.

[5.1.](#) Path MTU Discovery

DTLS performs path MTU discovery as described in Section 4.1.1.1 of [[I-D.ietf-tls-rfc4347-bis](#)]. A detailed description how to perform path MTU discovery is given in [[RFC4821](#)]. The necessary probe packets are the HeartbeatRequest messages.

This method using HeartbeatRequest messages for DTLS is similar to the one for the Stream Control Transmission Protocol (SCTP) using the padding chunk (PAD-chunk) defined in [[RFC4820](#)].

[5.2.](#) Liveliness check

Sending HeartbeatRequest messages allows the sender to make sure that it can reach the peer and the peer is alive. Even in case of TLS/TCP this allows a check at a much higher rate than the TCP keep-alive feature would allow.

Besides making sure that the peer is still reachable, sending

HeartbeatRequest messages refreshes the NAT state of all involved NATs.

HeartbeatRequest messages SHOULD only be sent after an idle period that is at least multiple round trip times long. This idle period SHOULD to be configurable up to a period of multiple minutes and down to a period of one second. A default value for the idle period SHOULD be configurable but it SHOULD also be tunable on a per peer basis.

[6.](#) IANA Considerations

[NOTE to RFC-Editor:

"RFCXXXX" is to be replaced by the RFC number you assign this document.

]

IANA needs to assign the heartbeat content type (value TBD) from the TLS ContentType Registry as specified in [[RFC5246](#)]. The reference should be RFCXXXX.

IANA needs to maintain a new registry for Heartbeat Message Types. The message types are numbers in the range from 0 to 255 (decimal). Initially IANA needs to assign the heartbeat_request (suggested value 1) and the heartbeat_response (suggested value 2) message type. The values 0 and 255 should be reserved. This registry uses the Expert Review policy as described in [[RFC5226](#)]. The reference should be RFCXXXX.

IANA needs to assign the heartbeat extension type (value TBD) from the TLS Extension Type Registry as specified in [[RFC5246](#)]. The reference should be RFCXXXX.

IANA needs to maintain a new registry for Heartbeat Modes. The modes are numbers in the range from 0 to 255 (decimal). Initially IANA needs to assign the peer_allowed_to_send (suggested value 1) and the peer_not_allowed_to_send (suggested value 2) modes. The values 0 and

as described in [[RFC5226](#)]. The reference should be RFCXXXX.

[7.](#) Security Considerations

This document does not add any additional security considerations in addition to the ones given in [[I-D.ietf-tls-rfc4347-bis](#)] and [[RFC5246](#)].

[8.](#) Acknowledgments

The authors wish to thank Pasi Eronen, Adrian Farrel, Stephen Farrell, Adam Langley, Nikos Mavrogiannopoulos, Tom Petch, Eric Rescorla, Peter Saint-Andre, and Juho Vaehae-Herttua for their invaluable comments.

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