

TLS  
Internet-Draft  
Intended status: Standards Track  
Expires: June 16, 2018

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December 13, 2017

**Exported Authenticators in TLS**  
**draft-ietf-tls-exported-authenticator-05**

Abstract

This document describes a mechanism in Transport Layer Security (TLS) to provide an exportable proof of ownership of a certificate that can be transmitted out of band and verified by the other party.

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## [1.](#) Introduction

This document provides a way to authenticate one party of a Transport Layer Security (TLS) communication to another using a certificate after the session has been established. This allows both the client and server to prove ownership of additional identities at any time after the handshake has completed. This proof of authentication can be exported and transmitted out of band from one party to be validated by the other party.

This mechanism provides two advantages over the authentication that TLS natively provides:

multiple identities - Endpoints that are authoritative for multiple identities - but do not have a single certificate that includes all of the identities - can authenticate with those identities over a single connection.

spontaneous authentication - Endpoints can authenticate after a connection is established, in response to events in a higher-layer protocol, as well as integrating more context.

This document intends to replace much of the functionality of renegotiation in previous versions of TLS. It has the advantages over renegotiation of not requiring additional on-the-wire changes during a connection. For simplicity, only TLS 1.2 and later are supported.

Post-handshake authentication is defined in TLS 1.3, but it has the disadvantage of requiring additional state to be stored in the TLS state machine and it composes poorly with multiplexed connection protocols like HTTP/2. It is also only available for client



authentication. This mechanism is intended to be used as part of a replacement for post-handshake authentication in applications.

## 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](#)].

## 3. Authenticator Request

The authenticator request is a structured message that can be exported from either party of a TLS connection. It can be transmitted to the other party of the TLS connection at the application layer. The application layer protocol used to send the authenticator SHOULD use TLS as its underlying transport to keep the request confidential.

An authenticator request message can be constructed by either the client or the server. This authenticator request uses the CertificateRequest message structure from Section 4.3.2 of [[TLS13](#)]. This message does not include the TLS record layer and is therefore not encrypted with a handshake key.

**CertificateRequest** This message is used to define the parameters in a request for an authenticator.

```
struct {  
    opaque certificate_request_context<0..2^8-1>;  
    Extension extensions<2..2^16-1>;  
} CertificateRequest;
```

**certificate\_request\_context** An opaque string which identifies the certificate request and which will be echoed in the authenticator message. The certificate\_request\_context MUST be unique within the scope of this connection (thus preventing replay of authenticators). The certificate\_request\_context SHOULD be chosen to be unpredictable to the peer (e.g., by randomly generating it) in order to prevent an attacker who has temporary access to the peer's private key from pre-computing valid authenticators.

**extensions** The extensions that are allowed in this structure include the extensions defined for CertificateRequest messages defined in Section 4.2. of [[TLS13](#)] and the server\_name [[RFC6066](#)] extension, which is allowed for client-generated authenticator requests.



#### 4. Authenticator

The authenticator is a structured message that can be exported from either party of a TLS connection. It can be transmitted to the other party of the TLS connection at the application layer. The application layer protocol used to send the authenticator SHOULD use TLS as its underlying transport to keep the certificate confidential.

An authenticator message can be constructed by either the client or the server given an established TLS connection, a certificate, and a corresponding private key. For clients, an authenticator request is required; for servers an authenticator request is optional. The authenticator uses the message structures from Section 4.4 of [TLS13], but different parameters. These messages do not include the TLS record layer and are therefore not encrypted with a handshake key.

Each authenticator is computed using a Handshake Context and Finished MAC Key derived from the TLS session. These values are derived using an exporter as described in [RFC5705] (for TLS 1.2) or [TLS13] (for TLS 1.3). These values use different labels depending on the role of the sender:

- o The Handshake Context is an exporter value that is derived using the label "EXPORTER-client authenticator handshake context" or "EXPORTER-server authenticator handshake context" for authenticators sent by the client and server respectively.
- o The Finished MAC Key is an exporter value derived using the label "EXPORTER-client authenticator finished key" or "EXPORTER-server authenticator finished key" for authenticators sent by the client and server respectively.

The context\_value used for the exporter is absent (length zero) for all four values. The length of the exported value is equal to the length of the output of the hash function selected in TLS for the pseudorandom function (PRF). Cipher suites that do not use the TLS PRF MUST define a hash function that can be used for this purpose or they cannot be used.

If the connection is TLS 1.2, the master secret MUST have been computed with the extended master secret [RFC7627] to avoid key synchronization attacks.

**Certificate** The certificate to be used for authentication and any supporting certificates in the chain. This structure is defined in [TLS13], Section 4.4.2.



The certificate message contains an opaque string called `certificate_request_context`, which is extracted from the authenticator request if present. If no authenticator request is provided, it is zero-length.

**CertificateVerify** This message is used to provide explicit proof that an endpoint possesses the private key corresponding to its certificate.

```
struct {  
    SignatureScheme algorithm;  
    opaque signature<0..2^16-1>;  
} CertificateVerify;
```

The algorithm field specifies the signature algorithm used (see Section 4.2.3 of [\[TLS13\]](#) for the definition of this field). The signature is a digital signature using that algorithm. The signature scheme MUST be a valid signature scheme for TLS 1.3. This excludes all RSASSA-PKCS1-v1\_5 algorithms and ECDSA algorithms that are not supported in TLS 1.3. If an authenticator request is present, the signature algorithm MUST be chosen from one of the signature schemes in the authenticator request. Otherwise, the signature algorithm used should be chosen from the "signature\_algorithms" extension of the ClientHello used in the connection handshake.

The signature is computed using the over the concatenation of:

- o A string that consists of octet 32 (0x20) repeated 64 times
- o The context string "Exported Authenticator" (which is not NULL-terminated)
- o A single 0 byte which serves as the separator
- o If the authenticator request is present, the value "Hash(Handshake Context || authenticator request || Certificate)"
- o If an authenticator request is not present, the value "Hash(Handshake Context || Certificate)"

where Hash is the hash function for the handshake.

**Finished** A HMAC over the value Hash(Handshake Context || Certificate || CertificateVerify) if an authenticator is present, or Hash(Handshake Context || authenticator request || Certificate || CertificateVerify) where Hash is the hash function for the handshake, and the HMAC is computed using the hash function from the handshake and the Finished MAC Key as a key.





The certificates chosen in the Certificate message MUST conform to the requirements of a Certificate message in the version of TLS negotiated. If an authenticator request is present, the signature algorithms used to choose the algorithm are taken from the "signature\_algorithms" in the from the authenticator. If there is no authenticator request, the signature algorithms are chosen from the "signature\_algorithms" extension from the ClientHello used in the connection. This is described in Section 4.2.3 of [TLS13] and Sections 7.4.2 and 7.4.6 of [RFC5246]. Alternative certificate formats such as [RFC7250] Raw Public Keys are not supported. The "server\_name" [RFC6066], "certificate\_authorities" (Section 4.2.4. of [TLS13]), or "oid\_filters" (Section 4.2.5. of [TLS13]) extensions are used to guide certificate selection, with the extensions provided in the authenticator request taking precedence over the extensions provided in the connection handshake.

If an authenticator request was provided, the Certificate message MUST contain only extensions present in the authenticator request. Otherwise, the Certificate message MUST contain only extensions present in the ClientHello.

The authenticator message is the concatenation of messages:  
Certificate || CertificateVerify || Finished

A given authenticator can be validated by checking the validity of the CertificateVerify message given the authenticator request (if used) and recomputing the Finished message to see if it matches.

## 5. API considerations

The creation and validation of both authenticator requests and authenticators SHOULD be implemented inside the TLS library even if it is possible to implement it at the application layer. TLS implementations supporting the use of exported authenticators MUST provide application programming interfaces by which clients and servers may request and verify exported authenticator messages.

Given an established connection, the application SHOULD be able to call the following APIs:

"request", which takes as input:

- o certificate\_request\_context (from 0 to 255 bytes)
- o set of extensions to include (this MUST include signature\_algorithms)



It returns an authenticator request, which is a sequence of octets that includes a CertificateRequest message.

"get context", which takes as input

- o authenticator

It returns the certificate\_request\_context.

"authenticate", which takes as input:

- o a set of certificate chains and associated extensions (OCSP, SCT, etc.)
- o a signer (either the private key associated with the certificate, or interface to perform private key operation) for each chain
- o an optional authenticator request

It returns the exported authenticator as output. It is RECOMMENDED that the logic for selecting the certificates and extensions to include in the exporter is implemented in the TLS library. Implementing this in the TLS library lets the implementer take advantage of existing extension and certificate selection logic.

It is also possible to implement this API outside of the TLS library using TLS exporters. This may be preferable in cases where the application does not have access to a TLS library with these APIs or when TLS is handled independently of the application layer protocol.

"validate", which takes as input: \* an optional authenticator request  
\* an authenticator

It returns the certificate chain and extensions.

## **6. IANA Considerations**

This document has no IANA actions.

## **7. Security Considerations**

The Certificate/Verify/Finished pattern intentionally looks like the TLS 1.3 pattern which now has been analyzed several times. In the case where the client presents an authenticator to a server, [[SIGMAC](#)] presents a relevant framework for analysis.



Authenticators are independent and unidirectional. There is no explicit state change inside TLS when an authenticator is either created or validated.

- o This property makes it difficult to formally prove that a server is jointly authoritative over multiple certificates, rather than individually authoritative over each.
- o There is no indication in the TLS layer about which point in time an authenticator was computed. Any feedback about the time of creation or validation of the authenticator should be tracked as part of the application layer semantics if required.

The signatures generated with this API cover the context string "Exported Authenticator" and therefore cannot be transplanted into other protocols.

## **8. Acknowledgements**

Comments on this proposal were provided by Martin Thomson.  
Suggestions for [Section 7](#) were provided by Karthikeyan Bhargavan.

## **9. References**

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