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Delegated Credentials for TLS
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Abstract

The organizational separation between the operator of a TLS server and the certificate authority that provides it credentials can cause problems, for example when it comes to reducing the lifetime of certificates or supporting new cryptographic algorithms. This document describes a mechanism to allow TLS server operators to create their own credential delegations without breaking compatibility with clients that do not support this specification.

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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1. Introduction

Typically, a TLS server uses a certificate provided by some entity other than the operator of the server (a "Certification Authority" or CA) [RFC5246] [RFC5280]. This organizational separation makes the TLS server operator dependent on the CA for some aspects of its operations, for example:

- Whenever the server operator wants to deploy a new certificate, it has to interact with the CA.

- The server operator can only use TLS authentication schemes for which the CA will issue credentials.

These dependencies cause problems in practice. Server operators often want to create short-lived certificates for servers in low-trust zones such as CDNs or remote data centers. This allows server operators to limit the exposure of keys in cases that they do not realize a compromise has occurred. The risk inherent in cross-organizational transactions makes it operationally infeasible to rely

on an external CA for such short-lived credentials. In OCSP stapling, if an operator chooses to talk frequently to the CA to obtain stapled responses, then failure to fetch an OCSP stapled response results only in degraded performance. On the other hand, failure to fetch a potentially large number of short lived certificates would result in the service not being available which creates greater operational risk.

To remove these dependencies, this document proposes a limited delegation mechanism that allows a TLS server operator to issue its own credentials within the scope of a certificate issued by an external CA. Because the above problems do not relate to the CAs inherent function of validating possession of names, it is safe to make such delegations as long as they only enable the recipient of the delegation to speak for names that the CA has authorized. For clarity, we will refer to the certificate issued by the CA as a "certificate" and the one issued by the operator as a "delegated credential".

2. Solution Overview

A delegated credential is a digitally signed data structure with the following semantic fields:

- A validity interval
- A public key (with its associated algorithm)

The signature on the credential indicates a delegation from the certificate that is issued to the TLS server operator. The secret key used to sign a credential is presumed to be one whose corresponding public key is contained in an X.509 certificate that associates one or more names to the credential.

A TLS handshake that uses credentials differs from a normal handshake in a few important ways:

- The client provides an extension in its ClientHello that indicates support for this mechanism.
- The server provides both the certificate chain terminating in its certificate as well as the credential.
- The client uses information in the server's certificate to verify the signature on the credential and verify that the server is asserting an expected identity.

- The client uses the public key in the credential as the server's working key for the TLS handshake.

Delegated credentials can be used either in TLS 1.3 or TLS 1.2. Differences between the use of delegated credentials in the protocols are explicitly stated.

It was noted in [XPROT] that certificates in use by servers that support outdated protocols such as SSLv2 can be used to forge signatures for certificates that contain the keyEncipherment KeyUsage ([RFC5280] section 4.2.1.3) In order to prevent this type of cross-protocol attack, we define a new DelegationUsage extension to X.509 that permits use of delegated credentials. Clients MUST NOT accept delegated credentials associated with certificates without this extension.

Credentials allow the server to terminate TLS connections on behalf of the certificate owner. If a credential is stolen, there is no mechanism for revoking it without revoking the certificate itself. To limit the exposure of a delegation credential compromise, servers MUST NOT issue credentials with a validity period longer than 7 days. Clients MUST NOT accept credentials with longer validity periods.

2.1. Rationale

Delegated credentials present a better alternative than other delegation mechanisms like proxy certificates [RFC3820] for several reasons:

- There is no change needed to certificate validation at the PKI layer.

- X.509 semantics are very rich. This can cause unintended consequences if a service owner creates a proxy cert where the properties differ from the leaf certificate.

- Delegated credentials have very restricted semantics which should not conflict with X.509 semantics.

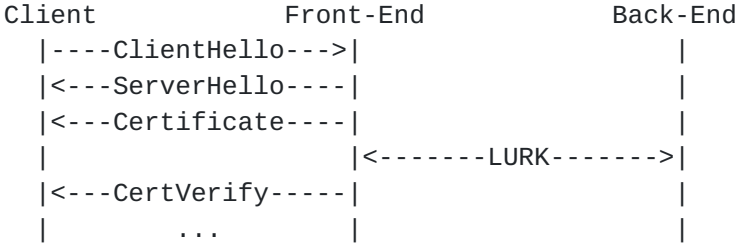
- Proxy certificates rely on the certificate path building process to establish a binding between the proxy certificate and the server certificate. Since the cert path building process is not cryptographically protected, it is possible that a proxy certificate could be bound to another certificate with the same public key, with different X.509 parameters. Delegated credentials, which rely on a cryptographic binding between the entire certificate and the delegated credential, cannot.

- Delegated credentials are bound to specific versions of TLS. This prevents them from being used for other protocols if a service owner allows multiple versions of TLS.

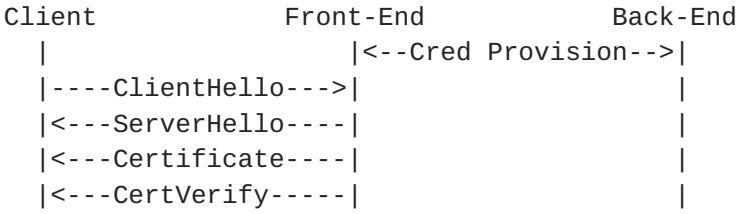
2.2. Related Work

Many of the use cases for delegated credentials can also be addressed using purely server-side mechanisms that do not require changes to client behavior (e.g., LURK [I-D.mglt-lurk-tls-requirements]). These mechanisms, however, incur per-transaction latency, since the front-end server has to interact with a back-end server that holds a private key. The mechanism proposed in this document allows the delegation to be done off-line, with no per-transaction latency. The figure below compares the message flows for these two mechanisms with TLS 1.3 [I-D.ietf-tls-tls13].

LURK:



Delegated credentials:



These two mechanisms can be complementary. A server could use credentials for clients that support them, while using LURK to support legacy clients.

It is possible to address the short-lived certificate concerns above by automating certificate issuance, e.g., with ACME [I-D.ietf-acme-acme]. In addition to requiring frequent operationally-critical interactions with an external party, this makes the server operator dependent on the CA's willingness to issue certificates with sufficiently short lifetimes. It also fails to address the issues with algorithm support. Nonetheless, existing

automated issuance APIs like ACME may be useful for provisioning credentials, within an operator network.

3. Client and Server behavior

This document defines the following extension code point.

```
enum {
  ...
  delegated_credential(TBD),
  (65535)
} ExtensionType;
```

A client which supports this document SHALL send an empty "delegated_credential" extension in its ClientHello.

If the extension is present, the server MAY send a DelegatedCredential extension. If the extension is not present, the server MUST NOT send a credential. A credential MUST NOT be provided unless a Certificate message is also sent.

When negotiating TLS 1.3, and using Delegated credentials, the server MUST send the DelegatedCredential as an extension in the CertificateEntry of its end-entity certificate. When negotiating TLS 1.2, the DelegatedCredential MUST be sent as an extension in the ServerHello.

The DelegatedCredential contains a signature from the public key in the end-entity certificate using a signature algorithm advertised by the client in the "signature_algorithms" extension. Additionally, the credential's public key MUST be of a type that enables at least one of the supported signature algorithms. A delegated credential MUST NOT be negotiated by the server if its signature is not compatible with any of the supported signature algorithms or the credential's public key is not usable with the supported signature algorithms of the client, even if the client advertises support for delegated credentials.

On receiving a credential and a certificate chain, the client validates the certificate chain and matches the end-entity certificate to the server's expected identity following its normal procedures. It then takes the following steps:

- Verify that the current time is within the validity interval of the credential and that the credential's time to live is no more than 7 days.

- Verify that the certificate has the DelegationUsage extension, which permits the use of Delegated credentials.

- Use the public key in the server's end-entity certificate to verify the signature on the credential.

If one or more of these checks fail, then the delegated credential is deemed invalid. Clients that receive invalid delegated credentials MUST terminate the connection with an "illegal_parameter" alert. If successful, the client uses the public key in the credential to verify a signature provided in the handshake: in particular, the CertificateVerify message in TLS 1.3 and the ServerKeyExchange in 1.2.

4. Delegated Credentials

While X.509 forbids end-entity certificates from being used as issuers for other certificates, it is perfectly fine to use them to issue other signed objects as long as the certificate contains the digitalSignature key usage (RFC5280 section 4.2.1.3). We define a new signed object format that would encode only the semantics that are needed for this application.

```
struct {
  uint32 valid_time;
  opaque public_key<0..2^16-1>;
} Credential;

struct {
  Credential cred;
  SignatureScheme scheme;
  opaque signature<0..2^16-1>;
} DelegatedCredential;
```

valid_time: Relative time in seconds from the beginning of the certificate's notBefore value after which the delegated credential is no longer valid.

public_key: The delegated credential's public key, which is an encoded SubjectPublicKeyInfo [RFC5280].

scheme: The signature algorithm used to sign the delegated credential.

signature: The signature over the credential with the end-entity certificate's public key, using the scheme.

The DelegatedCredential structure is similar to the CertificateVerify structure in TLS 1.3. Since the SignatureScheme is defined in TLS 1.3, TLS 1.2 clients should translate the scheme into an appropriate group and signature algorithm to perform validation.

The signature of the DelegatedCredential is computed over the concatenation of:

1. A string that consists of octet 32 (0x20) repeated 64 times.

2. The context string "TLS, server delegated credentials".

3. A single 0 byte which serves as the separator.

4. Big endian serialized 2 bytes ProtocolVersion of the negotiated TLS version, defined by TLS.

5. DER encoded X.509 certificate used to sign the DelegatedCredential.

6. Big endian serialized 2 byte SignatureScheme scheme.

7. The Credential structure.

This signature has a few desirable properties:

- It is bound to the certificate that signed it.

- It is bound to the protocol version that is negotiated. This is intended to avoid cross-protocol attacks with signing oracles.

The code changes to create and verify delegated credentials would be localized to the TLS stack, which has the advantage of avoiding changes to security-critical and often delicate PKI code (though of course moves that complexity to the TLS stack).

4.1. Certificate Requirements

We define a new X.509 extension, DelegationUsage to be used in the certificate when the certificate permits the usage of delegated credentials. When this extension is not present the client MUST not accept a delegated credential even if it is negotiated by the server. When it is present, the client MUST follow the validation procedure.

```
id-ce-delegationUsage OBJECT IDENTIFIER ::= { TBD }

DelegationUsage ::= BIT STRING { allowed (0) }
```

Conforming CAs MUST mark this extension as non-critical. This allows the certificate to be used by service owners for clients that do not support certificate delegation as well and not need to obtain two certificates.

5. IANA Considerations

TBD

6. Security Considerations

6.1. Security of delegated private key

Delegated credentials limit the exposure of the TLS private key by limiting its validity. An attacker who compromises the private key of a delegated credential can act as a man in the middle until the delegate credential expires, however they cannot create new delegated credentials. Thus delegated credentials should not be used to send a delegation to an untrusted party, but is meant to be used between parties that have some trust relationship with each other. The secrecy of the delegated private key is thus important and several access control mechanisms SHOULD be used to protect it such as file system controls, physical security or hardware security modules.

6.2. Revocation of delegated credentials

Delegated credentials do not provide any additional form of early revocation. Since it is short lived, the expiry of the delegated credential would revoke the credential. Revocation of the long term private key that signs the delegated credential also implictly revokes the delegated credential.

6.3. Privacy considerations

Delegated credentials can be valid for 7 days and it is much easier for a service to create delegated credential than a certificate signed by a CA. A service could determine the client time and clock skew by creating several delegated credentials with different expiry timestamps and observing whether the client would accept it. Client time could be unique and thus privacy sensitive clients, such as browsers in incognito mode, who do not trust the service might not want to advertise support for delegated credentials or limit the number of probes that a server can perform.

7. Acknowledgements

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8. References

8.1. Normative References

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