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TLS-Session-Bound Access Tokens for OAuth 2.0
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Abstract

This document defines a mechanism for binding OAuth 2.0 access tokens to a specific mutual TLS (mTLS) connection. The binding is achieved through a proof token that incorporates the TLS Exporter value [RFC5705] derived from the current connection and an access token hash, signed by the client’s private key corresponding to its mTLS certificate. This mechanism prevents stolen bearer tokens from being replayed on a different TLS connection. The proof is constructed once per (token, connection) pair and reused across all requests on that connection, delivering session binding with no per-request signing overhead and no additional key management beyond what mTLS already provides. The mechanism is applicable to TLS 1.2, TLS 1.3, and QUIC transports. While applicable to any OAuth 2.0 access token presented over mTLS, this specification is primarily motivated by the Token Exchange protocol [RFC8693], where multi-hop delegation chains in autonomous, agent-driven architectures create elevated replay risk.

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 24 November 2026.

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1. Introduction

1.1. The Bearer Token Replay Problem

OAuth 2.0 access tokens are typically *bearer tokens*: any party in possession of the token can use it to access protected resources, regardless of the presenter's identity or the communication channel. This is a known risk addressed by the OAuth 2.0 Security Best Current Practice [I-D.ietf-oauth-security-topics].

The Token Exchange protocol [RFC8693] amplifies this risk by enabling chained delegation across service boundaries. Each exchange produces a new bearer token, and a compromise at any point in the chain exposes downstream tokens.

Existing mitigations address parts of this problem:

* *RFC 8705 (mTLS Certificate-Bound Tokens)* [RFC8705]: Binds the token to the client's X.509 certificate thumbprint. However, the binding is to the _certificate identity_, not the _TLS connection_. If the same certificate is used across connections, or if the certificate and token are both exfiltrated, the token remains replayable.

* *RFC 9449 (DPoP)* [RFC9449]: Provides application-layer proof-of-possession using ephemeral, application-managed keys. Applicable to both public and confidential clients, but binds to the key, not to the TLS channel, and requires generating and managing a separate key pair.

* *Token Binding* [RFC8471][RFC8472][RFC8473]: Proposed direct TLS session binding but required a new TLS extension, was never specified for Token Exchange, encountered adoption barriers in browsers and TLS 1.3 transitions, and was ultimately abandoned.

None of these mechanisms provide *TLS-connection-level binding* for OAuth 2.0 access tokens in mTLS environments. This specification fills that gap by reusing the existing mTLS key pair (no additional key generation) and amortizing the proof to once per (token, connection) pair rather than once per request — delivering stronger binding than DPoP at lower per-request cost. The binding mechanism relies on TLS Exporter values, which are available in TLS 1.2, TLS 1.3, and QUIC (via its integrated TLS 1.3 handshake), making the specification transport-agnostic across modern encrypted transports.

1.2. The Agentic AI Amplifier

The rise of autonomous AI agents dramatically amplifies the bearer token replay risk. Unlike traditional OAuth flows where a human initiates discrete requests, agentic AI systems:

* *Autonomously chain API calls*: An agent may invoke hundreds of API calls across multiple services without human intervention, each potentially involving RFC 8693 token exchanges.

* *Perform multi-hop delegation*: Agent A exchanges its token for a delegated token to call Agent B, which exchanges again for Agent C. Each hop produces a new bearer token. A single compromise anywhere in this chain exposes all downstream tokens.

* *Run for extended periods*: Agents operate autonomously for hours or days, providing a broad window for token interception and replay.

* *Generate opaque traffic*: Agent-to-agent API calls are fully automated. A replayed token produces legitimate-looking traffic that is extremely difficult to distinguish from genuine requests—there is no human in the loop to detect anomalies.

* *Are susceptible to prompt injection*: A compromised or prompt-injected LLM agent can exfiltrate bearer tokens via tool calls, side channels, or log leakage. These tokens are immediately usable from any connection.

These characteristics make bearer token replay a *first-order threat* in agentic AI architectures. As autonomous agents increasingly drive API-to-API traffic volumes that exceed human-initiated requests, per-request cryptographic overhead becomes a significant scaling concern. This document addresses this gap by binding access tokens to the mTLS connection on which they are presented, with proof amortization that scales to high-volume agent traffic.

1.3. 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 uses the following terms:

TLS Exporter Value (EKM): A value derived from the TLS handshake using the mechanism defined in [RFC5705] (for TLS 1.2) or Section 7.5 of [RFC8446] (for TLS 1.3). EKM stands for Exported Keying Material. The exporter value is unique to the specific TLS connection and is available to both endpoints. This document uses "EKM" and "TLS Exporter value" interchangeably.

Session-Binding Proof: A signed JWT presented alongside the access token that cryptographically binds the token to the current mTLS connection via the TLS Exporter value.

Token Exchange: The protocol defined in [RFC8693] for exchanging one security token for another at an authorization server.

2. TLS Session Binding for Access Tokens

2.1. Overview

This specification defines a proof-of-possession mechanism that binds OAuth 2.0 access tokens to the mTLS connection on which they are presented. While applicable to any OAuth 2.0 access token, it is primarily designed for tokens issued via the Token Exchange protocol [RFC8693], where multi-hop delegation creates elevated replay risk. The mechanism operates as follows:

1. The client and resource server establish an mTLS connection. Both sides derive a TLS Exporter value unique to this connection.

2. When first presenting an access token on a given connection, the client constructs a *Session-Binding Proof*: a JWT containing the hash of the access token and the TLS Exporter value.

3. The client signs this JWT with the private key corresponding to its mTLS client certificate. The same proof MAY be reused for all subsequent requests using that token on the same connection.

4. The resource server verifies the proof by checking the signature against the client certificate’s public key, confirming the exporter value matches the current connection, confirming the token hash matches the presented access token, and confirming the issuance time is within an acceptable window. The server MUST perform these checks on every request but MAY use a per-connection cache to reduce subsequent verifications to a cache lookup.

A token that requires session binding includes a confirmation method claim (tls_exp) containing the TLS Exporter label, which signals to the resource server that the Session-Binding Proof MUST be presented and verified.

2.2. TLS Exporter Derivation

Both the client and resource server MUST derive the TLS Exporter value using the following parameters:

* *Label*: EXPORTER-oauth-tls-session-bound

* *Context*: Empty (zero-length)

* *Length*: 32 octets

For TLS 1.3, the exporter is derived as specified in Section 7.5 of [RFC8446]. For TLS 1.2, the exporter is derived as specified in [RFC5705].

Note: By binding to the TLS Exporter rather than the application traffic keys, the binding remains valid across TLS 1.3 KeyUpdate operations. Standard key rotation refreshes traffic keys but does not change the exporter master secret, avoiding unnecessary re-proof cycles while maintaining strong connection binding.

Note: This mechanism requires both the client and resource server to access the TLS Exporter derivation function from their TLS library. Most TLS libraries (OpenSSL, BoringSSL, Go crypto/tls) provide this API (e.g., SSL_export_keying_material()). However, some application frameworks and proxy platforms may not yet surface this function to their HTTP or extension layer. Implementors should verify that their TLS integration exposes exporter derivation to the layer responsible for constructing or verifying the Session-Binding Proof.

2.3. Session-Binding Proof Format

The Session-Binding Proof is a JWT with the following structure:

2.3.1. Header

```
{
  "typ": "tls-binding-proof+jwt",
  "alg": "ES256",
  "x5t#S256": "<base64url SHA-256 thumbprint of client certificate>"
}
```

The alg value MUST match the key type of the client’s mTLS certificate. The x5t#S256 value MUST be the base64url-encoded SHA-256 thumbprint of the DER-encoded client certificate, as defined in [RFC8705].

2.3.2. Payload

The payload contains REQUIRED connection-level claims that prove session binding, and OPTIONAL per-request claims for intra-session hardening.

```
{
  "ath": "<base64url SHA-256 hash of the access token>",
  "ekm": "<base64url TLS Exporter value>",
  "iat": 1710820000,
  "jti": "<unique identifier>",
  "htm": "POST",
  "htu": "/api/resource"
}
```

Note: The example above shows all defined claims. The ath, ekm, and iat claims are REQUIRED; the jti, htm, and htu claims are OPTIONAL per-request claims included only when intra-session hardening is required.

The payload claims are defined as follows:

2.3.2.1. Connection-Level Claims (REQUIRED)

ath: REQUIRED. The base64url-encoded SHA-256 hash of the ASCII encoding of the associated access token value.

ekm: REQUIRED. The base64url-encoded TLS Exporter value derived as specified in Section 2.2.

iat: REQUIRED. The time at which the proof was issued, as a NumericDate (seconds since the Unix epoch). The resource server MUST verify that this value is within an acceptable window.

2.3.2.2. Per-Request Claims (OPTIONAL)

The following claims provide intra-session request-level binding. They are OPTIONAL and intended for deployments that require defense-in-depth against intra-connection replay. When omitted, the proof can be reused across all requests on the same connection for the same token.

jti: OPTIONAL. A unique identifier for the proof. When present, the resource server MUST verify that this value has not been seen before within the token’s validity period.

htm: OPTIONAL. The HTTP method of the request to which the proof is attached (e.g., "GET", "POST"). When present, the resource server MUST verify that it matches the actual request method.

htu: OPTIONAL. The HTTP target URI of the request to which the proof is attached, without query and fragment parts. When present, the resource server MUST verify that it matches the actual request URI.

2.3.3. Signature

The JWT MUST be signed using the private key corresponding to the client's mTLS certificate. The signature algorithm MUST match the alg header parameter.

2.4. Token Confirmation Claim

An authorization server that supports TLS-session-bound access tokens MUST include a cnf (confirmation) claim in the issued access token (when the token is a JWT) or in the token introspection response. The cnf claim MUST contain:

```
{
  "cnf": {
    "x5t#S256": "<cert-thumbprint>",
    "tls_exp": "EXPORTER-oauth-tls-session-bound"
  }
}
```

x5t#S256: REQUIRED. The certificate thumbprint as defined in [RFC8705].

tls_exp: REQUIRED. A string value containing the TLS Exporter label that the client and resource server MUST use to derive the session-binding value. The presence of this claim signals that the resource server MUST require and verify a Session-Binding Proof whenever this token is presented. This follows the pattern of existing cnf members which carry key/binding material rather than boolean flags (see [RFC7800]).

3. Protocol Flow

3.1. Token Issuance with Session Binding

The mechanism for requesting and issuing TLS-session-bound tokens is as follows:

1. The client authenticates to the authorization server using mTLS and requests a token. This MAY be a token exchange per [RFC8693], a client credentials grant, or any other OAuth 2.0 grant type.

2. The authorization server issues a new access token.

3. If the authorization server policy requires TLS session binding for this client, it includes the cnf claim with tls_exp set to the exporter label in the issued token.

4. The client receives the token and notes the tls_exp requirement.

3.2. Authorization Server Behavior

The authorization server determines whether to issue TLS-session-bound tokens based on per-client configuration. The following client registration metadata parameter is defined:

tls_session_bound_access_tokens: OPTIONAL. A boolean value indicating that the authorization server MUST issue TLS-session-bound access tokens for this client. When set to true, the authorization server includes the tls_exp confirmation method in all access tokens issued to this client. Defaults to false.

The authorization server MAY also apply session binding based on:

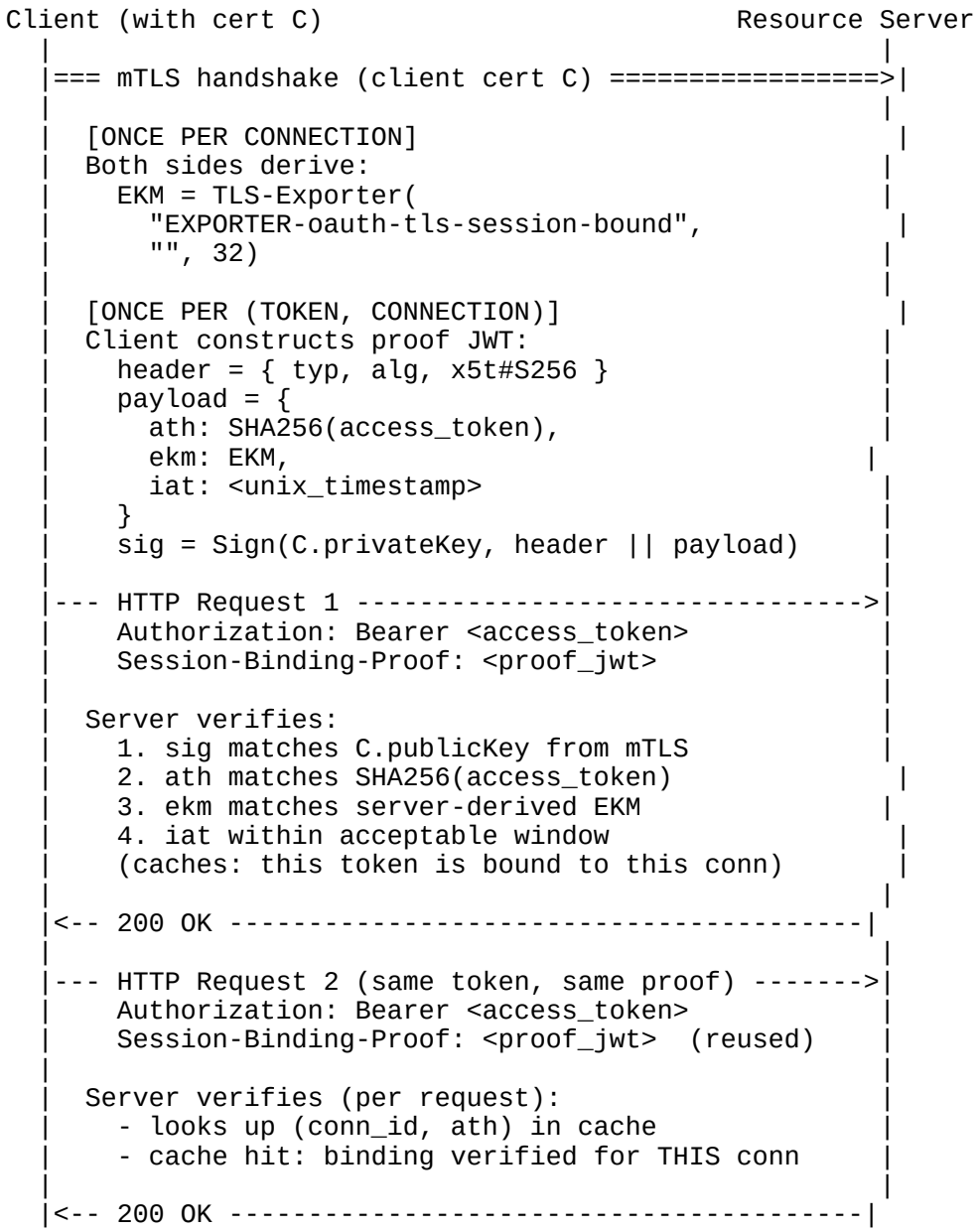
* Token exchange policy: When the subject_token or actor_token in an RFC 8693 exchange is itself session-bound, the resulting token SHOULD also be session-bound to maintain the security property across the delegation chain.

* Resource server requirements: When a resource server’s metadata indicates that it requires session-bound tokens.

* Risk-based policy: When the requested scope, audience, or delegation depth exceeds a policy threshold.

3.3. Resource Access with Session-Binding Proof

The following diagram illustrates the complete flow:


Client (with cert C)
Resource Server
=== mTLS handshake (client cert C) ==========>
[ONCE PER CONNECTION]
Both sides derive:
EKM = TLS-Exporter(
"EXPORTER-oauth-tls-session-bound",
"", 32)
[ONCE PER (TOKEN, CONNECTION)]
Client constructs proof JWT:
header = { typ, alg, x5t#S256 }
payload = {
ath: SHA256(access_token),
ekm: EKM,
iat: <unix_timestamp>
}
sig = Sign(C.privateKey, header || payload)
--- HTTP Request 1 ---------->
Authorization: Bearer <access_token>
Session-Binding-Proof: <proof_jwt>
Server verifies:
1. sig matches C.publicKey from mTLS
2. ath matches SHA256(access_token)
3. ekm matches server-derived EKM
4. iat within acceptable window
(caches: this token is bound to this conn)
<-- 200 OK ----------
--- HTTP Request 2 (same token, same proof) ------->
Authorization: Bearer <access_token>
Session-Binding-Proof: <proof_jwt> (reused)
Server verifies (per request):
- looks up (conn_id, ath) in cache
- cache hit: binding verified for THIS conn
<-- 200 OK ----------

3.3.1. Performance Characteristics

Because the Session-Binding Proof contains only connection-level claims (ekm, ath, iat), the client constructs and signs the proof *once per (token, connection) pair* and reuses it for all subsequent requests on that connection. The iat value reflects the time of proof construction, not the time of any particular request. This provides a significant advantage over DPoP:

* *Proof construction (client-side)*: One JWT signature per connection per token. DPoP requires one JWT signature per request.

* *Proof verification (server-side)*: Full JWT verification on first presentation; the server MAY cache the verified (connection, ath) binding and reduce subsequent verifications to a cache lookup. DPoP requires full JWT verification per request.

* *TLS Exporter derivation*: Once per connection, cached by both sides.

* *No separate key management*: Unlike DPoP, which requires generating, storing, and rotating an ephemeral key pair independent of TLS, this specification reuses the mTLS key pair. This eliminates an entire key lifecycle from the implementation.

When OPTIONAL per-request claims (jti, htm, htu) are included, the proof must be constructed per request (similar to DPoP). Deployments choose between per-connection efficiency and per-request intra-session hardening based on their threat model.

This amortization benefit assumes that mTLS connections are *long-lived* relative to the number of requests. If a deployment creates a new mTLS connection for every HTTP request-response cycle, the proof must be constructed on every request and the per-request cost becomes equivalent to DPoP. Deployments SHOULD use persistent connections (e.g., HTTP/2 or HTTP/1.1 with keep-alive) so that a single mTLS connection carries many requests. This is already standard practice in service mesh and workload-to-workload environments where mTLS is terminated at a sidecar or gateway.

3.3.2. Mid-Session Token Binding

A client MAY bind multiple tokens to a single mTLS connection concurrently. Each token requires its own Session-Binding Proof with a distinct ath (token hash) and the same ekm (TLS Exporter value) from the current connection.

This is common in workload-to-workload scenarios: a single mTLS connection between two microservices may carry requests on behalf of many different users, each with a distinct access token obtained via separate token exchanges. For example, 100 users interacting with an AI agentic service that delegates to a downstream service — each user's token is bound to the same mTLS connection via a separate proof. Similarly, when a token is refreshed or rotated mid-session, the client constructs a fresh proof for the new token without requiring a new mTLS connection.

The resource server MAY cache verified (connection_id, ath) bindings to avoid re-verifying proofs on subsequent requests. Each cache entry is small (a connection identifier plus a 32-byte hash), so even connections carrying hundreds of tokens have modest memory requirements. Caching is an optimization, not a requirement: if the server does not cache (or evicts entries under memory pressure), it simply falls back to full JWT signature verification on every request — equivalent to the per-request cost of DPoP.

When the client presents the access token to a resource server:

1. The client establishes an mTLS connection with the resource server.

2. The client derives the TLS Exporter value for the current connection (computed once and cached).

3. The client constructs a Session-Binding Proof JWT as specified in Section 2.3. If the proof does not contain per-request claims, the client MAY reuse the same proof for all subsequent requests using this token on this connection.

4. The client sends the HTTP request with:

   * The access token in the Authorization header: Authorization: Bearer <access_token>

   * The Session-Binding Proof in the Session-Binding-Proof header: Session-Binding-Proof: <proof_jwt>

5. The resource server performs the following verifications:

   a. *Standard mTLS verification*: Verifies the client certificate as part of the TLS handshake. b. *Token validation*: Validates the access token (signature, expiration, audience, etc.). c. *Certificate binding*: Verifies that the x5t#S256 in the token's cnf claim matches the presented client certificate. d. *TLS binding required*: Checks that cnf.tls_exp is present and a

Session-Binding Proof is present. e. *Proof signature*: Verifies the proof JWT signature against the public key in the client certificate. f. *Exporter match*: Compares the ekm claim in the proof against the TLS Exporter value for the current connection and confirms they match. g. *Token hash*: Computes SHA-256 of the presented access token and confirms it matches the ath claim. h. *Timestamp*: Confirms iat is within an acceptable window. i. *Per-request claims* (when present): Confirms htm and htu match the actual request, and jti has not been seen before.

The resource server MUST ensure that steps (a) through (i) are satisfied for every request. This is critical: an attacker who obtains a stolen token and proof may attempt to inject them on their own mTLS connection to the same resource server. Verification ensures the proof signature is checked against the certificate from _this_ connection's handshake, which will not match the attacker's certificate.

To satisfy this requirement efficiently, the resource server MAY cache verified bindings keyed on (connection_id, ath). On subsequent requests with the same token on the same connection, a cache hit confirms the binding was already verified; a cache miss (different connection, different token, or first presentation) triggers full verification. This cache is inherently per-connection, so a stolen proof presented on a different connection will always miss and fail full verification. When a TLS connection terminates, the resource server SHOULD purge all cache entries associated with that connection, as the bindings are no longer valid.

6. If all verifications succeed, the resource server processes the request. If any verification fails, the resource server MUST reject the request as specified in Section 3.5.

3.4. Token Introspection Considerations

When token introspection [RFC7662] is used, the introspection response MUST include the cnf claim with the tls_exp field. This allows resource servers that do not have direct access to the token's claims (e.g., opaque tokens) to determine whether session binding is required.

3.5. Error Responses

When verification of the Session-Binding Proof fails or the proof is missing, the resource server MUST respond with HTTP 401 and include a WWW-Authenticate header with the appropriate error code:

```
WWW-Authenticate: Bearer error="invalid_proof",
  error_description="Session-Binding Proof verification failed:
    exporter mismatch"

WWW-Authenticate: Bearer error="use_session_binding",
  error_description="This token requires a Session-Binding Proof"
```

The following error code values are defined:

invalid_proof: The Session-Binding Proof is malformed or failed verification. This includes signature verification failure, exporter mismatch, stale iat, jti reuse, ath mismatch, and htm/htu mismatch.

use_session_binding: The access token requires a Session-Binding Proof (the cnf.tls_exp claim is present) but no Session-Binding-Proof header was provided. This error signals to the client that it must construct and present a proof.

The resource server SHOULD include an error_description parameter with a human-readable explanation of the specific verification failure.

4. Integration with Existing Mechanisms

4.1. Relationship to RFC 8705 (mTLS-Bound Tokens)

This specification extends RFC 8705 by adding session-level binding on top of certificate binding. The x5t#S256 claim from RFC 8705 is reused. Deployments MAY support both mechanisms simultaneously: RFC 8705 provides certificate binding, while this specification adds per-connection session binding.

4.2. Relationship to RFC 9449 (DPoP)

DPoP and this specification address similar goals (proof-of-possession) but differ in binding targets, key management, per-request cost, and the provenance of the binding key:

* *Binding target*: DPoP binds tokens to an ephemeral application-layer key. This specification binds tokens to both the client identity (X.509 certificate) and the specific TLS connection (Exporter value). An attacker who exfiltrates a DPoP-bound token and the associated DPoP key can replay the token from any network location; an attacker who exfiltrates a session-bound token cannot, because reproducing the TLS Exporter value requires being on the same TLS connection.

* *Key management*: DPoP requires generating, storing, and rotating an ephemeral key pair independent of TLS. This specification reuses the mTLS key pair already established during the handshake, eliminating the entire DPoP key lifecycle.

* *Per-request overhead*: DPoP requires constructing and signing a new proof JWT for every HTTP request. This specification constructs the proof *once per (token, connection)* and reuses it across all requests on that connection (when per-request claims are omitted). This is a fundamental efficiency advantage in high-throughput workload-to-workload scenarios.

* *Identity provenance*: A DPoP key is self-generated by the client with no provenance beyond the client's own assertion — any process can create one. This specification reuses the mTLS key, which in workload deployments is issued through a verifiable attestation chain. When the mTLS credential is a standards-based workload identity (e.g., a SPIFFE X.509-SVID issued by SPIRE), the key's issuance was conditioned on node attestation followed by workload attestation. The Session-Binding Proof is therefore not merely "possession of a key" but "possession of a key whose issuance was verified against the workload's identity and execution context." See Appendix C for details.

* *Applicability*: DPoP is particularly valuable for *public clients* that cannot use mTLS. This specification is designed for *confidential clients and workloads* that already use mTLS. The two mechanisms are complementary rather than competing.

In summary, for mTLS-capable environments, this specification provides stronger security (connection-level binding vs. key-level binding), lower per-request cost (amortized proof vs. per-request proof), simpler implementation (no separate key management), and — when backed by a workload identity system — proof whose binding key has verifiable provenance through an attestation chain.

4.3. Relationship to Token Binding (RFC 8471-8473)

Token Binding [RFC8471][RFC8472][RFC8473] proposed direct TLS session binding for OAuth and HTTP but did not gain traction in industry. This specification addresses the same core problem — preventing cross-connection token replay — while avoiding the specific deployment barriers that Token Binding encountered.

* *No new TLS extension.* Token Binding required a dedicated TLS negotiation extension ([RFC8472]) that had to be implemented and enabled by browser vendors and TLS stacks. This specification uses the TLS Exporter mechanism ([RFC5705], [RFC8446]

Section 7.5), which is already available in every compliant TLS 1.2, TLS 1.3, and QUIC implementation without any extension or negotiation.

* *Session-scoped binding, not persistent client keys.* Token Binding associated tokens with long-lived, client-managed signing keys, creating persistent client identifiers across connections. This specification binds tokens to the TLS Exporter value, which is unique to each connection and exists only for the lifetime of that session. No persistent identifier is created beyond the TLS session itself.

* *Specified for Token Exchange.* Token Binding was not defined for use with RFC 8693 Token Exchange delegation chains. This specification is primarily motivated by exactly that scenario: each hop in a multi-hop agentic delegation chain produces a new bearer token, and session binding contains the blast radius of any single compromise to the specific connection on which that token is presented.

* *Explicit deployment scope constraint.* Token Binding encountered complexity in proxy and intermediary topologies, leading to additional specifications ([RFC8473]) to handle referred binding over HTTP. This specification avoids that complexity by explicitly restricting the binding guarantee to deployments where the verifier is a direct endpoint of the client TLS connection — either the resource server itself or a co-located sidecar. Forwarding the EKM through a remote intermediary would change the security property from session binding to proxy-attested binding, which is a categorically weaker guarantee. See Section 5 for details.

This specification is not applicable to browser-based web clients, as browsers do not currently expose TLS Exporter values to JavaScript. It is targeted at server-to-server, service-mesh, and agentic AI workloads where both endpoints have direct access to the TLS stack.

4.4. Relationship to WIMSE WIT/WPT

The WIMSE Workload Identity Token (WIT) and Workload Proof Token (WPT) defined in [I-D.ietf-wimse-s2s-protocol] provide a proof-of-possession mechanism for workload-to-workload communication. This specification is compatible with WIMSE and addresses a complementary problem.

WIT/WPT and this specification operate at different layers and answer different questions:

* *WIMSE WIT/WPT*: "Is this workload who it claims to be, and does it currently hold the private key corresponding to its identity?" (application-layer identity assertion and per-request proof of possession)

* *This specification*: "Is this OAuth access token being presented on the TLS connection that this workload authenticated?" (TLS-channel-level token binding scoped to a specific connection)

Neither mechanism alone provides both properties. In a workload-to-workload flow where both are deployed, WIT/WPT establishes and proves the workload's identity at the application layer while this specification ensures the OAuth authorization token is cryptographically bound to the specific connection that workload established. Together they close the complete chain: from attested workload identity to authorized, connection-scoped API access.

WPT is a per-request application-layer proof; this specification amortizes the proof to once per (token, connection) pair at the TLS-channel layer. The two mechanisms are not competing alternatives — deployments that require both workload identity proof and connection-level token binding SHOULD use both.

4.5. Relationship to Transitive Attestation

The Transitive Attestation profile [I-D.draft-mw-wimse-transitive-attestation] addresses a complementary problem: binding an identity to a verified execution environment ("Proof of Residency"). While this specification binds tokens to a TLS connection to prevent network-level replay, Transitive Attestation binds identities to a hardware-rooted host to prevent credential export. In high-assurance deployments, both mechanisms MAY be combined: Transitive Attestation ensures the token is used from the correct host, and TLS session binding ensures it is used on the correct connection.

4.6. Relationship to RFC 8693 (Token Exchange)

This specification does not modify the token exchange protocol itself. The authorization server's token exchange endpoint continues to operate as specified in [RFC8693]. The session binding is applied to the _resulting_ access token through the cnf claim. While this specification is applicable to any OAuth 2.0 access token, RFC 8693 Token Exchange is a primary motivator: each hop in a delegation chain produces a new bearer token, and session binding contains the blast radius of any single token compromise to the specific TLS connection on which it is presented.

5. Deployment Scope

5.1. Co-Located TLS Termination (Supported)

This specification requires that the entity verifying the Session-Binding Proof be an endpoint of the TLS connection on which the token is presented, or a sidecar co-located at the same trust boundary as the resource server that terminates that connection directly. In both cases, the verifier derives the EKM from the TLS session it directly participates in, and no EKM forwarding is required.

This covers two deployment models:

* *Pass-through mTLS*: TLS is terminated at the application server itself. Both the client and resource server derive the EKM directly from the same connection.

* *Co-located sidecar*: TLS is terminated at a sidecar (e.g., Envoy) running in the same pod or VM as the resource server. The sidecar derives the EKM directly and verifies the proof before passing the request to the application. This is the recommended deployment model for agentic AI environments. See Appendix B.

5.2. Remote TLS Termination (Out of Scope)

Deployments where TLS is terminated at a remote intermediary — such as a standalone load balancer or API gateway that is not co-located with the resource server — are outside the scope of this specification.

In such topologies, the EKM cannot be conveyed to the verifier without introducing a trust dependency on the intermediary's assertion of what the EKM was. This changes the security property from "bound to the TLS session" to "bound to what a proxy claims the TLS session's EKM was" — a weaker and categorically different guarantee that undermines the core security claim of this specification. Allowing EKM to escape the session boundary via an HTTP header would recreate the kind of mediated-trust complexity that contributed to TLS Token Binding's adoption failures [RFC8471][RFC8472][RFC8473].

Deployments requiring TLS-terminating intermediaries SHOULD place the TLS termination point and the Session-Binding Proof verifier within the same trust boundary — for example, by running an Envoy-based sidecar as both the TLS endpoint and the proof verifier, co-located with the resource server backend.

5.3. QUIC and HTTP/3

This specification is directly applicable to QUIC ([RFC9000]) and HTTP/3 transports. QUIC integrates TLS 1.3 into its handshake ([RFC9001]), and TLS Exporter values are available for use with QUIC connections as specified in Section 4.2 of [RFC9001].

The following considerations apply when using this specification over QUIC:

* *Exporter derivation*: The TLS Exporter MUST be derived using the 1-RTT exporter keys (post-handshake). Proofs MUST NOT be constructed using 0-RTT exporter values, as these are derived from pre-shared keys and provide weaker binding guarantees.

* *Connection migration*: QUIC connections may migrate across network paths (different IP addresses and ports) without a new TLS handshake. The TLS state — and therefore the EKM — persists across migrations. Session-Binding Proofs remain valid after connection migration.

* *Client authentication*: In TLS 1.3 over QUIC, post-handshake client authentication is not supported (Section 4.4 of [RFC9001]). Client certificates MUST be presented during the initial handshake. This simplifies the binding model: the client identity is fixed at connection establishment.

* *Long-lived connections*: QUIC connections are designed to be long-lived and resilient to network changes, aligning naturally with the long-lived connection guidance in Section 3.3.1.

6. Security Considerations

This section addresses security considerations in addition to those described in the OAuth 2.0 Security Best Current Practice [I-D.ietf-oauth-security-topics].

6.1. Threat Model

The following table summarizes the threats addressed by this specification, the specific mechanism that mitigates each threat, and whether DPoP provides equivalent protection.

6.1.1. T1: Cross-Connection Token Replay

* *Threat*: An attacker intercepts a bearer token and presents it on a different TLS connection.

* *Mitigation*: The ekm claim in the proof is derived from the TLS handshake transcript and is unique per connection. The resource server compares it against its own locally-derived EKM. A replayed proof will fail the EKM comparison.

* *DPoP equivalent*: No. DPoP binds to an application-layer key, not to the TLS connection. If the DPoP key is also exfiltrated, replay succeeds.

6.1.2. T2: Cross-Host Token Replay

* *Threat*: An attacker on a different host obtains a bearer token and attempts to use it.

* *Mitigation*: The proof is signed with the client's mTLS private key. The resource server verifies the signature against the public key from the current mTLS handshake. A different host presents a different certificate, so signature verification fails.

* *DPoP equivalent*: Partial. DPoP binds to an ephemeral key, which may not be hardware-protected.

6.1.3. T3: Token Exfiltration via LLM Prompt Injection

* *Threat*: A compromised or prompt-injected AI agent exfiltrates a bearer token via tool calls, side channels, or log leakage.

* *Mitigation*: The attacker obtains the token but cannot produce a valid proof. When deployed with a security sidecar (see Appendix B), the mTLS private key resides in a separate process inaccessible to the agent's LLM runtime. When deployed without a sidecar (direct integration, see Appendix C), the private key resides in the same process as the agent; key isolation in this variant depends on platform-level controls such as hardware-backed key storage. In both cases, even if the attacker also obtains the proof, the EKM will not match on a different connection.

* *DPoP equivalent*: No. DPoP keys are application-layer and typically reside in the same process as the agent, making co-exfiltration with the token likely.

6.1.4. T4: Token + Proof Exfiltration (Both Stolen)

* *Threat*: An attacker obtains both the access token and the Session-Binding Proof, and attempts to use them on their own mTLS connection to the same resource server.

* *Mitigation*: Two independent protections apply: (1) the attacker's mTLS certificate differs from the original client's, so the proof signature does not match the public key from the attacker's handshake — the resource server verifies the proof against the certificate presented on _this_ connection; (2) even if the attacker somehow presents the same certificate, a different TLS connection produces a different EKM, so the ekm claim does not match the server's locally-derived value.

* *DPoP equivalent*: No. If both the DPoP proof and the DPoP key are exfiltrated, the attacker can replay from any connection.

6.1.5. T5: Multi-Hop Delegation Chain Compromise

* *Threat*: A token is stolen at one hop in a delegation chain (A→B→C→D) and replayed at a different hop.

* *Mitigation*: Each hop uses a distinct mTLS connection with a distinct EKM. A token bound to one hop's connection cannot be replayed on another.

* *DPoP equivalent*: Partial. DPoP binds per key, but the key is not inherently tied to a specific hop's connection.

6.2. Residual Risks

6.2.1. Intra-Connection Replay

Within the same TLS connection, an attacker with access to the channel (e.g., a compromised middleware component) could observe and replay requests. This risk is mitigated by including the OPTIONAL per-request claims:

* The jti claim, which provides per-proof uniqueness when the server maintains a replay cache.

* The htm and htu claims, which bind the proof to a specific HTTP method and URI.

* Short iat validity windows that limit the temporal scope of any replay.

Deployments that require intra-connection replay protection SHOULD include per-request claims.

6.2.2. Compromised Private Key

If the client's mTLS private key is compromised, the attacker can produce valid proofs. Mitigations include:

* *Hardware-backed key storage*: Storing the private key in a TPM, HSM, or TEE prevents software-level exfiltration.

* *Short-lived certificates*: Using short-lived credentials (e.g., SPIFFE SVIDs with hourly or shorter expiry) limits the window during which a compromised key can be exploited.

* *Transitive Attestation*: [I-D.draft-mw-wimse-transitive-attestation] binds identity to a verified execution context, providing evidence if the execution environment is tampered with.

7. IANA Considerations

7.1. OAuth Token Confirmation Methods

This specification registers the following confirmation method in the IANA "OAuth Token Confirmation Methods" registry established by [RFC7800]:

* *Confirmation Method Value*: tls_exp

* *Confirmation Method Description*: TLS Exporter Session Binding

* *Change Controller*: IETF

* *Reference*: [this document]

7.2. OAuth Dynamic Client Registration Metadata

This specification registers the following client metadata value:

* *Client Metadata Name*: tls_session_bound_access_tokens

* *Client Metadata Description*: Boolean indicating the client requires TLS-session-bound access tokens

* *Change Controller*: IETF

* *Reference*: [this document]

7.3. HTTP Header Fields

This specification registers the following HTTP header fields:

7.3.1. Session-Binding-Proof

* *Header Field Name*: Session-Binding-Proof
* *Status*: permanent
* *Reference*: [this document]

7.4. TLS Exporter Label

This specification registers the following TLS Exporter label in the IANA "TLS Exporter Labels" registry:

* *Value*: EXPORTER-oauth-tls-session-bound
* *DTLS-OK*: N
* *Recommended*: Y
* *Reference*: [this document]

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[RFC8472] Popov, A., Nystrom, M., and D. Balfanz, "Transport Layer Security (TLS) Extension for Token Binding Protocol Negotiation", October 2018, <https://www.rfc-editor.org/rfc/rfc8472>.

[RFC8473] Popov, A., Nystrom, M., Balfanz, D., Harper, N., and J. Hodges, "Token Binding over HTTP", October 2018, <https://www.rfc-editor.org/rfc/rfc8473>.

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Appendix A. Contributors

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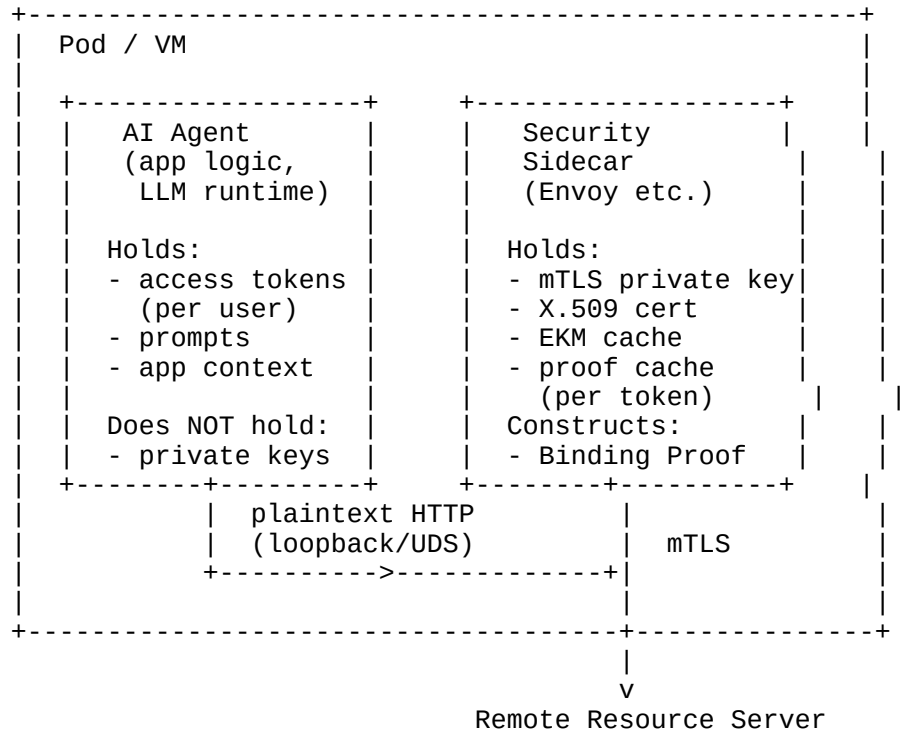
Appendix B. Sidecar Deployment for Agentic AI

In agentic AI architectures, a common deployment pattern places a security sidecar (e.g., Envoy, Istio proxy, or a purpose-built agent gateway) alongside each AI agent workload. This appendix describes how TLS-session-bound tokens integrate with this pattern and the resulting security benefits.

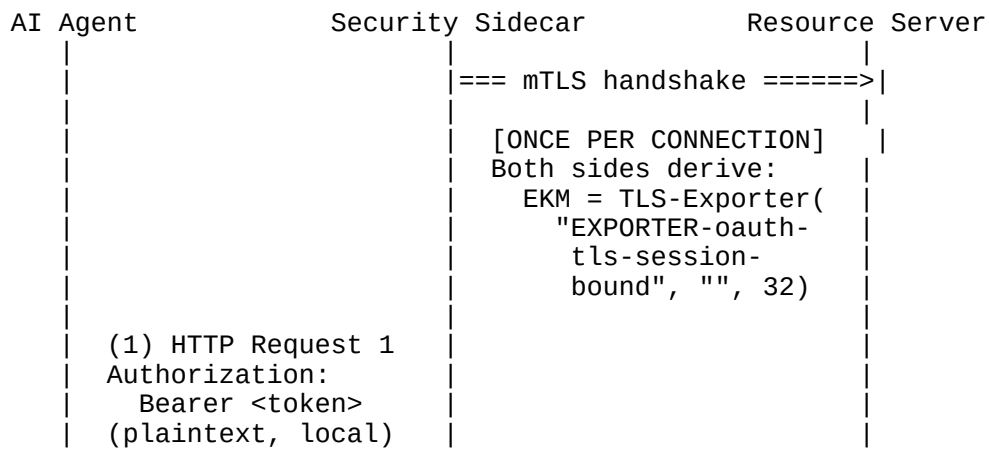
B.1. Architecture

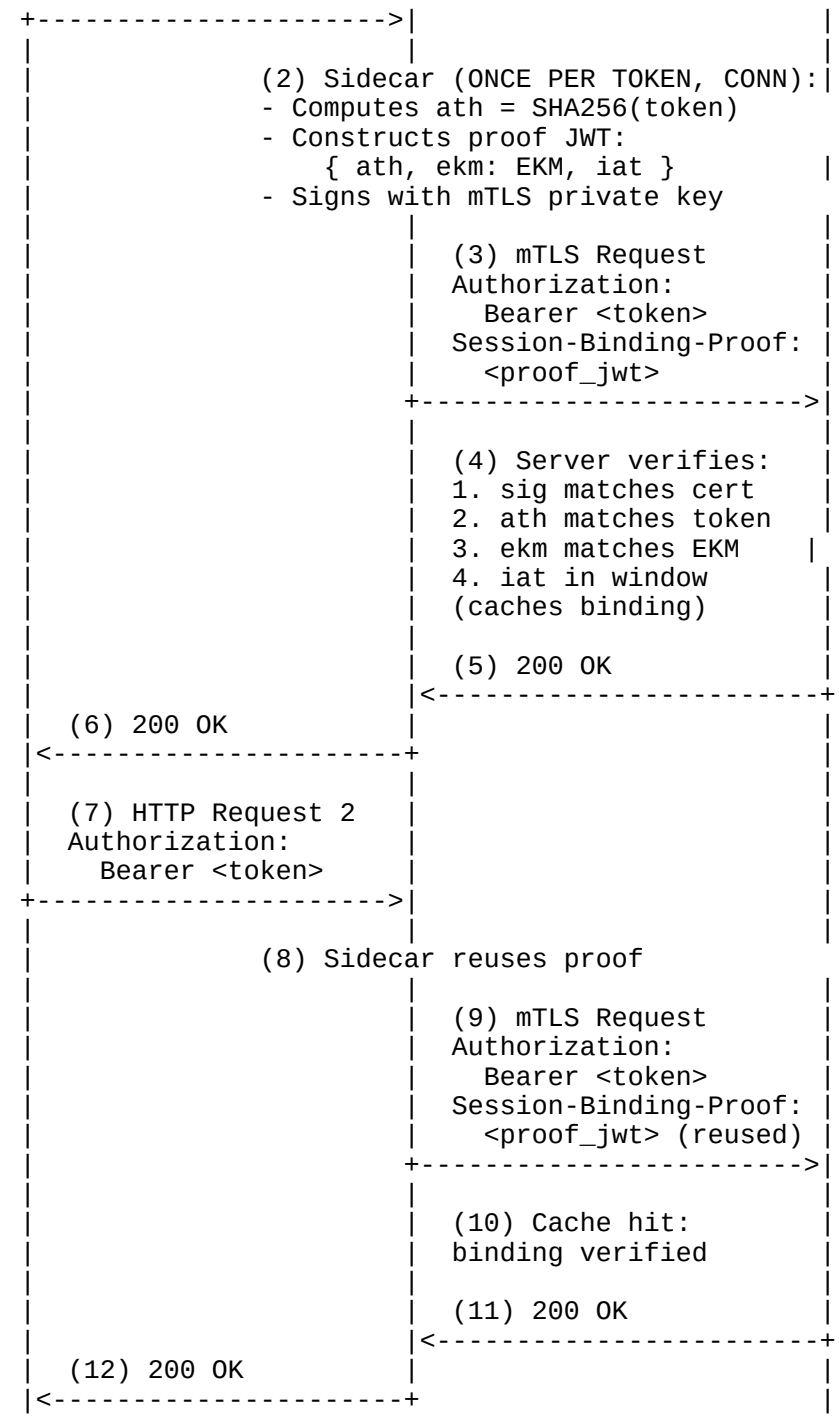
The following diagram shows the deployment layout. The AI agent and security sidecar run in the same pod or VM. The sidecar holds the mTLS private key, manages all authenticated outbound connections, and maintains a cache of signed proofs. A single mTLS connection to a remote resource server may carry requests on behalf of many different users, each with a distinct access token; the sidecar constructs and signs a proof once per (token, connection) pair and reuses it for subsequent requests with the same token.



B.2. Request Flow

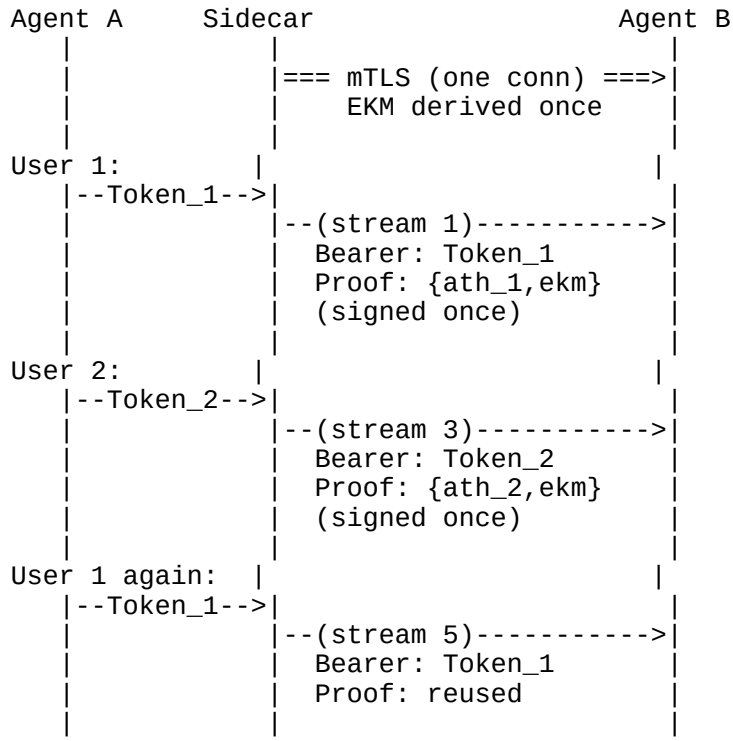
The following diagram shows how requests flow from the AI agent through the sidecar to the remote resource server. The sidecar transparently adds the Session-Binding Proof and reuses it for subsequent requests with the same token.




(2) Sidecar (ONCE PER TOKEN, CONN):
- Computes ath = SHA256(token)
- Constructs proof JWT:
{ ath, ekm: EKM, iat }
- Signs with mTLS private key
(3) mTLS Request
Authorization:
Bearer <token>
Session-Binding-Proof:
<proof_jwt>
(4) Server verifies:
1. sig matches cert
2. ath matches token
3. ekm matches EKM
4. iat in window
(caches binding)
(5) 200 OK
(6) 200 OK
(7) HTTP Request 2
Authorization:
Bearer <token>
(8) Sidecar reuses proof
(9) mTLS Request
Authorization:
Bearer <token>
Session-Binding-Proof:
<proof_jwt> (reused)
(10) Cache hit:
binding verified
(11) 200 OK
(12) 200 OK

B.3. HTTP/2 Multi-User Multiplexing

In a typical agentic deployment, Agent A serves multiple users concurrently. Each user's request triggers an on-behalf-of (OBO) token exchange, producing a distinct access token. All outbound requests to Agent B share a single HTTP/2 mTLS connection, multiplexed across streams:



Each token is signed *once* when first seen on this connection. Subsequent requests with the same token reuse the cached proof. With N users and M requests per user, the total signing cost is N (one per token) rather than N× M (one per request as with DPoP).

B.4. Security Benefits

This architecture provides defense-in-depth against agentic AI threat vectors:

* *Prompt injection token exfiltration*: Even if a compromised LLM exfiltrates an access token via tool calls, log leakage, or side channels, the attacker cannot produce a valid Session-Binding Proof. The mTLS private key resides exclusively in the sidecar process, which is not accessible to the agent's application logic or LLM runtime.

* *Key isolation*: The agent never has access to the signing key. The sidecar can enforce hardware-backed key storage (TPM, HSM) independently of the agent's runtime environment.

* *Transparent integration*: The agent application code requires no modifications beyond standard OAuth token handling. The session binding is entirely transparent — the sidecar intercepts outbound requests and adds the proof.

* *Centralized policy enforcement*: The sidecar can apply additional policy checks (token scoping, rate limiting, destination allowlisting) before constructing the proof, providing a security control plane for agent traffic.

* *Audit boundary*: All authenticated outbound traffic passes through the sidecar, providing a natural audit point for logging which tokens were used, to which destinations, and when.

B.5. Relationship to Existing Infrastructure

This deployment model aligns with the service mesh architecture used in SPIFFE/SPIRE environments, where the sidecar already manages workload identity certificates. When combined with Transitive Attestation [I-D.draft-mw-wimse-transitive-attestation], the sidecar can additionally attest that the agent is running in a verified execution environment while simultaneously binding all tokens to the active TLS connection.

B.6. Implementation Considerations

The sidecar must access the TLS Exporter value from the mTLS connection it terminates in order to construct the Session-Binding Proof. See Section 2.2 for the general implementation note on TLS Exporter API availability across TLS libraries and frameworks.

B.6.1. Connection Lifecycle Management

Sidecars that implement this specification should handle TLS connection lifecycle events to manage the EKM and proof caches correctly. A typical implementation uses a layered architecture:

* *Connection-level layer* (e.g., a network filter or transport callback): Derives the EKM when a new mTLS connection is established and stores it in connection-scoped state. Registers a callback for connection close events.

* *Request-level layer* (e.g., an HTTP filter): Reads the cached EKM from the connection-scoped state, constructs or retrieves the cached proof for each token, and injects the Session-Binding-Proof header into outbound requests.

When a TLS connection terminates, all connection-scoped state — including the EKM and all cached proofs for that connection — SHOULD be purged automatically. Frameworks that support connection-scoped storage (e.g., per-connection filter state) provide this cleanup naturally without requiring explicit invalidation logic.

When a connection to the upstream resource server is lost and a new one is established, the sidecar derives a fresh EKM from the new handshake and constructs new proofs. Previously cached proofs are invalid because they contain the old connection’s EKM.

Appendix C. SPIFFE/SPIRE Integration

This appendix is non-normative. It describes how this specification integrates with SPIFFE/SPIRE workload identity infrastructure and the additional security properties that result when the mTLS certificate is a SPIFFE X.509-SVID.

C.1. Identity-Provenance Property

When the mTLS certificate is an arbitrary X.509 certificate, this specification provides connection-scoped token binding: the token cannot be replayed on a different TLS connection. When the mTLS certificate is a SPIFFE X.509-SVID issued by a SPIRE deployment, the binding acquires a richer semantic property.

A SPIFFE X.509-SVID is issued only after a two-stage attestation process:

1. *Node attestation*: The SPIRE agent running on the node proves to the SPIRE server that the node is what it claims to be (e.g., via cloud provider instance identity documents, TPM attestation, or Kubernetes service account tokens).

2. *Workload attestation*: The SPIRE agent verifies the properties of the workload process requesting the SVID (e.g., binary hash, Unix UID/GID, Kubernetes pod labels, container image digest) against policies registered in the SPIRE server.

The resulting SVID is short-lived (typically between one minute and one hour, depending on deployment policy) and is automatically rotated by the SPIRE agent before expiry.

When a Session-Binding Proof is signed by the private key of a SPIFFE X.509-SVID, the resource server's verification implies the following chain:

* The access token was presented on a specific TLS connection (EKM binding).

* That connection was established by the workload whose private key signed the proof.

* That workload was attested by a SPIRE agent as running on an attested node.

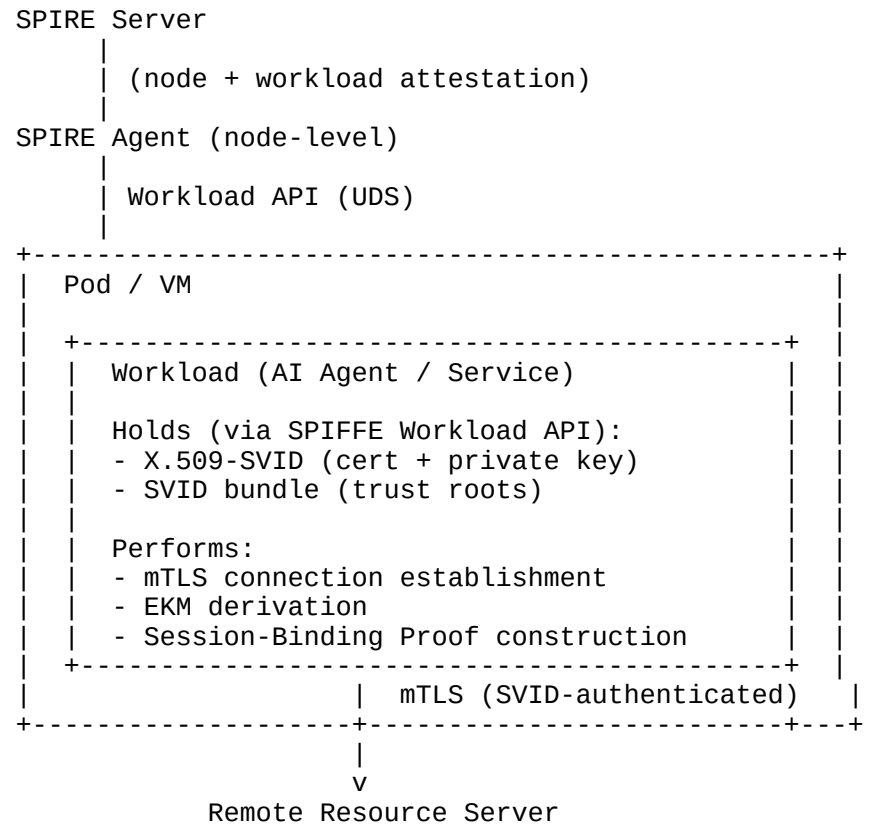
* The SVID was valid and within its short-lived issuance window at the time of proof construction.

This property — authorization bound to attested workload identity — is not achievable with DPoP, whose key has no provenance beyond self-generation, or with RFC 8705 alone, which binds to a certificate thumbprint but does not constrain how the certificate was issued or how long it has been valid. The combination of this specification with SPIFFE/SPIRE delivers identity-rooted proof of possession: the binding key is not "a key the client generated" but "a key issued to a specific attested workload through a verifiable trust chain."

C.2. Deployment Variants

C.2.1. Without Sidecar (Direct Integration)

In this variant, the workload process itself obtains the SVID via the SPIFFE Workload API and uses it directly for mTLS connections. The workload also constructs the Session-Binding Proof using the SVID private key.



The SPIFFE Workload API (typically a Unix domain socket) delivers the current SVID and its private key to the workload process. The workload uses this SVID as its mTLS client certificate and constructs the Session-Binding Proof by signing with the corresponding private key.

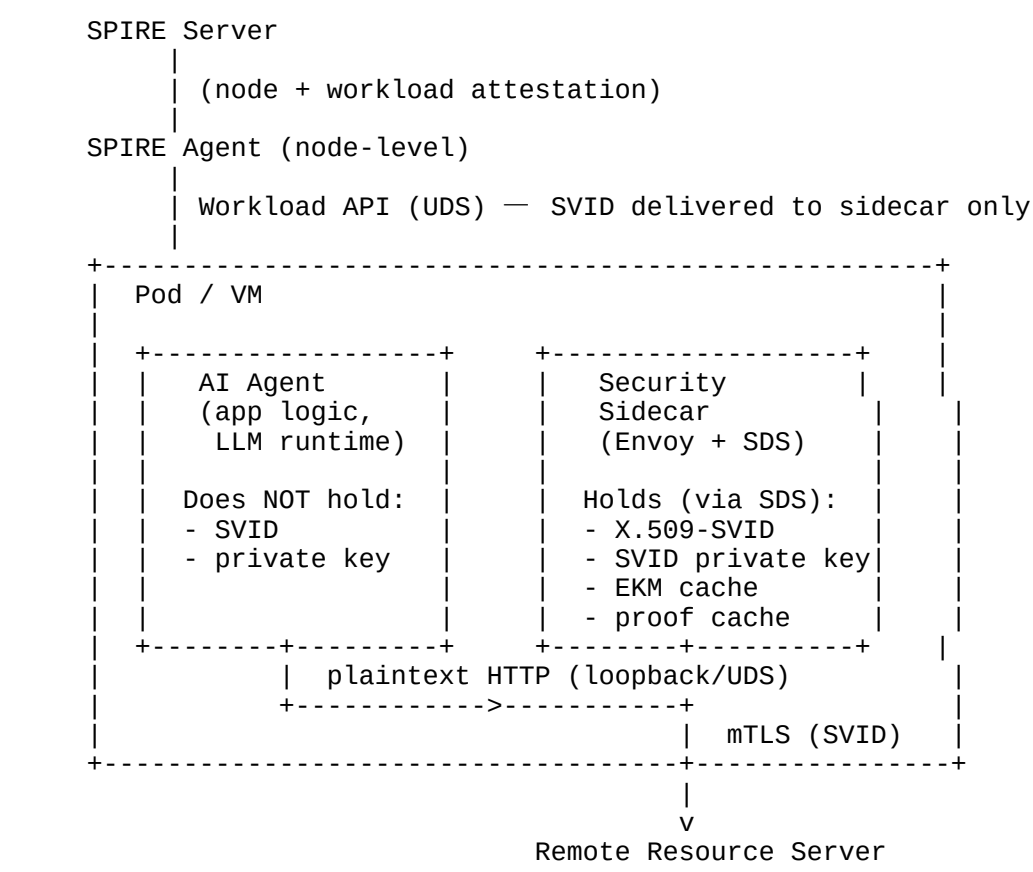
SVID rotation: When the SPIRE agent rotates the SVID (before expiry), the workload receives the new SVID via the Workload API. The workload SHOULD establish new mTLS connections using the new SVID. Each new connection produces a new EKM; fresh proofs must be constructed for any tokens presented on those connections. Previously cached proofs, which reference the old connection's EKM, remain valid only on connections established with the old SVID.

Security note: In this variant, the SVID private key resides in the same process as the agent's application logic and LLM runtime. The key-isolation benefit described in Appendix B does not apply. A workload compromise may expose both the access token and the private key. This variant is appropriate for environments where process-

level compromise is not the primary threat model, or where hardware-backed key storage (e.g., PKCS#11, TPM) is enforced at the platform level independently of the application.

C.2.2. With Sidecar (Recommended for Agentic AI)

In this variant, the SPIRE agent delivers the SVID exclusively to the sidecar. The workload process never receives the SVID private key. The sidecar holds the key, establishes all outbound mTLS connections, and constructs Session-Binding Proofs transparently. This is the pattern described in Appendix B, extended to SPIFFE/SPIRE environments.



Envoy-based sidecars typically receive SVID updates from the SPIRE agent via Secret Discovery Service (SDS). When the SVID rotates, the sidecar receives the new certificate and key via SDS and uses it for all subsequent outbound connections. The sidecar's connection lifecycle management described in Appendix B applies directly: on

SVID rotation, a new mTLS connection to the resource server produces a new EKM, and the sidecar constructs fresh proofs for any tokens presented on that connection. Resource servers caching (connection_id, ath) bindings are unaffected, as each cache entry is keyed on the connection rather than the certificate.

C.3. Relationship to WIMSE WIT/WPT

SPIFFE X.509-SVIDs and WIMSE Workload Identity Tokens (WITs) serve the same purpose — carrying attested workload identity — through different credential formats. This specification is compatible with both.

When WIMSE WIT/WPT is used alongside this specification in a workload-to-workload flow, the two mechanisms address complementary questions at different layers:

* *WIMSE WIT/WPT*: "Is this workload who it claims to be, and is this the workload that holds the corresponding private key?" (application-layer identity assertion and per-request proof of possession)

* *This specification*: "Is this OAuth access token being presented on the TLS connection that this workload authenticated?" (TLS-channel-level token binding)

Together they close the complete chain: workload identity is asserted and proven at the application layer (WIT/WPT), and the OAuth authorization token is cryptographically bound to the specific connection that workload established (this specification). Neither mechanism alone provides both properties.

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