Remote Attestation with Exported Authenticators (draft-fossati-seat-expat)

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Outline

1. Community Interest
2. Quick Recap of Protocol
3. Status of Formal Analysis
4. Discussion

Community Interest Since IETF 124

- Real implementors interest with real use cases
  - GA4GH and ELIXIR Europe (Pavel Nikonorov)
  - Edgeless Systems (Markus Rudy)
  - Zama (Ayoub Benaissa)
  - Flashbots (Peg Jones)
- Cocos AI publicly shared migration plan from intra-handshake to post-handshake attestation
- Internet-Drafts using our protocol
  - draft-aylward-aiga-2
  - draft-condrey-rats-pop-appraisal
  - draft-condrey-rats-pop-protocol
  - draft-ayerbe-trip-protocol (editor's version link)
- Internet-Draft with public commitment to use our protocol
  - draft-barney-caam (commitment link)
- Cited in CCC's response to NIST RFI (NIST-2025-0035)
- Invited talk at GlobalPlatform
- Presented in several CCC Attestation SIG meetings, FOSDEM, Linux Plumbers Conference, GA4GH etc.

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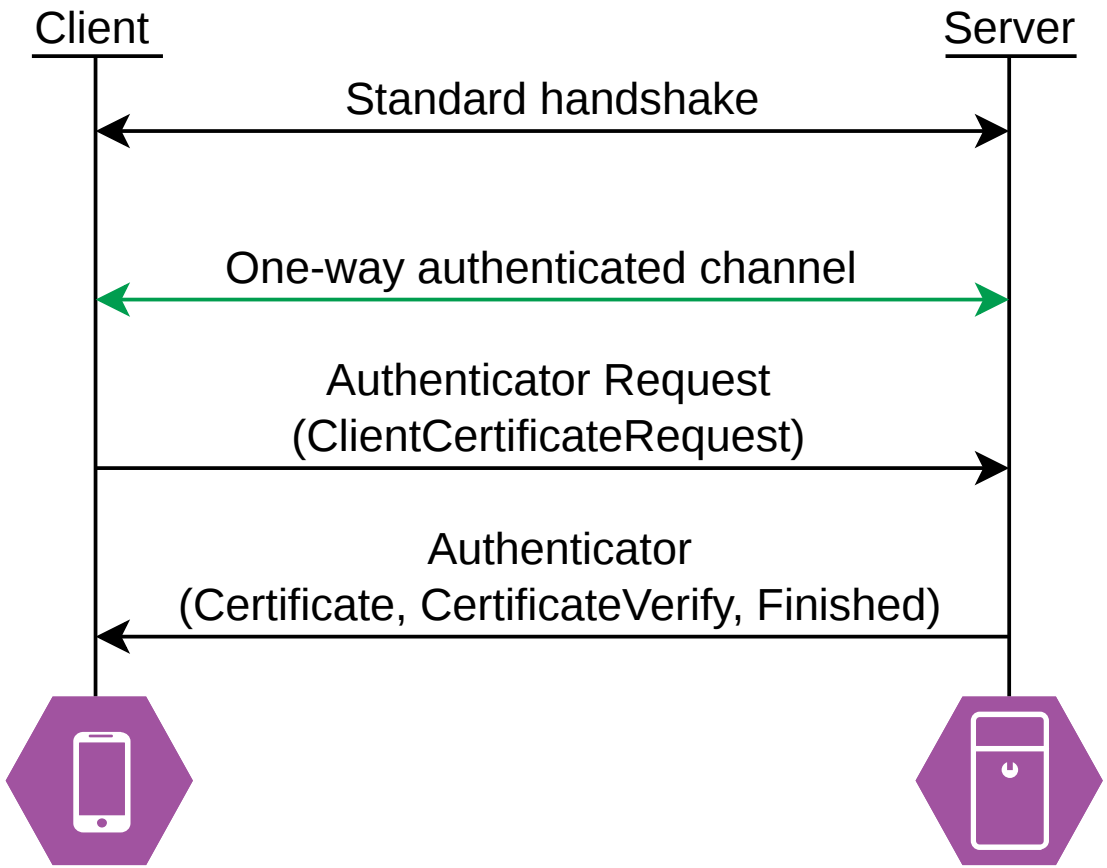
Exported Authenticators[1] (RFC 9261)

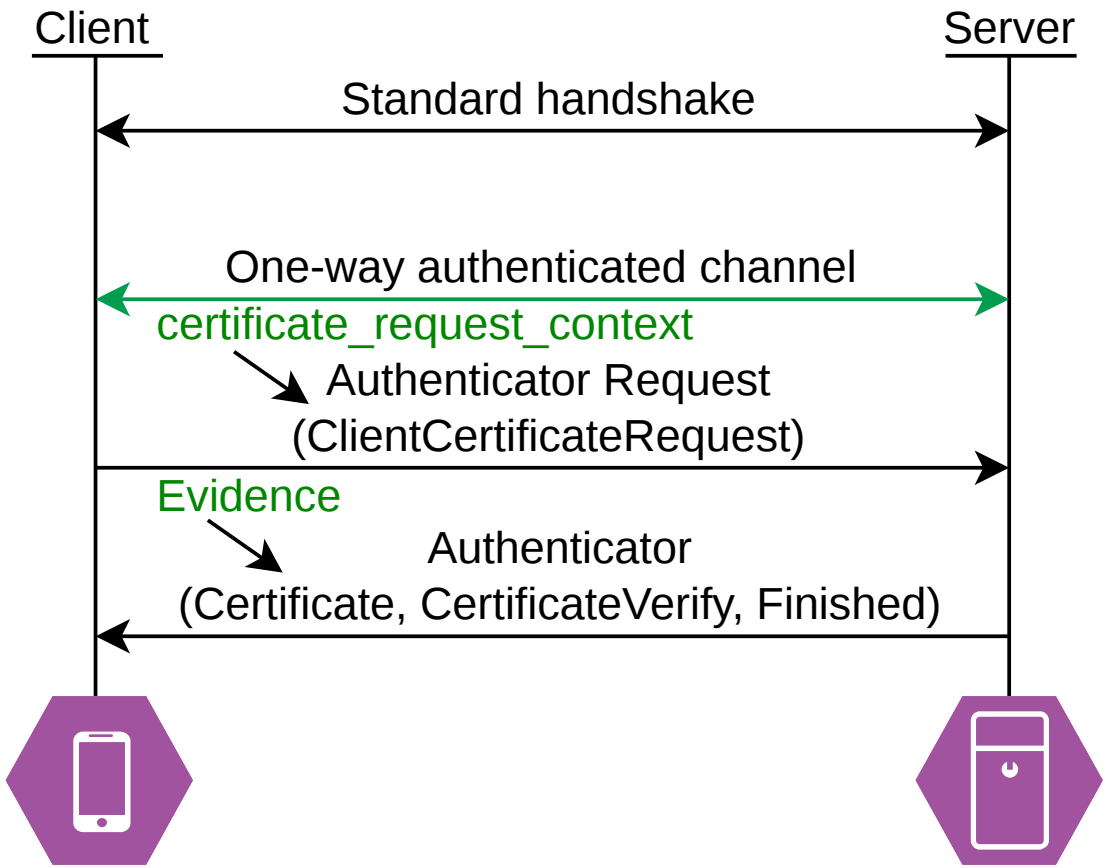
- ClientCertificateRequest: Same as CertificateRequest
- Key for HMAC of Finished using Exported Keying Material (EKM)



[1] Sullivan, *Exported Authenticators in TLS*, 2022.

Post-handshake Attestation[2]

- No change in TLS handshake protocol
- Example: TLS Server as RATS Attester



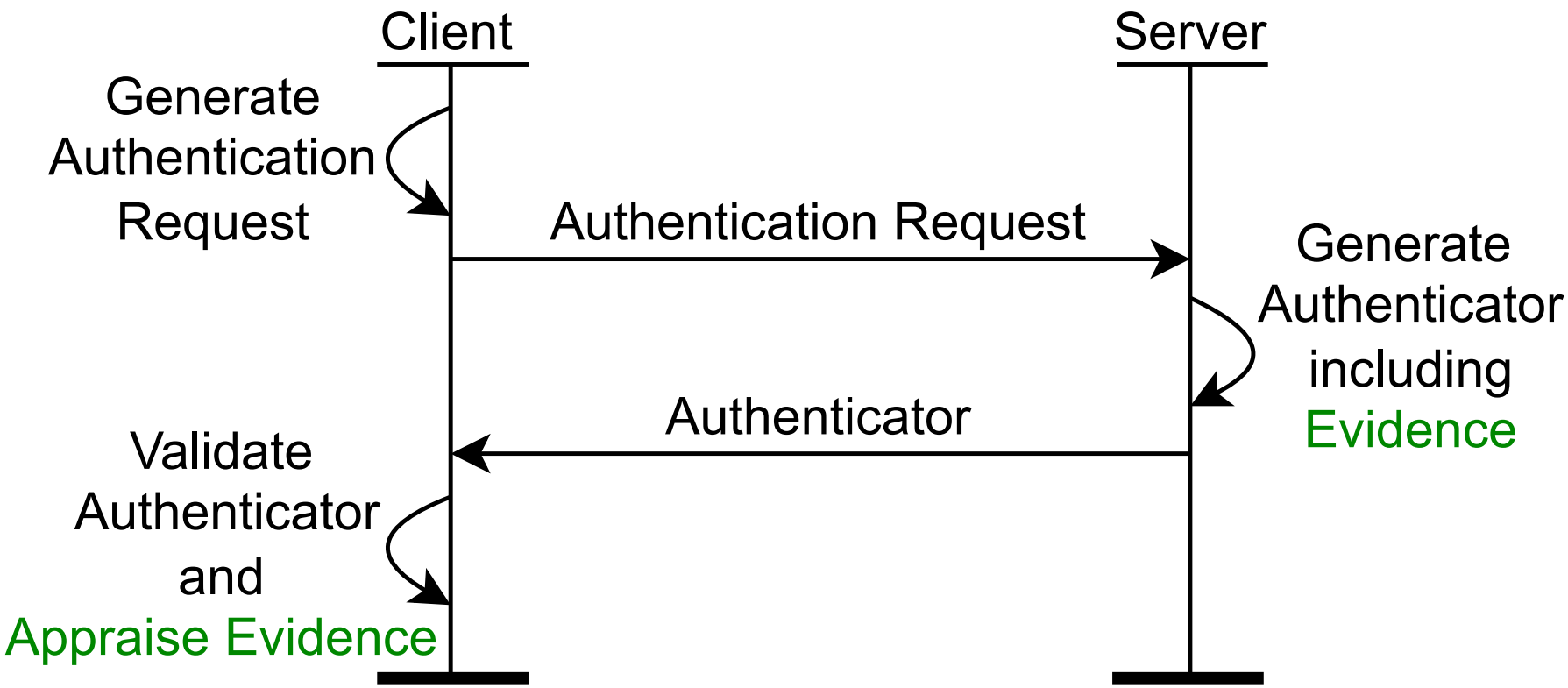
[2]Sardar, Moustafa, and Aura, "Identity Crisis in Confidential Computing: Formal Analysis of Attested TLS", 2026.

Benefits

- Simple, clean, and secure solution
- Orthogonality of TLS and RA
- Well-known and formally verified[3] mechanisms for strong channel bindings
  - What remains is the attestation part
- The draft adds (D)TLS extension and does not alter protocol messages or modify the key schedule.
- Supports background-check and passport model
- Supports re-attestation
- Avoids extra round trips for re-establishment
- Full claims availability
- Supports all use cases (inc. stringent requirements, e.g., GA4GH)

[3] Hoyland, "An Analysis of TLS 1.3 and its use in Composite Protocols", 2018.

Overview of Post-handshake Flow



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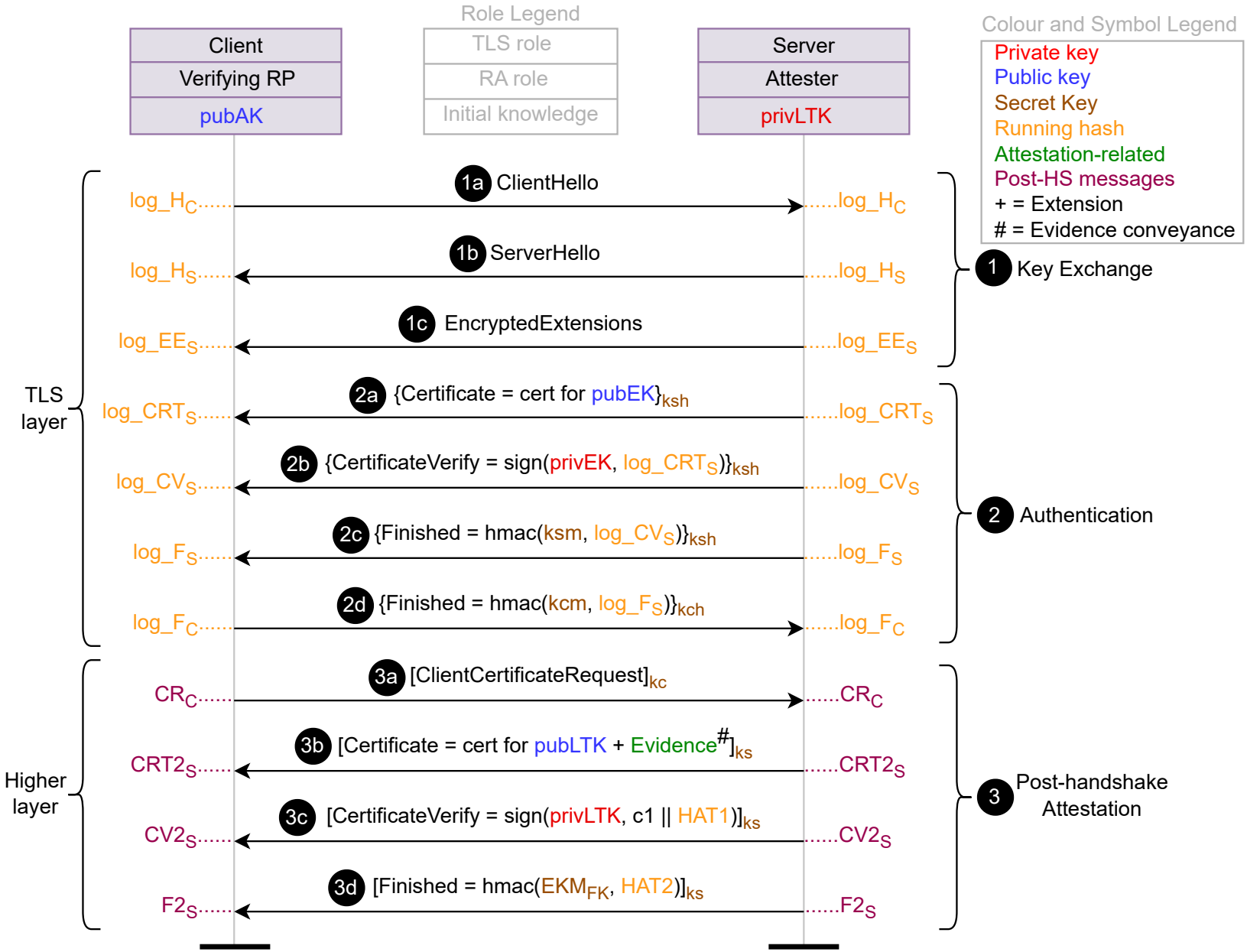
Detailed Model



Authenticator Request

- Let *na* represent the attestation nonce, then:

$$certificate\_request\_context = na \tag{1}$$

Authenticator

- Certificate message with CMW extension for Evidence

$$EKM_{RD} = TLS\text{-}Exporter(\text{"}attestationRD\text{"}, na, L) \tag{2}$$

$$\begin{aligned} rdata &= Hash(pubEK \mid\mid EKM_{RD}) \\ ev &= sign(privAK, rdata||dev\_state) \end{aligned} \tag{3}$$

- CertificateVerify message

$$EKM_{HC} = TLS\text{-}Exporter(\text{"}attestationHC\text{"}, na, L) \tag{4}$$

$$\begin{aligned} AT1 &= EKM_{HC} \mid\mid CR_C \mid\mid CRT2_S \\ HAT1 &= Hash(AT1) \end{aligned} \tag{5}$$

- Finished message

$$EKM_{FK} = TLS\text{-}Exporter(\text{"}attestationFK\text{"}, na, L) \tag{6}$$

$$HAT2 = Hash(AT1 \mid\mid CV2_S) \tag{7}$$

Core Idea for Relay Attack Protection

- Exporters for Certificate, CertificateVerify, and Finished messages bind them all to the connection
- Evidence bound to a fully authenticated endpoint
- Correlation properties in ProVerif

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Next Steps

- Requesting WG adoption call
- Present at CFRG for crypto scrutiny
- Some readings to be done for polishing formal analysis (Thanks to Nick for the pointers).
- Work with Nick for Errata of RFC9261
- Some open issues: welcome any feedback
- Shim layer vs. per-protocol integration
  - CCC Attestation SIG discussions seemed to converge to SHIM layer
- Seek more feedback from implementers

Links to Resources

- Wiki page
  - `github.com/EuroProofNet/ProgramVerification/wiki/AttestedTLS`
- Work-in-progress Implementation
  - `https://github.com/tls-attestation/attestation-exported-authenticators`
- Formal proof of insecurity of pre- and intra-handshake attestation
  - `github.com/CCC-Attestation/formal-spec-id-crisis`
- Attestation in Arm CCA and Intel TDX
  - `github.com/CCC-Attestation/formal-spec-TEE`
- Technical Concepts
- Validation of TLS 1.3 Key Schedule
- General Approach
- Weekly meetings: `github.com/tls-attestation#meetings`

Key References


Hoyland, Jonathan. "An Analysis of TLS 1.3 and its use in Composite Protocols". PhD thesis. Royal Holloway, University of London, 2018. URL: https://pure.royalholloway.ac.uk/en/publications/an-analysis-of-tls-13-and-its-use-in-composite-protocols/.


Sardar, Muhammad Usama, Mariam Moustafa, and Tuomas Aura. "Identity Crisis in Confidential Computing: Formal Analysis of Attested TLS". In: *Proceedings of the 21st ACM ASIA Conference on Computer and Communications Security (ACM ASIACCS 2026)*. New York, NY, USA: ACM, 2026. URL: https://www.researchgate.net/publication/398839141_Identity_Crisis_in_Confidential_Computing_Formal_Analysis_of_Attested_TLS.


Sullivan, Nick. *Exported Authenticators in TLS*. RFC 9261. July 2022. DOI: 10.17487/RFC9261. URL: https://www.rfc-editor.org/info/rfc9261.