Design Space, Tradeoffs and Formal Analysis of Attested TLS Protocols for Confidential Computing

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Based on joint works with Arto Niemi, Hannes Tschofenig, Thomas Fossati, Simon Frost, Ned Smith, Ionut Mihalcea, Yaron Sheffer, Tirumaleswar Reddy, Carsten Weinhold and Michael Roitzsch

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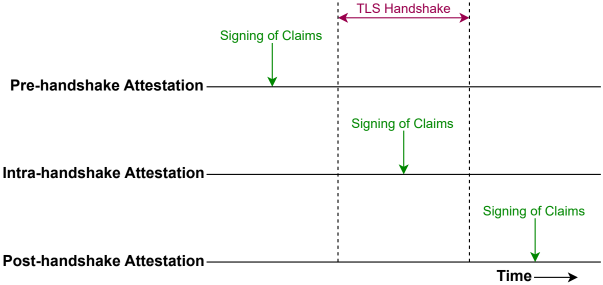
Teleport

Categories of Attested TLS Protocols

- Temporal ordering of Remote Attestation and TLS at Attester side



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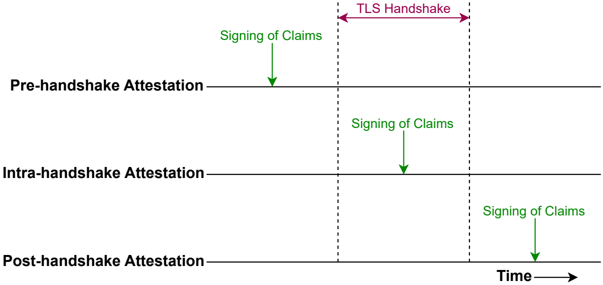
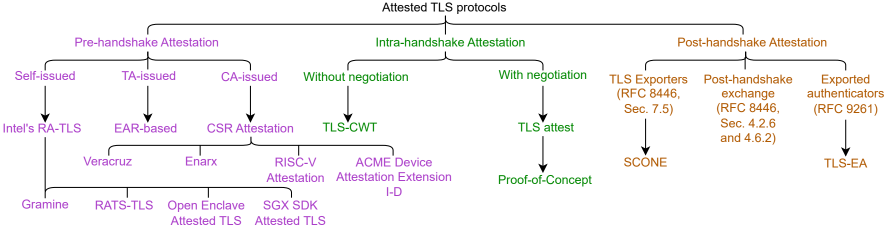


- Typical changes in each category
  - CA/RA/TA = Certification/Registration/Trusted Authority

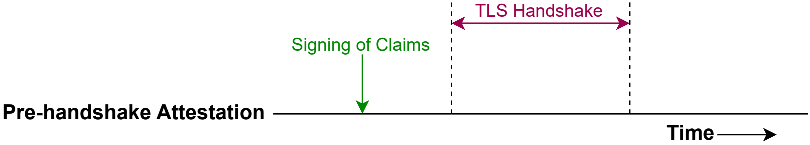
	Protocol	Deployment	Application layer
Pre-handshake attestation	✓	✓ (CA/RA/TA)	×
Intra-handshake attestation	✓ (Invasive)	×	×
Post-handshake attestation	✓ (Negotiation extension)	×	✓

Design Space

- Fragmentation in industry



Pre-handshake Attestation

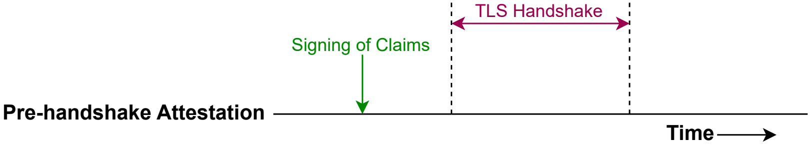


- General limitation
  - Per-session Evidence freshness[1] is not provided.

[1]Sardar, Niemi, Tschofenig, and Fossati, "Towards Validation of TLS 1.3 Formal Model and Vulnerabilities in Intel's RA-TLS Protocol", 2024.

[2]Ounsworth, Tschofenig, Birkholz, Wiseman, and Smith, *Use of Remote Attestation with Certification Signing Requests*, 2025.

Pre-handshake Attestation

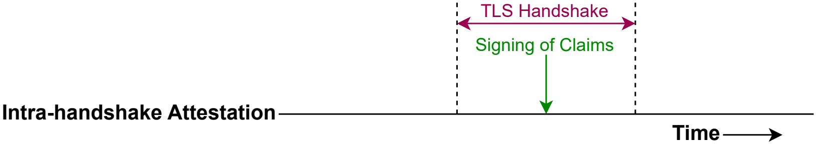


- General limitation
  - Per-session Evidence freshness[1] is not provided.
- Example: CSR attestation[2]

[1] Sardar, Niemi, Tschofenig, and Fossati, "Towards Validation of TLS 1.3 Formal Model and Vulnerabilities in Intel's RA-TLS Protocol", 2024.

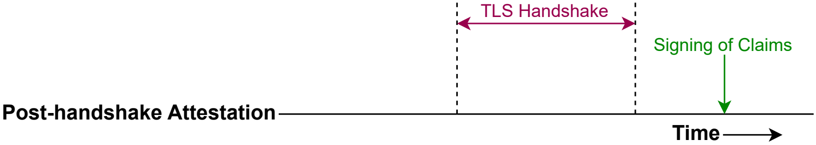
[2] Ounsworth, Tschofenig, Birkholz, Wiseman, and Smith, *Use of Remote Attestation with Certification Signing Requests*, 2025.

Intra-handshake Attestation



- General limitations
  - Invasive changes in TLS protocol (potentially as deep as key schedule)
  - Challenges in attestation credential refresh

Post-handshake Attestation



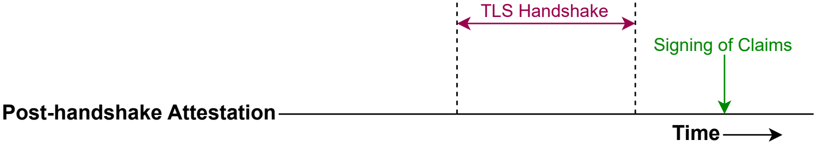
- General limitations
  - Requires application-layer changes
  - Small latency impact (only for first authentication request)

[3] Fossati, Sardar, Reddy.K, Sheffer, Tschofenig, and Mihalcea, *Remote Attestation with Exported Authenticators*, 2025.

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

[5] Birkholz, Smith, Fossati, Tschofenig, and Glaze, *RATS Conceptual Messages Wrapper (CMW)*, 2025.

Post-handshake Attestation



- General limitations
  - Requires application-layer changes
  - Small latency impact (only for first authentication request)
- Proposal[3]
  - Mechanism: Exported Authenticators[4]: RFC 9261
  - Format: Conceptual Message Wrapper[5] (CMW)
  - Formal analysis in ProVerif (work in progress)

[3] Fossati, Sardar, Reddy.K, Sheffer, Tschofenig, and Mihalcea, *Remote Attestation with Exported Authenticators*, 2025.

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

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Key References

Birkholz, Henk, Ned Smith, Thomas Fossati, Hannes Tschofenig, and Dionna Glaze. *RATS Conceptual Messages Wrapper (CMW)*. Internet-Draft draft-ietf-rats-msg-wrap-16. Work in Progress. Internet Engineering Task Force, July 2025. 39 pp. URL: https://datatracker.ietf.org/doc/draft-ietf-rats-msg-wrap/16/.

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Ounsworth, Mike, Hannes Tschofenig, Henk Birkholz, Monty Wiseman, and Ned Smith. *Use of Remote Attestation with Certification Signing Requests*. Internet-Draft draft-ietf-lamps-csr-attestation-19. Work in Progress. Internet Engineering Task Force, May 2025. 51 pp. URL: https://datatracker.ietf.org/doc/draft-ietf-lamps-csr-attestation/19/.

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

ACK

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