SoK: Attestation in Confidential Computing

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[1]TU Dresden

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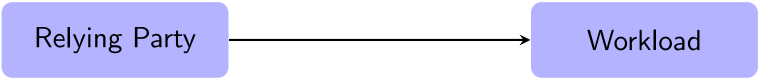
March 29, 2023

Outline

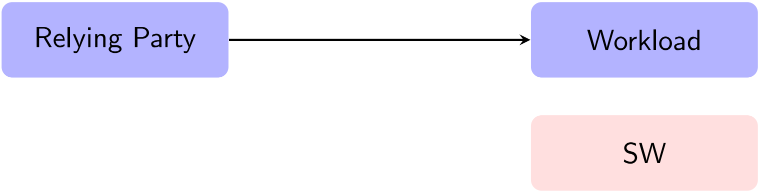
Confidential Computing

Relying Party

Confidential Computing



Confidential Computing



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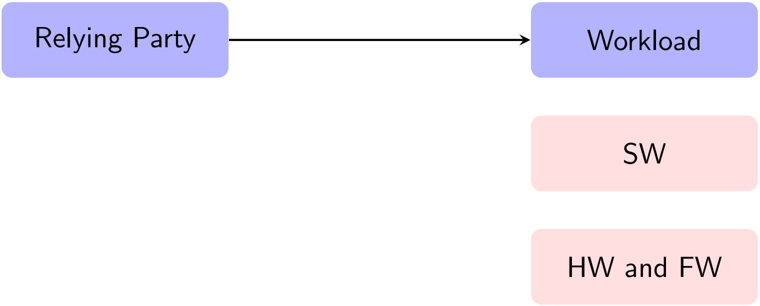

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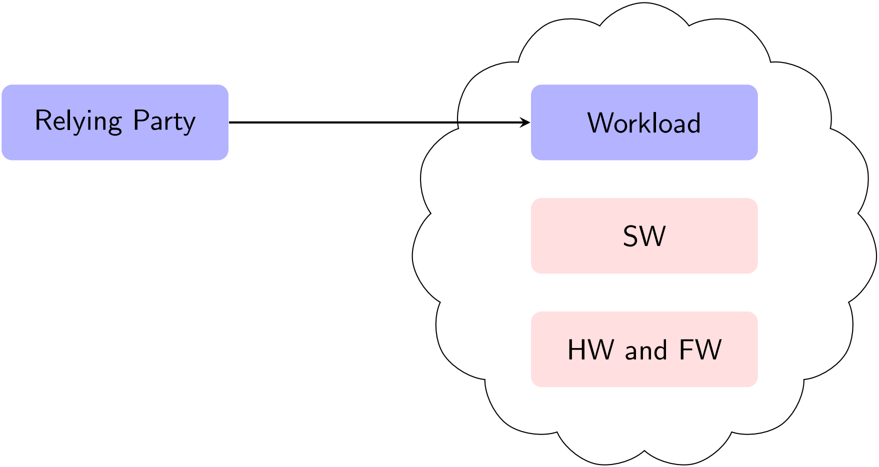
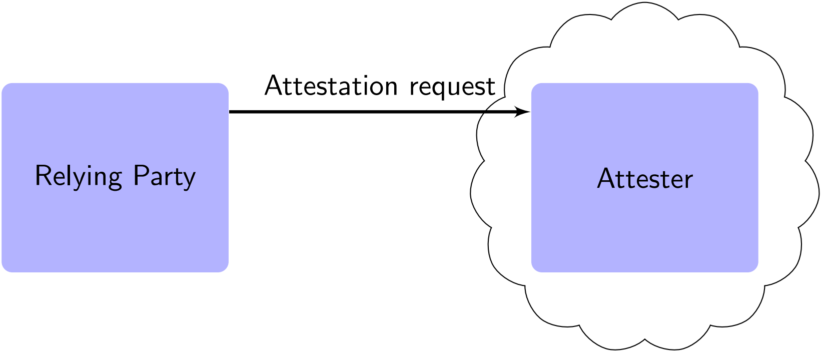


Attestation



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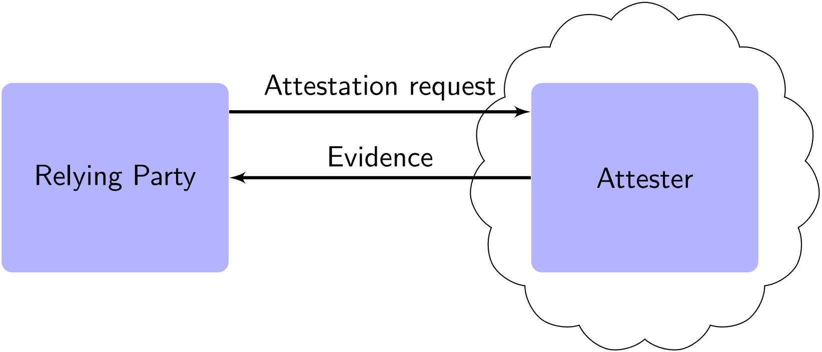

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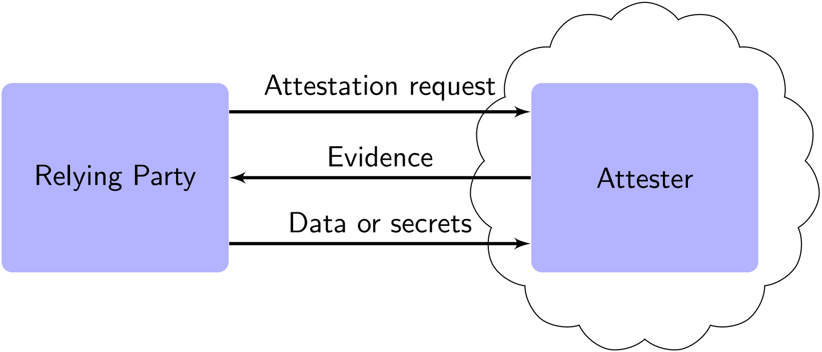

Problem Statement

Holistic view of attestation

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TEE-agnostic attestation architecture

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Mappings to attestation architecture

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Formal specs

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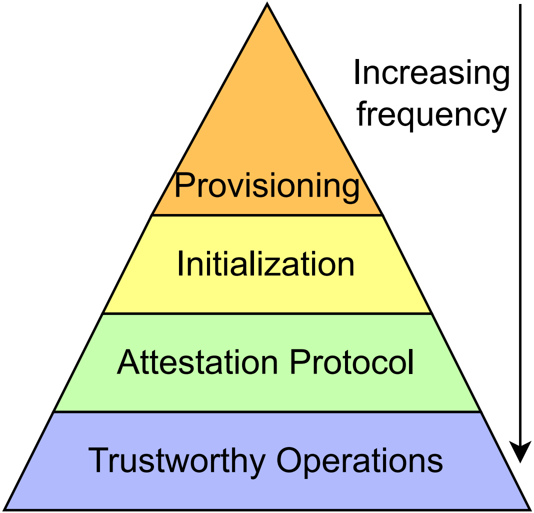
2. Contributions
   - Holistic View
   - TEE-agnostic Architecture
   - Mappings
   - Formal Specs
   - Design and Security Issues: TDX
   - Design and Security Issues: SCONE

Holistic View of Attestation



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- Mappings
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Attestation Architecture

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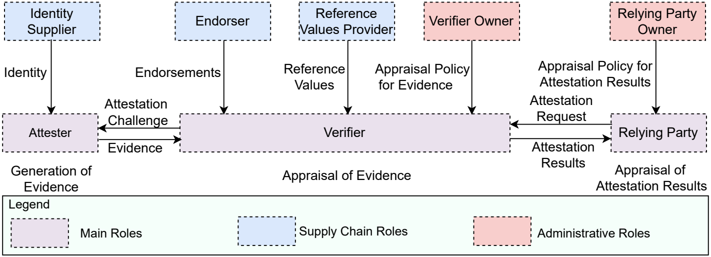

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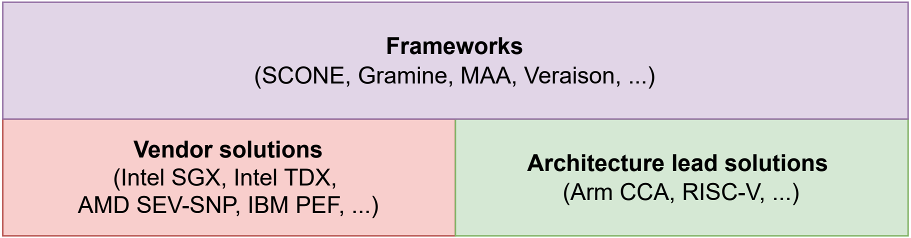
Main Groups for Attestation



Overview of Related Work

Related work				
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Ménétrey et al.[3,4]				
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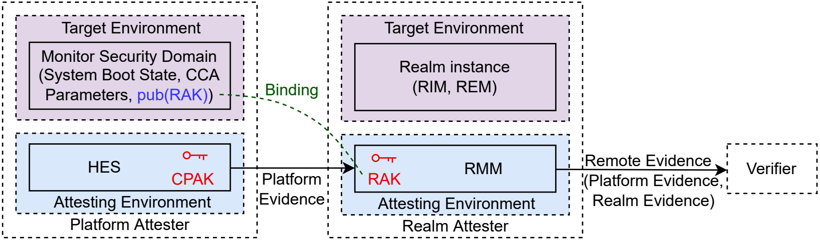
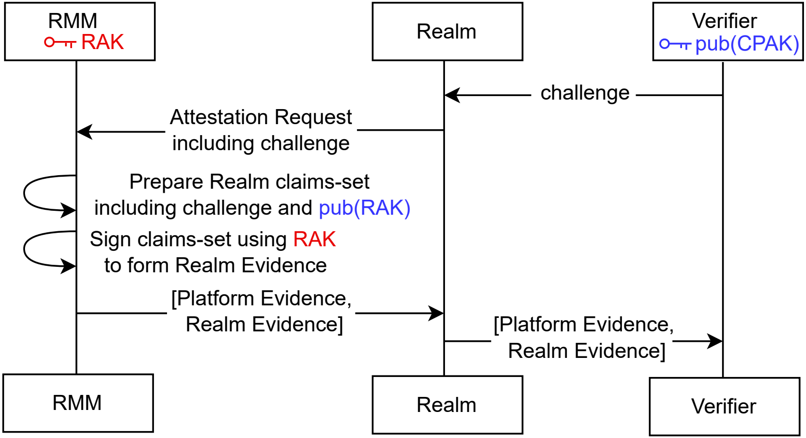
Arm CCA Attestation Architecture Overview



Outline

Arm CCA Evidence Generation



Formal Analysis in ProVerif

- Assumptions
  - Verifier has preconfigured pub(CPAK) for signature verification
  - Secure channel between HES and RMM to transport the RAK key pair
- Integrity of Platform and Realm Evidence

$$\texttt{query } \mathit{data} : \mathit{bitstring} \,; \quad \texttt{event } (\mathit{accepted}(\mathit{data})) \texttt{ ==> } \texttt{inj-event } (\mathit{sent}(\mathit{data})). \tag{1}$$

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Claimed TCB

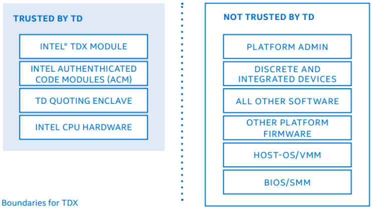
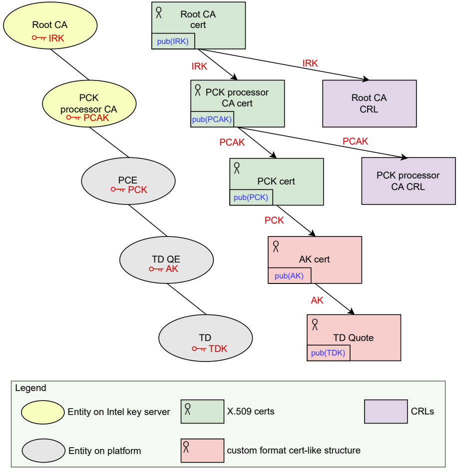


Figure 5.1. Trust Boundaries for TDX



TCB Fixed

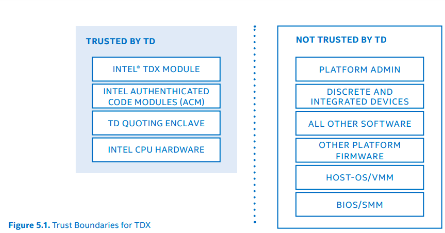


Figure: Old

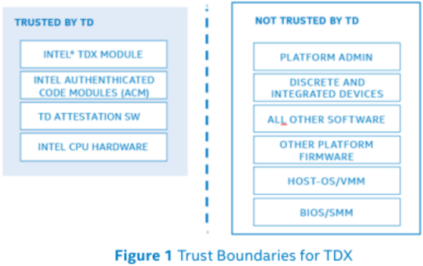
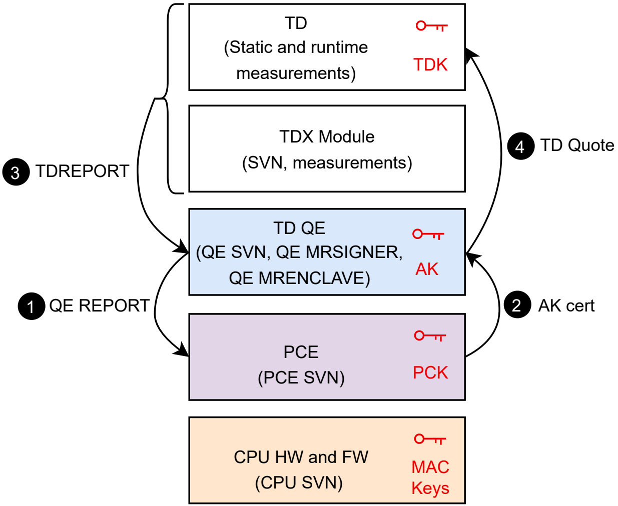


Figure: Updated

SVN for TD?


TD
(Static and runtime
measurements)
TDK
TDX Module
(SVN, measurements)
TD QE
(QE SVN, QE MRSIGNER,
QE MRENCLAVE)
AK
PCE
(PCE SVN)
PCK
CPU HW and FW
(CPU SVN)
MAC
Keys
3 TDREPORT
1 QE REPORT
4 TD Quote
2 AK cert

Missing Specs

Provisioning phase

Missing Specs

Provisioning phase

Structure of Remote Evidence (TD Quote)

Missing Specs

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Structure of Remote Evidence (TD Quote)

Structure of AK cert

Missing Specs

Provisioning phase

Structure of Remote Evidence (TD Quote)

Structure of AK cert

KDF for Local Evidence

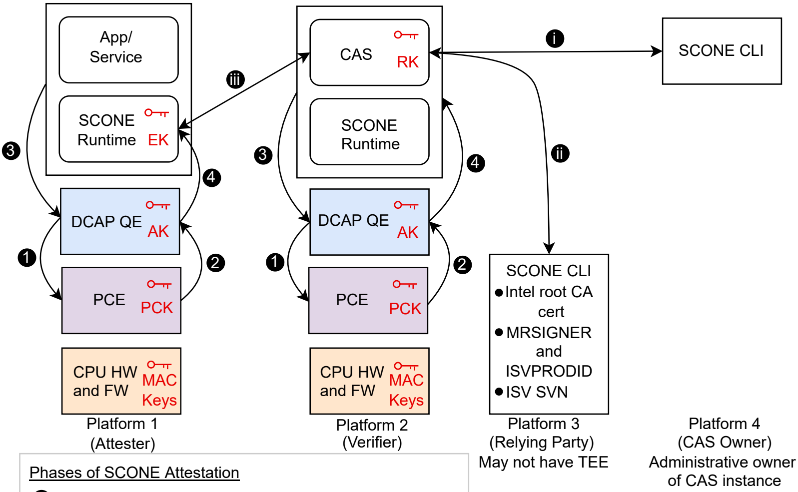
Outline

Order of QE selection

Chosen based on platform capabilities (not by app owner)

- Perspective 1
    1. DCAP QE (qe3)
    2. SCONE QE + EPID QE
    3. EPID QE
- Perspective 2
    1. DCAP QE (qe3)
    2. EPID QE
    3. SCONE QE (can use only if platform ID is known)
- Perspective 3
    - Everything (out of EPID, DCAP, SCONE Quote) that Platform 1 supports is sent to the CAS. So order is not important. CAS decides based on the policy.
        - food for thought: what do we gain?
        - unnecessary overhead without any apparent gain

LA vs. RA



Phases of SCONE Attestation

- (i) SCONE CLI (Platform 4) verifies CAS remotely
- (ii) SCONE CLI (Platform 3) verifies CAS remotely
- (iii) CAS verifies App enclave (Platform 1) remotely

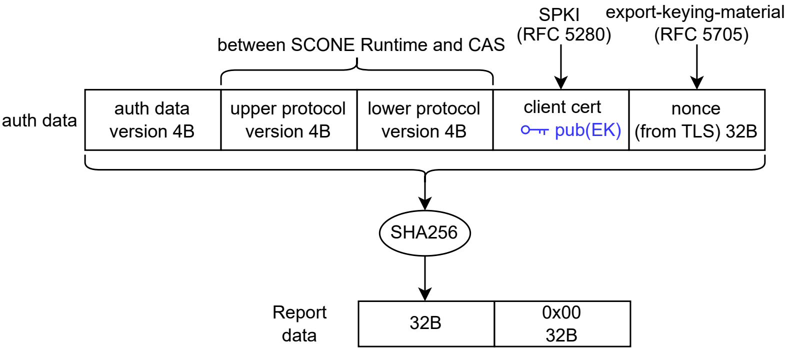
Initialization

- (1) QE REPORT
- (2) AK cert

Attestation Protocol

- (3) REPORT
- (4) Quote

When is a property attested?



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Challenges

ca. 1500 pages of specs of TDX

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Inherits specs from SGX (SDM alone ca. 5000 pages)

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Specs in natural language

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Specs in natural language

Closed-source nature of SCONE

Take-home

- Towards TEE-agnostic *verification* infrastructure for transparency and interoperability

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- TDX: how do we precisely express trust boundaries?

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- TDX: how do we precisely express trust boundaries?
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- Lots of work required for precise specification and standardization for understanding underlying assumptions

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- TDX: how do we precisely express trust boundaries?
- SCONE: when do we say that something is attested?
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  - Integration with TLS (RA-TLS)

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- TDX: how do we precisely express trust boundaries?
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- Lots of work required for precise specification and standardization for understanding underlying assumptions
  - Integration with TLS (RA-TLS)
  - Integration with vTPM

Key References

Birkholz, Henk et al. *Remote ATtestation procedureS (RATS) Architecture*. RFC 9334. Jan. 2023. DOI: 10.17487/RFC9334. URL: https://www.rfc-editor.org/info/rfc9334.

Ménétrey, Jämes, Christian Göttel, Anum Khurshid, et al. "Attestation Mechanisms for Trusted Execution Environments Demystified". In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 13272 LNCS (2022), pp. 95–113. ISSN: 16113349. DOI: 10.1007/978-3-031-16092-9_7.

Ménétrey, Jämes, Christian Göttel, Marcelo Pasin, et al. "An Exploratory Study of Attestation Mechanisms for Trusted Execution Environments". In: *5th Workshop on System Software for Trusted Execution (SysTEX 2022)*. 2022. URL: https://systex22.github.io/papers/systex22-final79.pdf.

Niemi, Arto, Sampo Sovio, and Jan Erik Ekberg. "Towards Interoperable Enclave Attestation: Learnings from Decades of Academic Work". In: *Conference of Open Innovation Association, FRUCT*. Vol. 2022-April. IEEE Computer Society, 2022, pp. 189–200. ISBN: 9789526924472. DOI: 10.23919/FRUCT54823.2022.9770907.

Trusted Computing Group. *DICE Attestation Architecture*. Tech. rep. 2021. URL: https://trustedcomputinggroup.org/wp-content/uploads/DICE-Attestation-Architecture-r23-final.pdf.

Call to Action

- Get involved: https://github.com/CCC-Attestation/formal-spec-TEE
- Additional information: link here
- Specify your attestation designs using presented architecture and proposed formalism