Attested Noise Protocol for Low-TCB Trusted Execution Environments

Ivan Petrov
ivanpetrov@google.com
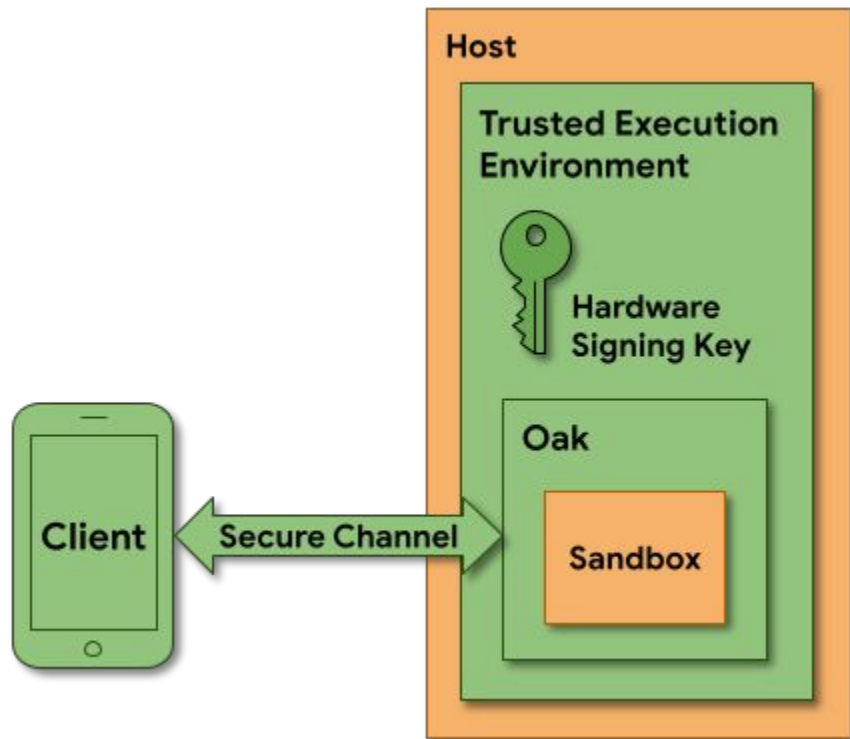
Katsiaryna Naliuka
katsiaryna@google.com

Agenda

1. Project Oak
2. Noise Protocol
3. Remote Attestation

Google

Project Oak

Host

Trusted Execution Environment

Hardware Signing Key

Oak

Sandbox

Client ← Secure Channel →

github.com/project-oak/oak

Research project aiming to make it possible for users to reason about **how their data will be used** by the server in ways verifiable by external reviewers

Google

Oak Building Blocks

Trusted Execution Environments

- Minimize the Trusted Computing Base (TCB)
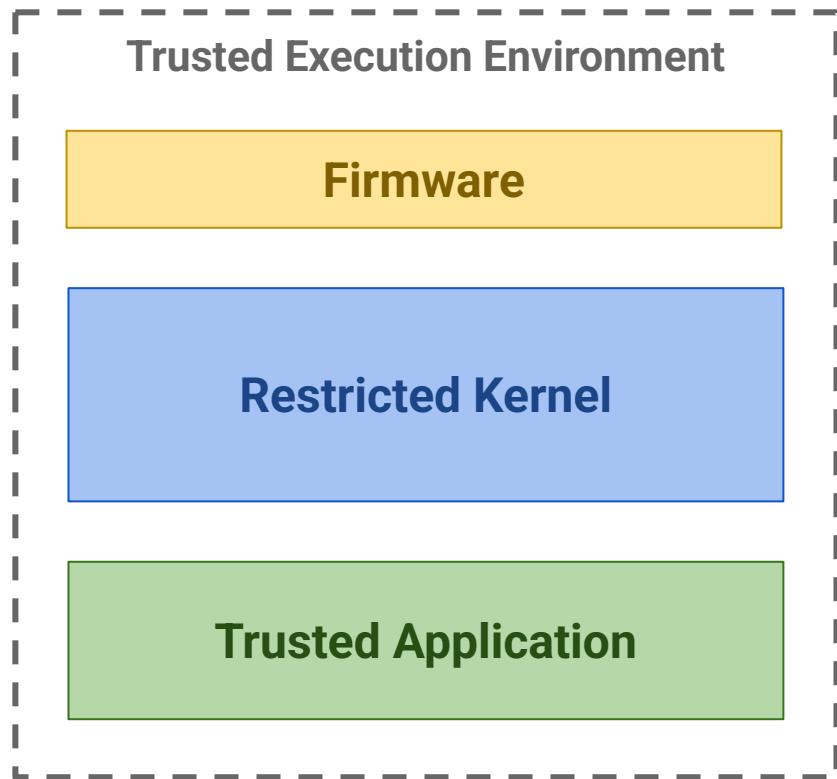- Use restricted environments and sandboxing

Remote Attestation

- Provide complete view of the workload

Transparency

- Open-source code
- Reproducible builds
- Verifiable Logs

Google

Restricted Environment

Trusted Execution Environment

Firmware

Restricted Kernel

Trusted Application
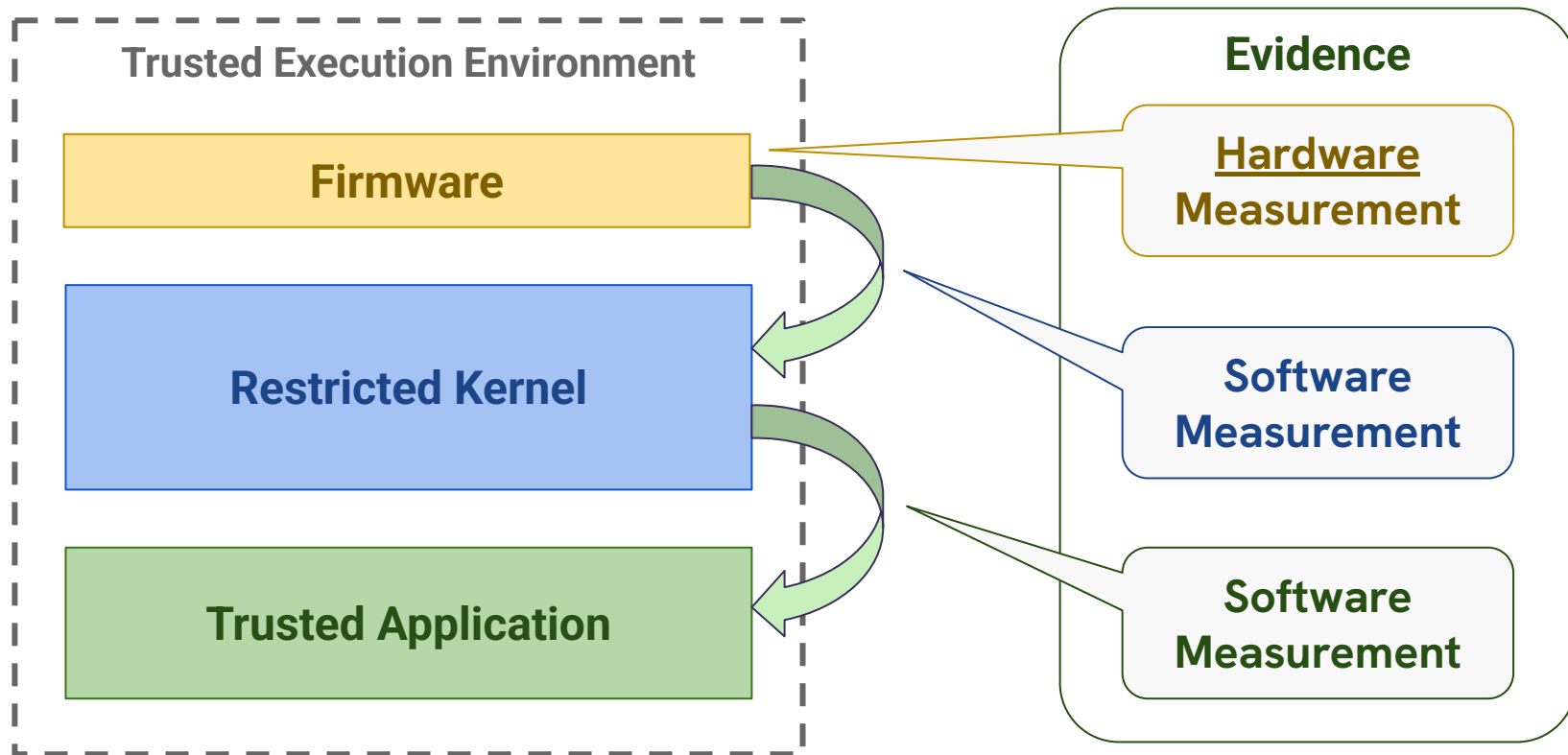
Firmware

- vBIOS + Bootloader

Restricted Kernel

- Minimal syscall interface
- Single process, single-threaded
- No unattested executable pages

Features

- Minimal TCB
- Written in Rust
- Attestation stays valid after boot

Google

Device Identifier Composition Engine (DICE)

Trusted Execution Environment

Firmware

Restricted Kernel

Trusted Application

Evidence

Hardware Measurement

Software Measurement

Software Measurement

Google

Goal

Use a Minimalistic Crypto Protocol

- Bind encrypted channel with remote attestation

- Don't need PKI

- Don't need certificates

- Minimize the amount of parsers

- Rust-only implementation

Google

Goal

Use a Minimalistic Crypto Protocol

- Bind encrypted channel with remote attestation

- Don't need PKI

- Don't need certificates

- Minimize the amount of parsers

- Rust-only implementation

Noise Protocol Framework
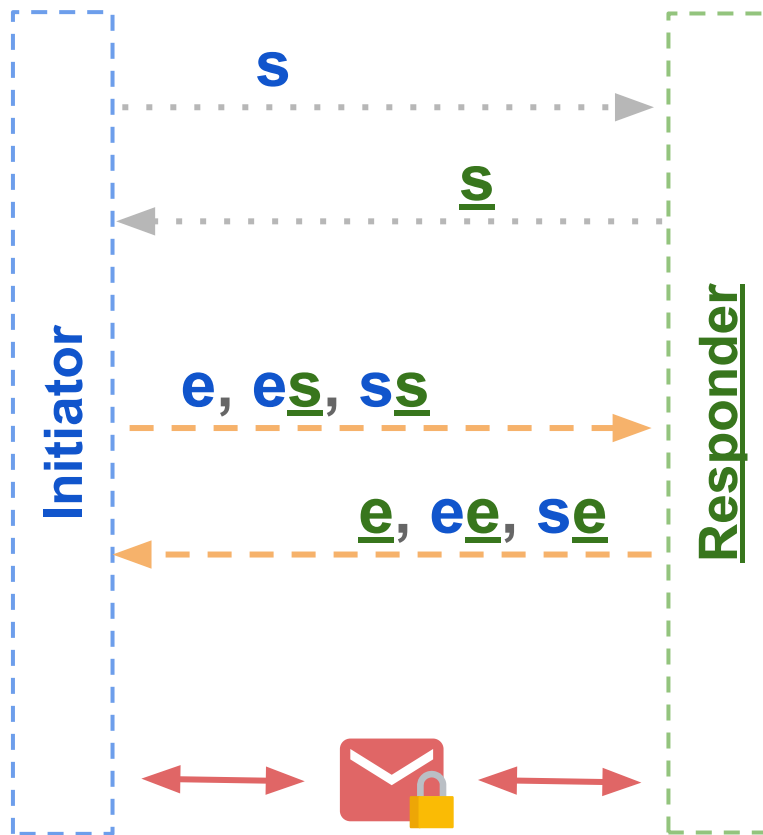
www.noiseprotocol.org

Google

Noise Protocol

- Framework for building simple crypto protocols

- Directly based on Diffie–Hellman key agreement
  - *No certificates/certificate authorities*

- Doesn't restrict the wire format
  - Protocol provides bytes

- Authentication is optional

Google

Noise Protocol: patterns

- Noise patterns are based on the keys used in the handshake
  - *Ephemeral keys*
  - *Static keys, e.g., long term identity key*
    - *Pre-shared with the other party*
    - *Exchanged during the handshake*
- Formal proofs for confidentiality and authentication security guarantees
- Handshake pattern analysis tool: noiseexplorer.com

Google

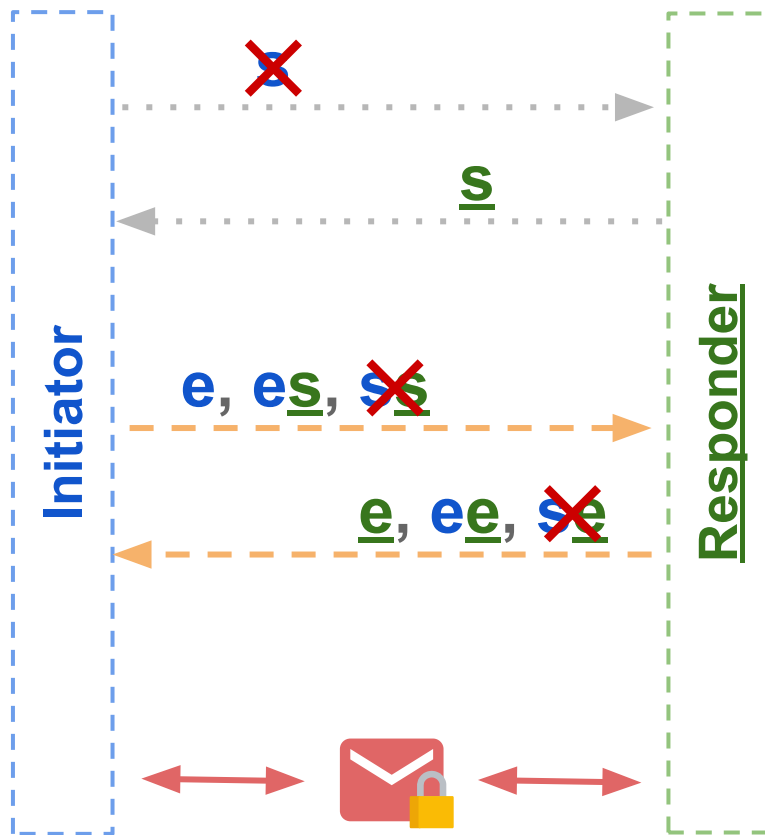# Noise Protocol

Initiator

s →

← s

e, e**s**, s**s** →

← e, e**e**, s**e**

Responder

Notation

- **s** - *static key*
- **e** - *ephemeral key*
- **es**, **ee**, ... - *Diffie-Hellman*

Key agreement

- Rules for updating the local state
- Used to produce 2 symmetric keys (encryption/decryption)
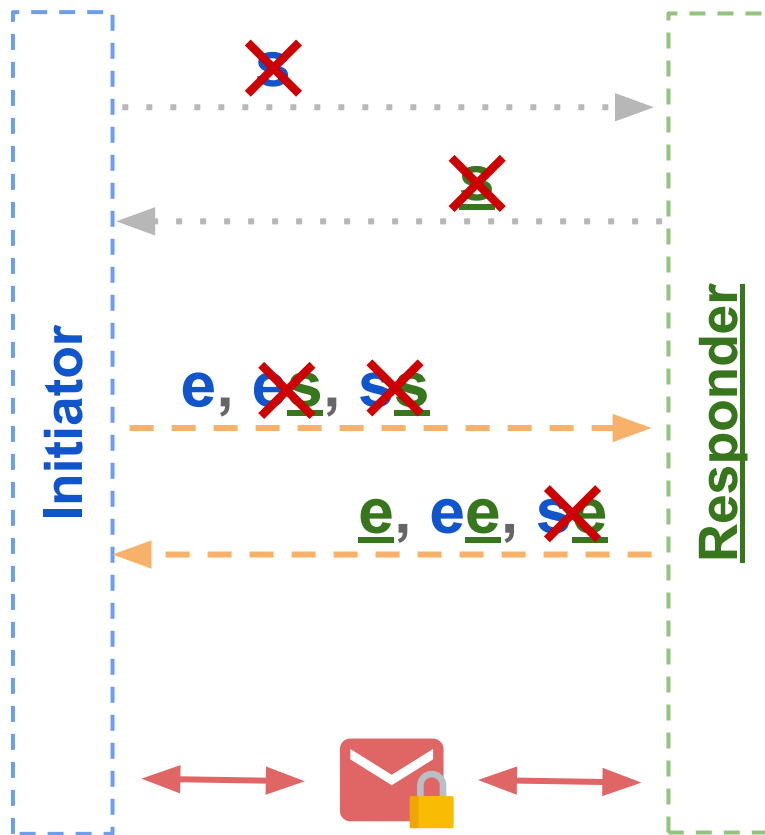
Google

Noise Protocol

Notation

- **s** - *static key*
- **e** - *ephemeral key*
- **es**, **ee**, ... - *Diffie-Hellman*

Key agreement

- Rules for updating the local state
- Used to produce 2 symmetric keys (encryption/decryption)

Google

Noise Protocol

Notation

- **s** - *static key*
- **e** - *ephemeral key*
- **es**, **ee**, ... - *Diffie-Hellman*

Key agreement

- Rules for updating the local state
- Used to produce 2 symmetric keys (encryption/decryption)

Google

Noise Attestation

- Bind attestation to the Noise handshake

  - *Allows making it a <u>separate</u> step*

- Use Noise without modifications

  - *Retains security formal proofs*

- Supports bidirectional attestation

- Supports multiple attestations

Google

Noise Attestation

Initiator ←→ **Responder**
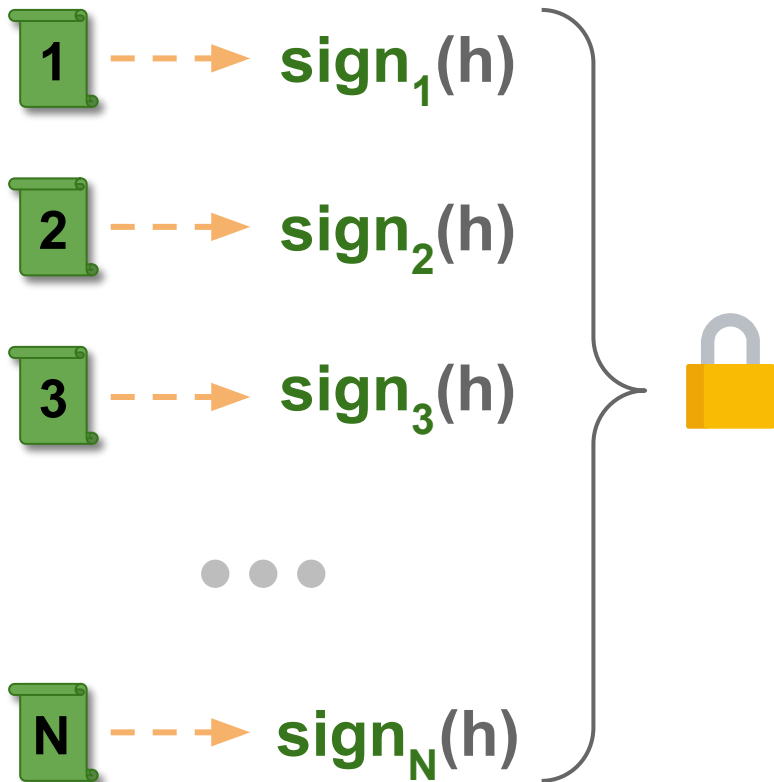
Responder Evidence

e

e, ee, sign(h)
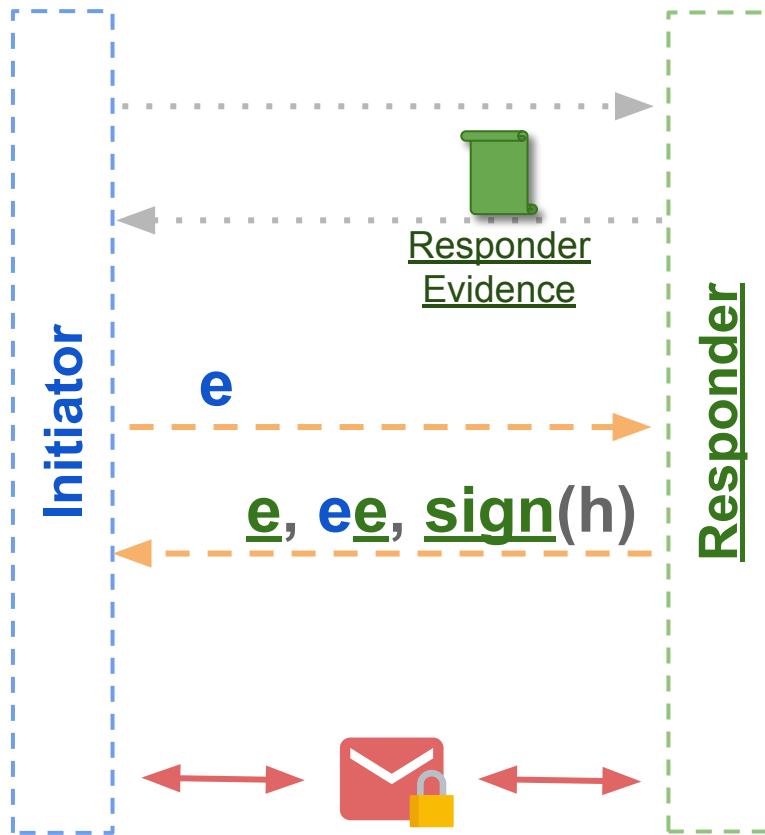
- Responder provides attestation evidence
- Evidence contains a binding key
- Binding is done by signing the handshake transcript **h**
  - *Includes a usage string*

Google

Bidirectional Noise Attestation
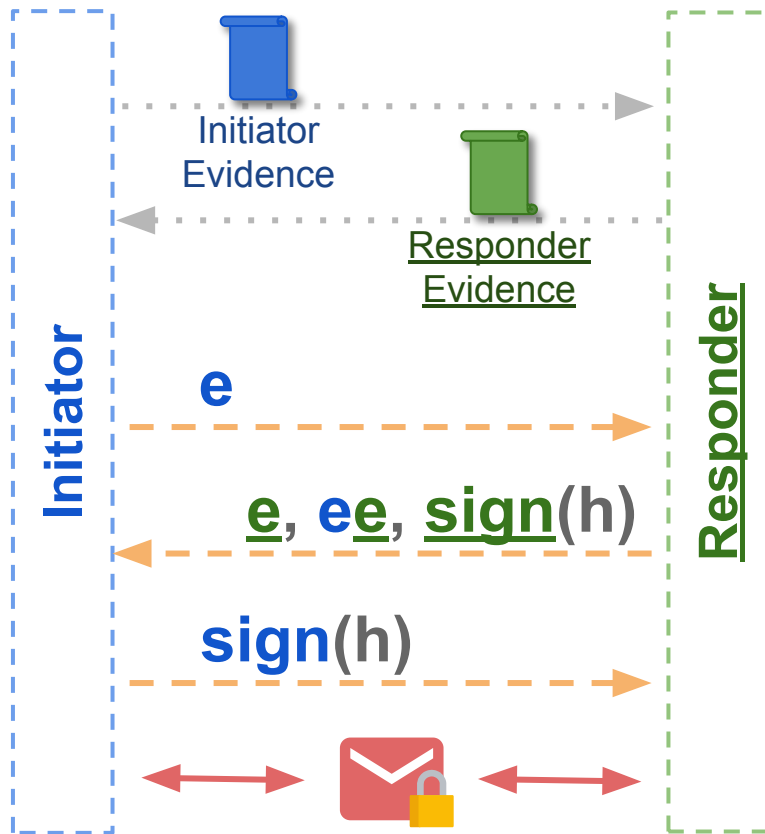
- The same approach can be applied to attest both parties

Multiple Attestations

$$\text{sign}_1(h)$$

$$\text{sign}_2(h)$$

$$\text{sign}_3(h)$$

$$\text{sign}_N(h)$$

- This approach also allows us to bind multiple attestations to the channel
  - *By signing the handshake with individual binding keys*
- This feature can be useful, if the system has multiple attestable components

Noise

- Small implementation:
  - 0.9K LOC Noise implementation
  - 2.5K SDK for attestation binding
  - Small subset of Rust Crypto
- Doesn't need additional parsers
- Provides patterns that don't require PKI

But:

- Custom solution

TLS

- Standard well accepted solution
- Wide variety of features for authentication support

But:

- BoringSSL
  - Threading
  - Standard library for C++ bindings
  - 1.6M LOC
    - but it's *not* a fair comparison

Google

Conclusion

- Use-case which minimizes the TCB

- Need for a minimalistic crypto protocol

- Use Noise Protocol Framework

- Bind end-to-end encrypted channel to remote attestation

Links

- Project Oak: github.com/project-oak/oak

- Noise Implementation:

  github.com/project-oak/oak/tree/main/oak_crypto/src/noise_handshake

- Attestation SDK: github.com/project-oak/oak/tree/main/oak_session

Google