RustZone: Writing Trusted Applications in Rust

Eric Evenchick

Black Hat Asia 2018

About Me

- Principal Research Consultant @ Atredis Partners

- Founder, Developer of Open Source Hardware Things @ Linklayer Labs

linklayer

Outline

- Trusted Execution Environments
- TrustZone
- TEE Problems
- Rust
- Rust + TrustZone
- Demo
- Questions

Trusted Execution Environments

What?

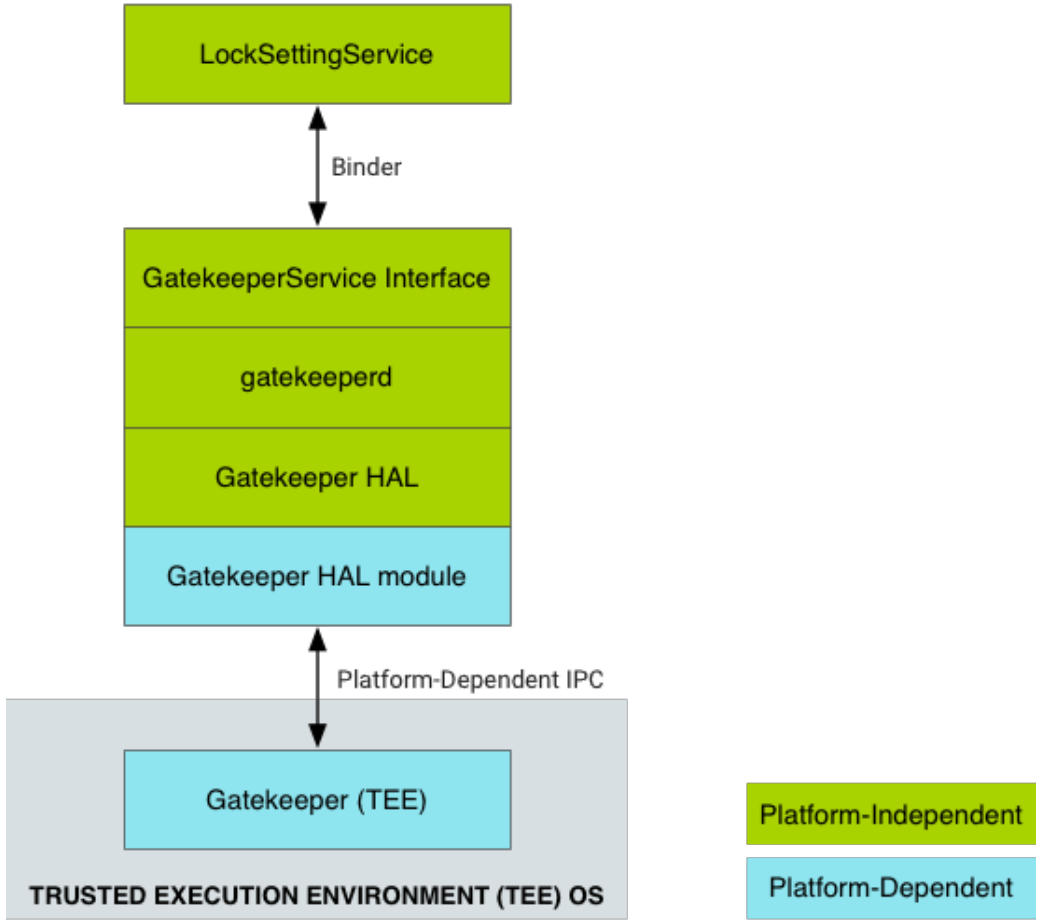
- An isolated environment within a processor for performing secure operations
- Segmentation of code, data, and hardware access
- Combination of hardware features and software

Today’s TEEs

- Hardware:
  - AMD: Platform Security Processor
  - Intel: Trusted Execution Technology, Software Guard Extensions (SGX)
  - ARM: TrustZone
- Software:
  - Trustonic Kinibi
  - Qualcomm QSEE
  - OP-TEE

Use Cases

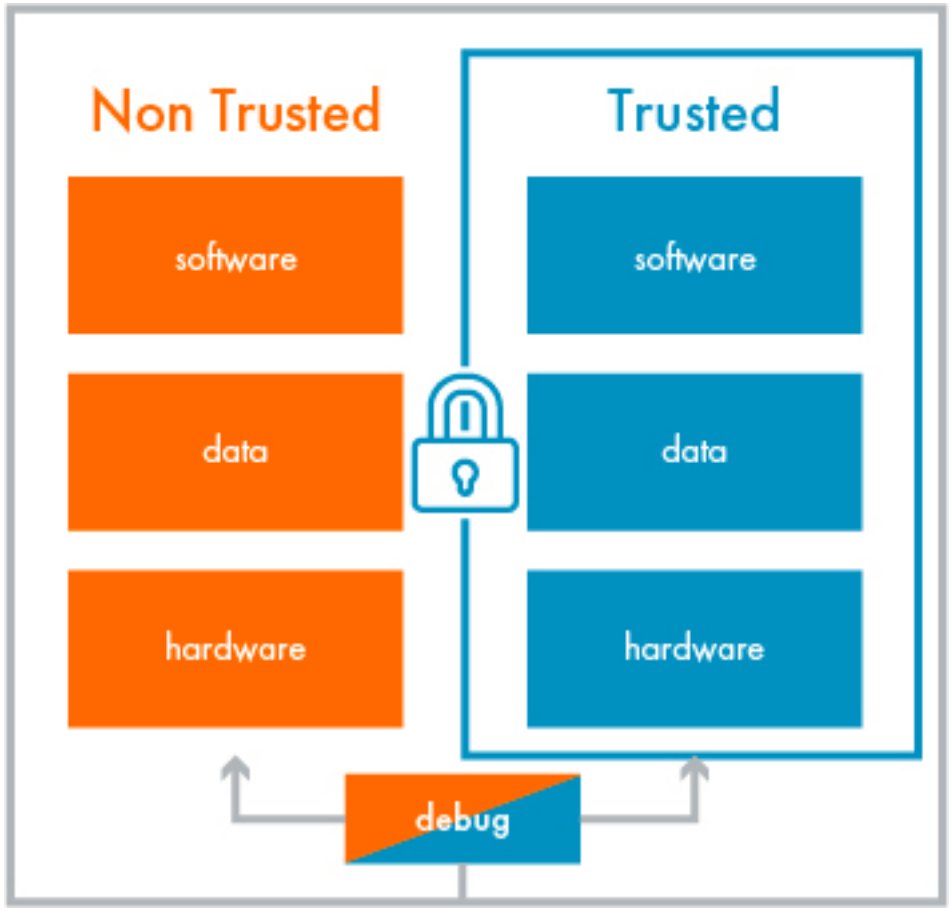
- Authentication
  - Android GateKeeper
- Financial Applications
- Secure Boot
- DRM
  - WideVine
- An additional layer of protection from the host OS
- Protect the system from the user ☹



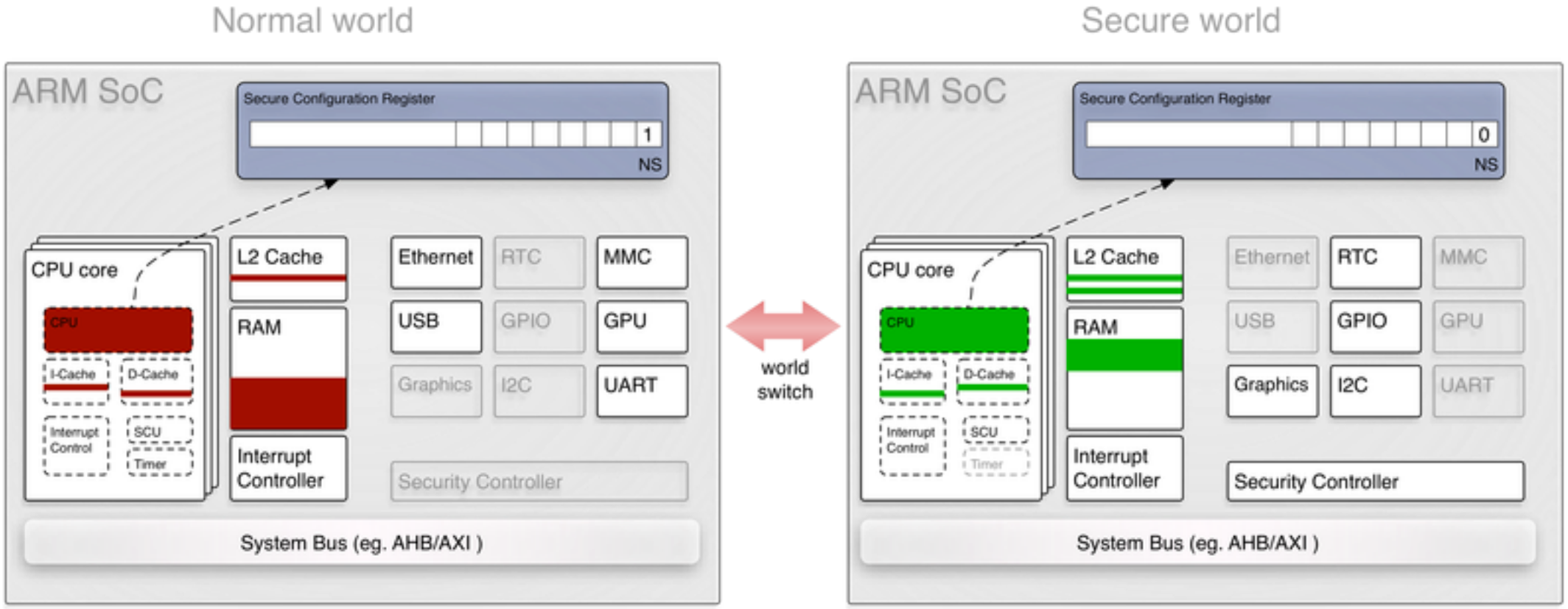
TrustZone

The TrustZone TEE

- The ARM TEE
- Normal and Secure *Worlds*
- Normal World: Rich OS and applications (Linux, Android, QNX, etc…)
- Secure World: Limited operating system and Trusted Applications
- Processor can switch between two worlds
- Configure processor to restrict access to resources



TrustZone in Practice



http://genode.org/documentation/articles/trustzone

TEE Problems

TEE OS Protections

- ASLR is Rare
- No Stack Canaries or Guard Pages
- Secure World has fewer protections than Normal World?
- No High Level Language Support, we must write C!

Writing (good) C is Hard

- Common Memory Problems
  - Buffer overflows
  - Use after free
- Type Issues
  - Void means nothing, and everything!
- Limited Help from Compiler
- Programmers can do Silly Things
  - memcpy, strcpy, sprintf, etc…

Example: WideVine Trusted Application

- DRM Implementation for Android
- Undocumented Command with Buffer Overflow
- End Result: Arbitrary Code Execution in Secure World

- More info: http://bits-please.blogspot.ca/2016/05/qsee-privilege-escalation-vulnerability.html

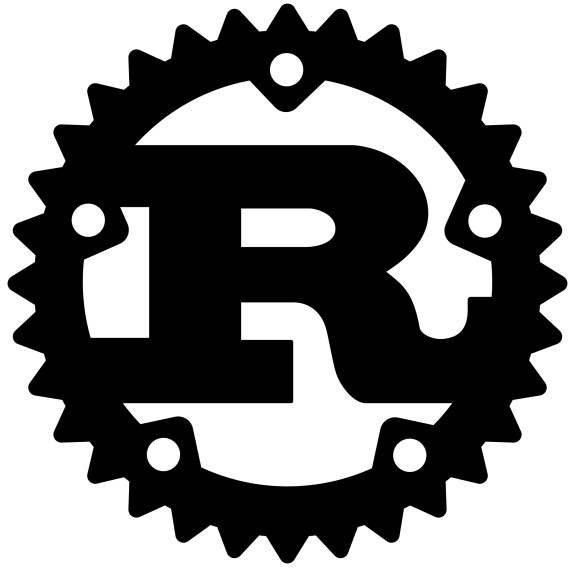
Example: Samsung OTP Buffer Overflow

- Service in Normal World to generate a One-Time Password (OTP)
- Any user can access this service!
- Trusted Application parses request leading to stack buffer overflow

Rust

What’s Rust?

- New systems programming language
- In development since 2010, sponsored by Mozilla
- Works for embedded:
  - Works without libc
  - Compiles to bytecode
  - No garbage collection or runtime
  - Raw memory access



Why Rust?

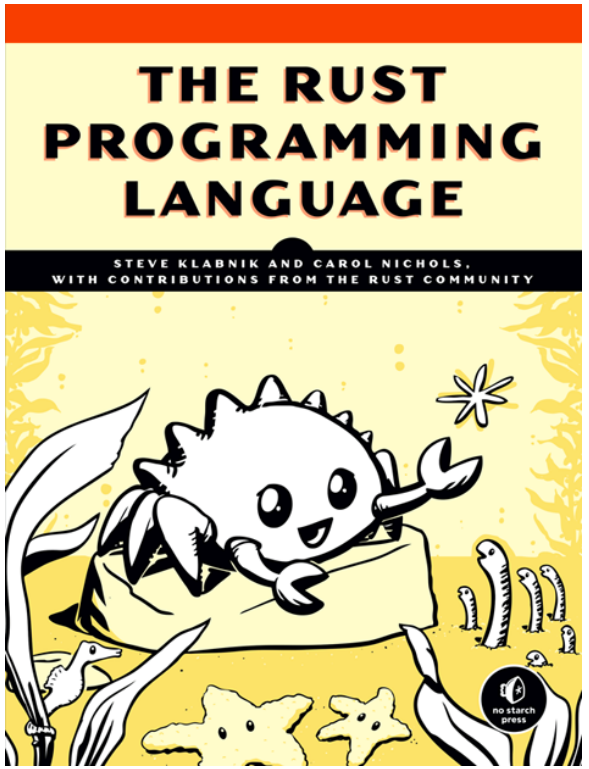
- Compile time memory safety checks
- Memory ownership and borrow checking
- Find bugs at compile time, not runtime
  - eg, match
- Good tools, getting better
- Great C Foreign Function Interface!

Rust / C FFI

- Call C from Rust **and** Call Rust from C
- Need *unsafe* blocks for:
  1. Dereferencing a raw pointer
  2. Calling an unsafe function or method
  3. Accessing or modifying a mutable static variable
  4. Implementing an unsafe trait
- Goal: limit *unsafe* code

Learning Rust

- The Rust Book: https://doc.rust-lang.org/book/
  - Paper version soon: https://nostarch.com/Rust
- Rust by Example: https://rustbyexample.com/
- Julia Evans' Blog: https://jvns.ca/categories/rust/



Rust + TrustZone

Step 1: Get an OS

- Need an OS to run in the Secure World
- OP-TEE
  - Free and Open Source
  - Implementations for many platforms, including QEMU
  - Well Documented
  - https://www.op-tee.org/

Step 2: Generate Rust Bindings

- We need Rust bindings for OP-TEE's API
- bindgen to the rescue!

```
void TEE_MACInit(
        TEE_OperationHandle operation, const void *IV,
        uint32_t IVLen);
```

bindgen

```
extern "C" {
        pub fn TEE_MACInit(operation: TEE_OperationHandle,
        IV: *const c_types::c_void, IVLen: u32);
}
```

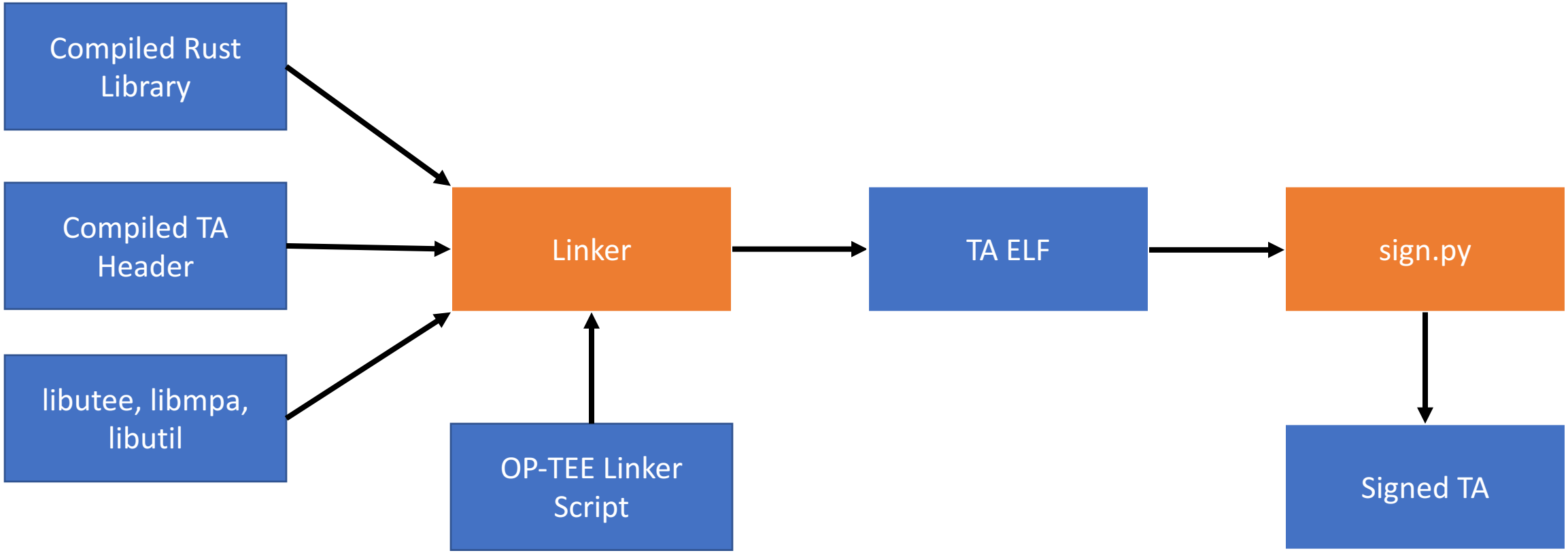
Step 3: Write a Rust Library

- Yes, a *library*.
- Need to implement 5 functions:
  - TA_CreateEntryPoint
  - TA_DestroyEntryPoint
  - TA_OpenSessionEntryPoint
  - TA_CloseSessionEntryPoint
  - TA_InvokeCommandEntryPoint

Step 3: Write a Rust Library

```
pub fn InvokeCommandEntryPoint(_sessionContext: *mut c_types::c_void,
                               commandID: u32, _paramTypes: u32,
                               params: &mut [optee::TEE_Param; 4]) ->
optee::TEE_Result
{
    ta_print!("Rust TA InvokeCommandEntryPoint");
    match commandID {
        0 => {
            unsafe {params[0].value.as_mut().a += 1};
            ta_print!("Incremented Value");
        },
        1 => {
            unsafe {params[0].value.as_mut().a -= 1};
            ta_print!("Decremented Value");
        },
        _ => {
            return optee::TEE_ERROR_BAD_PARAMETERS;
        }
    }
    return optee::TEE_SUCCESS;
}
```

Step 4: Compile, Link, Sign



Demo

Conclusions

Conclusions

- TEEs are useful, but have the usual issues
- Rust is an potential replacement for C with some added benefits
- Should you write your Trusted Applications in Rust?

Thanks! Questions?

eric@evenchick.com

@ericevenchick

https://github.com/ericevenchick/rustzone