SCONE

Secure CONtainer Environment

Secure Docker containers using Intel SGX

INTRODUCTION

CONTAINERS VS. VMS

- performance advantage
  - IO
  - Latency
  - Startup
- weaker security
  - Kernel must protect a larger interface
  - Isolation is only software-based

SGX RECAP

- SGX Enclaves shield code and data from being accessed by other software, especially higher-privileged software
- Enclave memory resides in the Enclave Page Cache

IDEA

- Data should be protected not only from other containers, but also from the kernel and hypervisor
- We use Intel SGX to secure classic Docker containers from the OS by executing the process in the enclave

CHALLENGES

- Minimize TCB to keep the attack vector small
- keep performance overhead low
- Support existing applications

BASIC GOALS

1. Small TCB
    - We only keep a libc library inside the enclave
2. Low performance overhead
    - user-level threading implementation
    - asynchronous syscall queue
3. Transparency to Docker engine

CONTAINERS

MAIN GOAL

Create a secure container mechanism that protects confidentiality and integrity of:

1. Process memory
2. Code
3. External I/O

from attackers with sudo access

DETAILED THREAT MODEL

Attacker has access to:

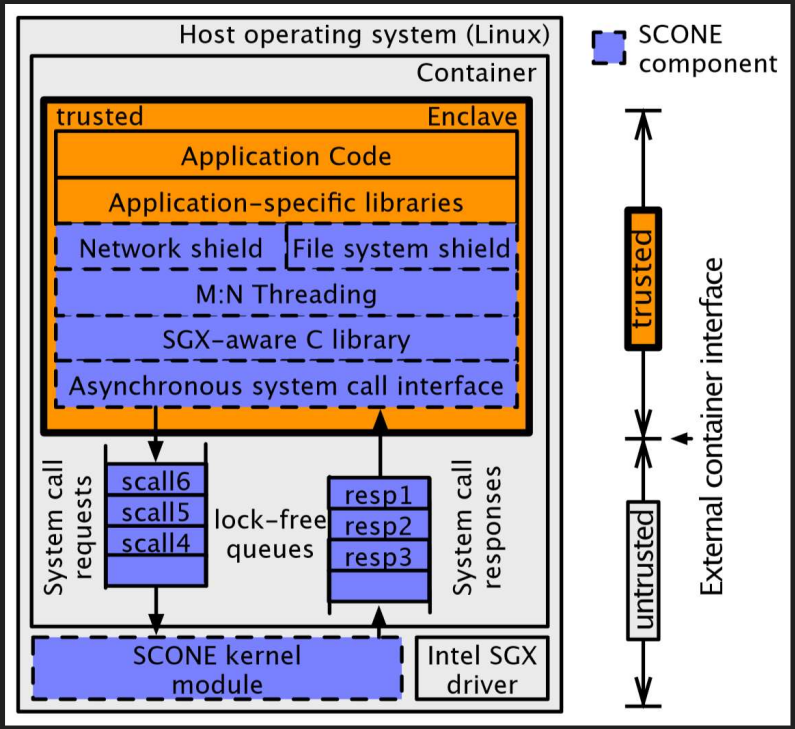
- sudo
- hardware
- entire software stack, including OS

Outside of scope:

- DoS attacks
- Side-channel attacks

DESIGN

SCONE ARCHITECTURE



INTERFACE SHIELDING

Shields focus on:

- preventing low level attacks
- ensuring confidentiality and integrity of shared data

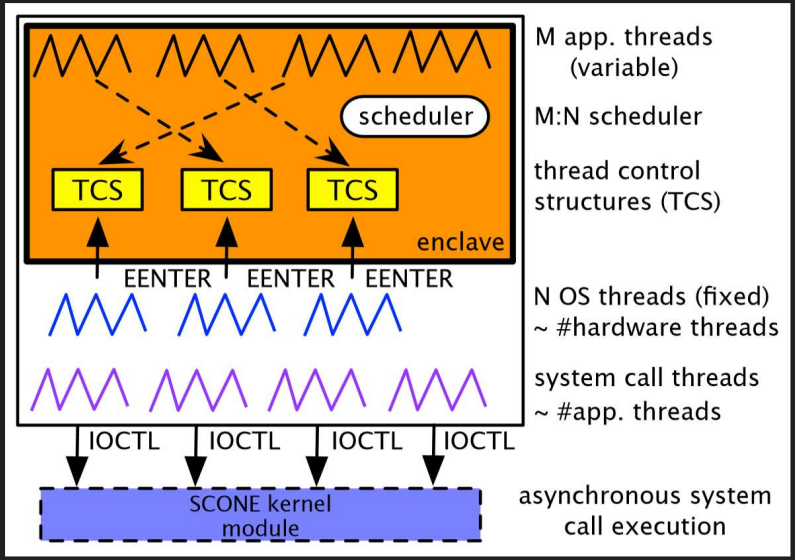
SCONE provides three kinds of shields:

- File system shield
- Network shield
- Console shield

THREADING MODEL

- M application threads get mapped to N OS threads
- OS threads that enter the enclave get handled by scheduler
- SCONE kernel module reserves hardware threads to queue syscalls

THREADING MODEL



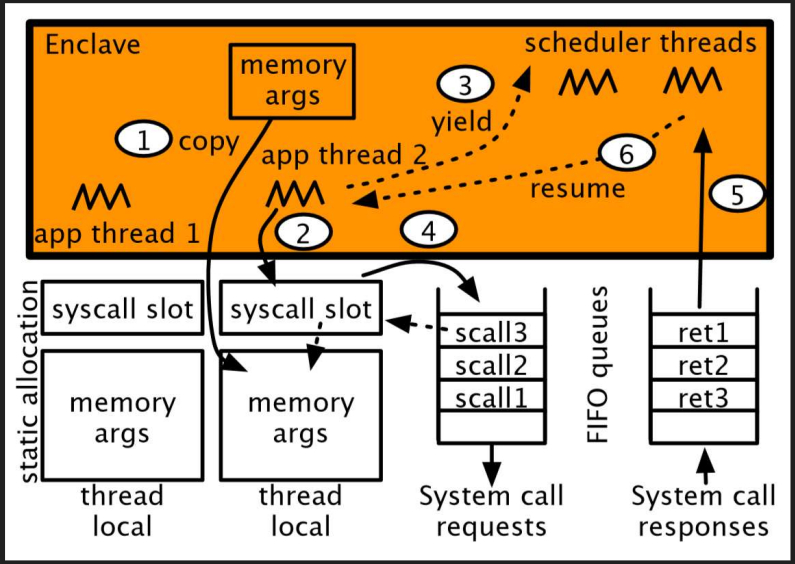
SYSTEM CALLS

- SGX can't execute syscalls directly, so we need helper functions
- Arguments must be copied to non-enclave memory and then be processed
- Transitions are expensive

Solution: **asynchronous syscall interface**

- Consists of request and response queue

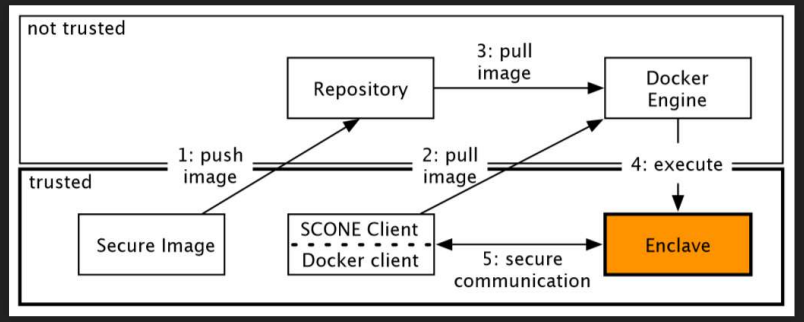
SYSTEM CALL FLOW



WORKFLOW IN DOCKER

- One container consists of one protected process
- Otherwise indistinguishable from regular container

WORKFLOW


not trusted
Repository
3: pull image
Docker Engine
1: push image
2: pull image
4: execute
trusted
Secure Image
SCONE Client
Docker client
5: secure communication
Enclave

BENCHMARK SUMMARY

APP BENCHMARK

- SCONE-async containers achieve almost native performance
- Single-thread applications don't perform well

FILE SYSTEM SHIELD

- Small datasets perform well
- Larger datasets drop to 35% throughput, worst case

SYSCALLS

- SCONE-async achieves almost native syscall frequency, further improvements possible

CONCLUSION

- SCONE TCB Size is 60-200%
- Average throughput is at least 60%, sometimes even better than native
- All we need is static recompilation and the kernel module

QUESTIONS

SOURCES

Research paper here
Intel SGX Documentation here
Slides available soon