Hardware Security

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Rootkit

Purpose

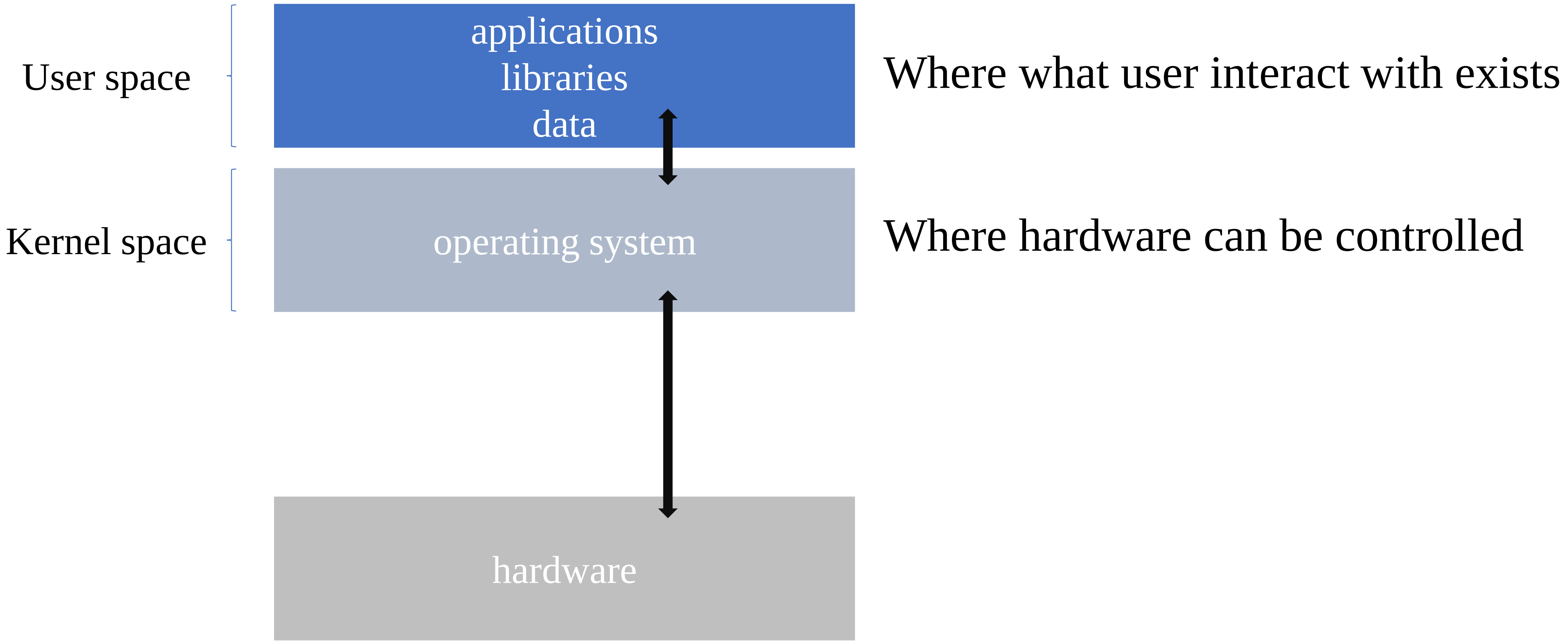
- Give attacker a permanent root access to a system
- Hide its presence
  - Hide from filesystem
  - Hide its activity
  - etc…
- Steal information
- Allow remote code execution

Typical attacker steps

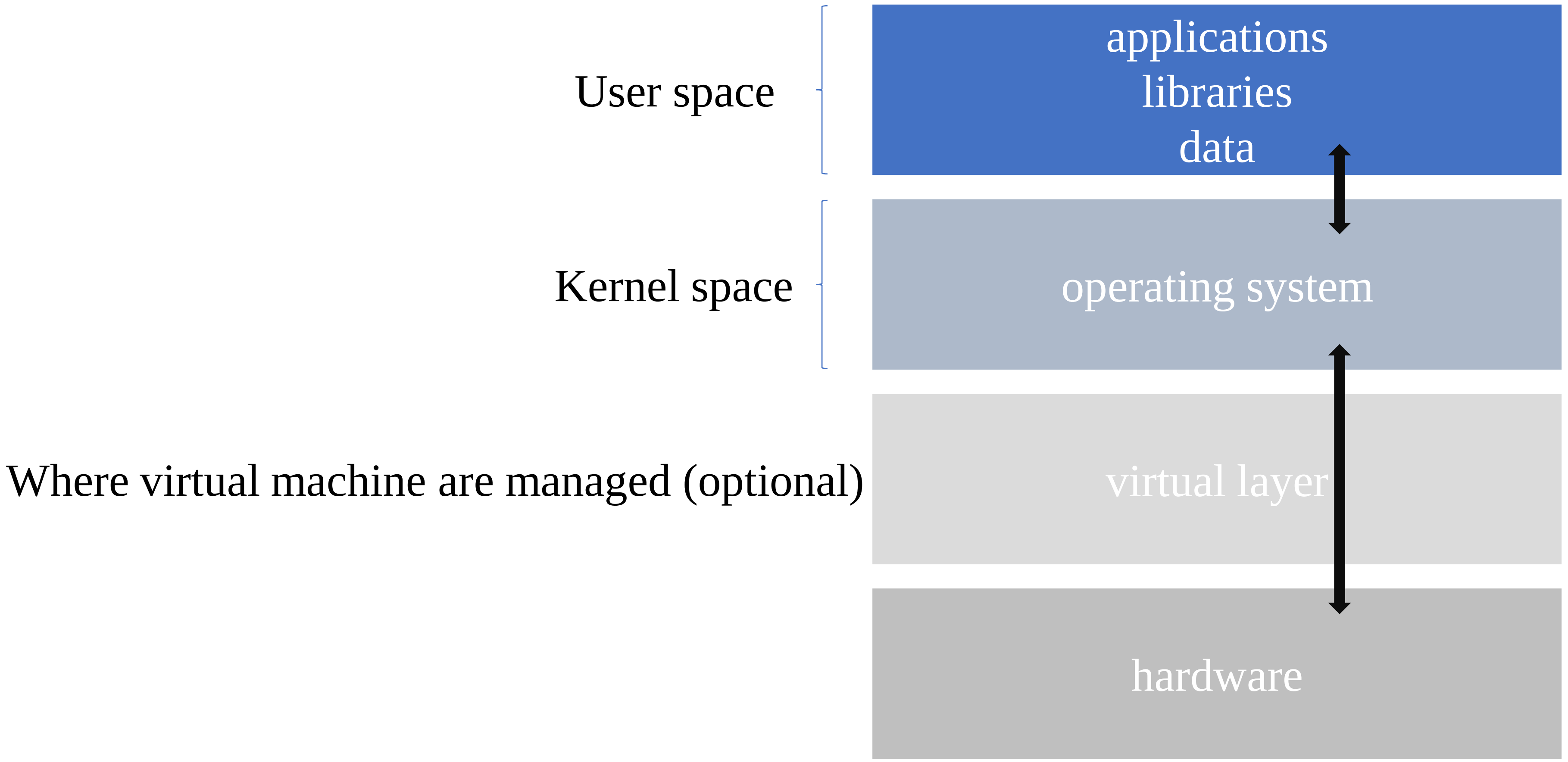
- Initial intrusion (e.g. exploit remote execution)
- Open remote access (e.g. reverse shell)
- Privilege escalation (e.g. see Lecture 1)
- Download the malicious payload (our rootkit)
- Install rootkit
- Perform malicious action on command
  - DDOS
  - Steal data
  - etc…

Kernel rootkit

Rootkit high-level understanding



Rootkit high-level understanding



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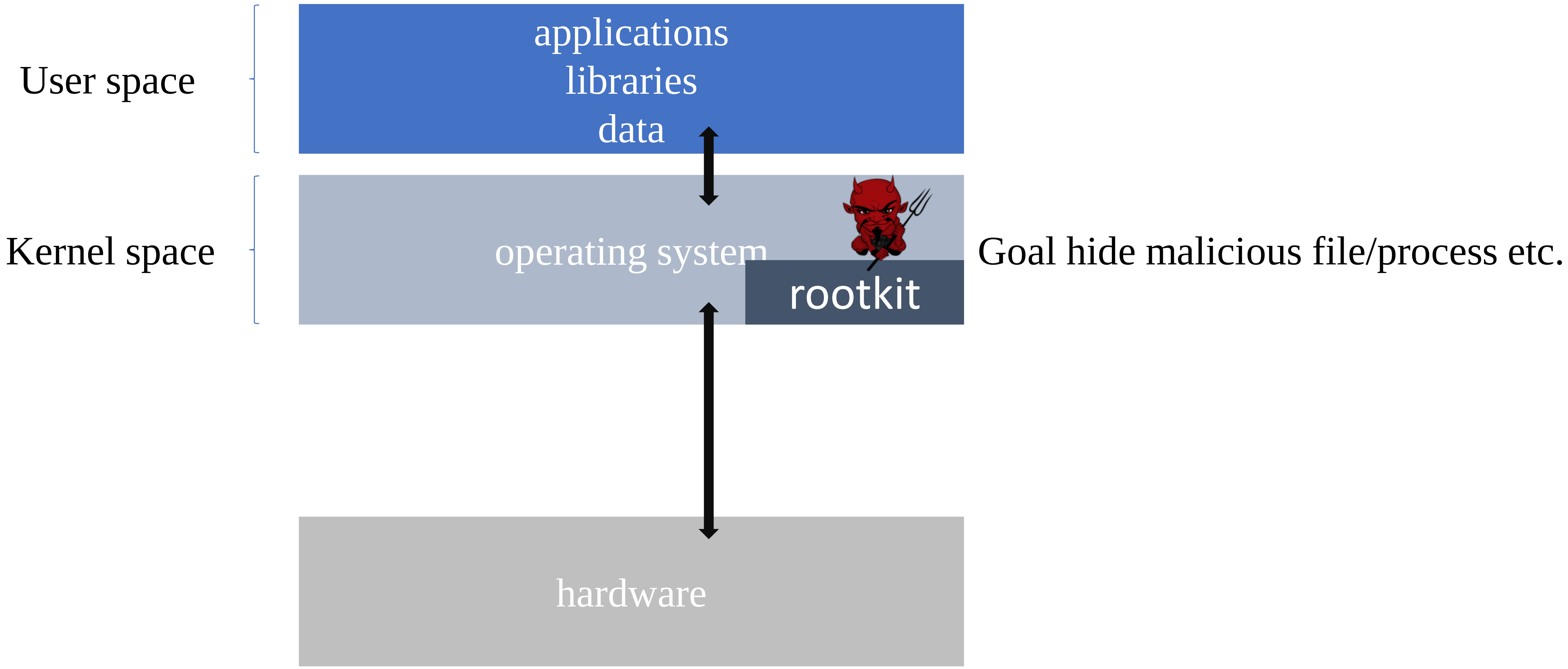

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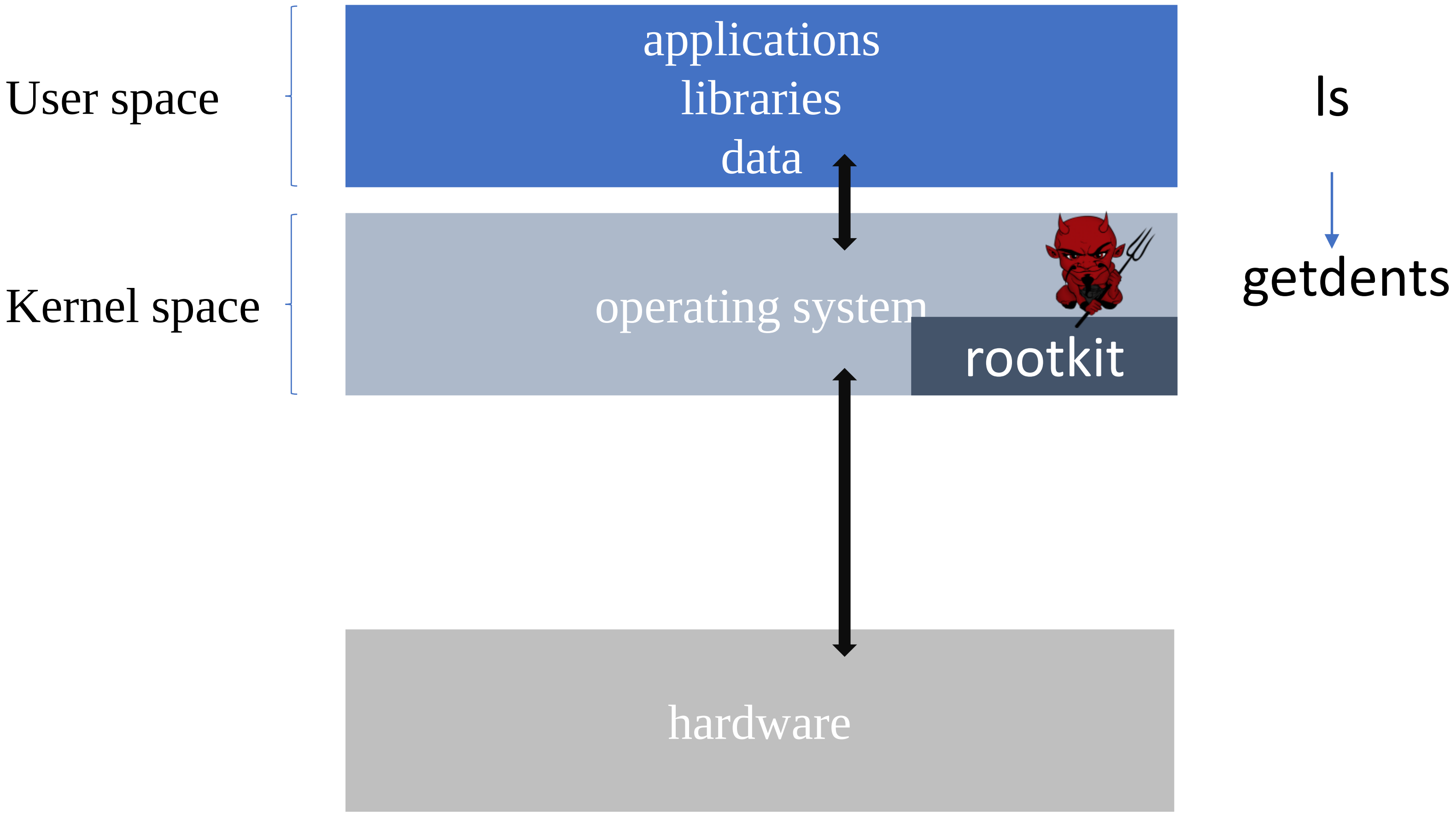

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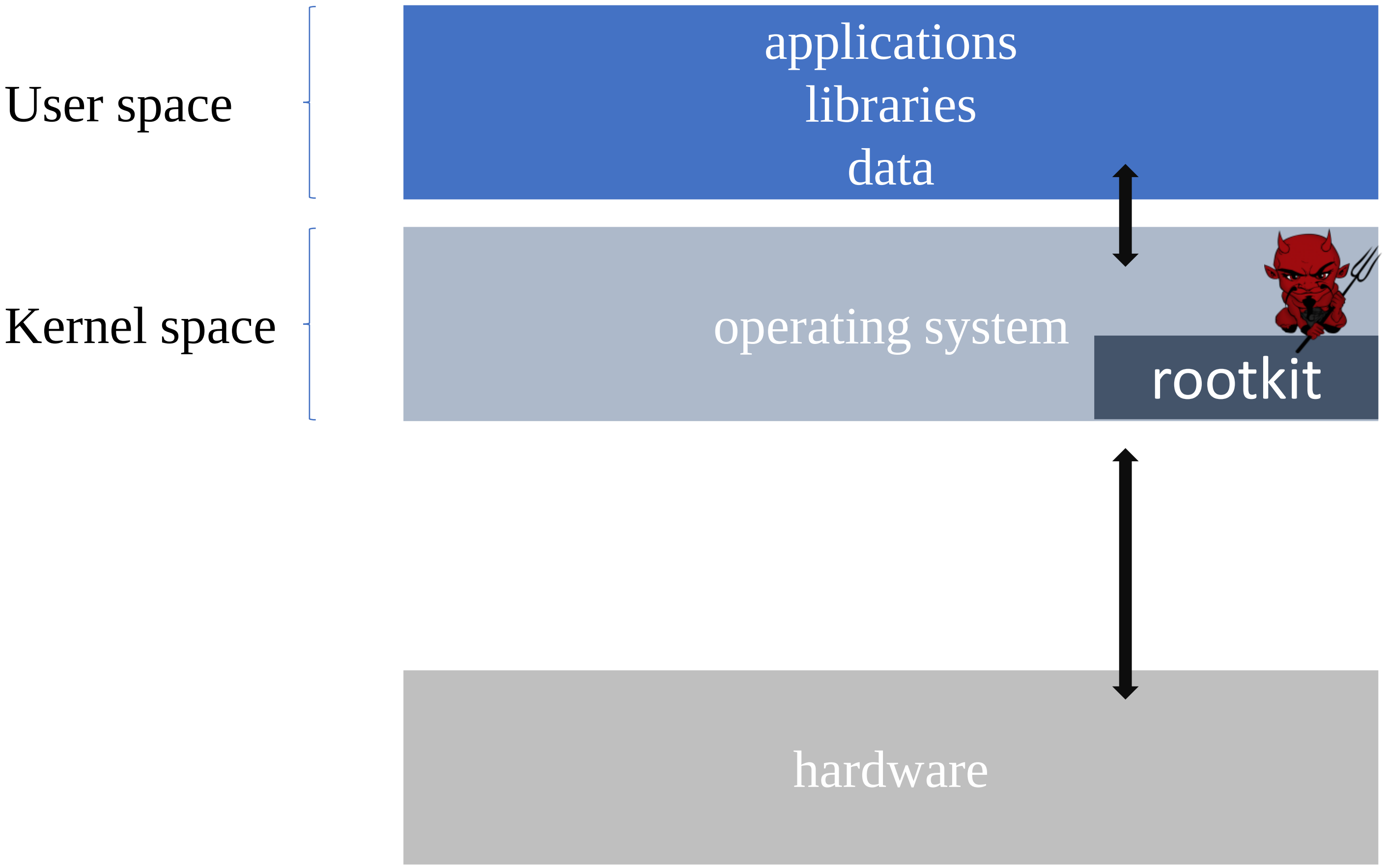


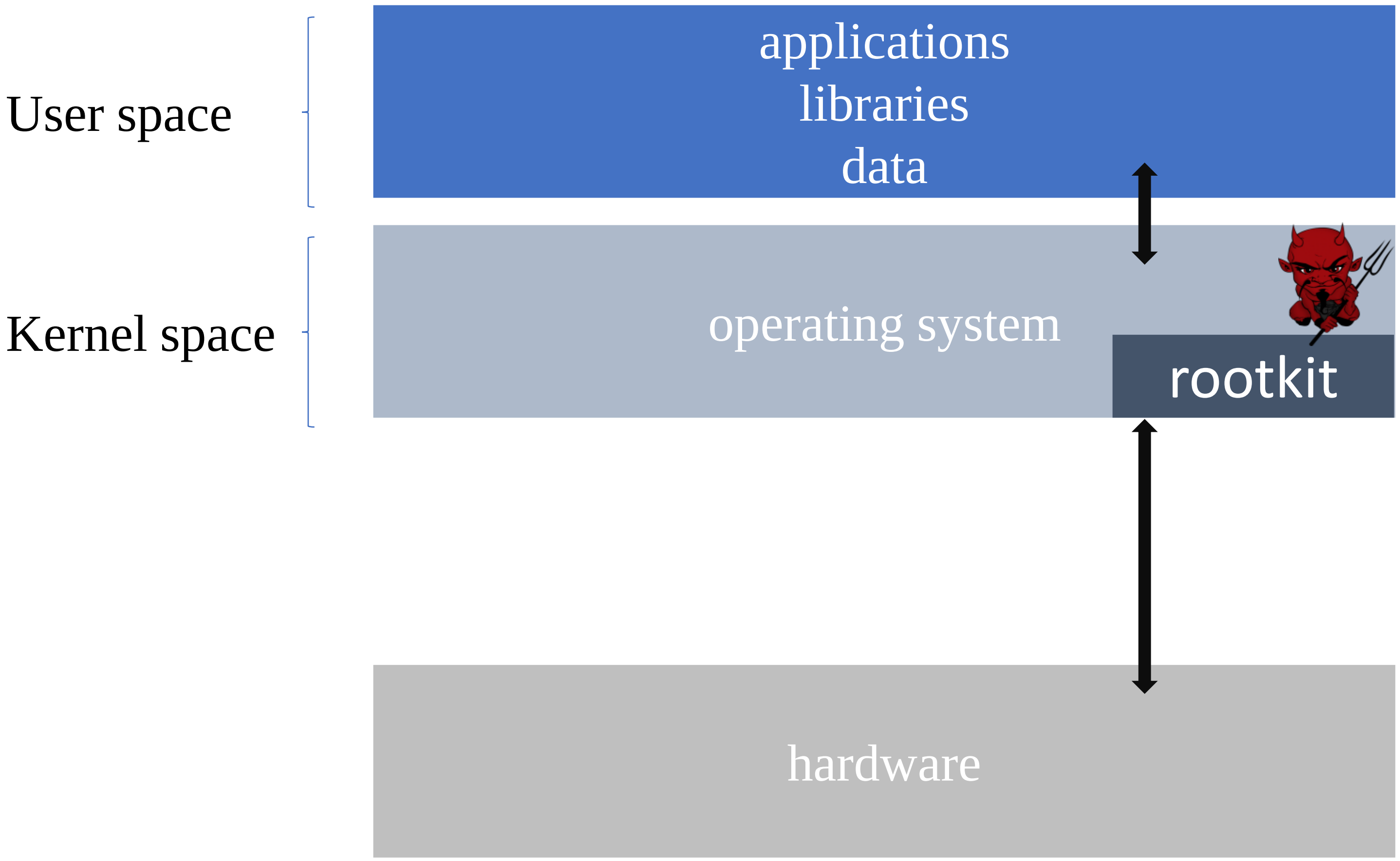
ls

getdents

modify returned value to exclude

../malicious/

Rootkit high-level understanding



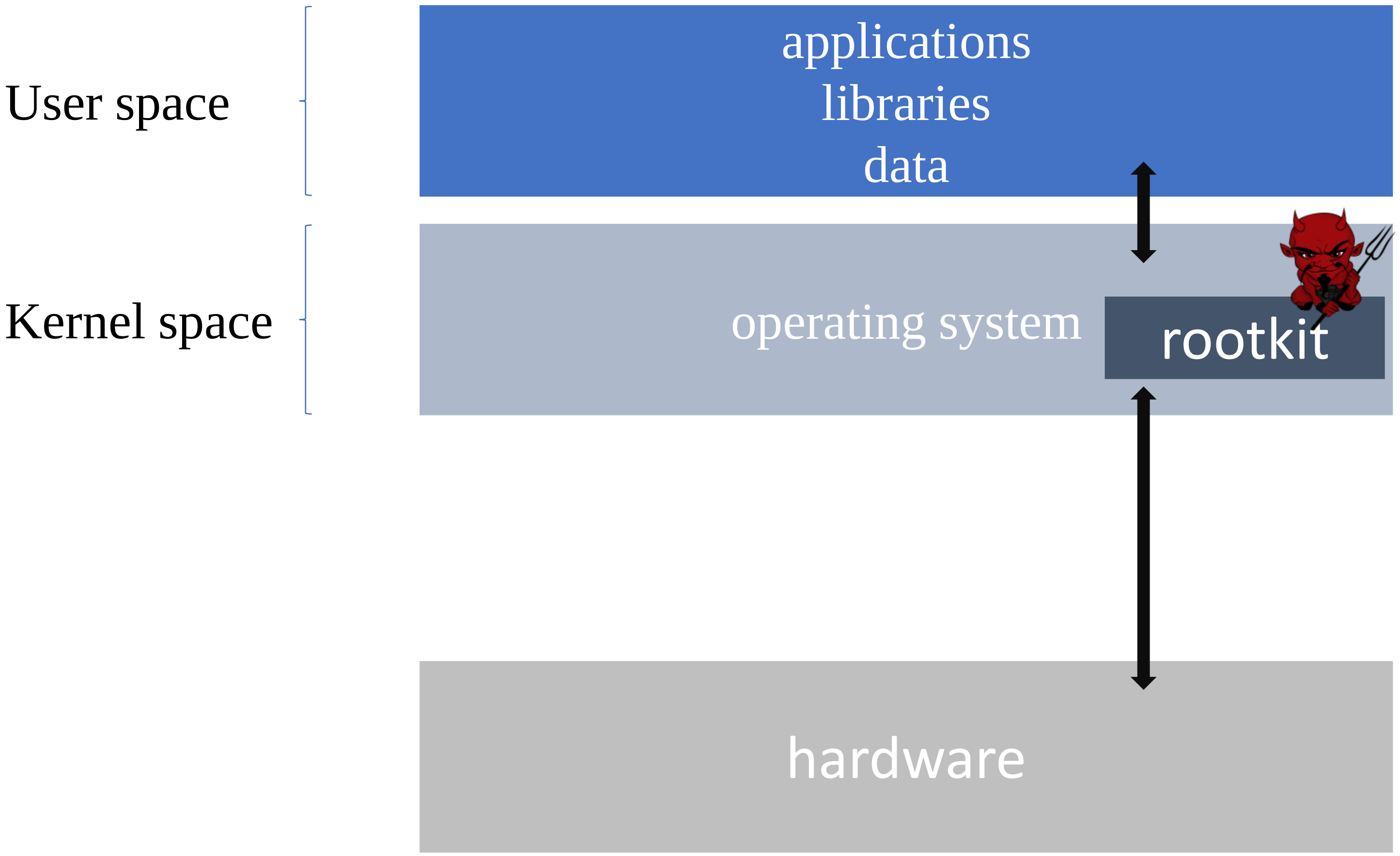
Modify the behaviour of anything that could reveal malware presence, e.g.:

- *ls*
- *ps*
- *lsmod*
- etc…

Give an easy mean to obtain root privileges, e.g.:

- modify fork behaviour

Rootkit high-level understanding



Roughly three techniques

- Modify the kernel code;
- "Hooking" modify where certain functions point to;
- Modify data structure (e.g. active process list)

Types of rootkit

- Application rootkit
- Kernel rootkit
- Virtualized rootkit
- Bootloader rootkit
- Hardware & firmware rootkit

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They can be prevented/detected by going (at least) one layer down

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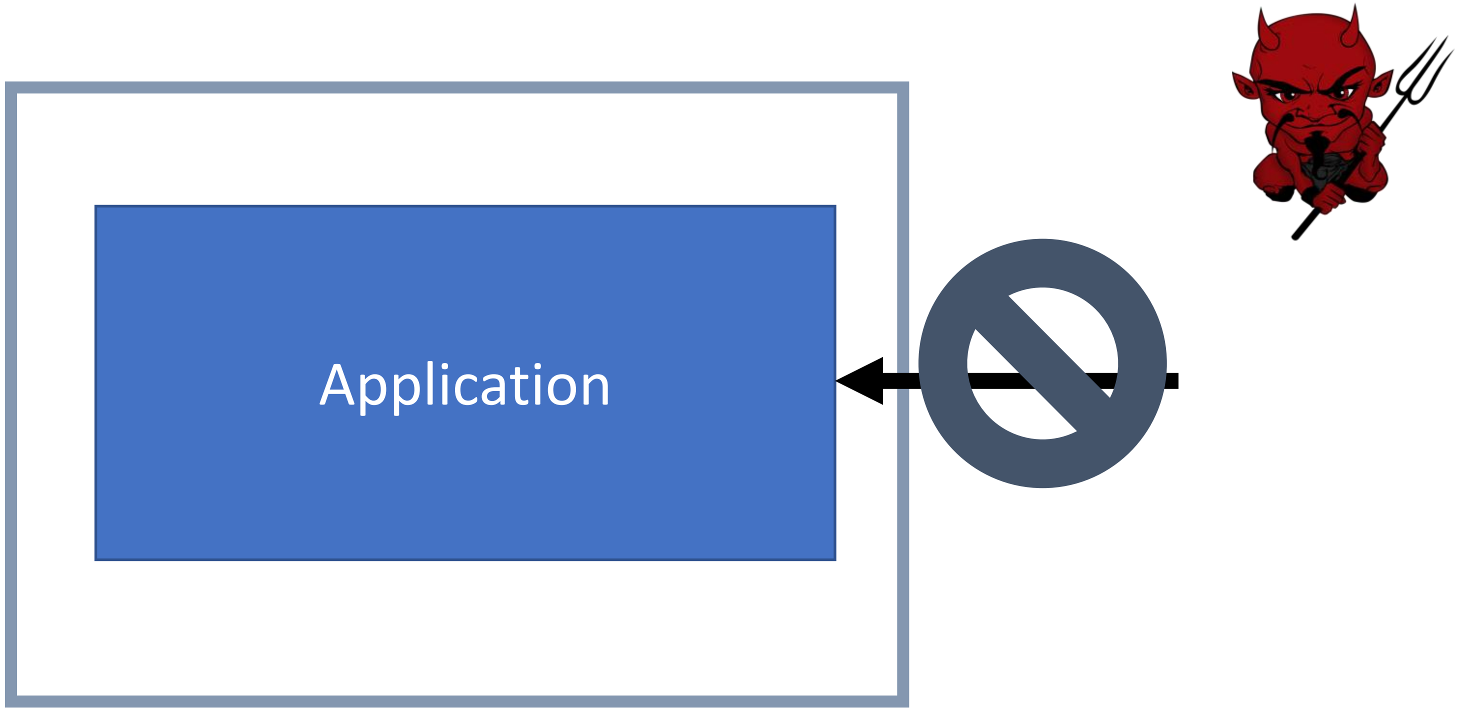
Trusted Computing Base

Trusted Computing Base (TCB)

- What part of the system do I need to trust in order to achieve my objective



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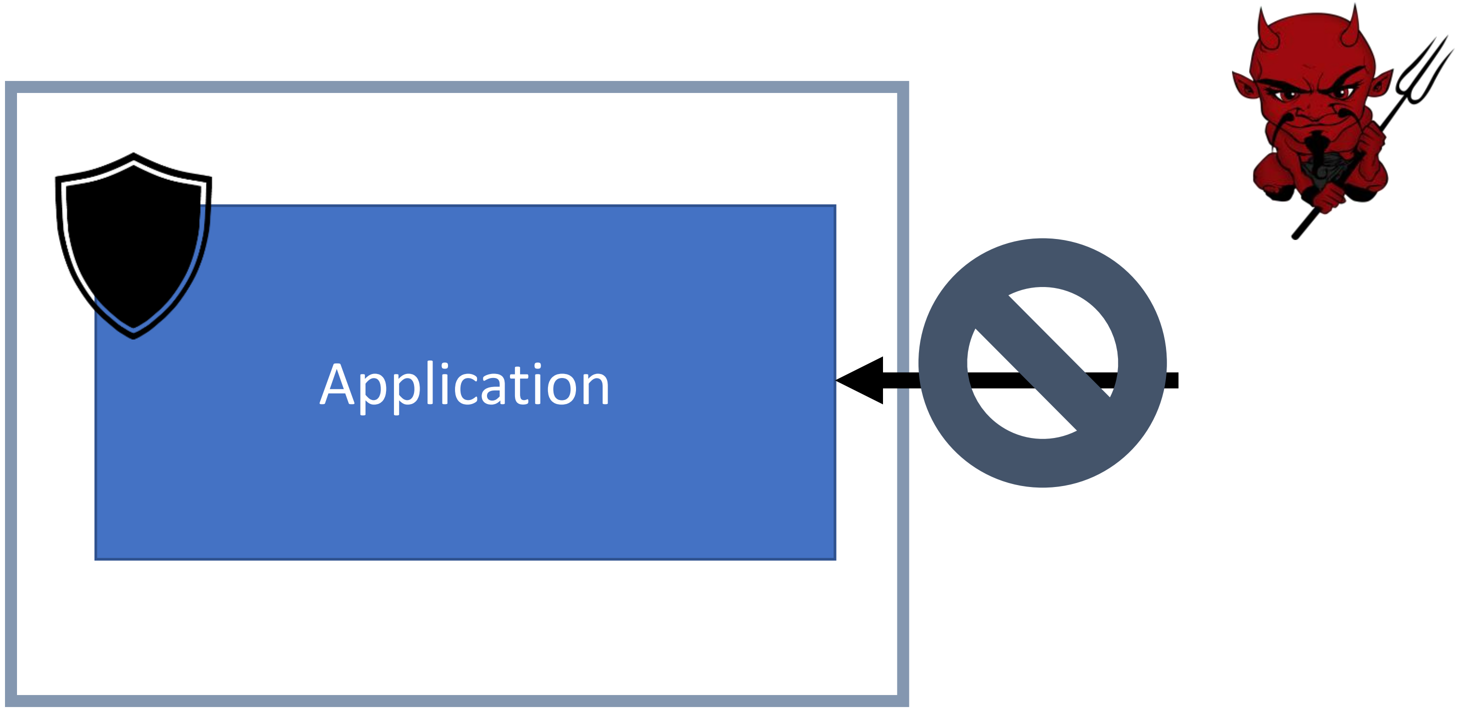

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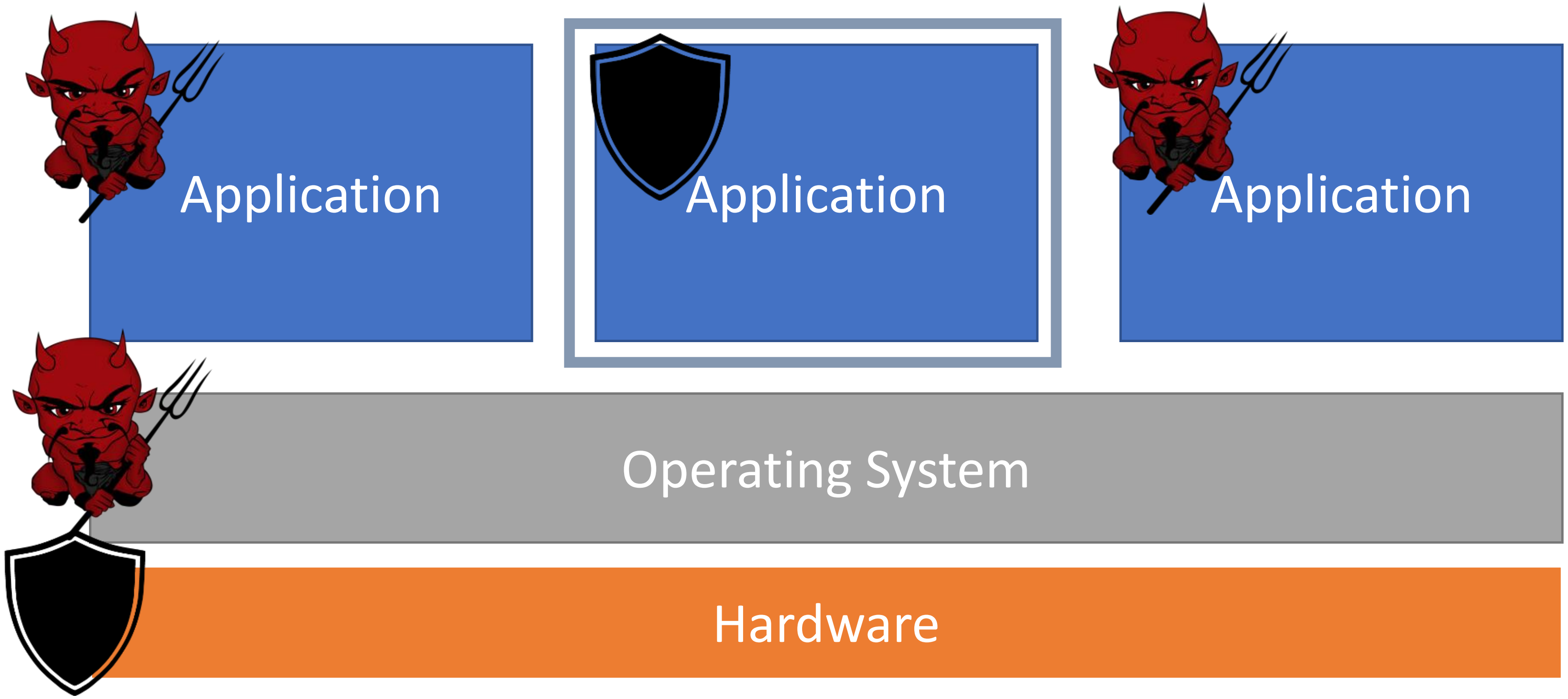

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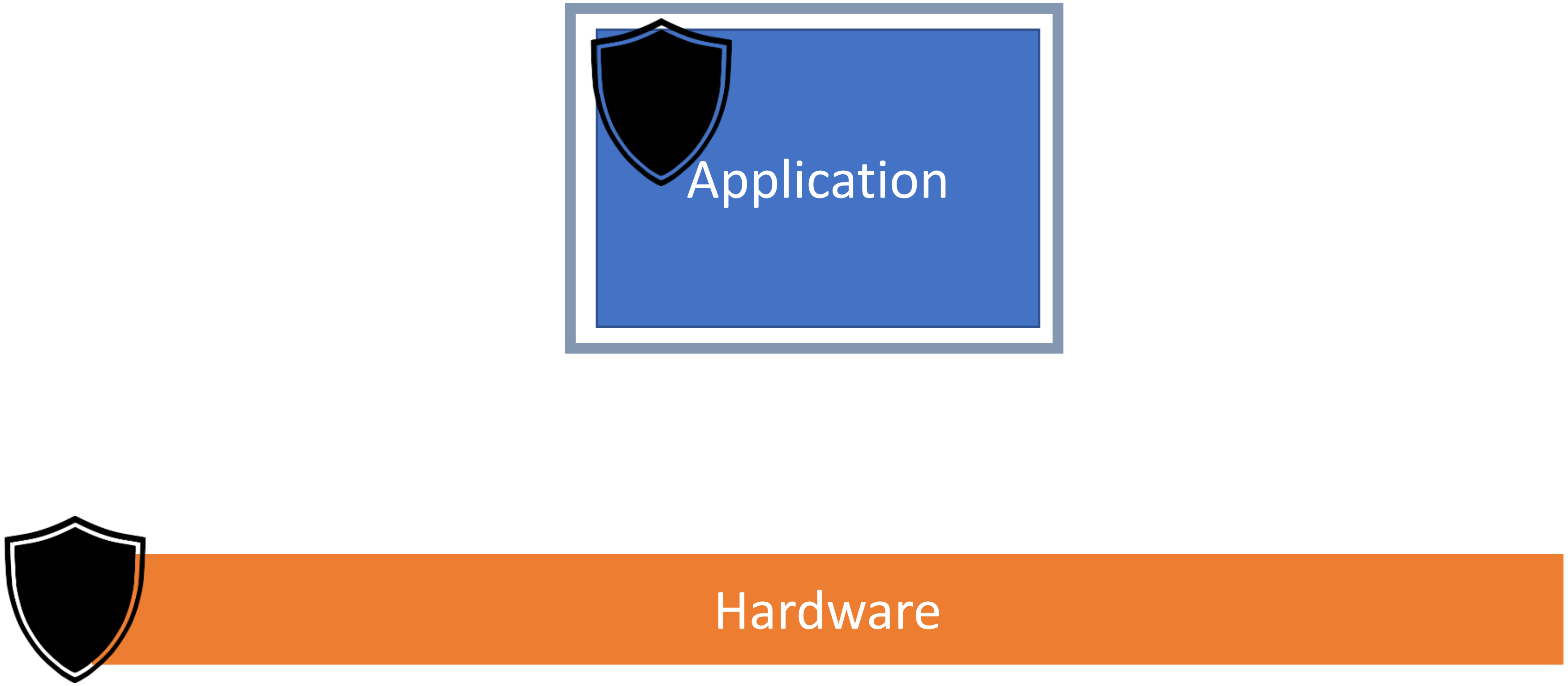

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Trusted Platform Module

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TPM (Trusted Platform Module)

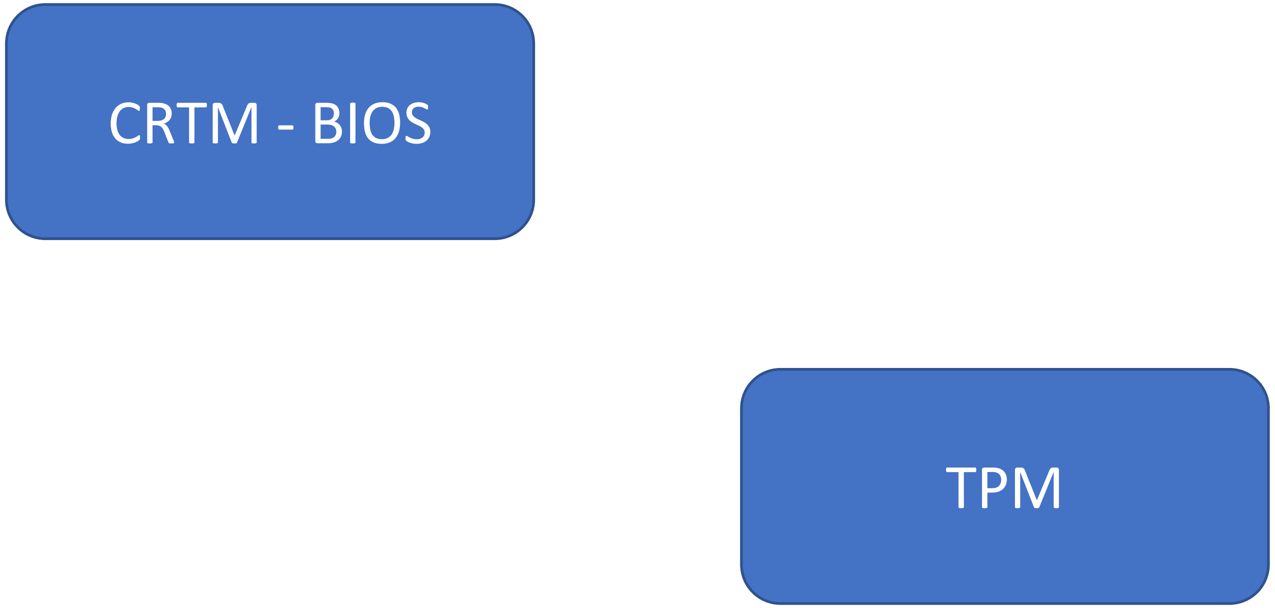
- Trusted Computing Group
  - Microsoft, Intel, IBM etc…
- Promoting standard for more trusted computing
  - Additional chip on the motherboard
  - … called TPM
- Used for
  - Disk encryption
  - **System Integrity**
  - Password protection
  - … and more

Requirements

- We can achieve trust if we can verify the system has booted correctly
- We assume the PC hardware has not been modified
  - Key function is in the hardware TPM
- We need to monitor the boot process
  - Initial boot measure by the “Core Root of Trust” (CRTM)
  - Hash the BIOS, store results in TPM, start the BIOS
  - BIOS do its job, load the next stage, hash it store in TPM etc…

Core Root of Trust : The first piece of BIOS code that executes on the main processor during the boot process. On a system with a Trusted Platform Module the CRTM is implicitly trusted to bootstrap the process of building a measurement chain for subsequent attestation of other firmware and software that is executed on the computer system.

Authenticated Boot



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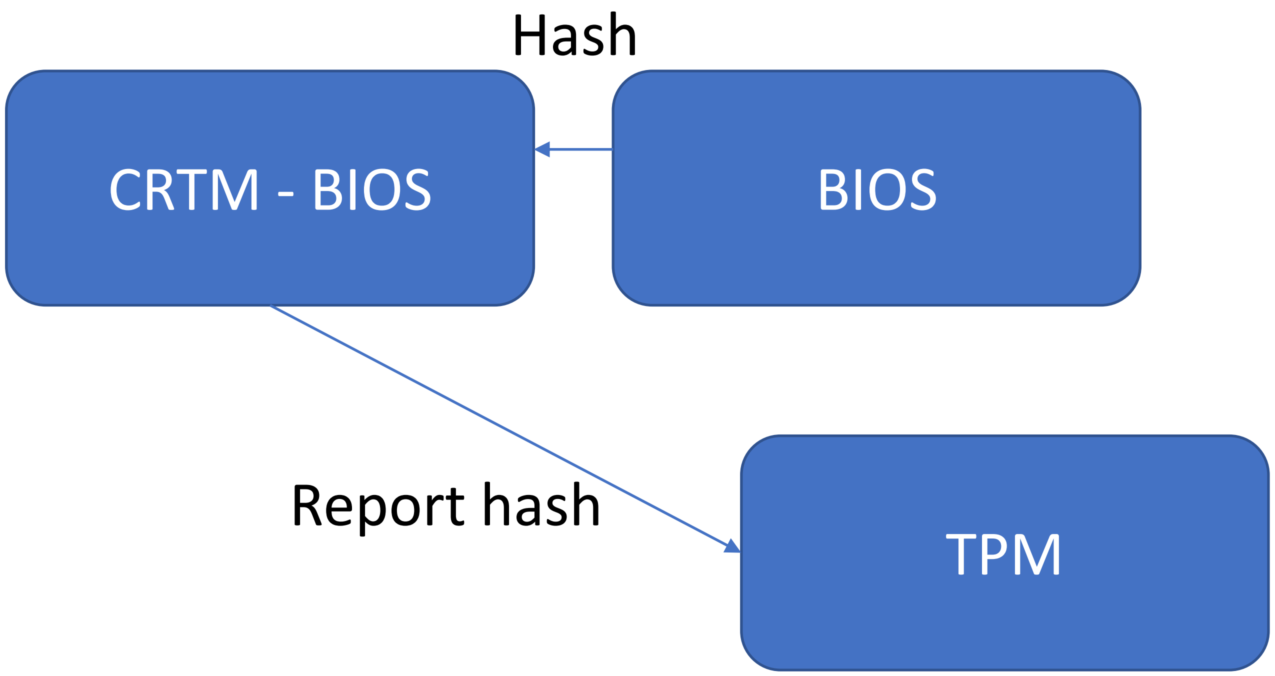

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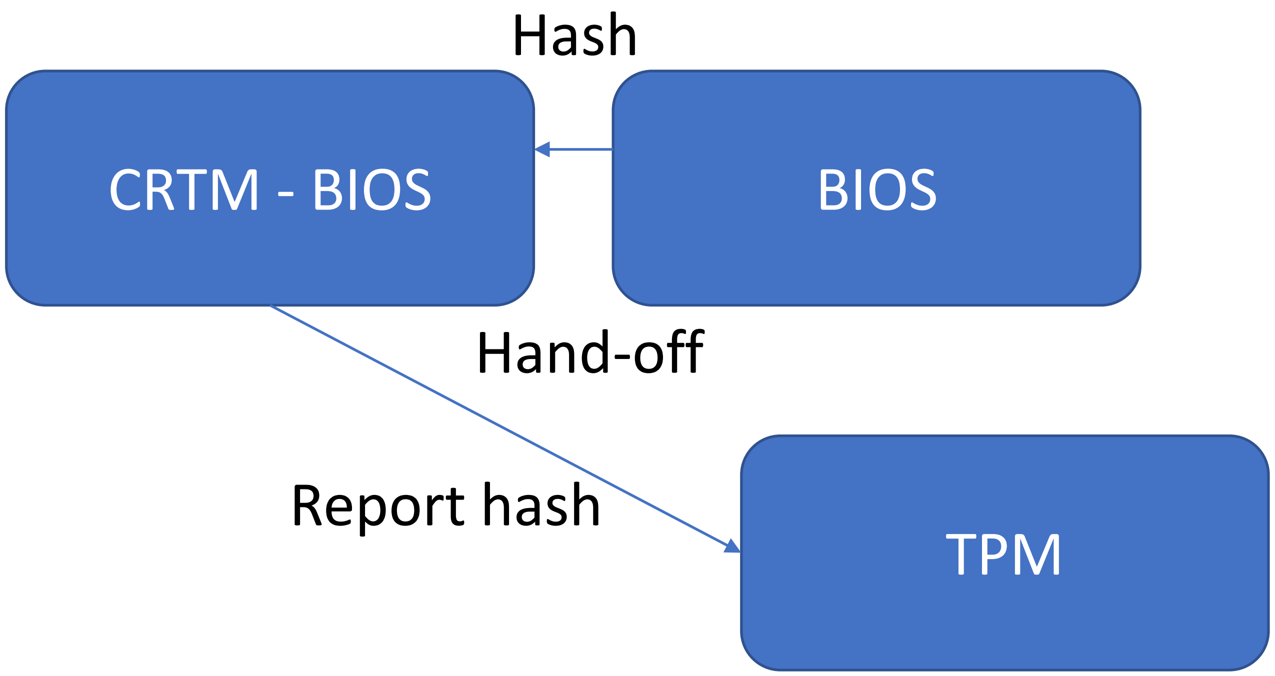

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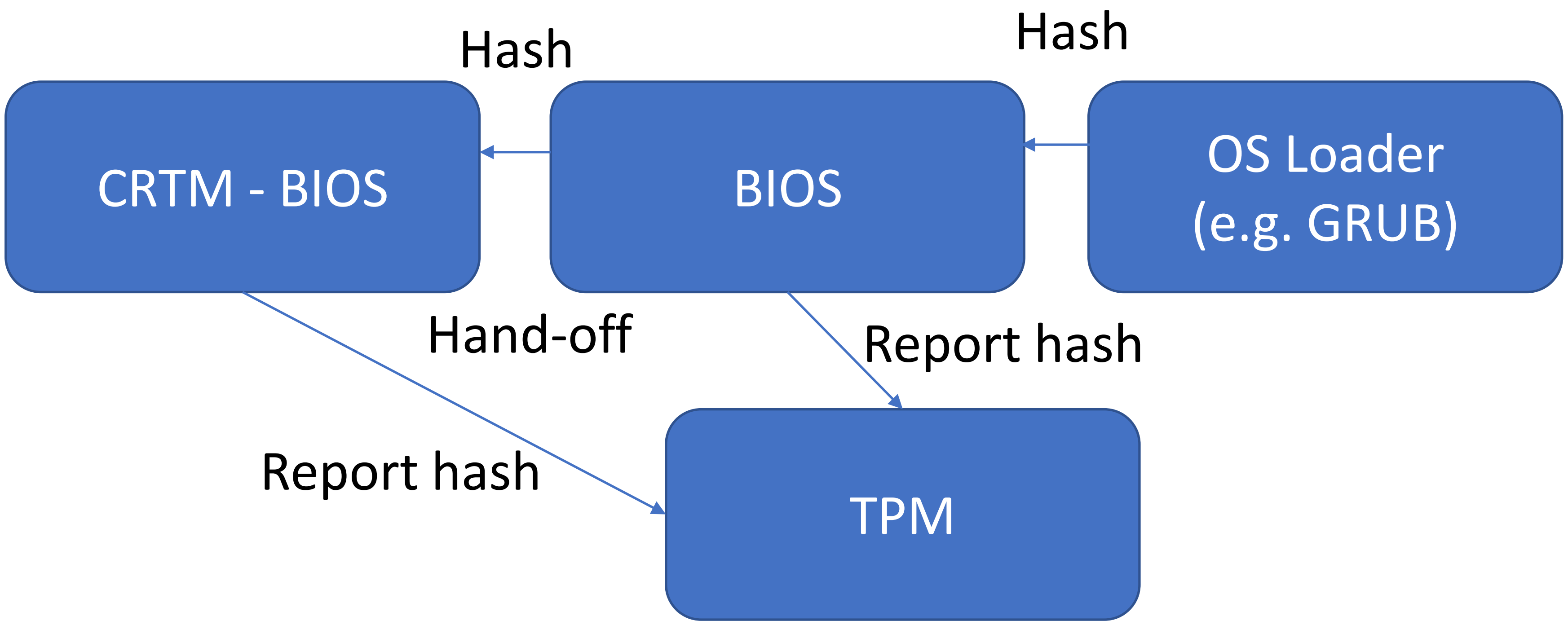

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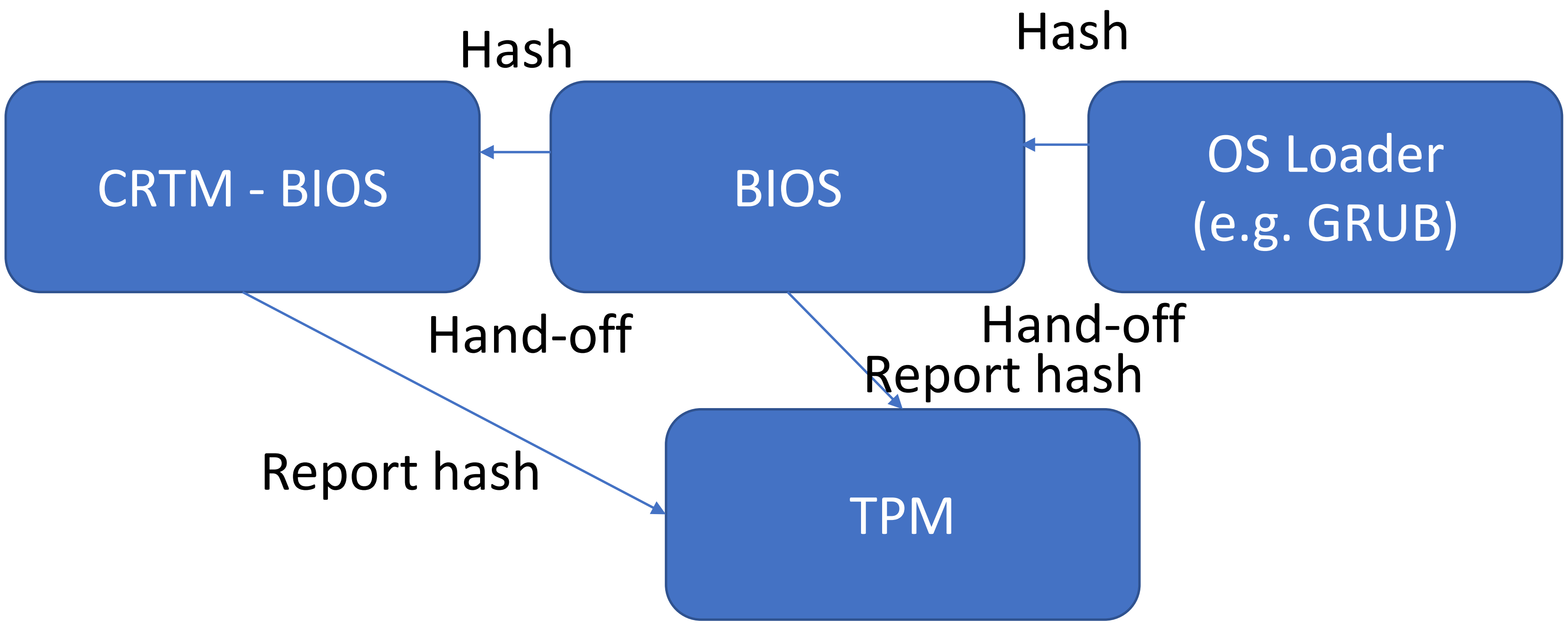

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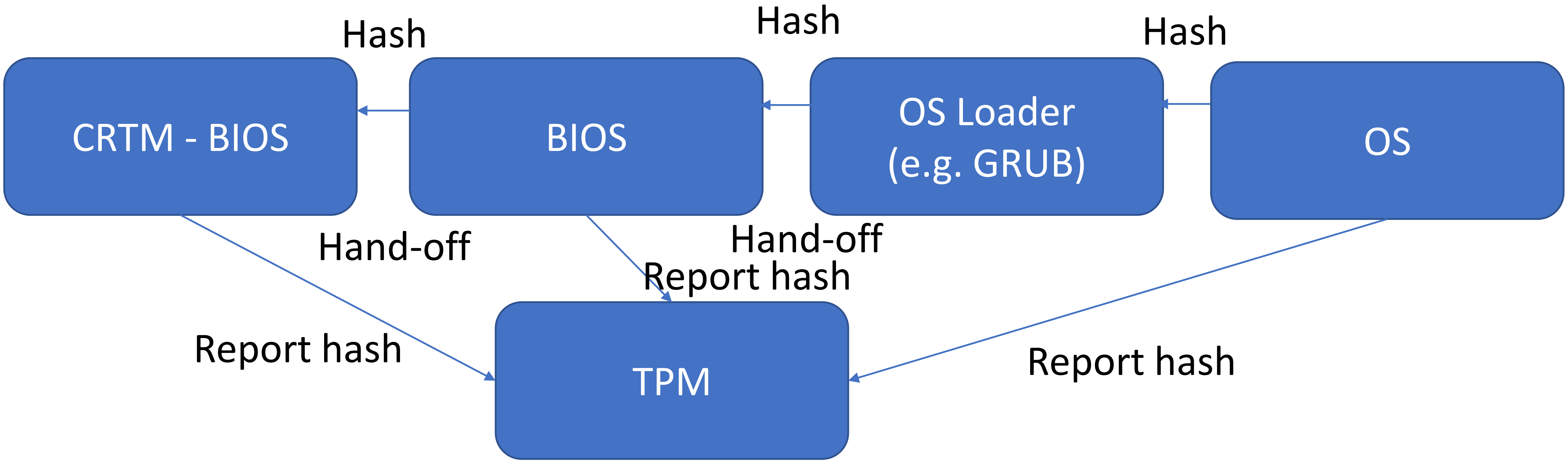
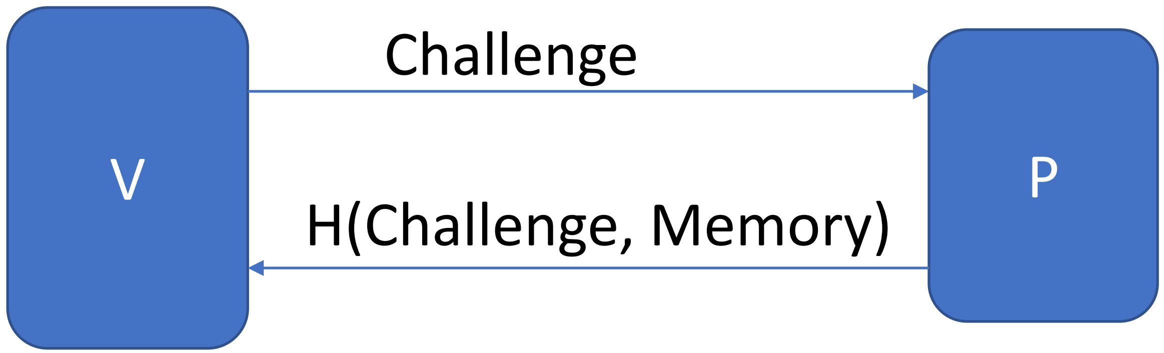


TPM registers

- Platform configuration registers (PCRs)
  - Used to store platform integrity metrics
- A PCR hold a summary of a series of value
  - Not the entire chain of hash
  - The chain can be infinite
- A PCR register is extended
  - PCR = HASH(PCR | new measurement)
  - Shielded TPM location (i.e. cannot be modified from outside)
  - Measurement are provided by software

Remote attestation

- Untrusted prover “P” and trusted verifier V
- V knows P expected memory content
- V send challenge with a nonce to P
- P compute a measurement
- V verify the measurement



What remote attestation tells you

Positive result

- Correct memory content
- Good device

Negative result

- Malfunctioning device
- Malicious device

No response

- Malfunctioning device
- Malicious device

TPM and Remote Attestation

- PCR cannot be modified
  - Only reset at reboot
- TPM contains a key used to sign the attestation
- Verifier
  - Verify the TPM certificate/key
  - Verify the PCRs
- Attestation
  - PCRs value
  - sign(PCRs, challenge[nonce])

TPM and Remote Attestation

- You need not to stop at the OS
  - Can attest kernel modules (e.g. drivers)
  - Applications?
  - Configurations?
  - Scripts?

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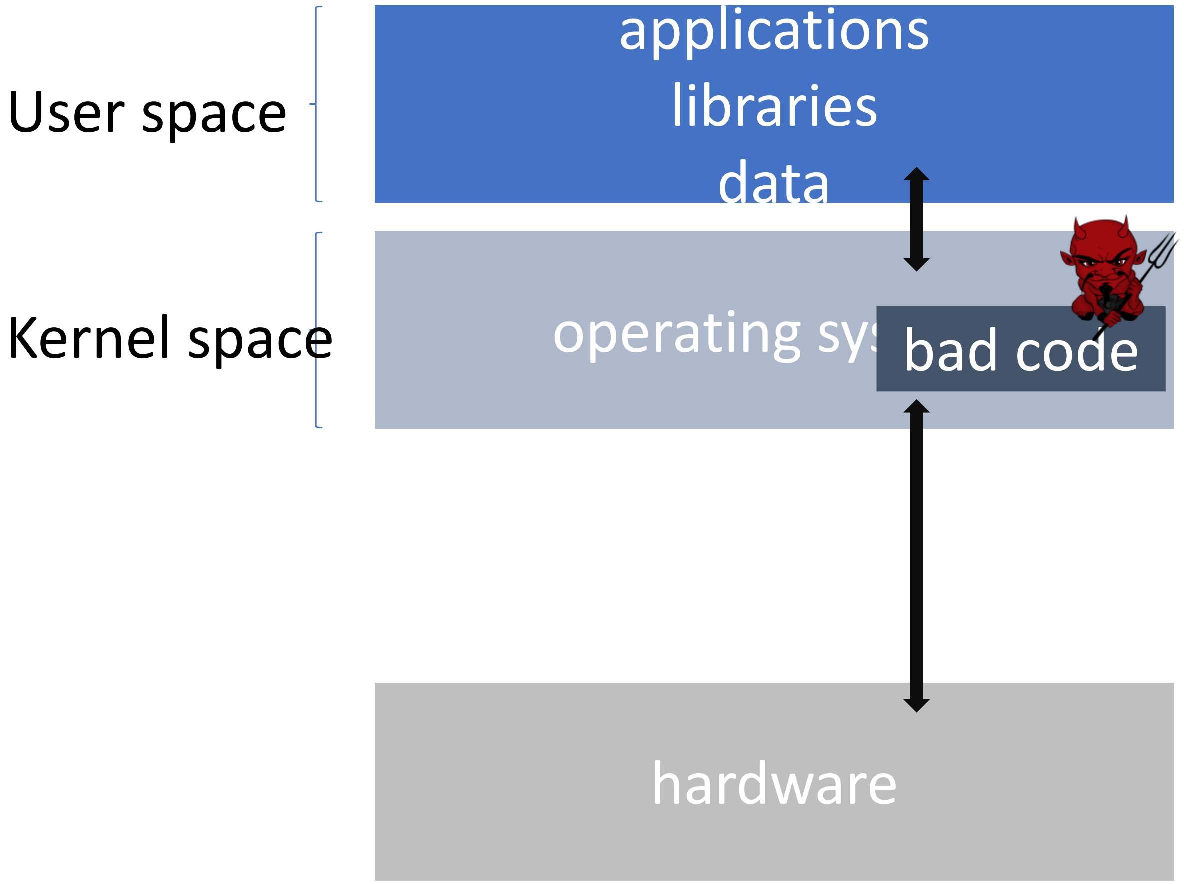
Intel SGX

Rootkit high-level understanding



Motivation

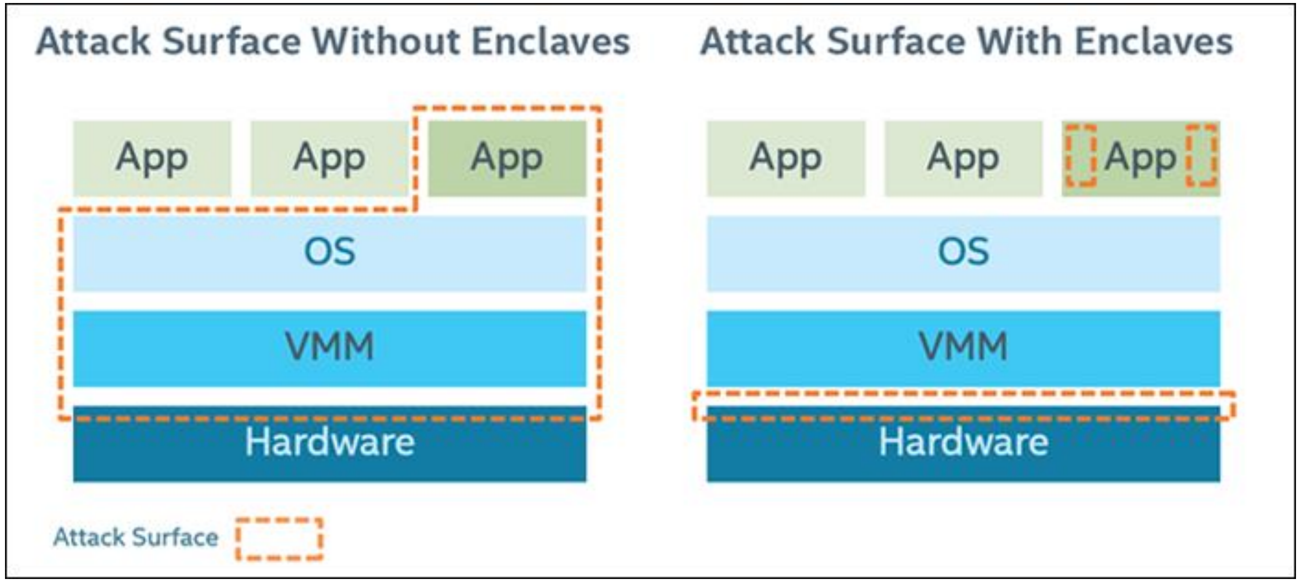
- An attacker can compromise
  - User space
  - Operating Systems
  - Even the hardware!
- What can we do?

Execute code in its own secure enclave!

SGX Hardware supported enclave

Idea: run an application within some isolation unit so it cannot be affected by the OS

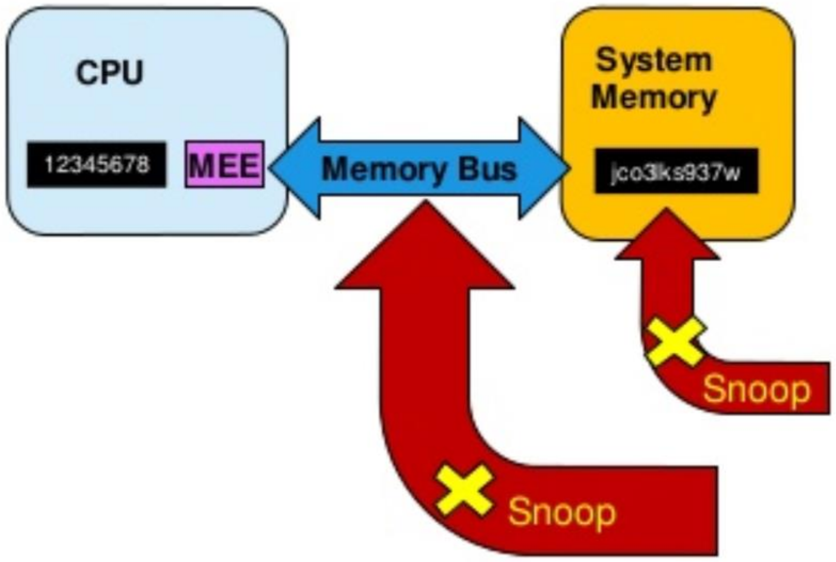
- Do not trust the OS or the VMM/hypervisor
- only need to trust the hardware
- reduce attack surface



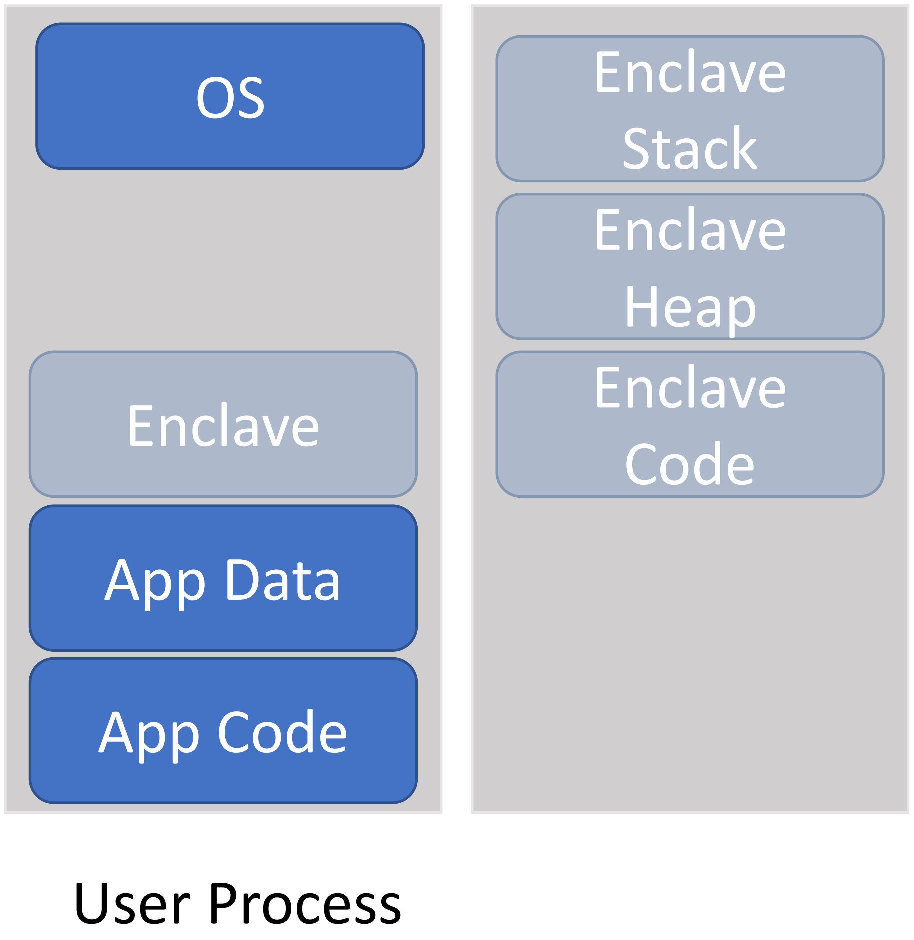
SGX preventing memory snooping attack

- Security boundary is CPU package
- Data unencrypted inside the CPU
- Data outside the CPU is encrypted
- External memory reads and bus snooping only see encrypted data

* MEE: SGX Memory Encryption Engine



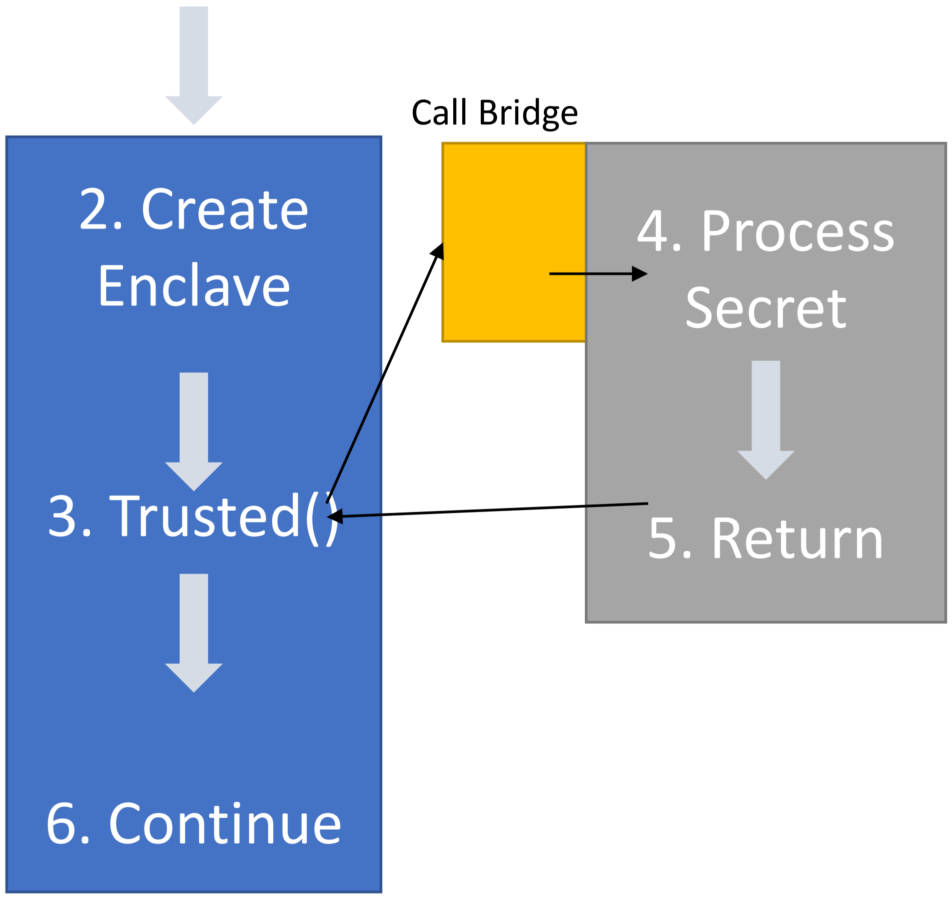
SGX Programming environment



- Enclave has its own code and data
  - Provide confidentiality
  - Provide integrity
- Controlled entry point
  - Can enter enclave code only at specific point
  - Enclave execution takes over

SGX Application Flow

1. Define and partition application into trusted and untrusted part
2. App create enclave
3. Trusted function is called
4. Code in enclave process some secret
5. Trusted function returns
6. App continue as normal



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ARM Trustzone

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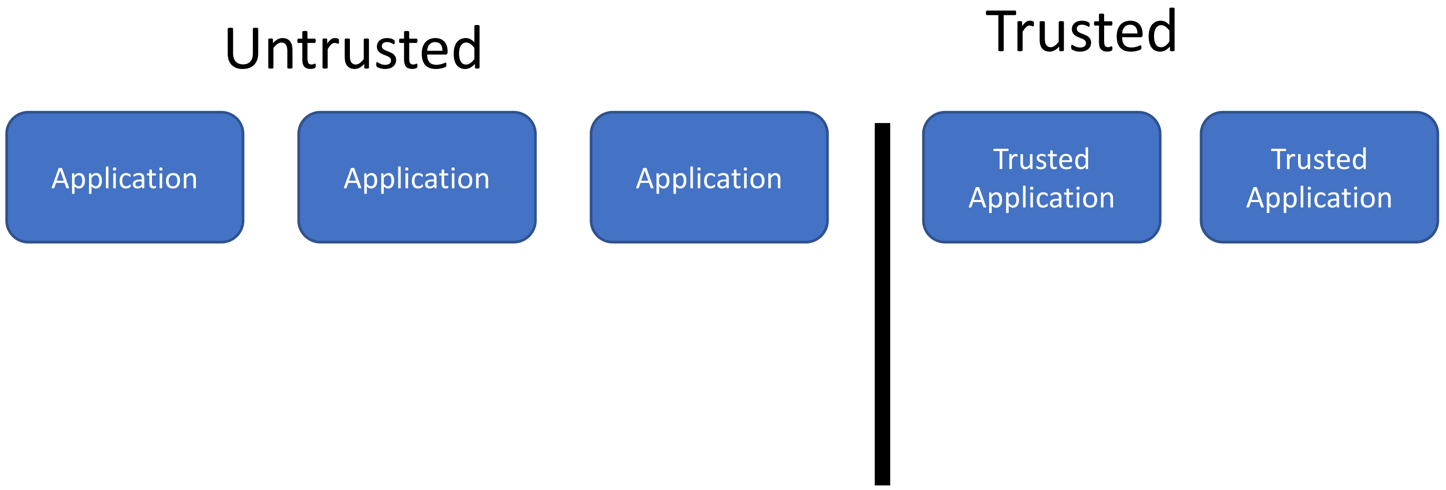

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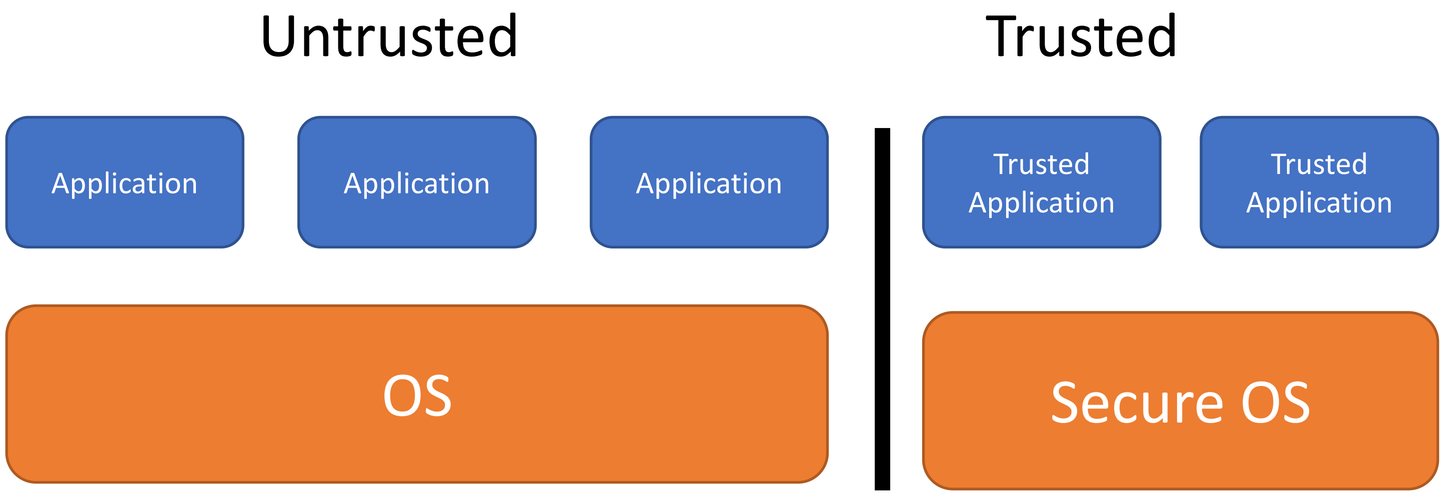

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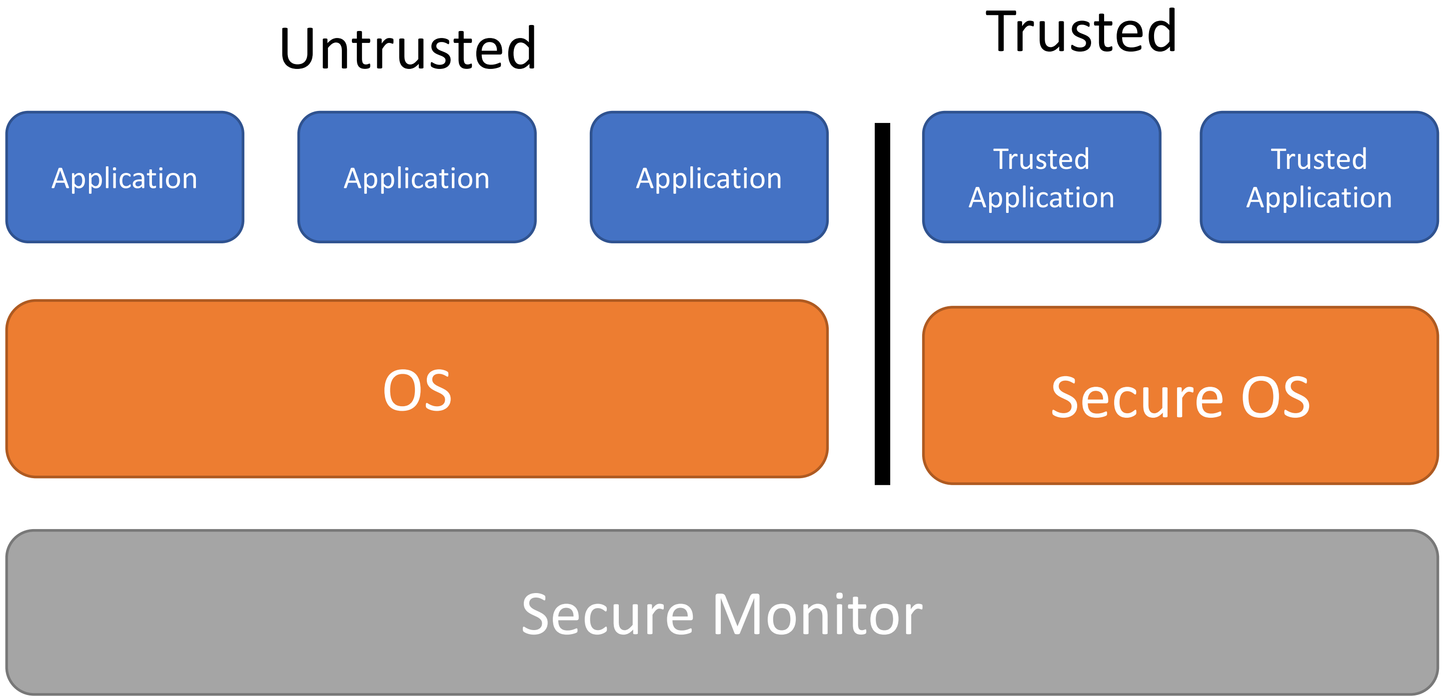
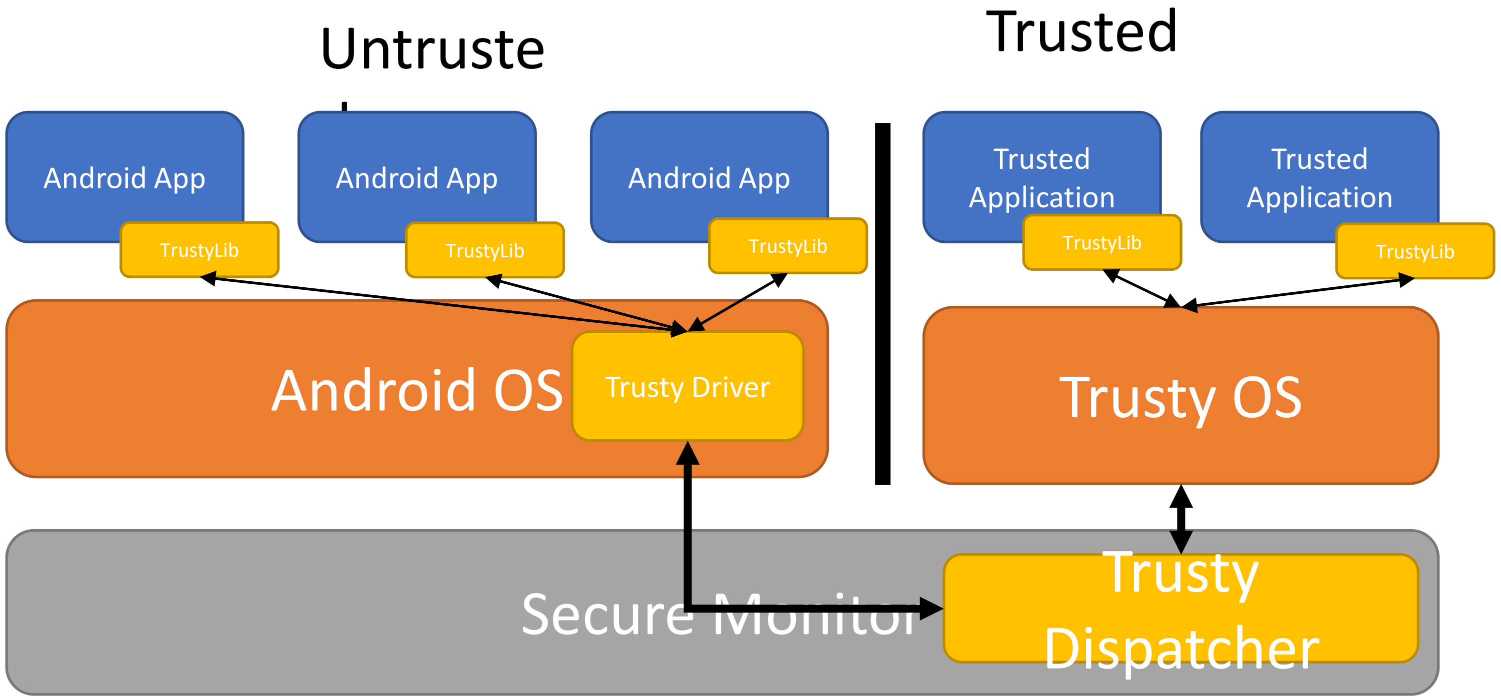


Own processor
Own RAM address
Own devices
etc…

ARM Trustzone



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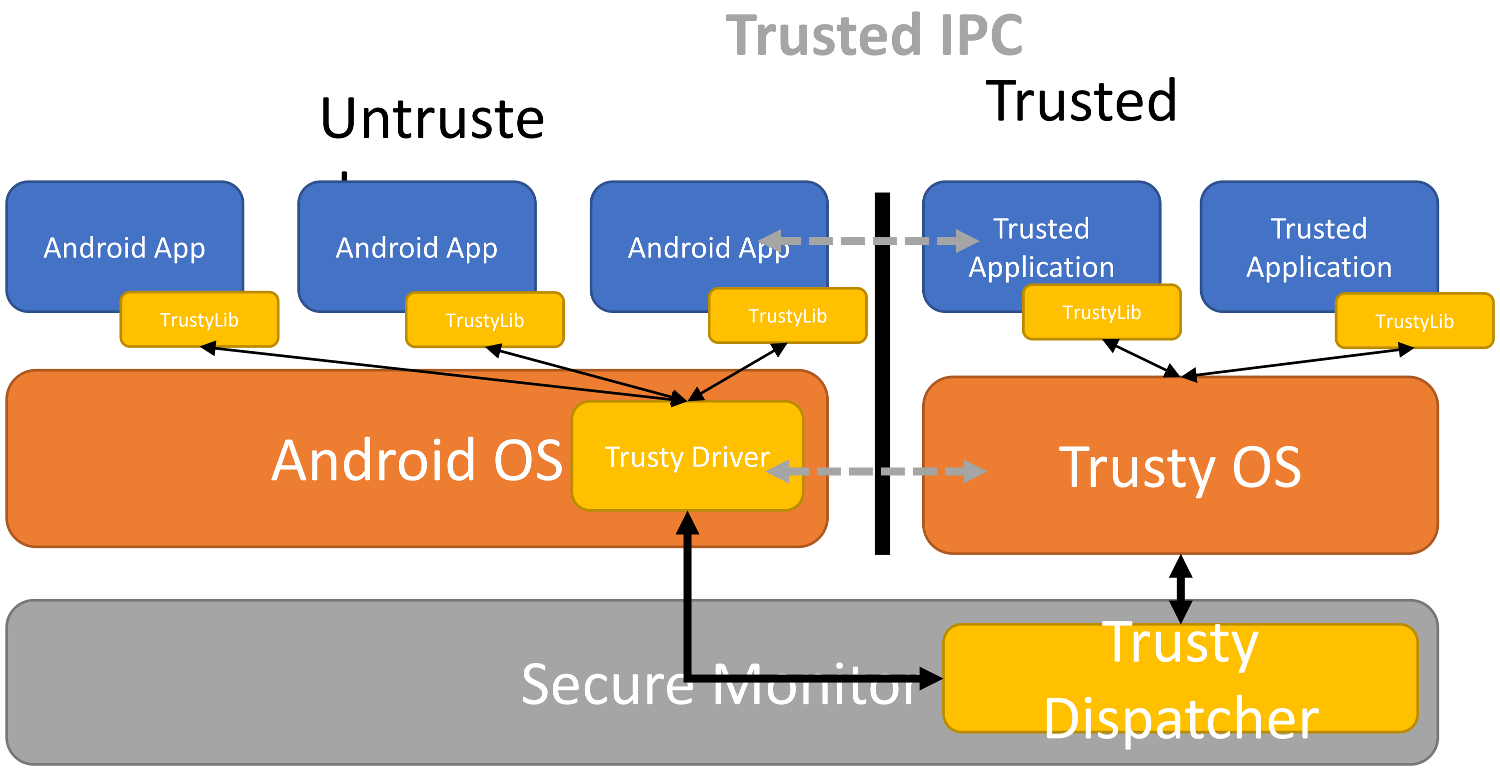


Trusted IPC example

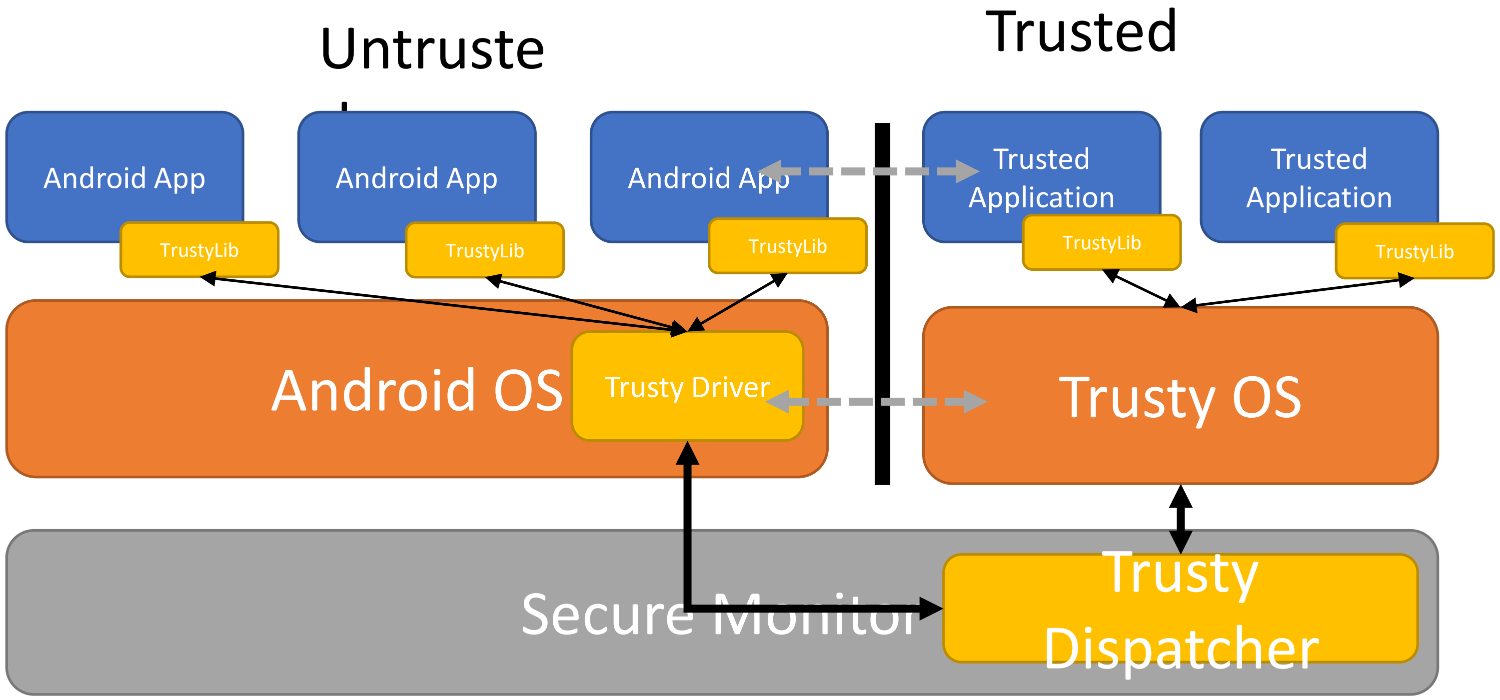
- connect(path, flags)
- send_msg(handle, msg)
- get_msg(handle, *msg_info)
- read_msg(handle, id, offset, *msg)

Trusted service declare endpoints

Untrusted apps can connect and exchange with trusted apps

Occur through driver + secure monitor

ARM Trustzone



Examples:

- Digital Right management
- Secure banking
- Multi-factor authentication
- etc…