Attestation with SGX

SGX also provides the attestation service.

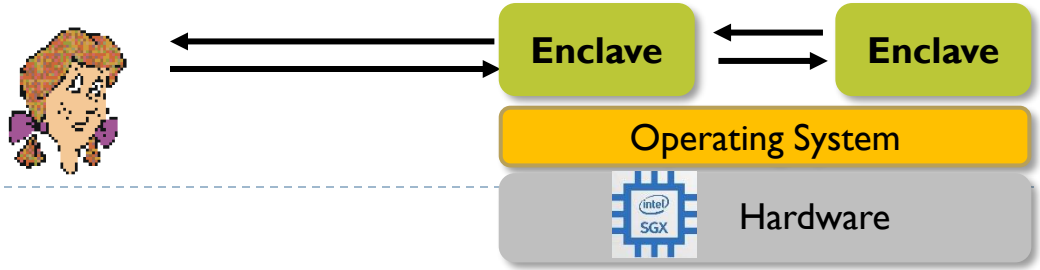
- Integrity measurement architecture: enclave measurement of the code, data, stack, heap, security flags, location of each page…
- Attestation protocol: attestation key and cryptographic protocol.

Remote attestation

- A remote client attests the integrity of the code in the enclave.

Local attestation

- In some scenarios, multiple enclaves collaborate on the same task, exchanging data at runtime.
- Collaborating enclaves have to prove to each other that they are trusted.



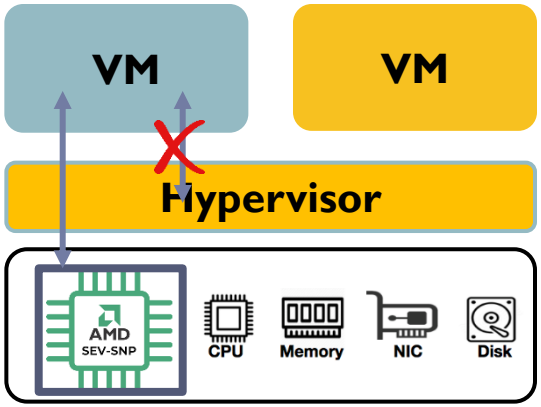
AMD Secure Encrypted Virtualization (SEV)

A hardware extension to protect VMs against untrusted hypervisor

- SEV: basic memory encryption for protecting VMs (release: 2016)
- SEV-ES (Encrypted State): encrypt CPU registers (release: 2018)
- SEV-SNP (Secure Nested Paging): adding integrity protection (release: 2020)

Mechanism

- The processor encrypts the data (memory page, registers, configurations) of the guest VMs, so the hypervisor is not allowed to access the data.
- Uses an AMD Secure Processor to manage encryption keys.
- Transparent encryption with minimal modifications to the VM.



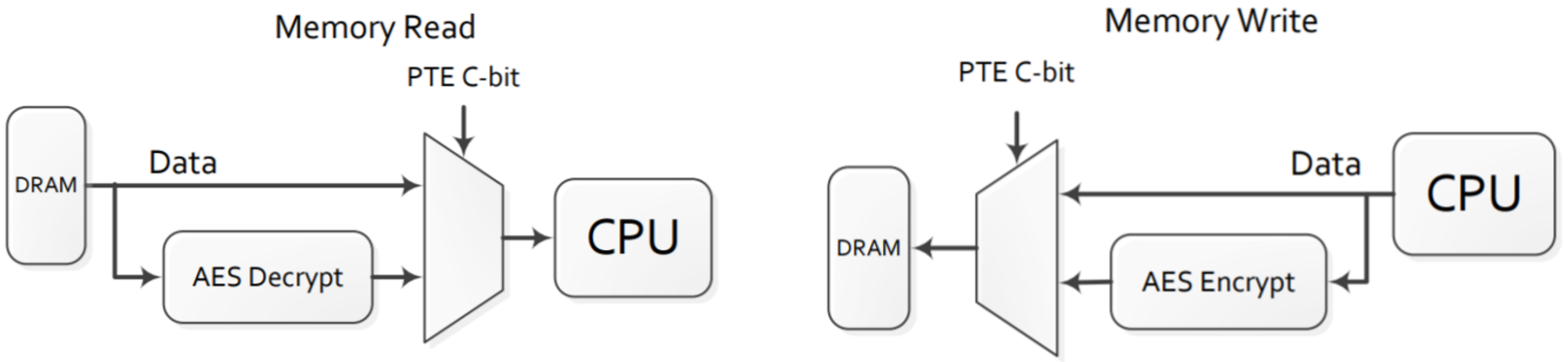
AMD Secure Memory Encryption (SME)

Virtual memory encryption is realized by SME

- An AMD architectural capability for main memory encryption
- Performed via dedicated hardware in the memory controllers
- Use AES engine to encrypt data and control with C-bit in Page Table Entry

C-bit

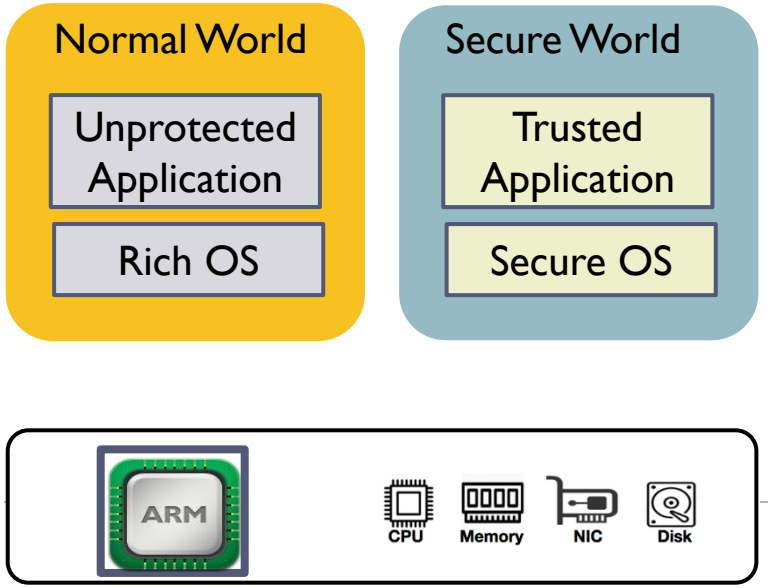
- Locate at physical address bit 47
- Set this bit to 1 to indicate this page is encrypted.
- Allow users to encrypt full memory of the VM, or selected memory pages



ARM TrustZone

The first commercial TEE processor (2003 in ARMv6 architecture)

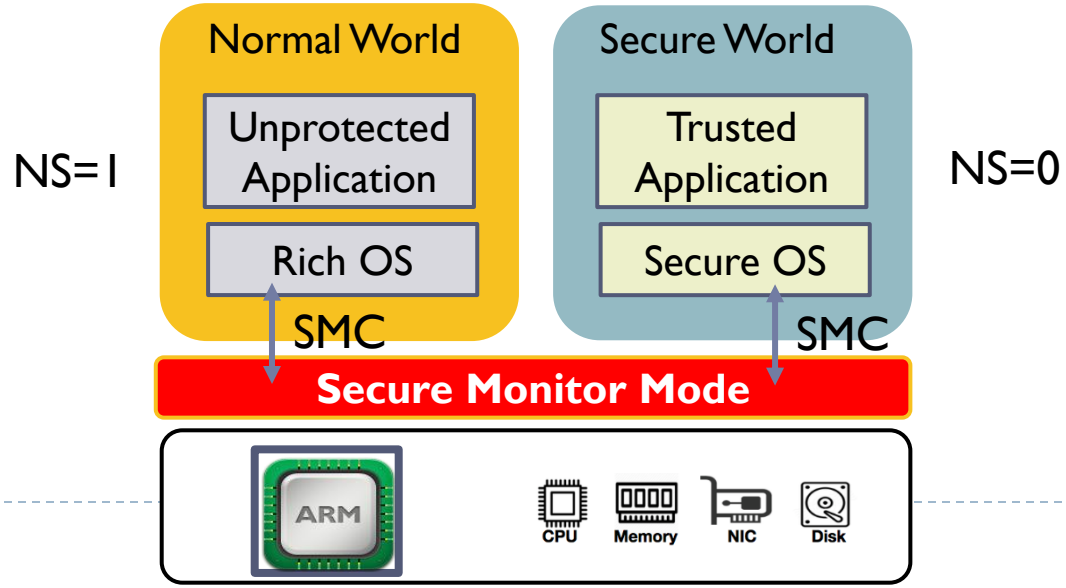
- Create two environments that can run simultaneously on the same processor. Each world has an independent OS
- Normal world: runs the normal unprotected applications and a rich OS. They have restricted access to the hardware resources in the secure world
- Secure world: runs the sensitive protected applications and a smaller secure OS, isolating them from the untrusted world. They have full access to the hardware resources in the normal world.



ARM TrustZone

Context switch

- The Non-secure bit in the Secure Configuration Register is used to determine which world the processor is currently running.
- A third privilege mode: secure monitor, in addition to user and kernel.
- When the processor wants to switch the world, it first issues a special instruction Secure Monitor Call (SMC) to enter the secure monitor mode. Then it performs some cleaning works and enter the other world.



Application of TEE: Double-edged Sword

Positive usage

- Cloud computing: you do not need to trust the cloud provider
- Digital right management
- Cryptocurrency and blockchain

Negative usage

- Adversaries leverage TEE to hide malicious activities for stealthier attacks (conflicting with malware analysis)