Outline

- **Protection Strategies**
  - Confinement
  - Reference Monitor
- **Hardware-assisted Protection**
  - Basic Functionalities
  - Trusted Platform Module
  - Trusted Execution Environment

Using Hardware to Protect Software

Software is not always trusted

- Privileged software (OS, hypervisor) usually has very large code base, which inevitably contains lots of vulnerabilities.
- Once it is compromised, the attacker can do anything to any apps running on it.

SW	Line of codes
Linux Kernel 5.12	28.8M
Windows 10	50M
VMWare	6M
Xen	0.9M

Commercial software typically has 20 to 30 bugs for every 1k lines of code

Hardware is more reliable

- After the chip is fabricated, it is hard for the attacker to modify it. The integrity of hardware is guaranteed.
- It is also very hard for the attacker to peek into the chip and steal the secret (e.g., encryption key). The confidentiality of hardware is guaranteed.
- It is more reliable to introduce security-aware hardware to protect the operating system and applications

Basic Functionality: Encryption

Encryption performed using dedicated hardware

- Trusted Platform Module (TPM)
- Hardware Security Modules (HSM)
- Advanced Encryption Standard New Instructions (AES-NI)

Benefits

- Performance efficiency: faster execution with optimized hardware
- Energy efficiency: lower power consumption compared to software solutions
- Security: resistant to software-level attacks and malware
- Ease of use: transparent encryption with minimal user interaction.

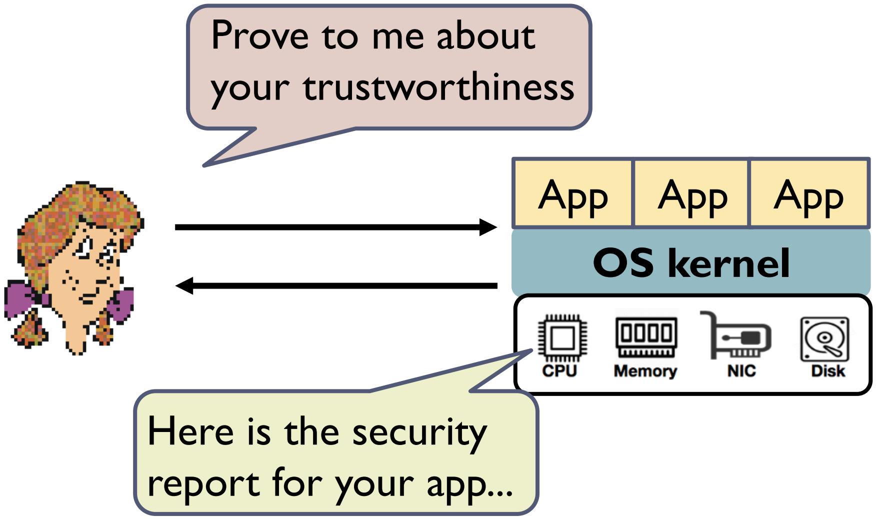
Applications

- Data protection in storage
- Secure boot
- Cloud security

Basic Functionality: Remote Attestation

A mechanism that allows a user to know whether her app executes securely on a trusted platform.

- A remote platform provides unforgeable evidence about the security of its software to a client.
- A common strategy to prove the software running on the platform are intact and trustworthy.



Prove to me about your trustworthiness

App

App

App

OS kernel

Here is the security report for your app...

Major components for remote attestation

- Integrity measurement architecture: provide reliable and trustworthy security report
- Remote attestation protocol: ensuring the attestation report is transmitted to the client without being modified by attackers in OS, apps or network

Outline

- **Protection Strategies**
  - Confinement
  - Reference Monitor
- **Hardware-assisted Protection**
  - Basic Functionalities
  - Trusted Platform Module
  - Trusted Execution Environment

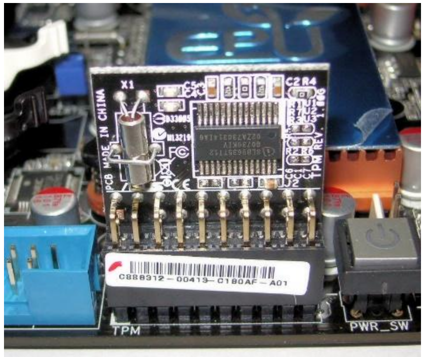
Trusted Platform Module (TPM)

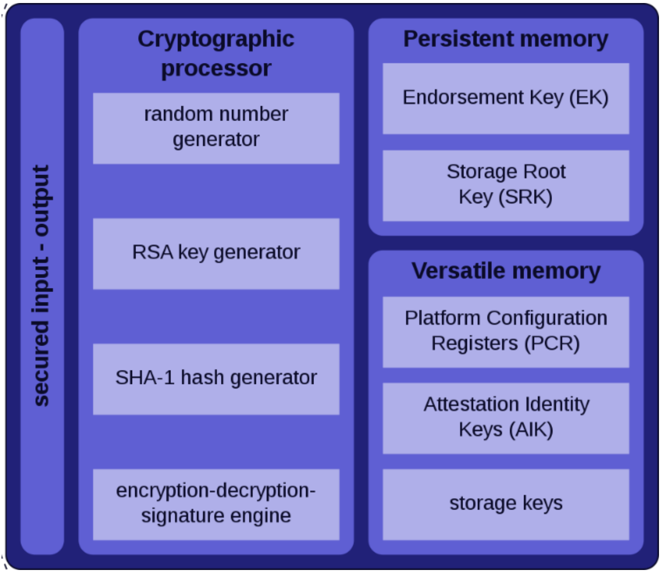
A chip integrated into the platform

- A separated co-processor
- Its state cannot be compromised by malicious host system software

Inside the chip

- Random number and key generators
- Crypto execution engine
- Different types of crypto keys.





Development and Implementation

Designed by Trusted Computing Group (TCG)

- First version: TPM 1.1b, released in 2003.
- An improved version: TPM 1.2, developed around 2005-2009
  - Equipped in PCs in 2006 and in servers in 2008
  - Standardized by ISO and IEC in 2009
- An upgraded version: TPM 2.0, released on 9 April 2014.

Application of TPM

- Intel Trusted Execution Technology (TXT)
- Microsoft Next-Generation Secure Computing Base (NGSCB)
- Windows 11 requires TPM 2.0 as a minimal system requirement
- Linux kernel starts to support TPM 2.0 since version 3.20
- Google includes TPMs in Chromebooks as part of their security model
- VMware, Xen, KVM all support virtualized TPM.