Software-based TPM Emulator for Linux

Semester Thesis

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Outline

1. Motivation and Goals
2. Trusted Computing
3. Trusted Platform Module
4. TPM Emulator
5. Conclusion

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Status Quo

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- Many controversies about TC, TCG/TCPA, TPM (*Fritz-Chip*), and DRM.
- IBM provides a TPM device driver for their ThinkPads as well as some example applications.
- Dartmouth College works on a TPM-based file integrity measurement module (*Enforcer*) for Linux.

Motivation, and Goals

"What I cannot create I do not understand." (R. Feynman)

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- Give people the means to easily explore TPMs for educational and experimental purposes.

Goals

- Implementation of a software-based TPM emulator for Linux in cooperation with IBM (David Safford, Jeff Kravitz) and Dartmouth College (Omen Wild).

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Trusted Computing

- A Trusted (Computing) Platform is a platform that is trusted by local and remote users.
- A relationship of trust must be established between the user and the computing platform so that the user believes that an expected boot process, a selected operating system, and a set of selected security functions in the computing platform have been properly installed and operate correctly.

Overview

The Trusted Platform Module (TPM) is a hardware component that provides four major functions:

1. Cryptographic functions: RSA, (P)RNG, SHA-1, HMAC
2. Secure storage and reporting of hash values representing a specific platform configuration
3. Key storage and data sealing
4. Initialization and management functions (opt-in)

Auxiliary functions since version 1.2:

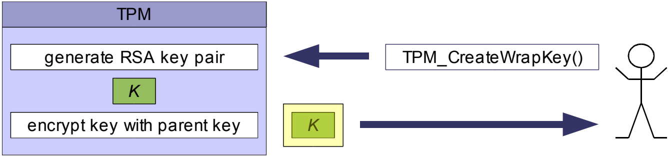
- Monotonic counters and timing-ticks
- Non-volatile storage
- Auditing

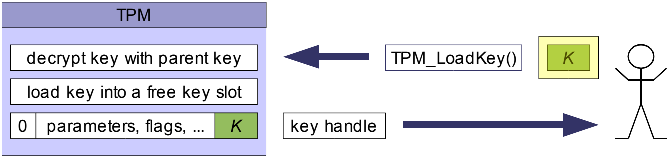
Platform Configuration

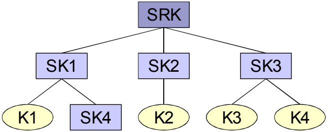
- Obtaining metrics of platform characteristics that affect the integrity of a platform and storing them into the PCRs.
- A PCR update includes history:
  PCR[n] $\leftarrow$ SHA-1(PCR[n] $+$ measured data).
- Transitive trust (inductive trust) is applied to extend the trust boundary during bootup:
  TPM, CRTM $\rightarrow$ BIOS $\rightarrow$ MBR $\rightarrow$ OS $\rightarrow$ Application.

PCR Index	PCR Usage
0	CRTM, BIOS, and Platform Extensions
1	Platform Configuration
2	Option ROM Code
3	Option ROM Configuration and Data
4	IPL Code (usually the MBR)
5	IPL Code Configuration and Data

Key Generation and Storage







Signing and Sealing

Binding Encryption of a message using a public key. The (migratable) private key is managed (stored) by the TPM.

Sealing Encryption of a message using a public key with additional binding to a set of platform metrics (system must be in a specific configuration to successfully unseal the data).

Signing Signing of a message digest using a signing only private key.

Sealed-Signing Signing of a message digest using a signing-only private key with inclusion of the current platform metrics.

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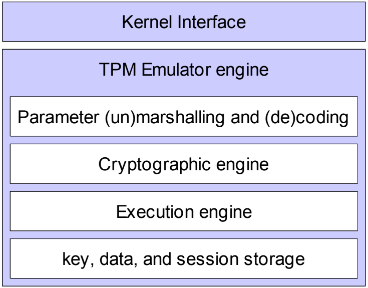
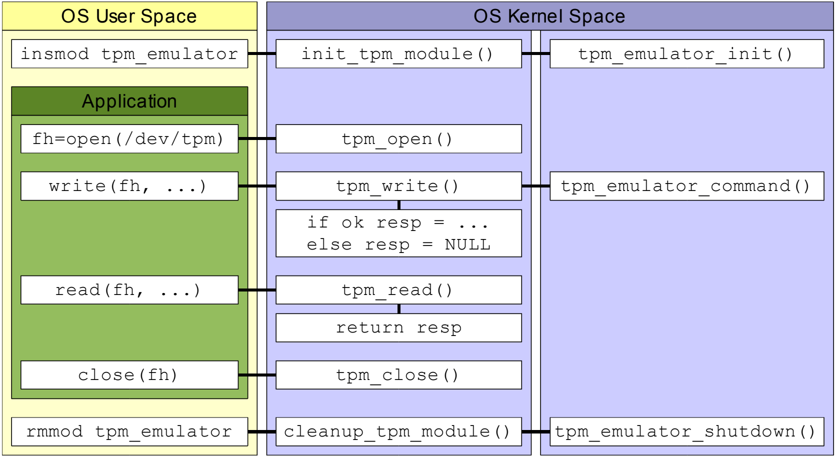
Overview

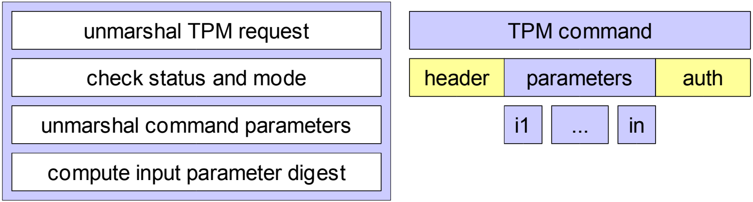
- Emulator is provided as a Linux kernel module (i.e., device driver for the device file `/dev/tpm`)
- One goal was to be compatible with the driver from IBM
- Two main parts: kernel interface and emulator engine
- Startup mode is specified by a module parameter
- Command serialization by means of semaphores



Command Execution I



Command Execution II



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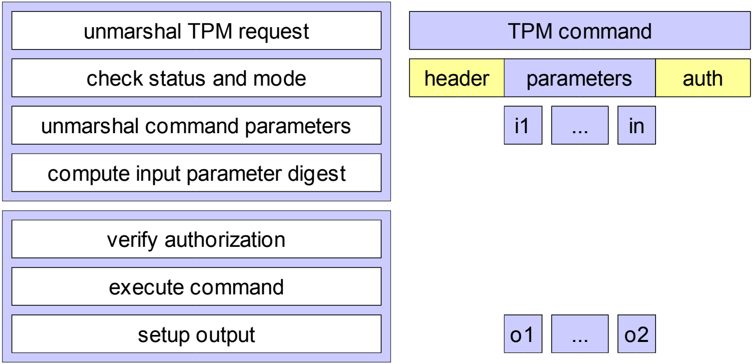

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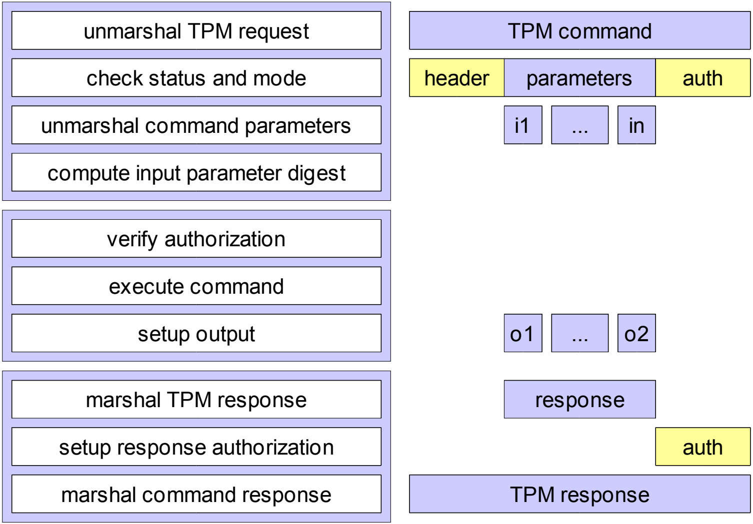

Two Selected Problems I

Problem 1: Persistent Storage

- Seems to be easy, just write all data to hard disk.
- But file system is under the user's control – what if disk is not yet mounted or temporarily unmounted?
- As a general design rule: kernel functions should not directly write to hard disks!
- Possible solution: use user tool to (re)store TPM's data. Drawback: TPM knows when saving is advisable, not the user.

Two Selected Problems II

Problem 2: (Un-)Marshalling and command decoding

- Only five basic TPM types: BYTE, BOOL, UINT16, UINT32, UINT64, and BLOB (BYTE*).
- All non-basic TPM types are just compositions (structures, arrays) of either basic or other non-basic types.
- Simple, repetitive statements – but error-prone and extensive. Luckily, it can be auto-generated for the most part.
- About 95% of the (un)marshalling code has been auto-generated out of the (PDF) specification by means of Perl, awk, and sed scripts.

Conclusion and Outlook

- TPM Emulator works with (almost) all TPM applications I know about.
- By now, about 50 out of 120 TPM commands are implemented (∼42%).
- Complete TPM Device Driver Library for the emulator according to TCG Software Stack (TSS) specification.
- Jeff Kravitz from IBM is preparing a new TPM library and some additional examples.
- Omen Wild from Dartmouth College is confident to find some students who might support the project.
- Jesus Molina from the University of Maryland is porting the emulator to a PCI embedded system. Goal is the development of a free TPM device as well as an appropriate BIOS.

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