TEE Based Protection of Cryptographic Keys on Embedded IoT Devices

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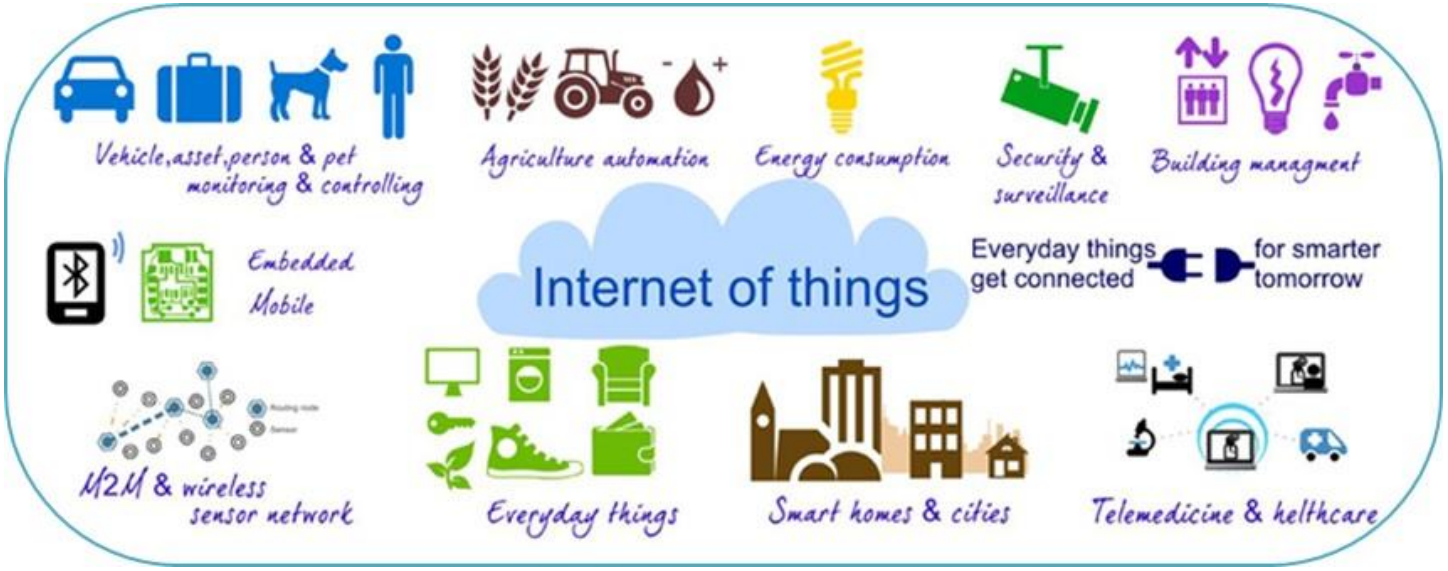
Introduction

- Embedded devices are increasingly connected to the Internet
  → Internet of Things (IoT)



https://iotworm.com/internet-of-things-applications-area/

- Remote management requires secure remote access
- Devices must store and use long-term cryptographic keys

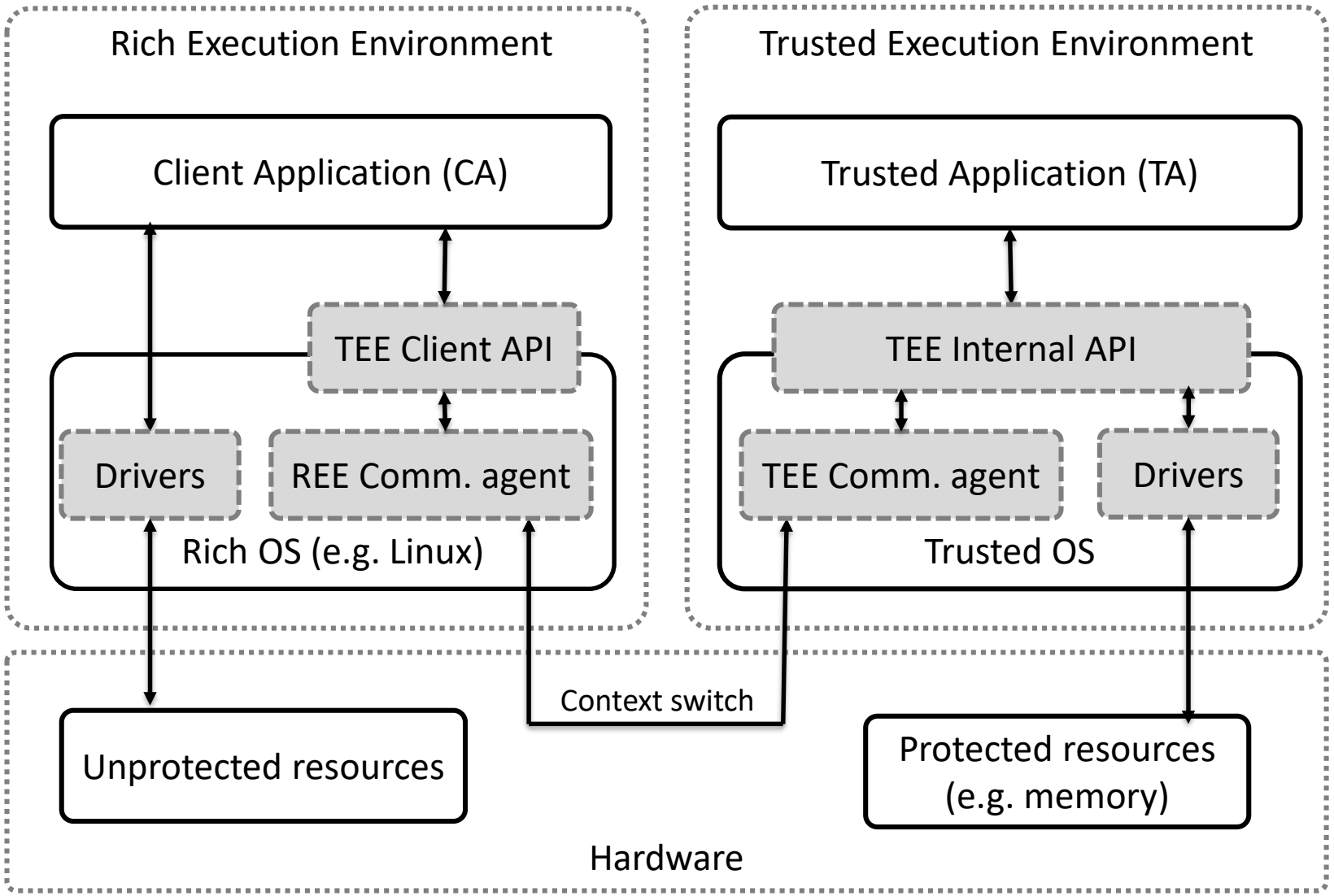
Protecting crypto keys

- Traditionally: additional physical component
  - Trusted Platform Module (TPM) and secure co-processors
  - Hardware security module (HSM)

- Pros: hardened, intrusion-resistant
- Cons: costly →← IoT devices must be cost effective

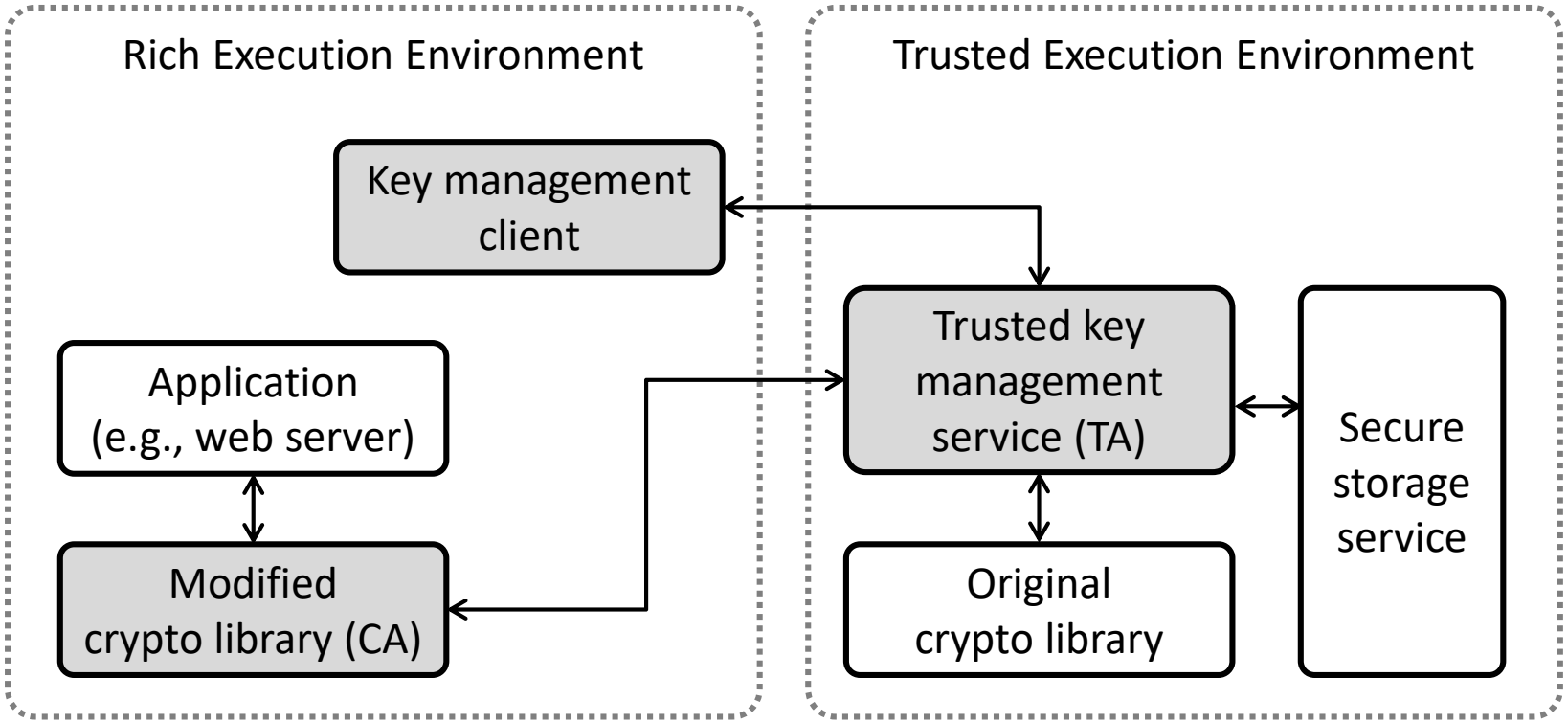
- Emerging technology: Trusted Execution Environments (TEEs)
  - Software with minimal hardware support
  - Available on many platforms, e.g. ARM TrustZone, Intel SGX, AMD Secure Technology

GlobalPlatform's TEE specification



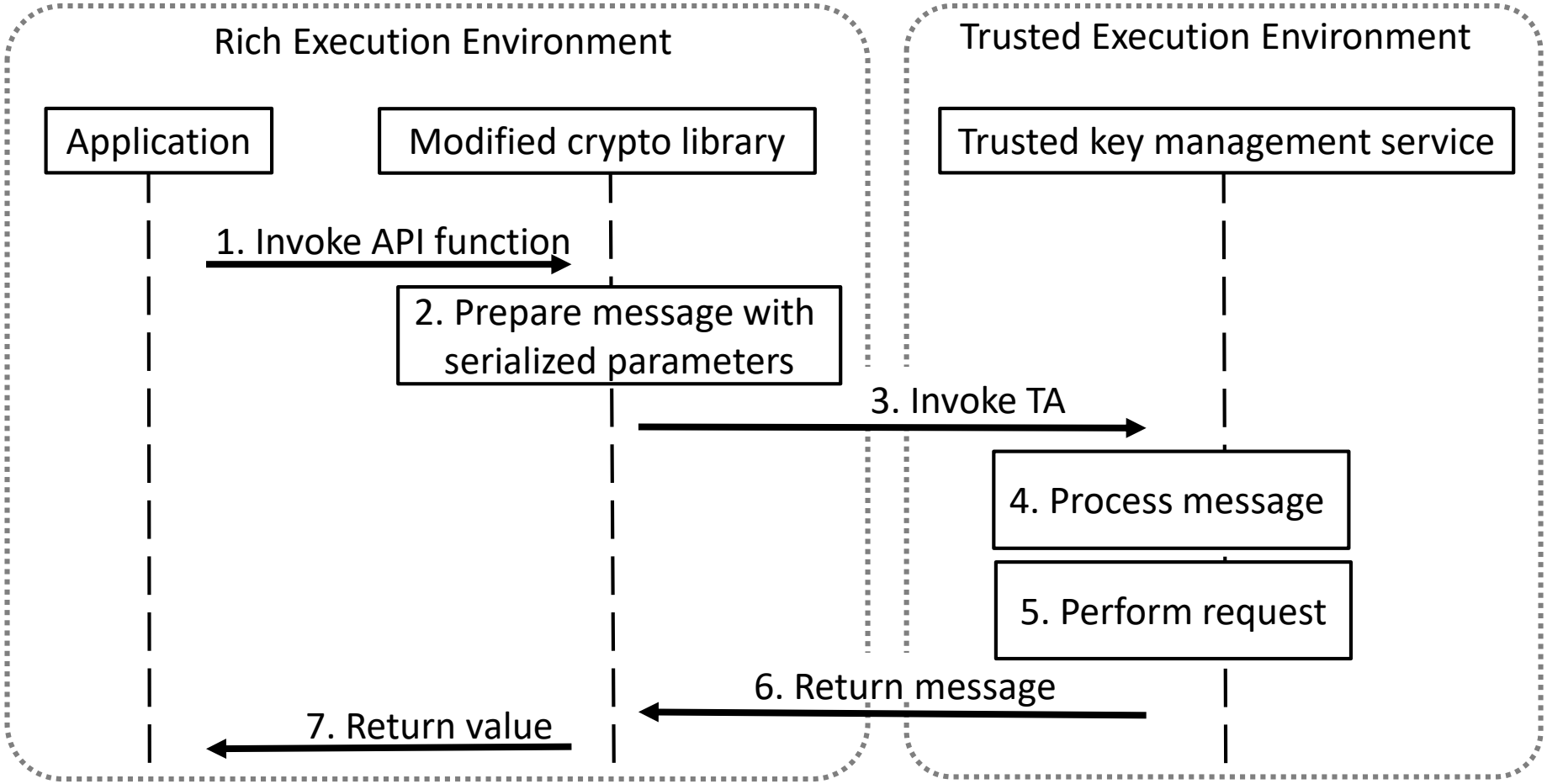
Architectural Overview

- Long-term crypto keys are stored and used in the TEE
- Crypto libraries and key management apps can request actions



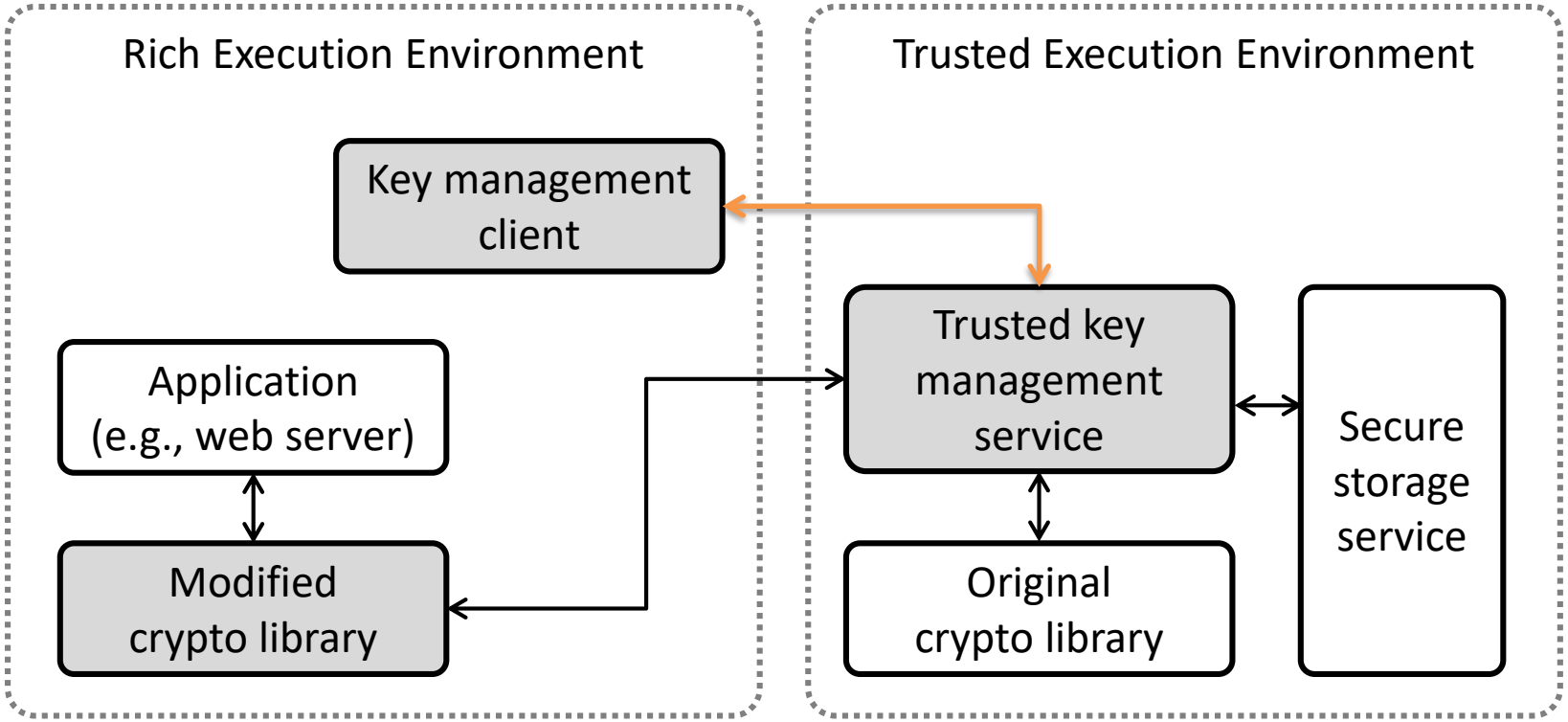
Communication with the TEE

- Programmer invokes API functions
- Under the hood: params are serialized and passed to TA (TEE)



Key management

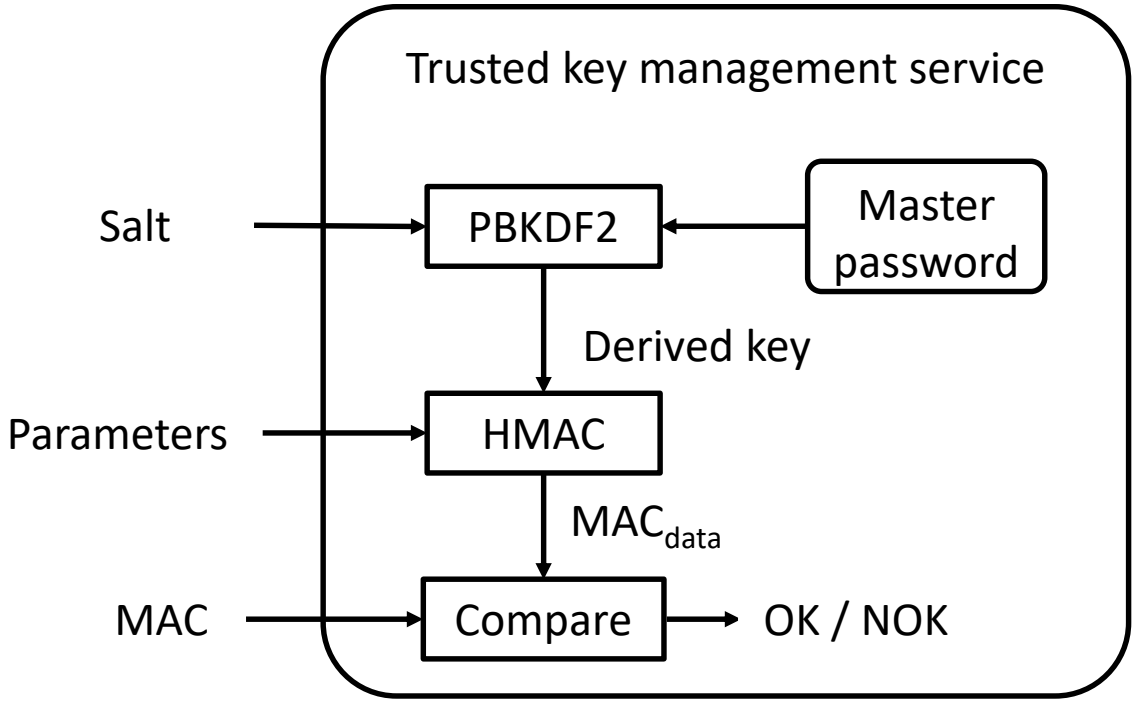
- Generate new keypair
- Load existing keypair
- Remove keypair



Authenticating requests

- Key management functions can only be invoked by the operator
  → Requests must be authenticated

- Requests contain: parameters of invoked operation, salt, MAC



Implementation: OP-TEE + mbedtls

- **`tee_set_master_password`** – install master password

- Key management functions:
  - **`tee_load_keypair`** – load a keypair into TEE
  - **`tee_generate_keypair`** – generate a new keypair in TEE
  - **`tee_remove_keypair`** – remove existing keypair from TEE

- Public functions for all applications
  - **`tee_pk_decrypt`** – decrypt data using a key handle
  - **`tee_pk_sign`** – sign data usign a key handle
  - **`tee_get_publickey`** – extract a public key
  - **`tee_get_keyinfo`** – get information about a key (size, type)

Summary and future work

- Remote access is important for embedded IoT devices
  → Long-term crypto keys are required

- New method for protecting crypto keys with TEE
  - Emerging technology supported by many chips
  - Keys are stored in the Secure Storage → Access to keys is restricted
  - Apps can only reference keys using handles → Keys are not leaked
- Crypto operations (even sign and decrypt) can be called by anyone (even attacker)
- BUT: Private keys cannot be extracted from the device
  → Rogue device can't be cloned

- Future work: remote attestation using crypto keys in TEE

Acknowledgements

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