
Hello, and welcome to this introduction to Trusted Firmware for Cortex-M, also called TFM.

# ARM TF-M introduction

## ARM Open-Source reference implementation of PSA standard / Kind of Secure OS

- **TF-M (Trusted Firmware-M): ARM driven Open-Source software framework provides a reference implementation of the PSA standard on ARM-CM33 (TrustZone) core**
  - Secure part
    - PSA immutable RoT (Root of Trust): Secure Boot & Secure Firmware Update
    - PSA Updatable RoT:
      - Secure isolation configuration, secure IT management…
      - Secure cryptographic services based on opaque key APIs
      - Storage: protect data Confidentiality/authenticity/Integrity in NV Flash storage
      - Internal Trusted Storage service: NV secure/privilege Flash storage services
      - Attestation: prove product identity via Entity Attestation Token
    - Application Updatable RoT: 3rd party secure services
  - Non-Secure part: User Application using PSA APIs to access secure services

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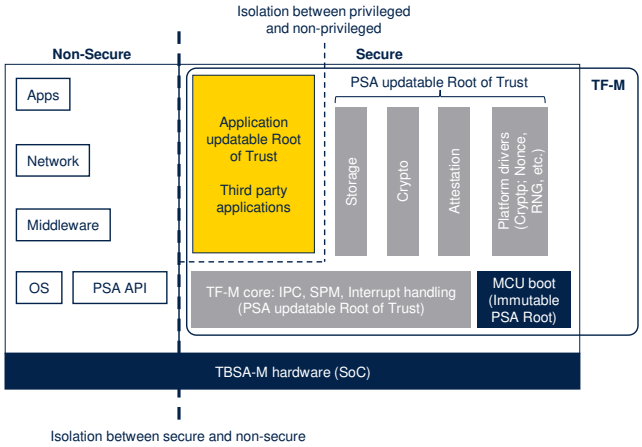
**TF-M TRUSTED FIRMWARE (https://www.trustedfirmware.org )**




The TFM framework is composed of a Secure Boot and Secure Firmware Update application executed after reset and a set of secure services available at run time.
MCU-boot is a root of Trust and is immutable, it is the first code executed after each reset.
A Non secure application and part of secure application can be updated via the mcu_boot application.
The TFM-core manages the PSA Level 2 isolation inside the secure application and controls access to the secure services from the non-secure application via the PSA APIs.
The following secure services can be requested by the IoT application:

- Crypto services
- Secure Storage

- Attestation services.

TFM is modular:

- Each grey box can be deactivated independently (via compilation switches) so that secure services can be easily reduced to only keeping the MCU boot part
- Secure Crypto services can be configured to only support the crypto algorithms needed by the application

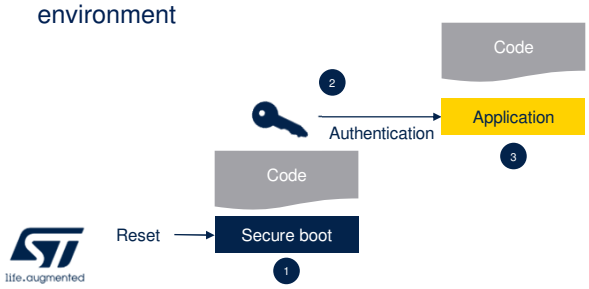
TFM core and TFM secure services are used for STM32U5 PSA Level 3 certification, that includes resistance against physical attack in addition to PSA Level 2 certification requirements.

They are based on the hardware protections provided by the STM32U5 Series, referred to as TBSA-M hardware in the figure.

# SBSFU Services (PSA Immutable RoT)

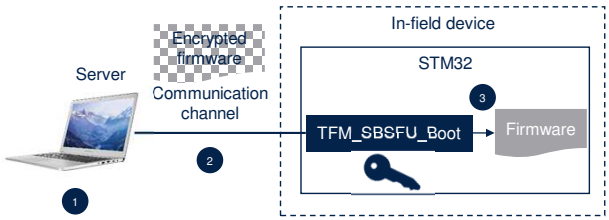
**Secure Boot (SB)**

- Ensures the integrity and authenticity of the user application image that is executed based on cryptographic checks
- Step1: SB implements a root of trust as a first trusted component
- Step2: every other component is authenticated
- Step3: user application execution in a trusted environment




**Secure Firmware Update (SFU)**

- Provides a secure implementation of in-field firmware updates
- Downloads a new firmware image to a device in a secure way
- The device authenticates, decrypts and installs the new firmware image and executes it

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A device deployed in the field operates in an untrusted environment and it is therefore subject to threats and attacks.
To mitigate the risk of attack, the objective is to run only authentic firmware on the MCU.
The Secure Firmware Update relies on a server providing the encrypted firmware and SBSFU service available in the MCU.
The OEM server and web services are responsible for:

- Storing the new version of the device firmware
- Communicating with the device and sending the new image version in encrypted form.

The STM32U5 is deployed in the field. It embeds a code that runs the firmware update process.
It communicates with the server and receives a new

firmware image, authenticates and decrypts it and installs the new firmware image before executing it.

## Secure services at run-time

**SST: Secure Storage Service**

- Implements PSA protected storage APIs
- Relies on HW flash isolation from non-secure area accesses
- Data encryption with AES-GCM based AEAD policy
- High level requirements addressed:
  - Confidentiality: resistance to HW/SW attacks
  - Access Authentication to establish the identity of requester
  - Integrity - Resistance to tampering to detect malicious HW/SW attacks
  - Reliability - Resistance to power failure scenarios and incomplete write cycles
  - Configurability: modular configuration
  - Performance: optimization to suit resource constraints

**Internal trusted storage service (ITS)**

- Implements PSA internal trusted storage APIs
- Relies on HW flash isolation from non-secure area accesses and application updatable RoT
- No encryption, located in the most secure flash region
- High level requirements addressed:
  - Confidentiality: resistance to HW/SW attacks
  - Access Authentication to establish the identity of the requester
  - Integrity - Resistance to tampering by attackers with physical access by HW isolation mechanism
  - Reliability - Resistance to power failure scenarios and incomplete write cycles
  - Configurability to scale increaser/decrease memory footprint

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The TF-M secure storage (SST) service implements PSA Protected Storage APIs.
The service is supported by hardware isolation of the flash access domain and relies on hardware to isolate the flash area from non-secure accesses.
The current design of the SST service relies on the hardware abstraction level provided by TF-M.
The SST service implements an AEAD encryption policy base on AES-GCM, as a reference, to protect data integrity and authenticity.
The design also meets the following high level requirements:

- Confidentiality: Resistance to unauthorized accesses by hardware/software attacks
- Access Authentication: Mechanism to establish the

identity of the requester (a non-secure entity, a secure entity, or a remote server).
- Integrity: Resistance to tampering by the normal users of a product, package, or system or by others with physical access to it. If the content of the secure storage is maliciously modified, the service is able to detect.
- Reliability: Resistance to power failure scenarios and incomplete write cycles.
- Configurability: High level of configurability to increase or decrease the memory footprint to cater for a variety of devices with varying security requirements.
- Performance: Optimized for use in resource constrained devices with a very small silicon footprint, the PPA (power, performance, area) should be optimal.

The TF-M internal trusted storage (ITS) service implements PSA internal trusted storage APIs that can write data in a microcontroller built in Flash memory region that is isolated from non-secure or unprivileged applications by hardware security protection mechanisms. The design also meets the following high-level requirements:

- Confidentiality: Resistance to unauthorized accesses by hardware/software attacks, due to hardware isolation of the flash access domain.
- Access authentication: Mechanism to establish the identity of the requester (a non-secure entity, a secure entity, or a remote server).
- Integrity: resistance to tampering by attackers with physical access is provided by the internal flash device itself, while resistance to tampering by non-secure or application updatable RoT attackers is provided by the hardware isolation mechanism.

- Reliability: Resistance to power failure scenarios and incomplete write cycles.
- Configurability: High level of configurability to increase or decrease the memory footprint to cater for a variety of devices with varying requirements.

# Secure services at run-time (2)

**Secure cryptographic service**

- Provides PSA cryptographic APIs in a PSA updatable RoT secure partition in TF-M.
- Based on mbed-crypto*, refer to PSA crypto APIs
- Can be used by other services running in the secure processing environment (SPE)
- Can be used by applications running in the non-secure processing environment (NSPE)

**Initial attestation service (IAT)**

- TF-M Initial Attestation Service allows the application to prove the device identity during an authentication process to a verification entity
- Can create an entity attestation token (EAT) on request, which contains a fixed set of device specific data

* github.com/ARMmbed/mbed-crypto

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The TF-M cryptographic service provides an implementation of the PSA cryptographic API in a PSA updatable RoT secure partition in TF-M.
It is based on mbed-crypto, which is a reference implementation of the PSA cryptographic API.
For more details on the PSA cryptographic API or the mbed-crypto implementation, refer to the MbedCrypto GitHub repository directly.
The service can be used by other services running in the secure processing environment (SPE), or by applications running in the non-secure processing environment (NSPE), to provide cryptographic functionality.
TF-M Initial Attestation Service allows the application to prove to a verification entity the device identity during an authentication process.

The initial attestation service can create an entity attestation token (EAT) on demand, which contains a fixed set of device specific data.
The Device must contain an attestation key pair, which is unique for each device.
The token is signed with the private part of attestation key pair.
The public part of the key pair is known by the verification entity. The public key is used to verify the authenticity of the token.
The data items in the token are used to verify the integrity of the device and assess its trustworthiness. The provision of the Attestation key is beyond the scope of the attestation service and should take place during the manufacture of the product

# Thank you



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Thank you for attending this presentation!
You can now refer to the presentations that detail the operation of the TFM

- TFM flash memory footprint
- TFM offer in STM32U5
- TFM pointers.