Mbed TLS workshop — PSA Cryptography API

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Platform Security Architecture

A framework for building secure devices – openly published.

Analyze

Threat models
& security analyses

Architect

Hardware & firmware
architect specifications

Implement

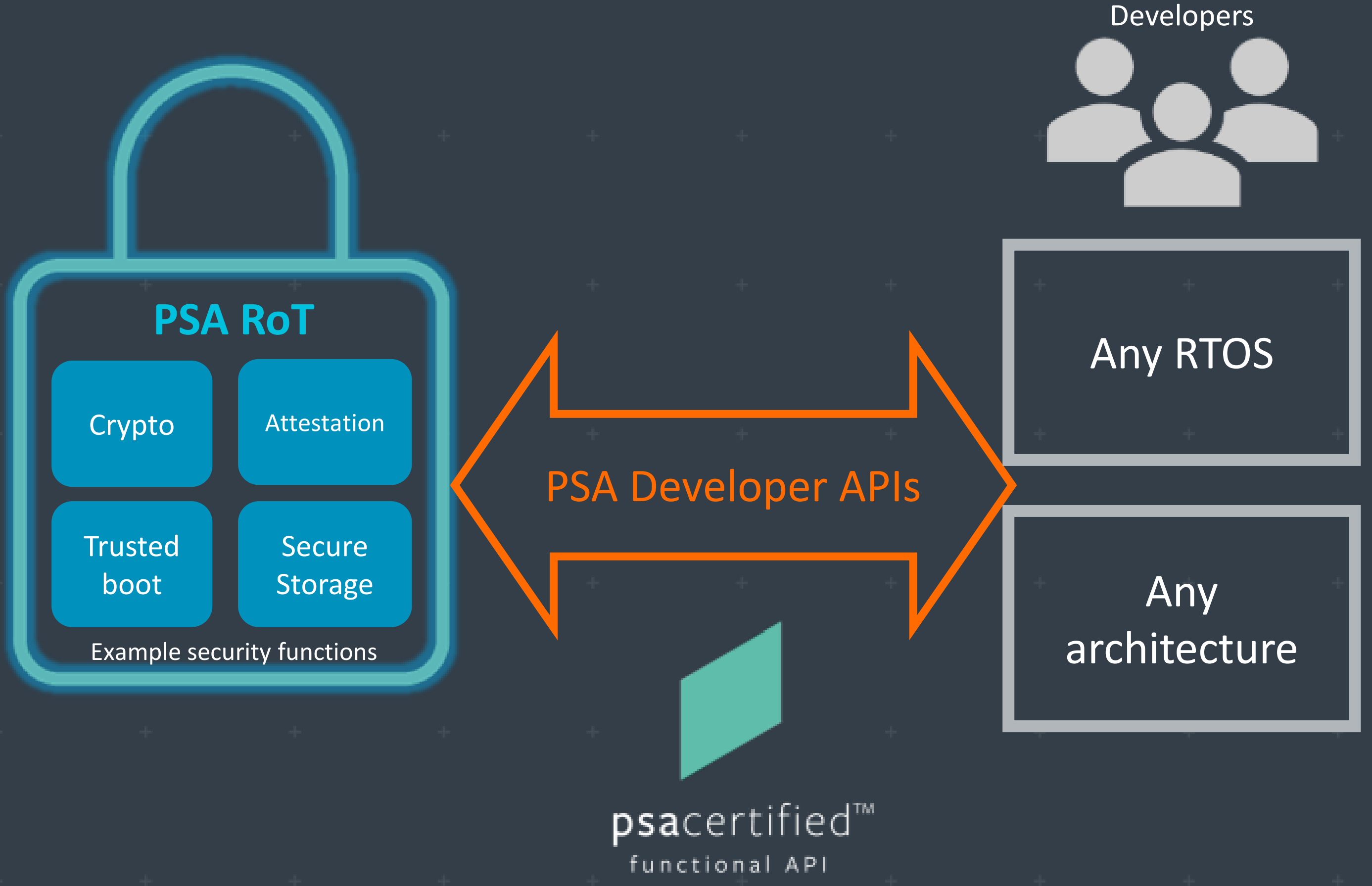
Firmware
source code

Certify

Independently
tested

psacertified™

PSA Developer APIs – making security easy to use



A consistent set of APIs simplifies developer access to security functions across the industry

Balancing ease of use vs flexibility

ease of use

- Cryptography is hard to use, easy to misuse
  - Functional tests don't tell you your code is insecure
- Make the most obvious path secure
  - But please do read the documentation!
- The best crypto API is no API
  - *"If you're typing the letters A-E-S into your code you're doing it wrong"* — Thomas Ptacek
  - Secure storage:
    `f = open("/ext/myfile"); read(f);`
  - Secure communication: `TLSSocket sock;`
    `sock.connect("example.com", 443);`

  But how does this work under the hood?

flexibility

- Need low-level primitives to implement TLS, IPsec, WPA, LoRaWAN, Bluetooth, GSM, ZigBee, …
- Need to do dodgy-but-ok-in-this-context things sometimes
  - Deprecated crypto is still in use: MD5 (TLS 1.1), CBC (TLS 1.1), unauthenticated ciphers (storage), RSA PKCS#1 v1.5 (TLS 1.2), 3DES (banking), …
  - Key derivation in the real world is a mess
  - A key should only be used for one purpose… except when protocols dictate otherwise

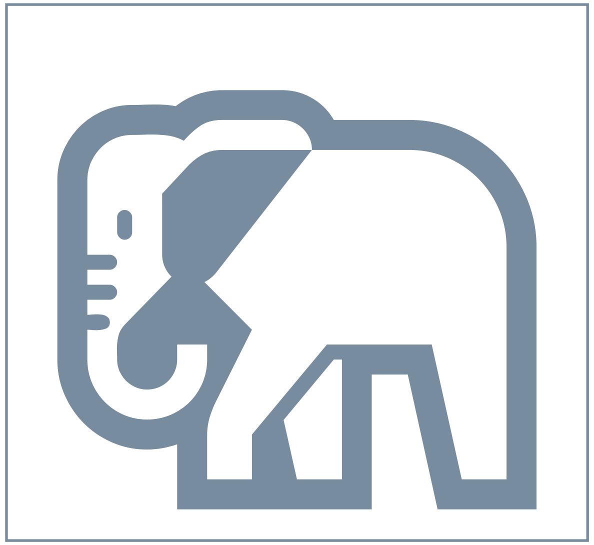
Use an existing crypto API?

- Evolve Mbed TLS?
  - Would be hard to add support for opaque keys
  - Too flexible: gives you a lot of rope to hang yourself
  - Very transparent data structures with visible pointers
    - Cumbersome to plug in hardware acceleration or keystore isolation
    - Relies heavily on malloc (so not suitable for e.g. MISRA)
- cryptlib? OpenSSL/BoringSSL/LibreSSL/…?
  - Too big, not easy to use
- NaCl/libsodium?
  - Not flexible enough: only includes black-box primitives
- Any API in C++/Rust/Go/…?
  - We need C, the common denominator

What about PKCS#11?

PKCS#11 = Cryptoki: standard interface for smartcards

The elephant in the room!



Not so easy to use

- Example: sign with existing key
-
```
/* Discover the key */
CK_ATTRIBUTE label_attribute =
  {CKA_LABEL, "Fred",
   strlen("Fred")};
C_FindObjectsInit(hSession,
    &label_attribute, 1);
C_FindObjects(hSession,
    &hKey, 1, &count);

/* Sign with the key */
CK_MECHANISM mechanism =
  {CKM_ECDSA_SHA256, NULL_PTR,
0};
C_SignInit(hSession,
    &mechanism, hKey);
C_Sign(hSession, msg, msg_len,
    &sig, &sig_len);
```

Not the right shape

- Big, we'd have to define a subset
- Key discovery is complex
- Lots and lots of parsing
- Standard compliance is poor in practice
- Not good at access control
  - Designed for a single user

Some API design guidelines

- Make it easy to use, hard to misuse
  - KISbntS: keep it simple, (but not too) stupid
- Uniform interface to memory buffers
  - Explicit sizes throughout
  - You don’t need to understand the algorithm to know how much memory to allocate
- Cryptographic agility
  - Select a key type and mode during key creation
  - Call sequence, buffer size calculations are uniform across algorithms of the same kind
- “Security agility”
  - Single API, multiple isolation levels under the hood

Suitable for limited resources

- Includes multipart APIs for messages that don’t fit in RAM
- The API can be implemented without malloc
  - (Mbed TLS currently uses malloc — maybe Mbed TLS 4.0 will be malloc-free?)
- All algorithms are optional
  - You can build a device with just what you need

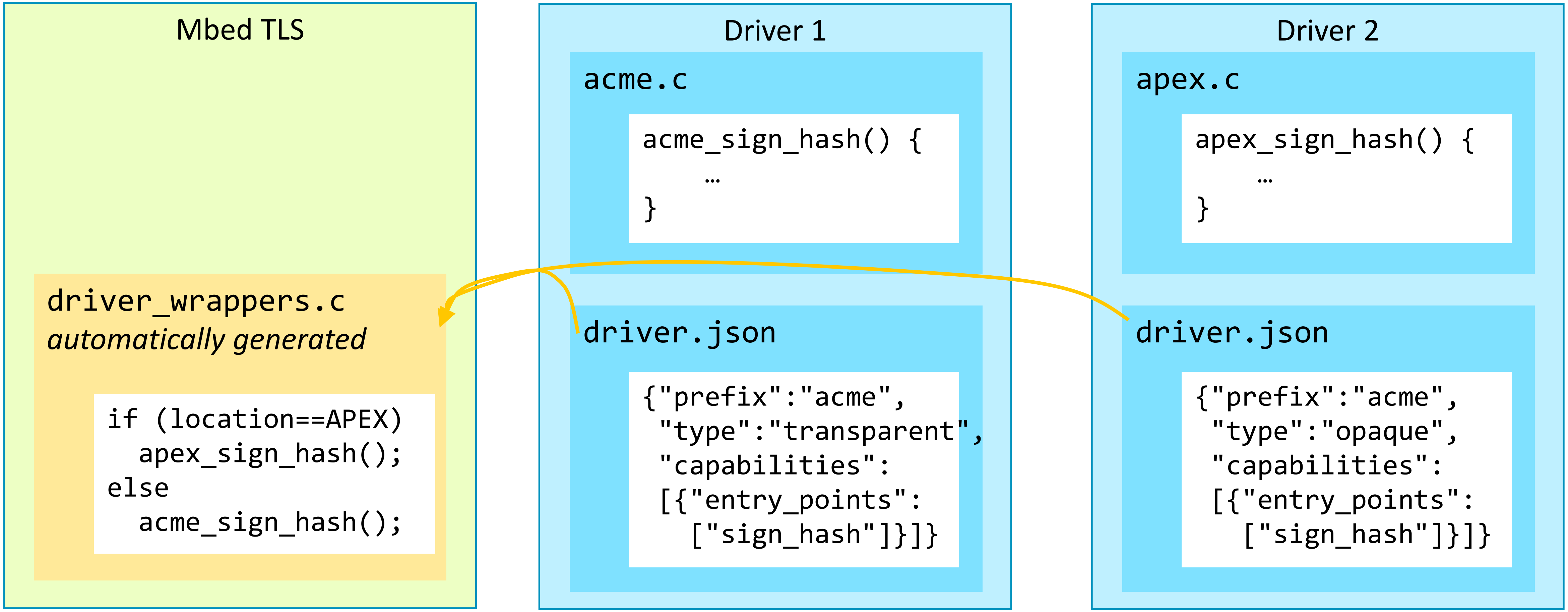
Main features

- Cryptographic primitives
  - Symmetric: hash, MAC, unauthenticated cipher, AEAD, key derivation
  - Asymmetric: signature, encryption, key agreement
- Key store
  - All keys are accessed through identifiers
    - No need to know where a key is to use it (RAM, internal storage, secure element, …)
    - Can run as a library in the same memory space, or as a separate service protected by MPU, MMU, TrustZone, TrustZone-M, …
  - Simple key policies
    - Declare what operations are allowed (sign, export, …) and what algorithm
- Random generation
- https://armmbed.github.io/mbed-crypto/psa/

Driver interface

- Combine a core (e.g. Mbed TLS) with one or more drivers
- Transparent drivers
  - For accelerators
  - Operations receive keys in cleartext
  - Can fall back to software (e.g. to deploy the same image on different hardware)
- Opaque drivers
  - For external secure elements, secure enclaves, accelerators with their own key encryption key, …
  - Operations receive keys in custom format:
    - wrapped key material, or
    - slot number or label of a key stores inside the secure element
- Entropy drivers

Building with drivers



Mbed TLS

driver_wrappers.c

automatically generated

```
if (location==APEX)
  apex_sign_hash();
else
  acme_sign_hash();
```

Driver 1

acme.c

```
acme_sign_hash() {
    …
}
```

driver.json

```
{"prefix":"acme",
 "type":"transparent",
 "capabilities":
 [{"entry_points":
   ["sign_hash"]}]}
```

Driver 2

apex.c

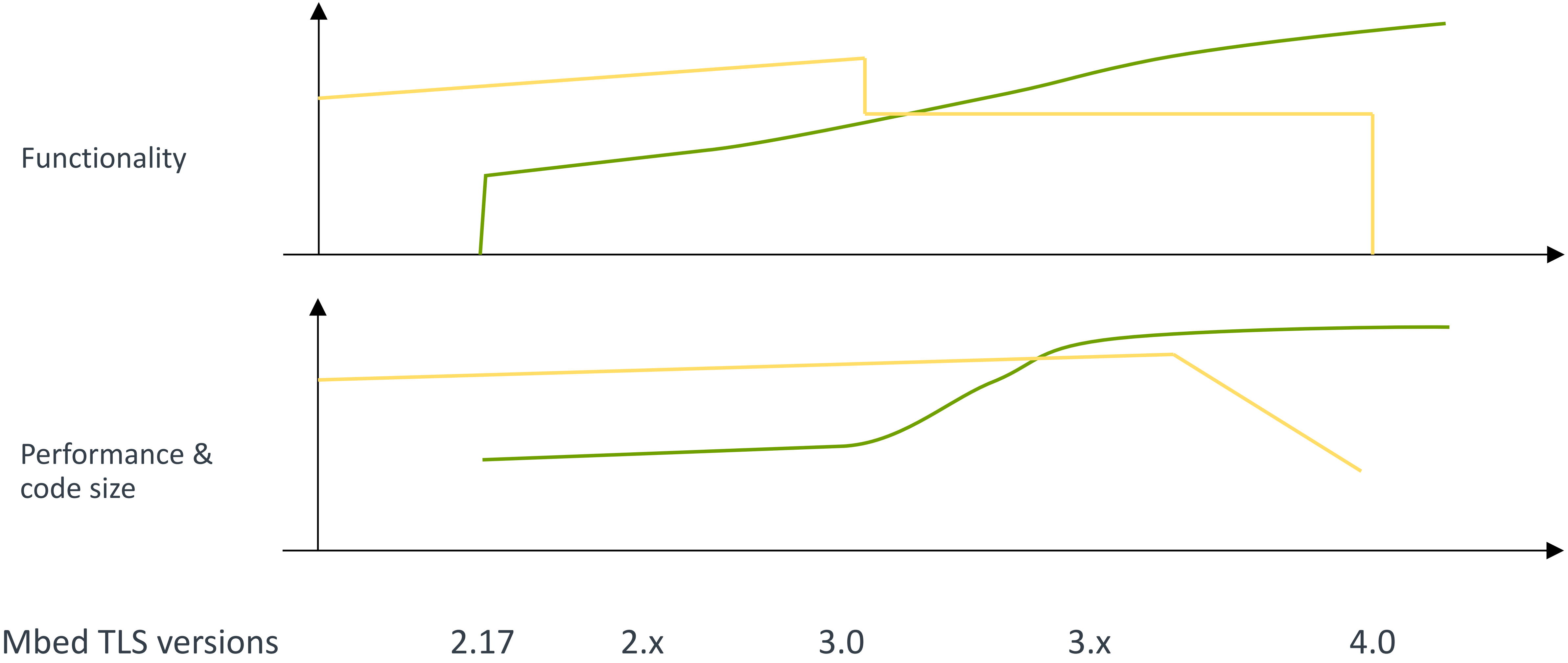
```
apex_sign_hash() {
    …
}
```

driver.json

```
{"prefix":"acme",
 "type":"opaque",
 "capabilities":
 [{"entry_points":
   ["sign_hash"]}]}
```

```
/src/mbedtls$ make PSA_DRIVERS="../acme/driver.json ../apex/driver.json"
/src/myapp$ ld myapp.o ../mbedtls/libmbedcrypto.a ../acme/acme.a ../apex/apex.a
```

Crypto APIs in Mbed TLS: mbedtls_xxx vs psa_xxx



Useful links

- Arm Platform Security Architecture (PSA):
  https://developer.arm.com/architectures/security-architectures/platform-security-architecture
- PSA Cryptography API information: https://armmbed.github.io/mbed-crypto/psa/
  - Reference documentation: PDF, HTML
  - Driver interfaces (DRAFT): accelerators and secure elements, entropy source
- Mbed TLS: https://github.com/ARMmbed/mbedtls
- Trusted Firmware-M (TF-M):
  https://developer.arm.com/tools-and-software/open-source-software/firmware/trusted-firmware/trusted-firmware-m

- We welcome feedback!
  - Public: on the psa-crypto mailing list (psa-crypto@lists.trustedfirmware.org)
  - Confidential: email us at mbed-crypto@arm.com

Thank You

Danke

Merci

谢谢

ありがとう

Gracias

Kiitos

감사합니다

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