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Plug & Trust MW Documentation

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Application note

Document information

Information	Content
Keywords	Plug & Trust, Middleware
Abstract	The document contains the documentation on Plug & Trust MW.

Plug & Trust MW Documentation

Release v04.02.00

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CONTENTS

CHAPTER ONE

NXP PLUG & TRUST MIDDLEWARE

The NXP Plug&Trust Middleware documentation covers following Secure Elements:

- EdgeLock™ SE050 (Including variants **A**, **B** and **C**)
- EdgeLock™ SE051 (Including variants **A** and **C**)
- A71CH (refer to the *A71CH* section at the end of this document)

Setting up SE05x and A71CH development environment for:

- Linux:
  - i.MX: Section 4.4 *i.MX Linux Build*
  - RaspberryPi: Section 4.5 *Raspberry Pi Build*
- Microcontroller:
  - Section 11.5.3 *Freedom K64F*
  - Section 11.5.4 *i.MX RT 1060*
  - Section 11.5.5 *LPC55S69*
  - Section 11.5.7 *MIMXRT1170*
- Android: Section 11.5.6 *Android: Hikey960*
- Windows: Section 4.1 *Windows Build*

Documentation also covers:

- Using the CLI Tool to configure the `Secure Element` for the Demos.
- Setting up the iMX and Kinetis Freedom boards to be used with the CLI Tool.
- Setting up and executing Demo Examples Section 5 — *Demo and Examples*.

Dedicated application notes:

- Overview of all available HW, SW and documentation:
  - SE05x Support Package
- Secure Element configurations are available here:
  - SE050 Configuration
  - SE051 Configuration
- Some of the important Application Notes are as shown below:
  - MCU/RTOS: K64F iMXRT1060 LPC55S69

    - MPU/Linux: iMX6UL iMX8MQ
    - Windows: AN12398
  - Details regarding SE050 and other detailed application notes can be found at https://www.nxp.com/products/:SE050
  - Details regarding SE051 and other detailed application notes can be found at https://www.nxp.com/products/:SE051

1.1 Organization of Documentation

This documentation is organized into following parts/sections.

- What has changed so far in the middleware stack be found in Section 2 — *Changes*.
- The overall middleware stack is explained in Section 3 — *Plug & Trust MW Stack*
  - The common SSS APIs, a subset of the overall stack, is explained in Section 3.3 — *SSS APIs*
- How to build MW for various reference platform/IDEs is explained in Section 4 — *Building / Compiling*.
  - Section 4.1 — *Windows Build*
  - Section 4.2 — *Import MCUXPresso projects from SDK*. Steps for i.MX RT 1060 and LPC55S are similar to those for *Import MCUXPresso projects from SDK*
  - For advanced users to take power of CMake's capabilities, Section 4.3 — *Freedom K64F Build (CMake - Advanced)*. Steps for i.MX RT 1060 and LPC55S are similar to those for *Freedom K64F Build (CMake - Advanced)*
  - Section 4.4 — *i.MX Linux Build*
  - Section 4.5 — *Raspberry Pi Build*
- The MW package has lots of examples, they are part of Section 5 — *Demo and Examples*.
  - Section 5.1.1 — *DEMO List* has an itemized list of the demos.
  - Section 5.1.1 — *Platforms List*
  - Section 5.1.1 — *Cloud connectivity Examples*
  - Section 5.1.1 — *OpenSSL Engine Examples*
  - Section 5.1.1 — *mbedTLS Examples*
  - Section 5.1.1 — *OPC UA Examples*
  - Section 5.1.1 — *SE05X Specific Examples*
  - Section 5.1.1 — *NFC (DESFire) Examples*
  - Section 5.1.1 — *Ease of Use Configuration Examples*
- Integration with other middlewares/systems is explained in Section 8 — *Plugins / Add-ins*.
  - Section 8.1 — *Introduction on OpenSSL engine*
  - Section 8.2 — *Introduction on mbedTLS ALT Implementation*
  - Section 11.5.6 — *Android: Hikey960*
  - Section 8.5 — *Introduction on Open62541 (OPC UA stack)*
  - Section 8.7 — *PKCS#11 Standalone Library*

- The CLI Tool is explained in Section 9 — *CLI Tool*
  - Section 9.7 — *List of ssscli commands*

1.2 Folder Structure

Folder / File Name	Description
README . First . txt	*PLEASE Read this file before using the Software Package*
EULA.pdf	Contains the End User License Agreement. Required to be agreed mandatorily before using the PlugAndTrustMW software
Third _ Party _ License.pdf	This file lists the Third Party license(s) in text that are part of this software package.
akm	This folder has the files corresponding to Android Key Master implementation as part of Plug&Trust MW Currently AKM solution is supported only on HiKey 960 development platform.
binaries	This folder has pre-build binaries and executables. e.g. It has firmware binaries to emulate Virtual COM port on freedom K64F, etc. binaries for platforms supported. For Ex: FRDM-K64F, i.MX RT1060.
binaries/PCWindows/ssscli	This folder contains pre-compiled ssscli tool. Version 03.XX specific library is under binaries/PCWindows/ssscli/03_XX and version 07.02 specific library is under binaries/PCWindows/ssscli/07_02. This tool runs on Windows.
demos	This folder contains various Demonstration Examples for the supported platforms. See *DEMO List* for list of supported Demos.
demos / Certificate_Chains	This folder contains the certificate chains as per OEF configuration The intermediate and RootCA certificates are required to connect to clouds using trust provisioned device certificates. See *Certificate Chains*
doc	This folder contains the documentation for Plug&Trust MW in the form of html files
ext	This folder contains files related to external dependencies that are required to build the Middleware and it's demo examples. e.g. amazon-FreeRTOS, openSSL, mbedTLS, JRCP, etc.
hostlib	This folder contains the *common* part of host library e.g. T=1oI2C communication protocol stack, SE05x APIs, etc.
hostlib/hostlib/accessManager	This folder contains the source code of the Access Manager application. The Access Manager supports concurrent access from multiple linux processes to an SE05x IoT applet.
nxp_iot_agent	This folder contains source code of the EdgeLock 2GO agent and demonstration examples.
projects	This contains MCUXpresso projects that can use CMake generated gnu-arm-gcc cross compiled build directories for easy download and debug.
pycli	This folder contains the NXP proprietary command-line tool (ssscli) for configuring and provisioning the SE05x (Secure Element) Please ensure that PYTHON Version 3.6 or later **(32 bit)** is installed. The default pre-compiled DLLs are 32bit and hence this tool needs a *32* bit Python.
scripts	This folder contains scripts for creating CMake projects
semslite	This folder contains source code of the SEMS Lite agent, demonstration examples and generator tools.
sss	This folder contains the "SSS" APIs interface to the Application Layer
tools	This folder contains the pre-built binaries and DLLs.

1.3 List of Platform Prerequisites

All the examples assume that build environment is setup and refer these sections for guidance.

Platform	Link
Windows	*Windows Build*
FRDM-K64F	*Import MCUXPresso projects from SDK* or *Freedom K64F Build (CMake - Advanced)*
RaspberryPi-3 / RaspberryPi-4	*Raspberry Pi Build*
IMX6UL / IMX8M	*i.MX Linux Build*
RT1060	*i.MX RT 1060*
LPC55S	*LPC55S69*

CHAPTER

TWO

CHANGES

2.1 Pending Refactoring items

The following items would be re-factored and changed in future releases. These topics are deemed to be deprecated and to be used with vigilance.

2.2 Known limitations

The following known limitations exist in this package. And they would be addressed in subsequent releases.

- [SSS] Cipher init manages crypto object: The SSS layer's implementation of multistep symmetric ciphers does not allow concurrent execution of ciphers with the same cipher mode (e.g. twice kAlgorithm_SSS_AES_CBC).
    - Workaround : Use lower layer api's instead of sss api's for creating multiple crypto objects.

  Refer *se05x Multiple Digest Crypto Objects example*.

2.3 Release `v04.02.00`

2.3.1 Build system changes

- Added support for powershell (`scripts/env_setup.ps1`) to set environment variables for generating build files. Refer - *Windows Build*
- Default applet in build configuration changed to SE050E.

2.3.2 APIs & enum/types Changes

- Extended `smStatus_t` with new error codes
- Updated behaviour of *`sss_se05x_key_object_get_handle()`* to return a success and print warning if it is unable to read attributes but the object exists so that other operations (like deleting) can proceed if they don't depend on object attributes.

2.3.3 Functional Changes

- Updated OEF specific SCP keys handling. See Section 3.9.1 *Configuring for OEF specific Platform SCP keys*

- mbed-crypto removed and PSA support moved to mbedTLS v2.26.0. See Section 8.3 *Platform Security Architecture*

2.3.4 New feature support

- SE050E applet support added. (Enabled by default in build configurations).
- SE051-H applet support added (Provides PAKE support).
- Openssl engine can be build with 'host crypto = mbedtls' and 'host crypto = user' also.

2.3.5 SSSCLI Changes

- Added precompiled libraries for Applet version 03.XX and 07.02 in `binaries/PCWindows/ssscli/03_XX` and `binaries/PCWindows/ssscli/07_02`. Default configuration is set to 03.XX

2.3.6 Examples / DEMO updates

- Added Secure Authenticator (Qi) demo Section 5.7.32 *Secure Authenticator (Qi) Authentication demo*
- Default port for access manager clients changed to 8040.
- Added read and delete policies to authentication objects created by Section 5.7.28 *Delete and Test Provision*

2.3.7 Other Miscellaneous Changes

- Access manager (with Unix sockets) clients to stop when access manager process is killed.
- FD_CLOEXEC option set when access manager opens unix socket. (*FD_CLOEXEC* flag specifies that the file descriptor should be closed when an *exec* function is invoked).
- Bug fix : Memory leak fix on open session with wrong keys
- Bug fix : Linux VCOM driver communicates very slow.
- Session handling cleaned up for PKCS11 library. Session ID is returned to the appplication instead of session handle pointer. Added mapping table from session handle to session handle pointer and added sanity checks before using the session for any operation. See Section 8.7 *PKCS#11 Standalone Library*

2.4 Release `v04.01.03`

2.4.1 Other Miscellaneous Changes

- Added documentation to configure MW for SE050E variant. `SE050E-documentation` SE050E-documentation

2.5 Release `v04.01.01`

2.5.1 SEMSLite

- Semslite header updated from a manually edited JSON file.

2.5.2 Other Miscellaneous Changes

- Fixed Prebuilt binaries for ssscli

2.6 Release `v04.01.00`

2.6.1 SEMSLite

- Semslite example updated for OEF A8FA.

2.6.2 Examples / DEMO updates

- EDDSA example added. See: Section 5.2.1 *EDDSA Example*.
- SCP03 session resume example added. See: Section 5.7.31 *SE05X SCP03 BOOT Example*.

2.6.3 Other Miscellaneous Changes

- User crypto implementation extended for AES ECB encrypt/decrypt
- Added PlatformSCP keys of the generic types
- PKCS#11: Refactored library with bugfixes
- PKCS#11: Added support to cache object entries during `C_FindObjects()` to improve execution time. Max cache entries controlled by macro `USER_MAX_ID_LIST_SIZE`.
- Bugfix: Access manager clients to stop when access manager process is killed.

2.7 Release `v04.00.01`

2.7.1 Build system changes

- New cmake option to enable unix sockets in access manager - *-DWithAccessMgr_UnixSocket:BOOL=*

2.7.2 Functional Changes

- Added unix socket support for access manager

2.8 Release `v04.00.00`

2.8.1 File/Folder relocation

2.8.2 Build system changes

- Support for new applet version 7.x

2.8.3 APIs & enum/types Changes

- **Policy changes for 7.x applet (Also refer - *Policies*)**
    - **Below policies removed from `sss_policy_sym_key_u` for applet version 7.x.**
        - Allow key derivation policy (`can_KD`)
        - Allow to write the object policy (`can_Write`)
        - Allow to (re)generate policy (`can_Gen`)
    - **Below policies are added for `sss_policy_sym_key_u` for applet version 7.x.**
        - Allow TLS PRF key derivation (`can_TLS_KDF`)
        - Allow TLS PMS key derivation (`can_TLS_PMS_KD`)
        - Allow HKDF (`can_HKDF`)
        - Allow PBKDF (`can_PBKDF`)
        - Allow Desfire key derivation (`can_Desfire_KD`)
        - Forbid External iv (`forbid_external_iv`)
        - Allow usage as hmac pepper (`can_usage_hmac_pepper`)
    - **Below policies removed from `sss_policy_asym_key_u` for applet version 7.x.**
        - Allow to read the object policy (`can_Read`)
        - Allow to write the object policy (`can_Write`)
        - Allow key derivation policy (`can_KD`)
        - Allow key wrapping policy (`can_Wrap`)
    - **Below policies are added for `sss_policy_common_u` for applet version 7.x.**
        - Allow to read the object policy (`can_Read`)
        - Allow to write the object policy (`can_Write`)
    - Added new policy - `ALLOW_DESFIRE_CHANGEKEY`, `sss_policy_desfire_changekey_authId_value_u`
    - Added new policy - `ALLOW_DERIVED_INPUT`, `sss_policy_key_drv_master_keyid_value_u`
    - **can_Read** and **can_Write** polices are moved from symmetric and asymmetric object policy to common policy in applet 7.x. **PLEASE UPDATE THE APPLICATIONS ACCORDINGLY**.
- **New attestation scheme for applet 7.x**
    - Updated API `Se05x_API_TriggerSelfTest_W_Attst()` for applet version 7.x.
    - Updated API `Se05x_i2c_master_attst_txn()` for applet version 7.x.
    - Updated API `sss_se05x_key_store_get_key_attst()` for applet version 7.x.
- New API added for PBKDF2 support: `Se05x_API_PBKDF2_extended()`. Supports optional salt object id and optional derived object id.
- New mode `kMode_SSS_Mac_Validate` added to support MAC validation feature in `sss_mac_one_go()` and `sss_mac_*` multistep APIs.
- New API added for ECDH calulation with option to select ECDH algorithm: `Se05x_API_ECDHGenerateSharedSecret_InObject_extended()`. ECDH algorithms supported - `EC_SVDP_DH` and `EC_SVDP_DH_PLAIN`.

- New API added *`sss_cipher_one_go_v2()`* with different parameters for source and destination lengths to support ISO/IEC 9797-M2 padding.
- Internal IV generation supported added for AES CTR, AES CCM, AES GCM modes: `kAlgorithm_SSS_AES_GCM_INT_IV`, `kAlgorithm_SSS_AES_CTR_INT_IV`, `kAlgorithm_SSS_AES_CCM_INT_IV`.
- New MAC algorithm - `kAlgorithm_SSS_DES_CMAC8` supported.
- New api *`Se05x_API_ECPointMultiply_InputObj()`* added.
- New api *`Se05x_API_WriteSymmKey_Ver_extended()`* added to set key with minimun tag length for AEAD operations
- Removed all deprecated defines starting with `With` and replaced with `SSS_HAVE_`

2.8.4 Functional Changes

- ECKey authentication is updated to read SE.ECKA public key with attestation using *`Se05x_API_ReadObject_W_Attst_V2()`* or *`Se05x_API_ReadObject_W_Attst()`* (based on applet version) instead of GetData APDU. To authenicate the public key read with attestation, signature verification is performed on the data received from SE. See details of *`Se05x_API_ReadObject_W_Attst_V2()`* / *`Se05x_API_ReadObject_W_Attst()`*.

2.8.5 New platform support

- Section 11.5.7 *MIMXRT1170* platform support added.

2.8.6 New feature support

2.8.7 SEMSLite

2.8.8 SSSCLI Changes

- Python version 3.9 supported
- Applet 7.x version policies updated

2.8.9 Documentation Changes

2.8.10 Examples / DEMO updates

- Attestation examples updated to handle new attestation scheme of applet 7.x. See: Section 5.2.1 *ECC NIST256 Key Attestation Example*,

  Section 5.2.1 *ECC MONTGOMERY-25519 Key Attestation Example*,

  Section 5.7.13 *Read object with Attestation*,

  Section 5.7.7 *I2C Master Example*
- Example added to demonstrate FIDO protocol. `se05x-fido-ecdaa` se05x-fido-ecdaa
- Example added Section 5.7.30 *SE05X Allow Without SCP example*
- Rotate PlatformSCP03 keys (se05x_RotatePlatformSCP03Keys) example with openssl host crypto - Fixed.

2.8.11 Communication Layer Changes

2.8.12 EdgeLock 2GO agent

2.8.13 User Interface Changes

2.8.14 External modules Changes

- MCU-SDK updated to SDK version 2.10.0
- mbedTLS updated to version 2.26.0
- Amazon-FreeRTOS updated to version 202012.00
- Openssl windows precompiled binaries updated to 1.1.1l

2.8.15 Other Miscellaneous Changes

- sss_se05x_cipher_update() and sss_se05x_aead_update() APIs modified to use input buffer directly.
- Bugfix: Write of large binary files with policy fails on applet 3.x.

2.9 Release `v03.03.00`

2.9.1 File/Folder relocation

2.9.2 Build system changes

- Option added to allow create-cmake-project.py to run deterministically for Raspberry Pi *Raspberry Pi Build*

2.9.3 APIs & enum/types Changes

2.9.4 Functional Changes

- Added call to `xLoggingTaskInitialize()` to enable FreeRTOS prints.

2.9.5 New platform support

2.9.6 New feature support

- Extended access manager to support A71CH. Refer `Build options for A71CH in Access Manager` in *Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*

2.9.7 SEMSLite

2.9.8 SSSCLI Changes

- Added API to set and get binary data. Refer - *List of ssscli commands*

2.9.9 Documentation Changes

2.9.10 Examples / DEMO updates

- Added example to demonstrate managing multiple crypto objects from application - se05x_MultipleDigestCryptoObj
- se05x_ConcurrentEcc demo modified to use runtime generated key

2.9.11 Communication Layer Changes

2.9.12 EdgeLock 2GO agent

2.9.13 User Interface Changes

2.9.14 External modules Changes

2.9.15 Other Miscellaneous Changes

- sss_openssl_cipher_one_go() api modified to use EVP calls for AES (ECB, CBC, CTR)
- sss_se05x_cipher_update() api modified to use block size of 256 to enhance performance.
- Session open retry feature added for accessManager clients - (Only with `-DSMCOM:STRING=JRCP_V1_AM` build option)

2.10 Release `v03.01.01`

2.10.1 File/Folder relocation

- N.A.

2.10.2 Build system changes

- N.A.

2.10.3 APIs & enum/types Changes

- N.A.

2.10.4 Functional Changes

- “READY=1” start up notification by access manager is disabled by default. Refer - *Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*

2.10.5 New platform support

- N.A.

2.10.6 New feature support

- N.A.

2.10.7 SEMSLite

- N.A.

2.10.8 SSSCLI Changes

- Prebuilt ssscli binary updated to support both SE050 and SE051

2.10.9 Documentation Changes

- N.A.

2.10.10 Examples / DEMO updates

- N.A.

2.10.11 Communication Layer Changes

- N.A.

2.10.12 EdgeLock 2GO agent

- N.A.

2.10.13 User Interface Changes

- N.A.

2.10.14 External modules Changes

- N.A.

2.10.15 Other Miscellaneous Changes

- N.A.

2.11 Release `v03.01.00`

2.11.1 File/Folder relocation

- N.A.

2.11.2 Build system changes

- Updated build tools installation for rpi build.

2.11.3 APIs & enum/types Changes

- Extended kSSS_KeyPart_Default for other objectType.
    - Earlier: Object type `kSSS_KeyPart_Default` is used for Binary Files, Certificates, Symmetric Keys, PCR and HMAC-key.
    - Now: UserID and Counter are added for `kSSS_KeyPart_Default`. This means objectType of UserID and Counter will be `kSSS_KeyPart_Default` after calling *`sss_key_object_get_handle`*. Comment for enum `sss_key_part_t` is updated accordingly.
- Added new API *`Se05x_API_WritePCR_WithType()`* with support to write transient PCR objects also.
- Deprecated API *`Se05x_API_WritePCR()`*. Added macro `ENABLE_DEPRECATED_API_WritePCR` to enable compilation of deprecated API *`Se05x_API_WritePCR()`*. Support will be removed by Q1 2022.
- Bugfix - Handling of result tag in case of failure in *`Se05x_API_AeadOneShot()`*, *`Se05x_API_AeadFinal()`* and *`Se05x_API_AeadCCMFinal()`*

2.11.4 Functional Changes

- Cleanup for heap management macros. Added support to redirect macros to FreeRTOS APIs. Section 3.19 *SSS Heap Management*.
- Changed from Heap_3 to Heap_4 for Section 11.5.3 *Freedom K64F* and Section 11.5.4 *i.MX RT 1060*
- Bugfix - KVN12 key can be used for PlatformSCP authentication now in SE051.
- Access manager will send "READY=1" start up notification to systemd. (Enabled by default on iMX and Rpi platforms)
- AKM - Improved error handling
- SE05x APDU - Response length set to 0 in error condition - *`tlvGet_u8buf()`*.
- Created separate library (`mwlog`) for logging framework. See Section 3.7 *Logging*
- Order of log level reversed. Current log level is - `{"ERROR", "WARN ", "INFO ", "DEBUG"}`.
- Added reserved commands for access manager - `hostlib/hostLib/accessManager/inc/accessManager.h`.

```
// For future use
#define RESERVED_ID1            0x60
#define RESERVED_ID2            0x61
#define RESERVED_ID3            0x62
#define RESERVED_ID4            0x63

#define RESERVED_ID5            0x70
#define RESERVED_ID6            0x71
#define RESERVED_ID7            0x72
#define RESERVED_ID8            0x73
```

2.11.5 New platform support

- N.A.

2.11.6 New feature support

- Mbedtls ALT is extended with ECDSA verify operation using `MBEDTLS_ECDSA_VERIFY_ALT` define. (Disabled by default). Using this all EC public key verify operations can be performed using SE05x.

2.11.7 SEMSLite

- N.A.

2.11.8 SSSCLI Changes

- N.A.

2.11.9 Documentation Changes

- N.A.

2.11.10 Examples / DEMO updates

- Added Secure Boot demo for LPC55S. Refer Section 3.20 *Secure Boot*.

2.11.11 Communication Layer Changes

- New smcom option `-DSMCOM:STRING=JRCP_V1_AM` added for client (using access manager) build. When using multiple clients with user authentication, this will ensure the user session is established in an atomic way per client connect.

2.11.12 EdgeLock 2GO agent

- Updated RTP server demo example to support RSA keys and Static Public Key for offline remote trust provisioning.

2.11.13 User Interface Changes

- N.A.

2.11.14 External modules Changes

- N.A.

2.11.15 Other Miscellaneous Changes

- Changed files under BSD3 License with NXP Copyright to Apache2 License.
- Changed files under Proprietary license to Apache 2 License.

2.12 Release `v03.00.06`

2.12.1 Examples / DEMO updates

- GetInfo to use Channel 0 instead of Channel 1 to query information from JCOP.
- Azure demo in KSDK using FreeRTOS needs more heap to perform data exchange. Heap increased to fix the issue.

2.12.2 EdgeLock 2GO agent

- EdgeLock 2GO agent demo example now provides report of provisioning result.
- Added client - server examples to demonstrate offline remote trust provisioning.
- Added support for i.MX RT1060.

2.13 Release `v03.00.05`

2.13.1 Functional Changes

- Added Platform SCP03 keys for SE051 (Variant A2 and C2).

2.13.2 New feature support

- Added support for Key Attestation when multiple digests are specified during key creation in Android Keymaster.

2.13.3 SSSCLI Changes

- Read ID list has been sorted based on object index.

2.13.4 Documentation Changes

- Updated documentation to include links to SE051 specific documents and Application Notes.

2.13.5 Examples / DEMO updates

- Added examples Section 5.7.26 *ECC Concurrent Example* and Section 5.7.27 *Symmetric Multi Step Concurrent Example* for Access Manager
- Access Manager (*Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*): miscelaneous implementation improvements.

2.14 Release `v03.00.04`

2.14.1 File/Folder relocation

2.14.2 Build system changes

- Building the OpenSSL Engine with `OPENSSL_NO_HW` defined is now triggering a build error. This changes the old behaviour where the OpenSSL Engine built did not support integration with the Secure Element.

2.14.3 APIs & enum/types Changes

2.14.4 Functional Changes

2.14.5 New platform support

2.14.6 New feature support

2.14.7 SEMSLite

2.14.8 SSSCLI / PyCLI Changes

- Added support for session authentication with Platform SCP03 combinations:
  - UserID_PlatfSCP03
  - AESKey_PlatfSCP03
  - ECKey_PlatfSCP03

2.14.9 Documentation Changes

- SEMS Lite documentation update
- Access Manager documentation update
- Yocto flow to create iMX8 SD card updated to Yocto Zeus

2.14.10 Examples / DEMO updates

- `demos/se05x/se05x_ReadWithAttestation` : Updated parsing of Object attributes. Take into account differences between SE050 and SE051 regarding Object attributes. (*Read object with Attestation*)

- `hostlib/hostlib/accessManager` : Additional functionality and miscelaneous bug improvements on an embedded Linux system. (*Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*)
  - Added command line option to allow incoming connections on all IP addresses, previously this was the default behaviour
  - Improvement: Server now closes STREAM connection in case Client has closed it.
  - Improvement: Fix applet version detection
  - Compile time removal (default) of incomplete and un-tested lock / unlock handling

2.14.11 Communication Layer Changes

2.14.12 User Interface Changes

2.14.13 External modules Changes

2.14.14 Other Miscellaneous Changes

- Bug Fix : Fix for attestation read of symmetric objects which have no read policy.

2.15 Release `v03.00.03`

2.15.1 File/Folder relocation

2.15.2 Build system changes

- Embedded Linux: Support for building against mbedTLS shared libraries

2.15.3 APIs & enum/types Changes

- smCom_Init: return type is now *U16* instead of *void*. Return value indicates success/failure to create mutex/semophore.
- The enumerated type **SE05x_EDSignatureAlgo_t** contained a value **kSE05x_EDSignatureAlgo_ED25519PH_SHA_512**. The mnemonic name of the value was misleading as it actually corresponded to the *Pure EDDSA algorithm* not the *Prehashed (PH) EDDSA algorithm*. This has now been corrected. **This will require corresponding update in the application code.**
  - EDDSA signature algorithm enumerated value **kSE05x_EDSignatureAlgo_ED25519PH_SHA_512** is changed into **kSE05x_EDSignatureAlgo_ED25519PURE_SHA_512**.
  - EDDSA attestation algorithm enumerated value **kSE05x_AttestationAlgo_ED25519PH_SHA_512** is changed into as **kSE05x_AttestationAlgo_ED25519PURE_SHA_512**.

2.15.4 Functional Changes

2.15.5 New platform support

- Embedded Linux / Yocto: using Yocto Zeus (5.4.24_2.1.0) as iMX reference environment

- Integrated KSDK Rel.12 specific changes into Plug&Trust MW

2.15.6 New feature support

- Multithreaded support extended from Posix to FreeRTOS
- SE05x Garbage collection API and example using the Garbage collection API

2.15.7 SEMSLite

- Support for MulticastPackageFormat 1.2
- KSDK Examples added
- SEMSlite CLI application now available as a pre-compiled Windows binary

2.15.8 SSSCLI / PyCLI Changes

2.15.9 Documentation Changes

2.15.10 Examples / DEMO updates

- `hostlib\hostlib\accessManager` illustrates how multiple processes can share access to a Secure Element on an embedded Linux system. (*Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*)

2.15.11 Communication Layer Changes

- Select Applet: No prequel with Select CM required for SE05x

2.15.12 User Interface Changes

2.15.13 External modules Changes

- `simw-top/ext/amazon-freertos` updated to KSDK version 202002.00_rev1
- `simw-top/ext/mbedtls` updated to KSDK version 2.16.2_rev2
- `simw-top/ext/mcu-sdk` updated to public release 2.8.0
- `simw-top/ext/paho.mqtt.c` updated to version 1.3.5

2.15.14 Other Miscellaneous Changes

- Fixed warnings when compiling with GCC 9.2
- Fixed typo in example code API: ex_sss_kestore_and_object_init() is now ex_sss_key_store_and_object_init()
- Extended SE051 specific APDU command and response buffer size to match SE051's capabilities.
- Removed support for intermediate versions of the SE051 product
- SSS API blocks SHA512 attestation, signing and verification for RSA512 key

2.16 Release `v03.00.02`

2.16.1 File/Folder relocation

2.16.2 Build system changes

- Cmake workareas for iMX/RspPi created by scripts/create_cmake_projects.py now default to linking against shared libraries
- Shared libraries installed by Cmake all go into /usr/local/lib (paho libraries no longer go into /usr/local/lib64)
- New Host Crypto library cmake option `MBEDCRYPTO` added: mandatory for PSA TF-M demo (*Platform Security Architecture*). Use `MBEDTLS` for other use cases and demos where mbedTLS host crypto is required.
- Supported Secure element versions (SE05X_Ver) are 03_XX (SE050) and 06_00 (SE051) only.

2.16.3 APIs & enum/types Changes

- AEAD APIs are added as a part of Se051.

  `sss_aead_context_free()`

  `sss_aead_context_init()`

  `sss_aead_finish()`

  `sss_aead_init()`

  `sss_aead_one_go()`

  `sss_aead_update()`

  `sss_aead_update_aad()`

2.16.4 Functional Changes

- Added heap management macros for SSS layer. *SSS Heap Management*
- Extend support to SE051 (default build is for SE050, to make SE051 specific features available in the host software, set SE05X_Ver to 06_00)

2.16.5 New platform support

2.16.6 New feature support

SEMS Lite - Enables the deployment and update of applets in the field, while enabling preservation of on device applet data.

2.16.7 SSSCLI / PyCLI Changes

- `ssscli connect se050` has been replaced with `ssscli connect se05x`

2.16.8 Documentation Changes

2.16.9 Examples / DEMO updates

- Examples Added for Se051

  -`se05x_ReadState` : *SE05X Read State example*

  -`se05x_Perso_Delete_Mod_RSAKeyGen` : *SE05X Personalization Remove RSA Key Generation Module*
- iMX/RspPi Linux cloud demos now link against Paho libraries that are included in the Plug&Trust MW in the `siwm/ext` folder. Except for Azure cloud demo which links against downloaded Paho from git master.
- PSA TF-M demo on LPC55S69 (*PSA Non Secure Example* or *Platform Security Architecture*)

2.16.10 Communication Layer Changes

2.16.11 User Interface Changes

2.16.12 Other Miscellaneous Changes

- T1oI2C:
  - Fixed: potential null pointer dereference
  - Fixed: RSYNC _ + CRC error results in saving response to uninitialised buffer.
- Yocto recipe for Plug&Trust Mw Package: contained in `scripts/yocto` folder
- `hostlib/hostLib/platform/linux/i2c_a7.c`: A call to *axI2CTerm()* now closes the I2C file descriptor associated with the I2C communication channel.
- Fix OpenSSL Engine Issue: Key Creation was not handed back to SW implementation (issue introduced in v02.16.00 and linked to X25519 and X448 curve support)

2.17 Release `v02.16.01`

Note: This release fixes an issue introduced in v02.16.00 (see under 'APIs & enum/types Changes'). If you are using v02.16.00 please migrate to v02.16.01.

2.17.1 APIs & enum/types Changes

- Removed member **object_exist** from C structure **Se05xPolicy_t**. This solves a potential issue with the direct usage from the following APIs:
  - *`Se05x_API_WriteECKey`*
  - *`Se05x_API_WriteRSAKey`*
  - *`Se05x_API_WriteSymmKey`*
  - *`Se05x_API_WriteBinary`*
  - *`Se05x_API_WritePCR`*

The potential issue prevented by this change is as follows: In case **object_exist** was not properly initialized, the specific object policy passed as an argument for an object to be created would not be applied, instead the default policy would be applied.

The invocation of the above API's from the SSS layer has been modified accordingly.

2.17.2 Documentation Changes

- The enumerated type **SE05x_EDSignatureAlgo_t** contains a value **kSE05x_EDSignatureAlgo_ED25519PH_SHA_512**. The mnemonic name of the value is misleading as it actually corresponds to the *Pure EDDSA algorithm* not the *Prehashed (PH) EDDSA algorithm*.

2.17.3 Other Miscellaneous Changes

- T1oI2C:
  - Fixed: potential null pointer dereference
  - Fixed: RSYNC _ + CRC error results in saving response to uninitialised buffer.
- Include pre-compiled a7x_vcom_to_* binaries for the iMX.RT1060 host platform (instead of iMX.RT1050) in the `simw/binaries` folder.
- Fixed issue with VCOM on RT1060

2.18 Release `v02.16.00`

2.18.1 File/Folder relocation

- **se05x_Inject_Certificate** renamed to **se05x_InjectCertificate**
- **se05x_minimal** renamed to **se05x_Minimal**
- **se05x_Get_Info** to **se05x_GetInfo**
- **se05x_Get_Certificate** to **se05x_GetCertificate**
- **ex_i2cMaster** to **se05x_I2cMaster**

2.18.2 Build system changes

2.18.3 APIs & enum/types Changes

2.18.4 Functional Changes

2.18.5 New platform support

- Added support for MIMXRT1060

2.18.6 New feature support

- Added EdgeLock2go examples
- Montgomery X25519 curve support added for Openssl engine

2.18.7 SSSCLI / PyCLI Changes

- Added support to create object policy and attach to objects
- Sign and Verify input data restricted to file, Command line facility is removed

2.18.8 Documentation Changes

2.18.9 Examples / DEMO updates

- Added example for LPC55S based *Key Injection to PUF*
- Added example for LPC55S based *Key Rotation using PUF*
- Examples renamed
  - `se05x_setAppletFeatures` => `se05x_SetAppletFeatures`
  - `se05x_Inject_Certificate` => `se05x_InjectCertificate`
  - `se05x_minimal` => `se05x_Minimal`
  - `ex_A71CHMain` => `a71ch_Main`
  - `se05x_Get_Info` => `se05x_GetInfo`
  - `se05x_Get_Certificate` => `se05x_GetCertificate`
  - `ex_i2cMaster` => `se05x_I2cMaster`
  - `ex_i2cMaster_with_Attestation` => `se05x_I2cMasterWithAttestation`
  - `cloud_demo_aws` => `cloud_aws`
  - `cloud_demo_gcp` => `cloud_gcp`
  - `cloud_demo_ibm_watson` => `cloud_ibm_watson`
  - `cloud_demo_azure` => `cloud_azure`

2.18.10 Communication Layer Changes

- smComSerial for Linux PC: Do not translate CR (carriage return) into NL (newline) character when reading data

2.18.11 User Interface Changes

2.18.12 Other Miscellaneous Changes

- MIMXRT1050 support replaced with MIMXRT1060
- ImportExternalObjectCreate example is removed. ImportExternalObjectPrepare prepares and sends the object.

2.19 Release `v02.15.00`

Internal Milestone - Not published to NXP Website

2.19.1 Build system changes

- Changed FIPS Selection. Now use *PTMW_FIPS* `-DSSS_HAVE_FIPS=ON` is no longer valid. Use `-DFIPS=SE050` to enable FIPS mode or `-DFIPS=None` to disable FIPS mode.

2.19.2 APIs & enum/types Changes

- Added support for extended applet features to be used with *`Se05x_API_SetAppletFeatures()`*.
- Updated *`Se05x_API_SetAppletFeatures()`* and *`sss_se05x_set_feature()`* signature. Defined new structure with applet features and extended features.
- Added `kAlgorithm_SSS_ECDAA` in `sss_algorithm_t` for Barreto Naehrig curves.
- Refactored `sss_algorithm_t`, added common algorithm `kAlgorithm_SSS_RSAES_PKCS1_V1_5`, removed SHA dependency.
- Added APIs `Se05x_API_WriteSymmKey_with_version()`, `Se05x_API_WriteECKey_with_version()`, `Se05x_API_WriteRSAKey_with_version()` and `Se05x_API_WriteBinary_with_version()` to create key with version information.
- Added API *`Se05x_API_TLSCalculateRsaPreMasterSecret()`* to support RSA Pre-master secret with client version.
- Updated PCR functionality to not pass hash value from outside. Application should pass an input which will be hashed inside the applet.

2.19.3 Functional Changes

- Enable usage of usleep for clang.
- Moved PSA driver initialization to secure application on LPC55S.
- Added support for flash storage of PSA keystore on LPC55S. See *Managing KeyIDs*.
- Added support for Platform SCP03 using PUF on LPC55S.

2.19.4 New feature support

- SEMS Lite added for applet install, upgrade, delete etc.
- Added support for AES GCM on AKM

2.19.5 Documentation Changes

- Added Documentation on *Over-The-Air (OTA) Updates* for Greengrass.
- Added documentation for SEMS Lite.

2.19.6 Examples / DEMO updates

- Updated example Section 5.7.18 *Configuring Applet Features* to demonstrate use of extended features.
- Added attestation examples. Section 5.2.1 and Section 5.2.1
- Added example to demonstrate `kAlgorithm_SSS_ECDAA` signing operation.
- Added example for secure pairing on LPC55S
- Added examples for SEMS Lite
- Added examples for Perso scripts to demonstrate how to personalize the applet.

2.19.7 Other Miscellaneous Changes

- Files `simw-top/hostlib/hostLib/platform/imx/i2c_a7.c` and `simw-top/hostlib/hostLib/platform/rsp/i2c_a7.c` have been merged and the resulting I2C wrapper file is now located at `simw-top/hostlib/hostLib/platform/linux/i2c_a7.c`
- Memory leak fixes in T1oI2C layer
- Buffer size fixes, support for `CKA_LABEL`, `CKA_CERTIFICATE_TYPE` and `CKA_ALWAYS_AUTHENTICATE` in PKCS#11.

2.20 Release `v02.14.00`

2.20.1 File/Folder relocation

- Renamed DTLS/SSL2 Server and client executables. New names are:
  - mbedtls_ex_orig_ssl_server2
  - mbedtls_ex_sss_dtls_client
  - mbedtls_ex_orig_dtls_server
  - mbedtls_ex_sss_ssl2_client
- Renamed project `greengrass` to `sss_pkcs11`
- Renamed file `greengrass.c` to `sss_pkcs11.c`
- Renamed folders of Reader Library examples.
  - `ex_prepare_MFDFEV2` => `ex_Ev2Prepare_Card`
  - `ex_prepare_se05x` => `ex_Ev2Prepare_se05x`

2.20.2 Build system changes

- Extensively revamped `fsl_sss_ftr.h` file for finer control of build configuration selection. This design will be extended extensively in future releases.
- On LPC55S with FreeRTOS, using native malloc instead of Heap_4.c for mbedTLS
- Compile time asserts added for sizes of structures.
- `scripts/env_setup.sh`, `scripts/env_setup.sh` prints info on which tools are used from which paths.

- Changed Applet selection in CMake (See Section 4.7.1 *PTMW_Applet*). We no longer use name `SE050_A`, `SE050_B` or `SE050_C` for builds / Applet selection. New names are `SE05X_A`, `SE05X_B` or `SE05X_C`
- CMake Option `Applet_SE05X_Ver` is no longer used. Instead, Section 4.7.2 *PTMW_SE05X_Ver* is introduced for future use.
- See Section 4.7.11 *PTMW_SE05X_Auth*
    - `FastSCP` is now called `ECKey`.
    - `AppletSCP` is now called `AESKey`.

2.20.3 New platform support

- i.MX8 support added (*Setup i.MX 8MQuad - MCIMX8M-EVK*)

2.20.4 APIs & enum/types Changes

- Use `Se05x_API_ReadObject_W_Attst()` instead of `sss_se05x_key_store_get_key_attst()` to read with attestation large binary files greater than 500 bytes. See example *Reading large binary objects with attestation*
- For Montgomery curves the key arguments, DH Shared secret and Signature are passed in Little Endian Convention. Refer to *SSS api key format (asymmetric keys)* for details on Endianness.
- `sss_derive_key_go()` is deprecated and is replaced by `sss_derive_key_one_go()`
- Added `sss_status_sz()` to convert SSS API Return code to string.
- Updated Enumeration from `SE05x_TransientType_t` to `SE05x_INS_t` in the following API's:
    - `Se05x_API_WriteECKey`
    - `Se05x_API_WriteRSAKey`
    - `Se05x_API_WriteSymmKey`
- Define `T1oI2C_UM1225_SE050` is no longer applicable, use `T1oI2C_UM11225_SE05X` instead.
- Added SE050 APIs `Se05x_API_CreateCounter`, `Se05x_API_SetCounterValue`, `Se05x_API_IncCounter`
- smCom Layer is refactored so that Application send down the connection handles/parameters to lower layer.

  e.g. SSCLI and Demos on PC which can take command line argument can now use the I2C device over command line at run time without recompiling the middleware/example.

2.20.5 Functional Changes

- Extensive support for *A71CH*.
- Added enable pin support for SE05X on Raspberry Pi
- Modified SE policy of keymaster HAL in Android
- Updated RSA reference key format for Android Key Master. It now uses prefix A5 to import import Key ID 00000001.

2.20.6 New feature support

- Added tool se05x_setAppletFeatures to configure applet features
- Added support to use Platform SCP keys from file system
- Added support to retrieve existing certificates in pem format
- Added tool to mandate Platform SCP03
- Integrated mBED Crypto PSA interface
- Added Secure-NonSecure example based on PSA for LPC55S
- Added examples of SE05X Import Transient objects, SE05X Export Transient objects, Import External Object Prepare and Import External Object Create
- Added example to demonstrate object read with attestation
- Added example to demonstrate how timestamp is incremented in SE
- Added example to demonstrate how to create APDU buffer to import external key objects.
- Lock and unlock secure element using transport key
- Upgraded mbedTLS to version 2.16

2.20.7 SSSCLI / PyCLI Changes

- Added support for ECC ED25519 and MONTH DH 25519 curves
- Fixed sign and verify operation for ED25519.
- Added API to inject HMAC key
- Endianness of ed25519 and mont_dh_25519 keys, signature and shared secret are updated to little endian.

2.20.8 Communication Layer Changes

- VCOM Interface updates on OSX and PC Linux
- Added connection handle in smCom layer. This allows connection data to be passed from application. Tested on windows, raspberry pi and imx platform.

2.20.9 APIs & enum/types Changes

- Re-Wrote (internal) low level Tx/Rx APIs for APDU TxRx.
    1) DoAPDUTxRx_s_Case2
    2) DoAPDUTx_s_Case3
    3) DoAPDUTxRx_s_Case4
    4) DoAPDUTxRx_s_Case4E
- Define `T1oI2C_UM1225_SE05X` is no longer applicable, use `T1oI2C_UM11225` instead.
- *`SE05x_CryptoModeSubType_t`*

  `SE05x_CryptoModeSubType_t::u8` renamed to `SE05x_CryptoModeSubType_t::union_8bit`
- Endianness of ed25519 and mont_dh_25519 signature and shared secret are updated to little endian.

2.20.10 Examples / DEMO updates

Updated Examples:

- Section 5.7.2 *SE05X Get Info example* Updated to show CPLC data.

New Examples:

- Section 5.7.11 *Import External Object Prepare*
- `import-external-obj-create` import-external-obj-create
- Section 5.7.13 *Read object with Attestation*
- Section 5.7.14 *SE05X Transport Lock example*
- Section 5.7.15 *SE05X Transport UnLock example*
- Section 5.7.16 *SE05X Timestamp*
- Section 5.7.19 *Write APDU to buffer*

2.20.11 Documentation Changes

- Updated notes on `ssscli se05x reset` and `Se05x_API_DeleteAll_Iterative()`
- Updated documentation of SE05X layer of SSS APIs, e.g. `sss_se05x_key_store_load()` now mentions that this API does not do anything special on SE05X.
- Updated wifi-eap document.
- Changed logging styles and updated misc documentation with the same information.
- Added documentation for PKCS#11 standalone library
- Updated Greengrass documentation with new PKCS#11 project name
- Added documentation for Import External Object example
- Extended API Documentation for SE05X Low Level APIs

2.20.12 Other Miscellaneous Changes

- Bug fix: Remaining cache data and input data handled in `sss_cipher_finish()` API
- OPC-UA Example enabled for compilation/running from Raspberry PI
- mbedTLS Upgraded to `v02.16.02`
- Added mbedCrypto for LPC55S / TF-M related work. (Ongoing, NXP Internal work)

2.21 Release `v02.12.05`

Handle PC Linux for VCOM Interface.

2.22 Release `v02.12.04`

Minor touch ups.

2.23 Release `v02.12.03`

AKM: Fix processing of keys without read policy.

2.24 Release `v02.12.02`

2.24.1 AKM Specific changes

- Fixed limitation in importing Key ID 00000001. (Using prefix 0xA5.)

2.24.2 Example Updates

- Updated example Section 5.2.1 *RSA Example* to also inject RSA key and run with FIPS compiled option.
- Added compile time check to skip examples Section 5.2.1 *HKDF Example* and Section 5.2.1 *ECDH Example* when compiled with FIPS

2.24.3 Other Miscellaneous Changes

- Added check to skip attempt to erase Trust Provisioned objects.

2.25 Release `v02.12.01`

2.25.1 AKM Specific changes

- Modified SE policy of keymaster HAL in Android
- Added Section 5.7.6 *SE05X Rotate PlatformSCP Keys Demo* to be build by Android build system.

2.25.2 New example / example updates

- Added support to retrieve existing certificates in pem format
- Ex se05x_Minimal.c shows `kSE05x_MemoryType_PERSISTENT` memory. (Earlier it used `kSE05x_MemoryType_TRANSIENT_DESELECT`)
- Extended Section 5.7.6 *SE05X Rotate PlatformSCP Keys Demo* & it's documentation.

2.25.3 Other Miscellaneous Changes

- Updated Platform SCP Keys & SSD_NAME from Application Note
- Added *Using Platform SCP Keys from File System*
- Logging. Added `USE_COLORED_LOGS` inside `nxLog.c`
- Support FastSCP with and without KDF counter.
- Added support of VEN pin support for SE05X on Raspberry Pi / iMX6.
- Supports applet version `03.06.00`

2.26 Release `v02.12.00`

2.26.1 New feature support

- Added demos *HMAC Example* and *ECDH Example*
- SHA (one shot and multi step) and HMAC (one shot and multi step) implementation in SCCP A71CH layer
- Added support for AWS Cloud example with Ease-of-Use configuration
- Added support of Multistep update for HMAC in Android Keymaster

2.26.2 SSSCLI / PyCLI Changes

- Updated AWS Provisioning certificate chain to remove Intermediate CA

2.26.3 Documentation Changes

- Added documentation for AWS Ease-of-Use

2.27 Release `v02.11.03`

2.27.1 File/Folder relocation

Moved this files: hostLib:

```
a71ch/src/a71ch_com.c => libCommon/infra/sm_connect.c
tstUtil/app_boot.h => libCommon/infra/app_boot.h
tstUtil/app_boot_nfc.c => libCommon/infra/app_boot_nfc.c
tstUtil/app_boot_nfc.h => libCommon/infra/app_boot_nfc.h
tstUtil/a7x_app_boot.c => libCommon/infra/sm_app_boot.c

tstUtil/tst_utils_kinetis.c => libCommon/infra/sm_demo_utils.c
tstUtil/tst_utils_kinetis.h => libCommon/infra/sm_demo_utils.h

tstUtil/tst_utils_rtos.c -> libCommon/infra/sm_demo_utils_rtos.c

inc/a71ch_const.h => sm_const.h
```

hostLib/libCommon/scp:

```
scp.c split to scp.c and scp_a7x.c
```

2.27.2 New feature support

- WiFi and cloud demos support for LPC55S

2.27.3 Scripts and Build changes

- `I2C` is not longer a valid define. Use `SCI2C` to select `SCI2C` for A71XX Family.
- NON Cmake based MCUXPresso projects from `projects/` folder are removed and no longer supported. These examples are now separately released as KSDK Packages.

2.27.4 Documentation Changes

- Updated API usage description for T1oI2C protocol stack

2.27.5 Other Miscellaneous Changes

- PKCS#11 Testbench Integration

2.28 Internal Release `v02.11.01`

2.28.1 APIs & enum/types Changes

- Added `phNxpEse_data` in `iFrameInfo_t` also in `sFrameInfo_t`
- Changed order of parameters to `sss_channel_context_init`:

```
// Earlier:
    sss_status_t sss_channel_context_init(
        sss_session_t *session, sss_channel_t *context);

// Now: Parameters are swapped
    sss_status_t sss_channel_context_init(
        sss_channel_t *context, sss_session_t *session);
```

- Changed order of parameters to *`sss_rng_context_init()`*:

```
// Earlier:
    sss_status_t sss_rng_context_init(
        sss_session_t *session, sss_rng_context_t *context);

// Now: Parameters are swapped
    sss_status_t sss_rng_context_init(
        sss_rng_context_t *context, sss_session_t *session);
```

- Renamed `sss_channel_context_init` to *`sss_tunnel_context_init()`*
- Renamed `sss_channel_context_free` to *`sss_tunnel_context_free()`*

2.28.2 Functional Changes

- Added support for jrcp server on Android platform
- Fixed bug in VCOM Close for A71XX Family
- Handle WTX for CCID/PCSC Interface

- Added open62541 (OPC UA)
- Added RSA support to `<simw-top>/demos/linux/tls_client/scripts/tlsServer.sh`, `tlsSeClient.sh` and `tlsExtendedSeClient.sh` scripts.
- Added `/reset` support for jrcp server V1.

2.28.3 New feature support

- Added support for AWS Greengrass core on Rpi.

2.28.4 Scripts and Build changes

- Fixed MSVC Compiler warnings
- CMake option `SSS_HAVE_FIPS` is not a boolean. Earlier it was a string.
- AKM android based system set to build with `SSS_HAVE_FIPS` and `SSS_HAVE_SCP_SCP03_SSS`
- `SSS_HAVE_TESTCOUNTERPART` and `WithSSS_TestCounterPart` are deprecated. Please use `SSSFTR_SW_TESTCOUNTERPART`
- In file `hostLib/platform/imx/i2c_a7.c`, check `I2C_FUNC_SMBUS_READ_BLOCK_DATA` only for SCI2C (A71CH)
- Removed obsolete variables `ENGINE_DRIVEN_LIB_TYPE` and `BUILD_A71CH_OPENSSL_ENGINE` from cmake build scripts. Only the cmake option `WithSharedLIB` now determines the type of library (shared or static) that will be built / installed.
- AKM android based system set to build with All authentication types

2.28.5 Documentation Changes

- Fixed ssscli pre-steps documentation for RaspberryPi.
- Updated documentation
- Added ssscli commands list.
- Added Ease-Of-Use documentation for Azure IoT Hub.

2.28.6 Communication Layer Changes

- Removed unwanted buffer handling from T1oI2C.

2.28.7 User Interface Changes

- Updated input parameters in `<simw-top>/demos/linux/tls_client/scripts/provisionTlsClient.py` script. Usage example:

  ```
  python provisionTlsClient.py --key_type ecc --connection_data 169.254.0.1:8050
  ```

  They are documented in Section 8.1 *Introduction on OpenSSL engine*

2.28.8 Other Miscellaneous Changes

- ECC Key overwrite on different curve id not allowed
- lwIP stack updated. Current version of lwIP is based on lwIP 2.1.2 and lwIP-contrib 2.1.0.
- Freertos version upgraded to 1.4.7_rev0
- Added NO_REGISTER_ALL flag for openSSL engine (openssl 1.1.1) to use the capabilities specified in openSSL conf file.
- openSSL 1.1.1 warnings fixed.

2.29 Release `v02.11.00`

2.29.1 File/Folder relocation

boards folder has been moved from

simw-top\ext\mcu-sdk to

simw-top\demos\ksdk\common

```
├───boards
│   ├───evkmimxrt1060
│   │   ├───project_template
│   │   ├───se_hostlib_examples
│   │   │   ├───cloud_demo
│   │   │   │   └───linker
│   │   │   └───mainA71CH
│   │   │       └───linker
│   │   └───xip
│   ├───frdmk64f
│   │   ├───project_template
│   │   └───se_hostlib_examples
│   │       ├───cloud_demo
│   │       │   └───linker
│   │       ├───mainA71CH
│   │       ├───se_hostlib_test
│   │       └───vcomA71CH
│   ├───frdmk82f
│   │   ├───project_template
│   │   └───se_hostlib_examples
│   │       ├───mainA71CH
│   │       ├───se_hostlib_test
│   │       └───vcomA71CH
│   ├───frdmkw41z
│   │   ├───project_template
│   │   └───se_hostlib_examples
│   │       ├───mainA71CH
│   │       └───se_hostlib_test
│   ├───lpc54018iotmodule
│   │   ├───project_template
│   │   └───se_hostlib_examples
│   │       ├───aws_jitr_demo_enet
│   │       ├───aws_jitr_demo_wifi
│   │       └───mainA71CH
│   │
```

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```
│   └───lpcxpresso55s
│       ├───project_template
│       └───se_hostlib_examples
│           └───cloud_demo
│               └───linker
```

freertos folder moved from

simw-top\ext\freertos to

simw-top\demos\ksdk\common\freertos

```
──freertos
  │   FreeRTOSConfig.c
```

other boards folder has been moved from

simw-top\ext\boards to

simw-top\demos\ksdk\common\freertos\boards

```
│
└───boards
    ├───evkmimxrt1060
    │       app.h
    │       aws_bufferpool_config.h
    │       aws_mqtt_agent_config.h
    │       aws_mqtt_config.h
    │       aws_secure_sockets_config.h
    │       CMakeLists.txt
    │       FreeRTOSConfig.h
    │       FreeRTOSIPConfig.h
    │       fsl_phy.h
    │       lwipopts.h
    │
    ├───frdmk64f
    │       app.h
    │       aws_bufferpool_config.h
    │       aws_mqtt_agent_config.h
    │       aws_mqtt_config.h
    │       aws_secure_sockets_config.h
    │       CMakeLists.txt
    │       FreeRTOSConfig.h
    │       FreeRTOSIPConfig.h
    │       fsl_phy.h
    │       lwipopts.h
    │
    └───lpcxpresso55s
            app.h
            aws_bufferpool_config.h
            aws_mqtt_agent_config.h
            aws_mqtt_config.h
            aws_secure_sockets_config.h
            CMakeLists.txt
            FreeRTOSConfig.h
            FreeRTOSIPConfig.h
            fsl_phy.h
            lwipopts.h
```

2.29.2 APIs & enum/types Changes

- Removed `SE05x_AuthCtx_UserID_t`. Use *`SE05x_AuthCtx_ID_t`* instead
- Removed `SE_ConnType_t`. Use `SSS_Conn_Type_t` instead
- Removed `SEConnType_t`. Use `SSS_Conn_Type_t` instead
- Removed `AppletConfig_SM` from *`SE05x_Applet_Feature_t`*
- Renamed `se05x_TP_PlatformSCP03keys` to `se05x_RotatePlatformSCP03Keys`

2.29.3 Functional Changes

- **Added CCID/PCSC Interface (Experimental):**
    - Added `kType_SE_Conn_Type_PCSC`
    - Added weak function `SysTick_Handler_APP_CB()` to allow unblocking of threads. This is needed to handle the IRQ based design of CCID Middleware.
- **Added support for hmac-sha224 in mbedtls and openssl SSS MAC apis:**
    - Added `kAlgorithm_SSS_HMAC_SHA224`
- Fix a crash seen in `sss_mbedtls_mac_context_free`.
- Renamed and modified project `se05x_Get_UID` as `se05x_Get_Info` to include platform information also.

2.29.4 New platform support

- Added support for secure world and non secure world implementation of LPC55S.

2.29.5 Scripts and Build changes

- Added AOSP build support for Android keymaster.
- Added `Host=lpcxpresso55s_s` and `Host=lpcxpresso55s_ns` to support secure world implementation of LPC55S.
- No longer supporting `-DApplet_SE05X_Ver=02_02_00`
- Creating `cmake_options.mak` similar to `fsl_sss_ftr.h` so that customer build systems can be used/extended.

2.29.6 SSSCLI / PyCLI Changes

- Switched to Python 3
- Prvoisioning scripts refactored to be more consistant with internal variable names for keys and certificates. (No behaviour change)
- Updated cryptography patch to support BrainpoolP256R1 curve
- Refactored scripts to use different variable names.
- For some versions of python cryptography module, `key_size` was not available. Handling this within python library now.

- Added PKCS#12 format reference key creation.
- Enabled pcsc connection method

2.29.7 Documentation Changes

- Documentation for Demos updated. Earlier, KSDK demos were mentioning Raspberry Pi steps as well. This is removed now.
- Included documentation on how to get SE UID
- Included documentation for Ease of Use with IBM Watson and GCP
- Added default cmake options for imx and rpi build document.
- i.MX / Yocto instructions updated to include Python3 and func-timeout Python package

2.29.8 Communication Layer Changes

- Optimized T1oI2C transreceive time by 3-8 ms.
- Poll waiting time has been reduced from 5ms to 1ms.
- T=1 I2C support for GP 0.39 specification.

> **Warning:** You need to add both `-DT1oI2C` and `-DT1oI2C_UM1225_SE050` in your build system makefile to select T=1 over I2C Interface of SE050.
>
> Earlier only `-DT1oI2C` was needed.

2.29.9 Other Miscellaneous Changes

- Support for DTLS example
- Included certificate chain in middleware for trust provisioned keys
- Included pre-built binary to get SE UID for FRDM-K64F, iMX-RT1060 and LPC55S
- Included pre-built binary for VCOM for LPC55S
- Added azure root certificate
- Key generation added for a71ch openssl engine (openssl 1.1.1)
- Compile time directives for SE050A/B/C in openssl engine
- Added `EX_SSS_BOOT_OPEN_HOST_SESSION` to let application decide on opening a host session
- Extended legacy openssl engine test scripts with multiple ecc keys testing. Also replaced ssscli tool with a71ch config tool for testing
- Added sampleConfig.json file for aws (linux) demo
- Added pre-built binaries to configure applet flavour (A, B or C) on iMX6 platform
- Added pre-built EXEs to configure applet flavour (A, B or C) from PC and VCOM Connection

2.30 Release `v02.10.00`

2.30.1 APIs & enum/types Changes

Renaming of structures to follow convention:

- `auth_scp03_dyn_context_t` –> *`NXSCP03_DynCtx_t`*
- `auth_scp03_static_context_t` –> *`NXSCP03_StaticCtx_t`*
- `se05x_auth_mech_scp03_context_t` –> *`NXSCP03_AuthCtx_t`*
- `se05x_auth_mech_fastscp_context_t` –> `SE05x_AuthCtx_FastScp_t`

Re-factored structure for cleaner isolation of static and dynamic objects:

- **`SE05x_AuthCtx_FastScp_t`, *`NXSCP03_AuthCtx_t`***
  - Moved members to separate structure `NXFastSCP03_StaticCtx_t`

Re-factored structure to reclaim static memory when not needed:

- *`NXSCP03_AuthCtx_t`*, `SE05x_AuthCtx_FastScp_t` and *`SE05x_AuthCtx_ID_t`* now uses pointers to objects that can be freed eventually by the application after they are used during intial suthentication.
- **`a71ch_auth_context_t`**
  - Removed `a71ch_auth_context_t` and using only `SE_Connect_Ctx_t`
- **`sss_sscp_session`**
  - Added member `mem_sscp_ctx : sscp_context_t` for memory.

Added configurability:

- *`NXSCP03_StaticCtx_t`* - Added keyVersioNo for platform SCP.
- **`sss_se05x_channel_context_t`**
  - Added member `channelLock : pthread_mutex_t` for simultaneous access.

Moved SE050 specific parameters to the end of structure:

- *`NXSCP03_DynCtx_t`* - `authType` is now the last member of the structure. Earlier it was the first structure.

New structure added:

- Added *`sss_connect_ctx_t`* and *`SE_Connect_Ctx_t`*

Promoted Auth to be generic instread of being SE050 Specific:

- `kSE05x_AuthType_UserID` –> `kSSS_AuthType_ID`
- `kSE05x_AuthType_SCP03` –> `kSSS_AuthType_SCP03`
- `kSE05x_AuthType_FastSCP` –> `kSSS_AuthType_FastSCP`
- `kSE05x_AuthType_AppletSCP03` –> `kSSS_AuthType_AppletSCP03`
- `kSE05x_AuthType_None` –> `kSSS_AuthType_None`

Add new use cases:

- `SmCommState_t` Added skip_select_applet to skip selecting the applet.

2.30.2 New platform support

- **Added LPC55s**
    - WiFi is not yet integrated on LPC55s demos
- **Raspberry PI**
    - Tested using Raspbian OS for SE050

2.30.3 Scripts and Build changes

- iMX RT 1050 drivers updated to SDK Release 2.6.1

2.30.4 SSSCLI / PyCLI Changes

- Added timeout mechanism in `ssscli`

2.30.5 Other Miscellaneous Changes

- In few files, NON-ASCII characters are replaced with their ASCII equivalents.

2.31 Release `v02.09.00`

- Integration Applet release v02.05.00
- Renamed `hostLib/se05x_02_02_00` to `hostLib/se05x_02_02_xx`
- No longer using the term PIN. Using UserID for Authentication Objects
- Integration Applet release v02.03.00

2.31.1 Middleware

- Refactor: Changed kSSS_KeyType_Certificate to kSSS_KeyType_Binary

2.31.2 CLI Tool

- Updated `ssscli --help` documentation
- option `--format` has been added to CLI commands to specify file format.
- option `--hashalgo` has been added to sign and verify commands.
- option `--auth_type` has been added to connect command.

2.32 Release `v02.07.00`

2.32.1 Middleware

- Re-Wrote CMake build system to use Drop Down for selection of values intead of Check Boxes.
- `WithSMCOM_SOCKET` renamed to `WithSMCOM_JRCP_V1`
- `WithSMCOM_JRCP` renamed to `WithSMCOM_JRCP_V2`
- Added support for `Applet_SE05X_Ver_02_02_xx`, removed support for other version of Applet.
- Renamed eSE05xTAG_t to SE05x_TAG_t
- Added Negative test cases to check T1oI2C functionality.
- Hard reset recovery Mechanism implemented.
- Logging implemented for Android platform

2.32.2 SMCom

- Added Thread smCom Layer (Experimental)
- Changed T=1 over I2C layer to support JCOP SR6 (Handling of CRC Changed)

  Note: This change makes it in-compatible with older CES release of SE050.

- API exposed for clearing T1oI2C 7816 params to SMCom Layer (smComT1oI2C_ComReset())
- Hard Reseting IC using ENA pin is implemented.
- Read polling count decreases.

2.32.3 SSS APIs

- Refactored RSA/CRT RSA Key types. RSA Deemed RAW By default.
- Added separate policies for Symmetric / Asymmetric keys
- Added policies for counters

2.32.4 CLI Tool

- Changed `set ecc NIST_P256` to `set ecc`
- Session Open uses PIN with pin ID “0x7DA00001” and key “[0xC0, 0x01, 0x02, 0x03, 0x04]”
- CLI Failure Stack dump captured in log file.
- Added ‘se05x’ specific commands

2.32.5 Development Platform

- (Hikey960) Added support for SE050 v2.2.4
- (Hikey960) Support for HMAC
- (Hikey960) Support for HMAC sign/verify
- (Hikey960) Support for AES encrypt/decrypt
- (Hikey960) Support for Attestation

2.33 Release `v02.06.00`

2.33.1 Demos

2.33.2 Plug & Trust Middleware

- (SE050) Added basic policies
- (SE050) Updated enums for EC Curve IDs
- (SE050) Support v1.1.0 and v1.2.0 from same stack
- (SSS, SE050) Added policies
- (CLI-Tool) Changed `ecc 256` to `ecc NIST_P256`

2.33.3 Documentation

- Updated section on *Logging*
- Updated section on *AOSP build Environment Setup*
- Added/Updated CMake Options
- Updated navbar and searchbox placement for handling of html display

2.33.4 Development Platform

- (Hikey960) Added support for SE050 v1.2.0
- (Hikey960) Support for ECC-521 and AES-128

2.34 Release `v02.05.00`

Added Android Key Master.

2.35 Release `v02.04.00`

Added SE050 EAR CH and SE050 EAR CL Applet supports.

2.36 Release `02.03.00`

Added support for SSS APIs.

CHAPTER

THREE

PLUG & TRUST MW STACK

3.1 Features

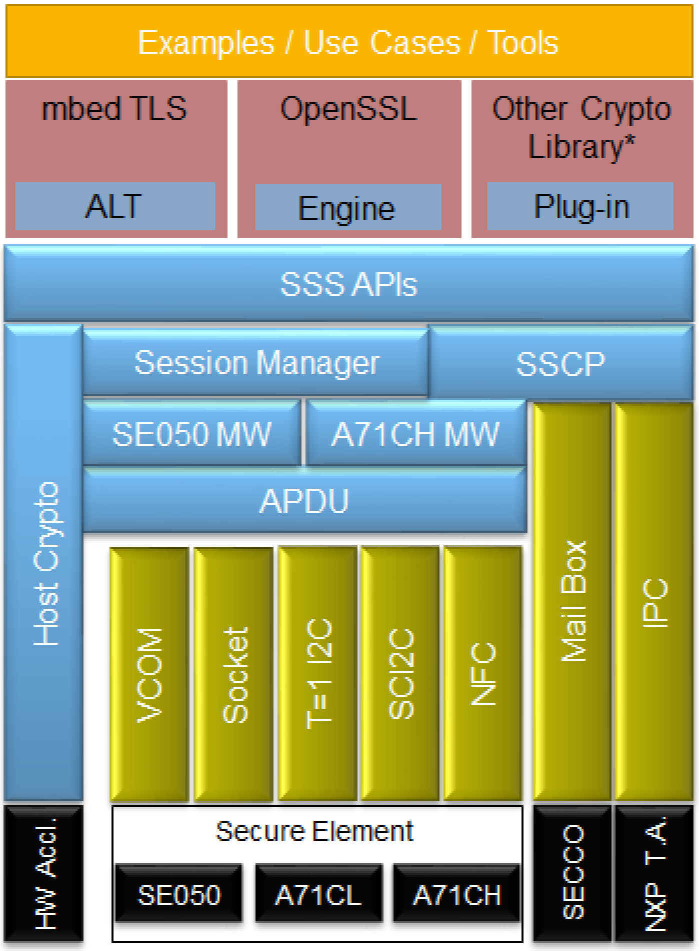
Supported development platforms: *Development Platforms*

The Plug & Trust Middleware Stack supports:

- **Directly accessible standard API/integration**
    - mbed TLS
    - OpenSSL
    - Android KeyStore
    - PKCS #11
- **Examples for quick integration**
    - TLS examples
    - Cloud service on-boarding examples
- Integration with NXP EdgeLock 2GO cloud service

Note: The supported features will vary according to the specific Secure Element used (e.g. A71CH, SE050A, SE051C). Refer to the Secure Element specific Data Sheet (e.g. SE050 Configuration) to find out what functionality is available.

3.2 Plug & Trust MW : Block Diagram



3.3 SSS APIs

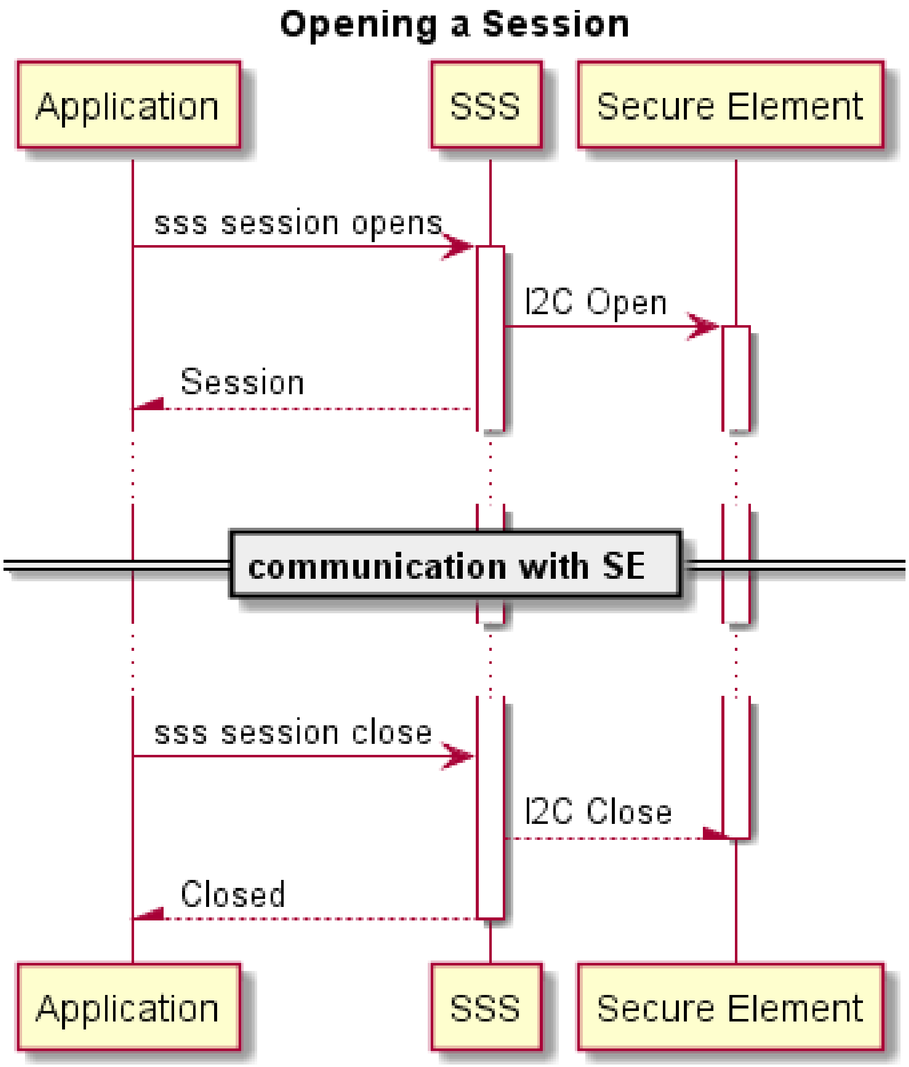
3.3.1 SSS: Introduction

`SSS` is an acronym for **S**ecure **S**ub **S**ystem

The SSS APIs are functional APIs to abstract the access to various types of Cryptographic Sub Systems. Such secure subsystems could be (but not limited to):

- Secure Elements
- Secure Enclaves
- Cryptographic HWs

3.3.2 Session



See *`sss_session_open()`*, *`sss_session_close()`*

Opening a Session

Sessions are tightly coupled with underlying system. For opening a session, *`sss_session_open()`*, subsystem is passed from `sss_type_t`, while the parameter `connectionData` plays a pivotal role where there are subsystem specific parameters to be handled.

Note: sss_session_open() must not be called concurrently from multiple threads. The application must ensure this.

SE05x Session

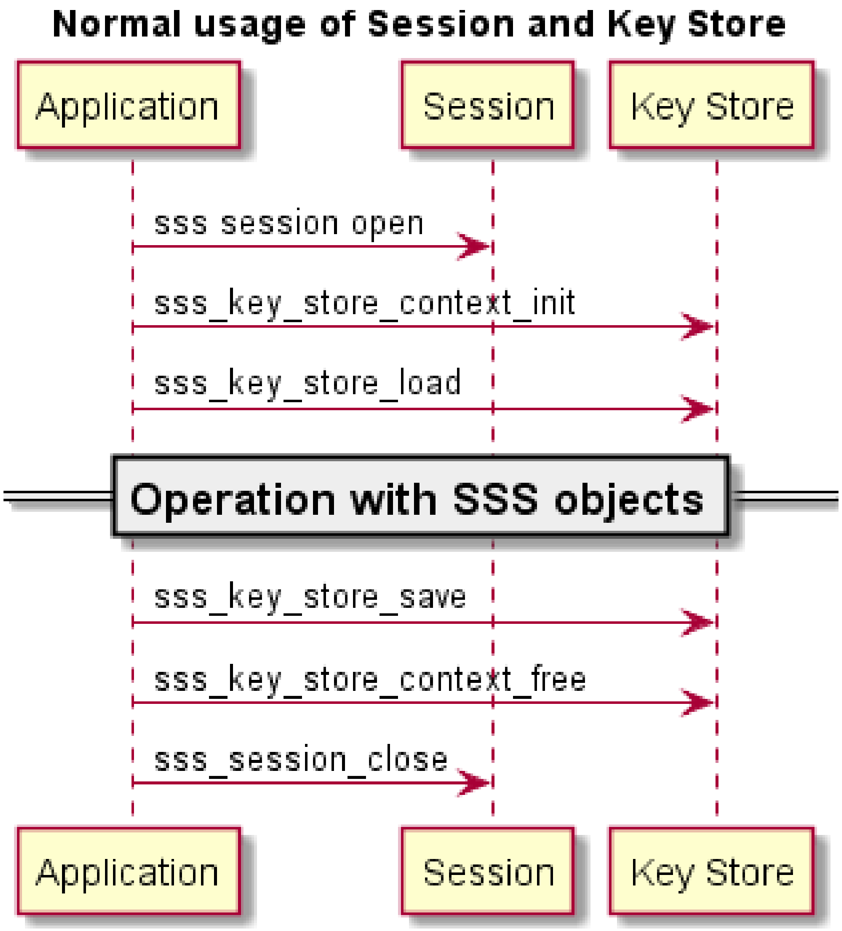
For example, a dedicated *`SE_Connect_Ctx_t`* is passed while opening a session to the SE05x Secure Element.

APIS

See *SSS Session types and APIs*

3.3.3 Key Store

KeyStore is a container for all secure keys and objects inside a secure storage.



APIs

See *SSS Keystore types and APIs*

Key Format

The `sss_key_store_set_key` and `sss_key_store_get_key` API's do not impose a specific format on the data parameter. Different implementations of the SSS API can have different capabilities in dealing with an input format (relevant for `sss_key_store_set_key`) and will use a specific output format (relevant for `sss_key_store_get_key`). The following section illustrates this by taking the example of the SE050 implementation in the context of EC Key pairs.

EC Key pair

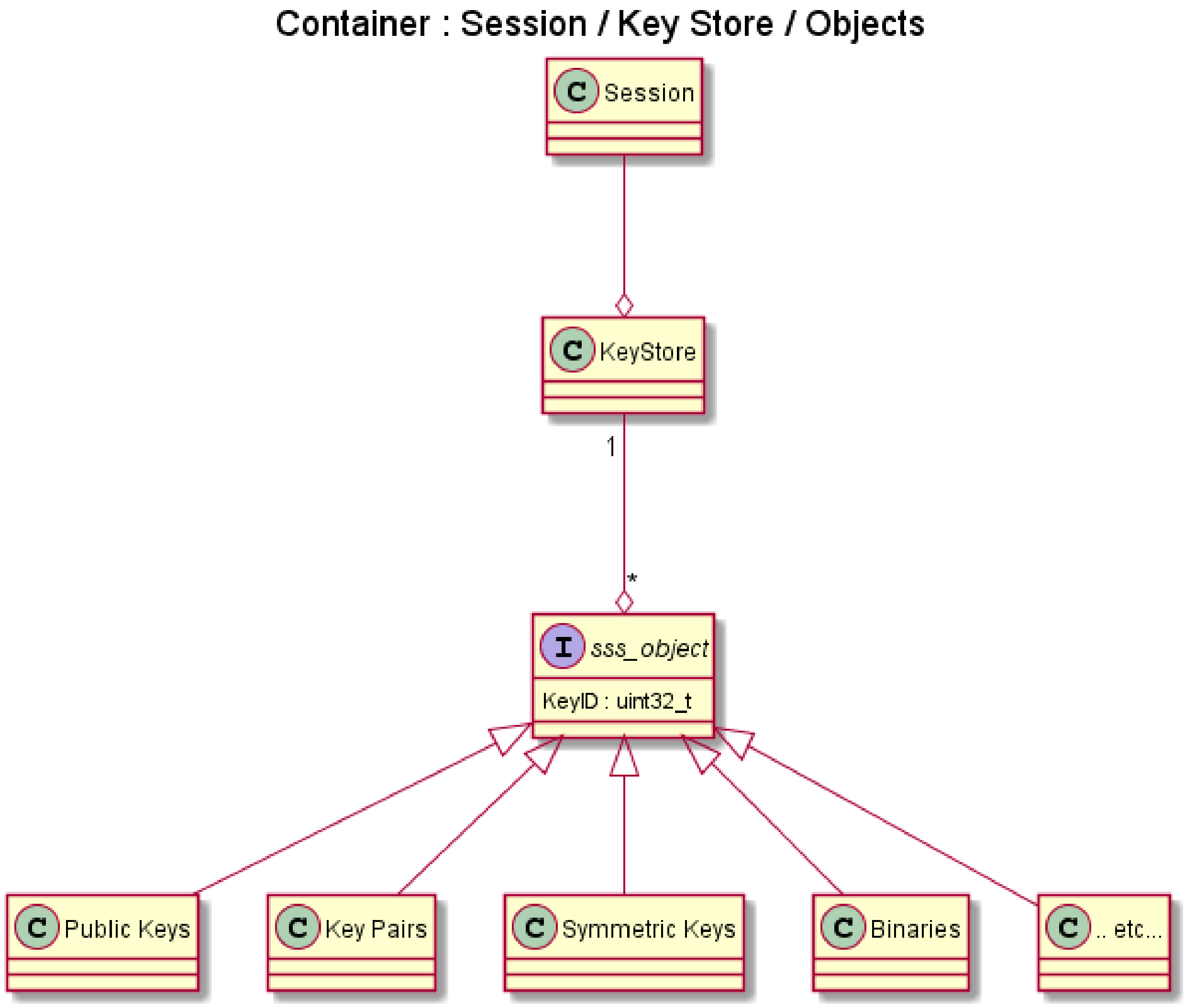
When passing an EC key pair as data argument to the `sss_key_store_set_key` API, the key pair data must be DER encoded using either the pkcs#8 format or classic OpenSSL format.

When retrieving an EC key pair as data argument from the `sss_key_store_get` API, the full key pair cannot be retrieved. Instead the public key value is returned. The public key is retrieved in ANSI X9.62 uncompressed format.

3.3.4 Key Object

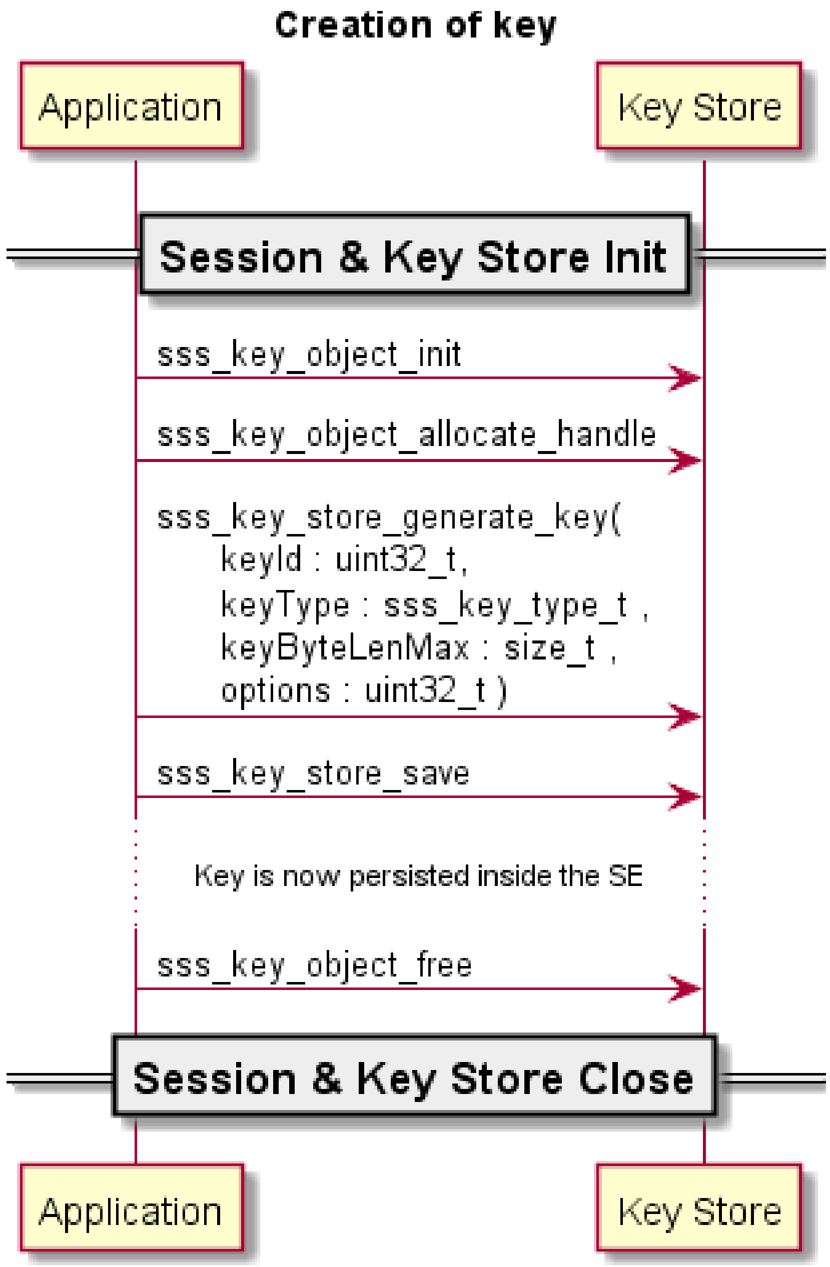
Objects / Key Objects are Low level entities of key/certificates in SSS domain.

Below we can see UML Hierarchy of an object:



Create / Provision

To create a key, the sequence of APIs looks as under. This is generally done during provisioning stage.



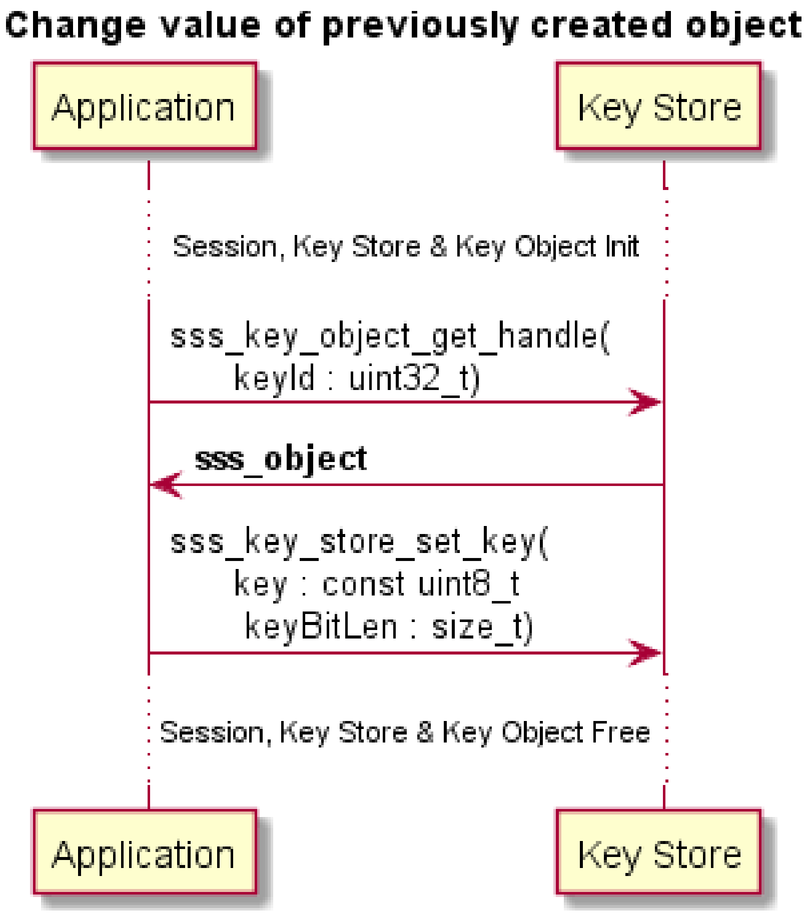
To set (inject) values in a previously allocated key, the sequence of APDUs look as under.

Note: Policies

This section would be updated later to show case creation of keys with different policies attached to it.

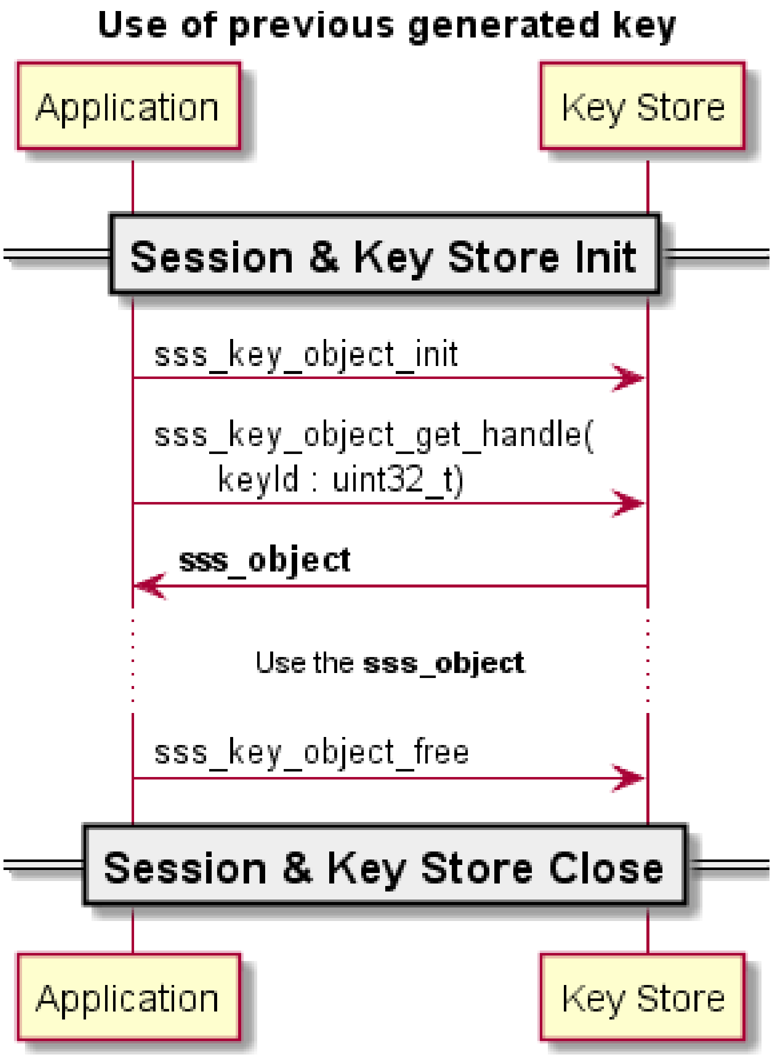
Change value of previously created Objects

To create a key, the sequence of APIs looks as under:


Change value of previously created object
Application
Key Store
Session, Key Store & Key Object Init
sss_key_object_get_handle(
keyId : uint32_t)
sss_object
sss_key_store_set_key(
key : const uint8_t
keyBitLen : size_t)
Session, Key Store & Key Object Free
Application
Key Store

Use previously provisioned/created Keys/Objects

To use a key, the API sequence is as under:



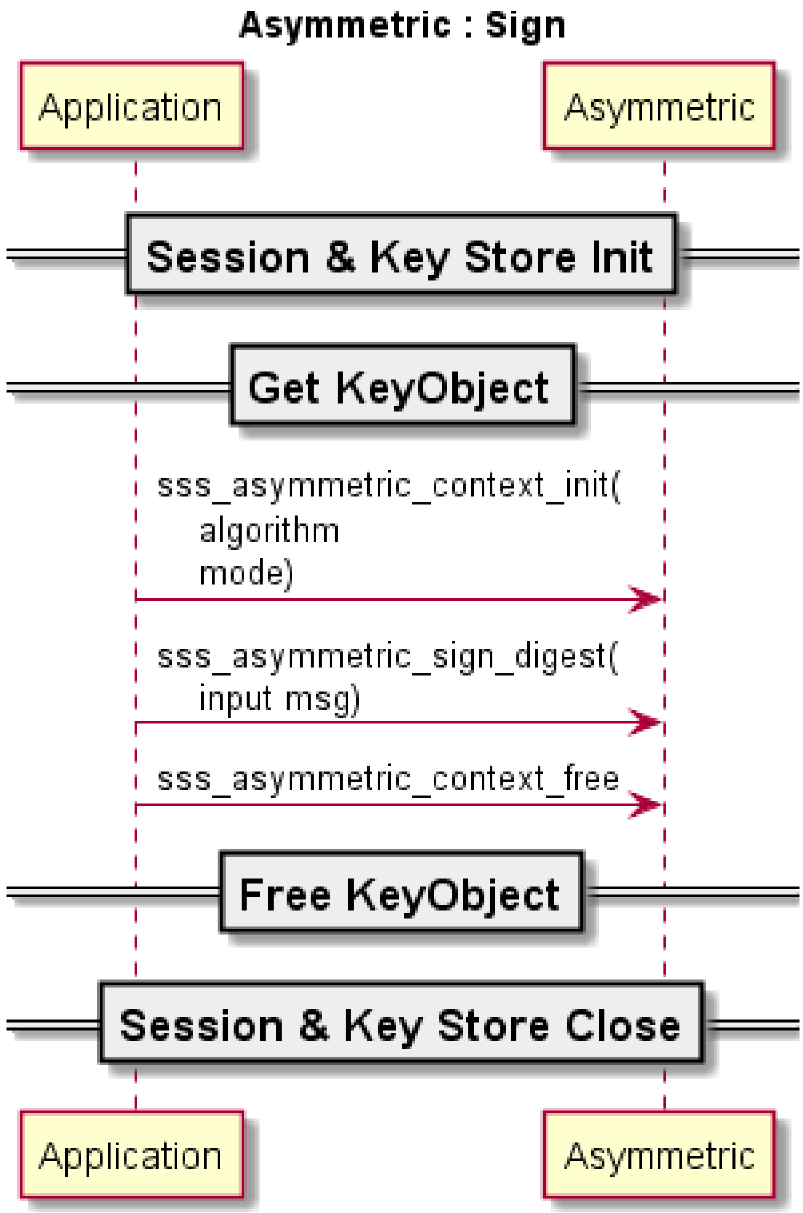
APIs

See *SSS KeyObject types and APIs*

3.3.5 Asymmetric

Sign

To perform sign operation , the sequence of APIs looks as under.

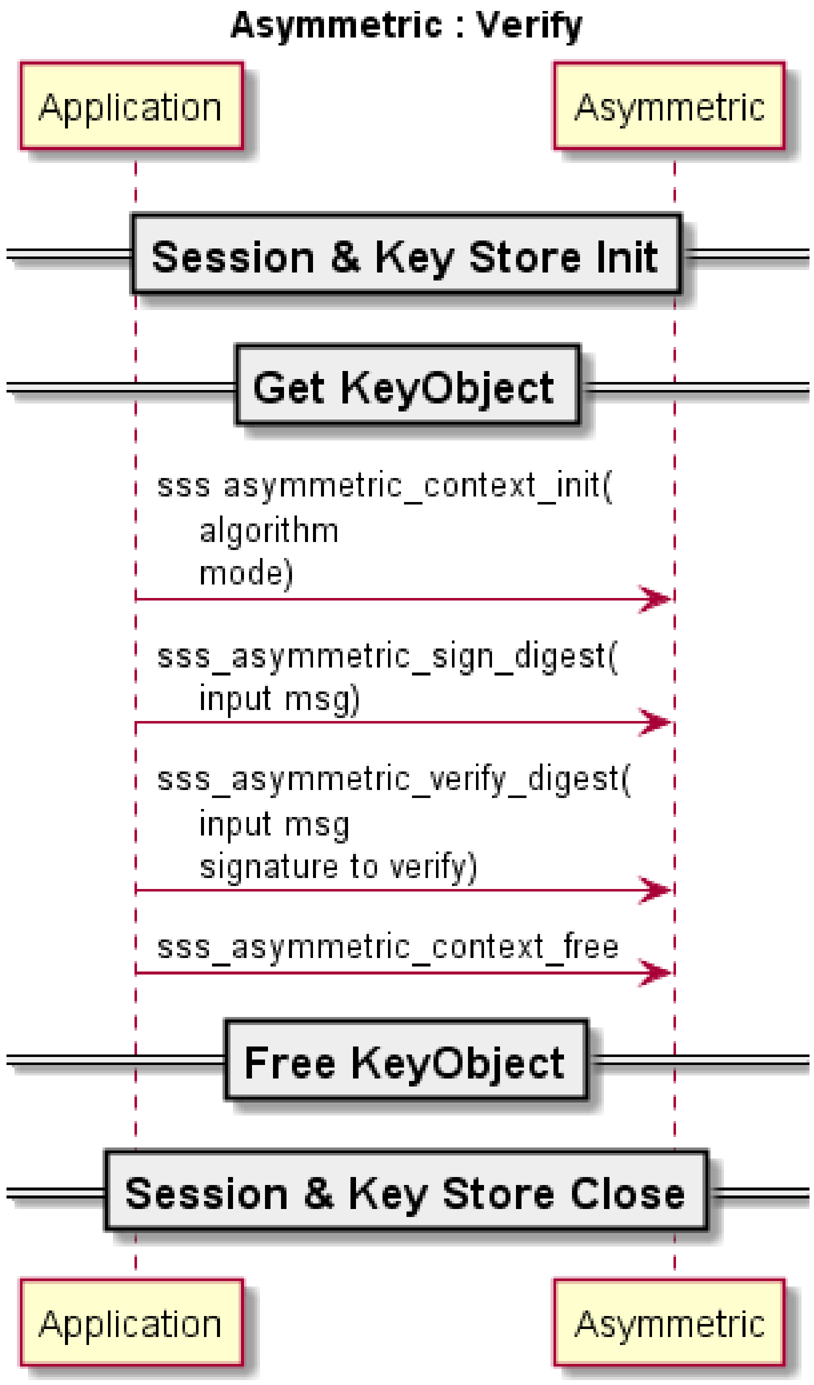


Note:

1) To perform rsa sign and verify on plain data (with hash calculated inside SE), use sss_se05x_asymmetric_sign and sss_se05x_asymmetric_verify apis.
2) Sign / Verify operations with Twisted Edward curve is supported only on plain data with hash calculated inside SE. Use sss_se05x_asymmetric_sign and sss_se05x_asymmetric_verify apis. Only SHA512 is supported.

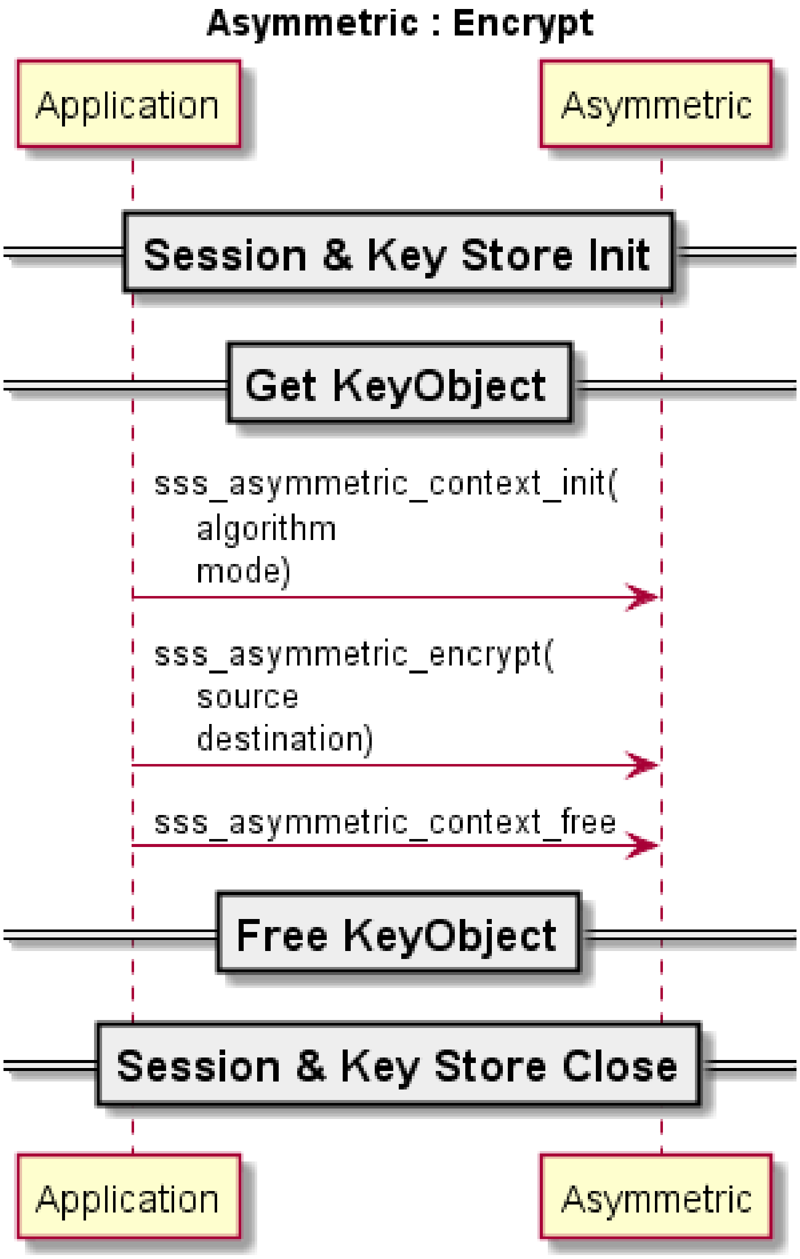
Verify

To perform sign verify operation , the sequence of APIs looks as under:



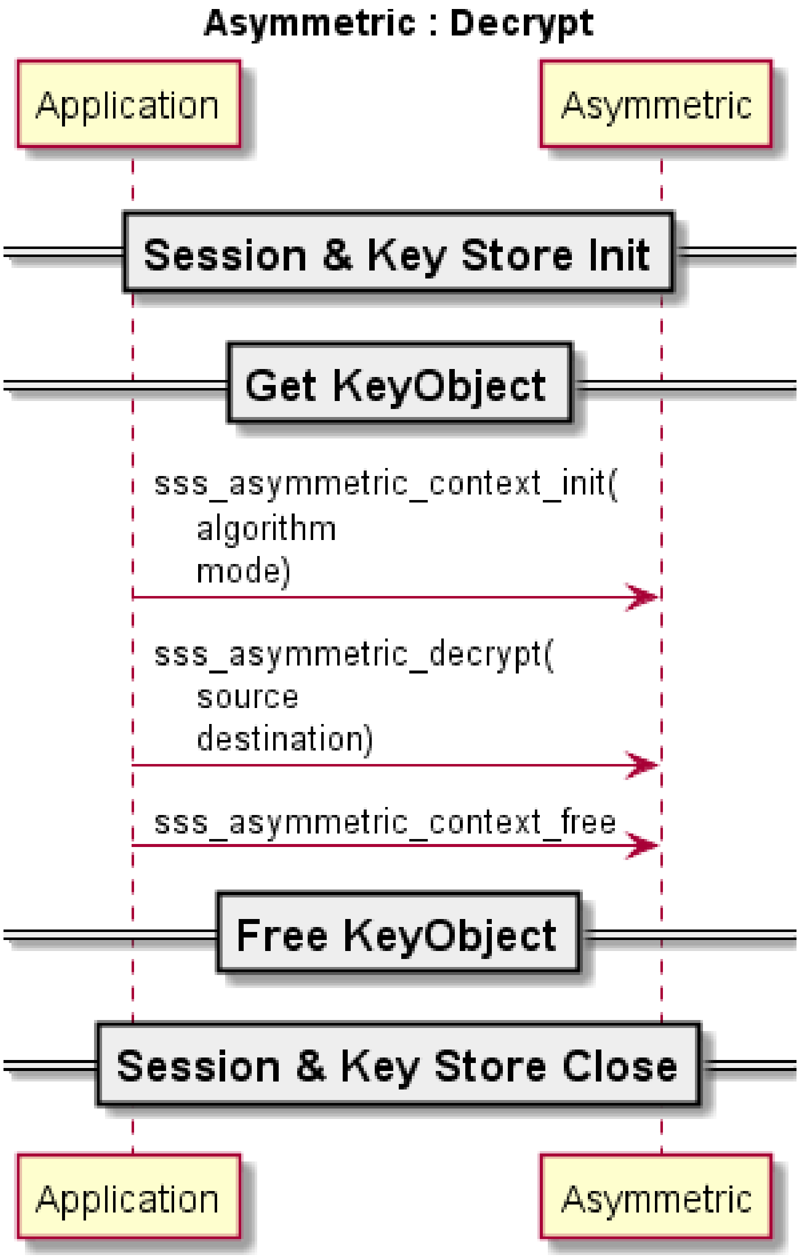
Encryption

To encrypt the data , the API sequence is as under:



Decryption

To Decrypt the encrypted data , the API sequence is as under:



Reference Example

Before we use any Cryptographic operations, we need relevent Keys to be declared.

Here is a reference snippet to *inject* a key into the Secure Domain. (If the key was already existing in the Key Store, these steps are not needed)

```
    /* Pre-requisite for Signing Part*/
    status = sss_key_object_init(&keyPair, &pCtx->ks);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_object_allocate_handle(&keyPair,
```

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(continued from previous page)

```
        MAKE_TEST_ID(__LINE__),
        kSSS_KeyPart_Pair,
        kSSS_CipherType_EC_NIST_P,
        sizeof(keyPairData),
        kKeyObject_Mode_Persistent);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_store_set_key(&pCtx->ks, &keyPair, keyPairData,␣
↪sizeof(keyPairData), EC_KEY_BIT_LEN, NULL, 0);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
```

Signing on a `digest` of length `digestLen` is performed as below.

```
    status = sss_asymmetric_context_init(&ctx_asymm, &pCtx->session, &keyPair,␣
↪kAlgorithm_SSS_SHA256, kMode_SSS_Sign);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    signatureLen = sizeof(signature);
    /* Do Signing */
    LOG_I("Do Signing");
    LOG_MAU8_I("digest", digest, digestLen);
    status = sss_asymmetric_sign_digest(&ctx_asymm, digest, digestLen, signature, &
↪signatureLen);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
    LOG_MAU8_I("signature", signature, signatureLen);
    LOG_I("Signing Successful !!!");
    sss_asymmetric_context_free(&ctx_asymm);
```

After the above operation, `signature` has the signature using the key object `keyPair`.

RSA Encryption algorithms supported

Supported rsa encyption / decryption algotithms - `PKCS1_OAEP` and `PKCS1_V1_5`.

```
    kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA1   = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,␣
↪0x01),
    kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA224 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,␣
↪0x02),
    kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA256 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,␣
↪0x03),
    kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA384 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,␣
↪0x04),
    kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA512 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,␣
↪0x05),
    kAlgorithm_SSS_RSAES_PKCS1_V1_5        = SSS_ENUM_ALGORITHM(RSAES_PKCS1_V1_5,␣
↪0x01),
```

RSA Signature algorithms supported

Supported rsa sign / verify algotithms - `PKCS1_PSS_MGF1` , `PKCS1_V1_5` and `No_Padding`.

Hash algorithms supported for sign/verify - `SHA1, SHA224, SHA256, SHA384, SHA512`

```
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_NO_HASH    = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x01),
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA1       = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x02),
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA224     = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x03),
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA256     = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x04),
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA384     = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x05),
    kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA512     = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_
↪5, 0x06),
    kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA1   = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_
↪MGF1, 0x01),
    kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA224 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_
↪MGF1, 0x02),
    kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA256 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_
↪MGF1, 0x03),
    kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA384 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_
↪MGF1, 0x04),
    kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA512 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_
↪MGF1, 0x05),
```

```
    kAlgorithm_SSS_RSASSA_NO_PADDING = SSS_ENUM_ALGORITHM(RSASSA_NO_PADDING, 0x01),
```

When using `PKCS1_PSS_MGF1` padding, there are few limitations on hash algorithm with rsa key size as below,

RSA Bit Length	Valid Hash Algorithm
512	SHA1, SHA224
1024	SHA1, SHA224, SHA256, SHA384
1152	SHA1, SHA224, SHA256, SHA384, SHA512
2048	SHA1, SHA224, SHA256, SHA384, SHA512
3072	SHA1, SHA224, SHA256, SHA384, SHA512
4096	SHA1, SHA224, SHA256, SHA384, SHA512

ECC Signature algorithms supported

Supported hash values for ecc sign / verify - `SHA1, SHA224, SHA256, SHA384, SHA512`

```
    kAlgorithm_SSS_ECDSA_SHA1   = SSS_ENUM_ALGORITHM(ECDSA, 0x01),
    kAlgorithm_SSS_ECDSA_SHA224 = SSS_ENUM_ALGORITHM(ECDSA, 0x02),
    kAlgorithm_SSS_ECDSA_SHA256 = SSS_ENUM_ALGORITHM(ECDSA, 0x03),
    kAlgorithm_SSS_ECDSA_SHA384 = SSS_ENUM_ALGORITHM(ECDSA, 0x04),
    kAlgorithm_SSS_ECDSA_SHA512 = SSS_ENUM_ALGORITHM(ECDSA, 0x05),
```

OR

```
    kAlgorithm_SSS_SHA1   = SSS_ENUM_ALGORITHM(SHA, 0x01),
    kAlgorithm_SSS_SHA224 = SSS_ENUM_ALGORITHM(SHA, 0x02),
    kAlgorithm_SSS_SHA256 = SSS_ENUM_ALGORITHM(SHA, 0x03),
    kAlgorithm_SSS_SHA384 = SSS_ENUM_ALGORITHM(SHA, 0x04),
    kAlgorithm_SSS_SHA512 = SSS_ENUM_ALGORITHM(SHA, 0x05),
```

ECDAA algorithm

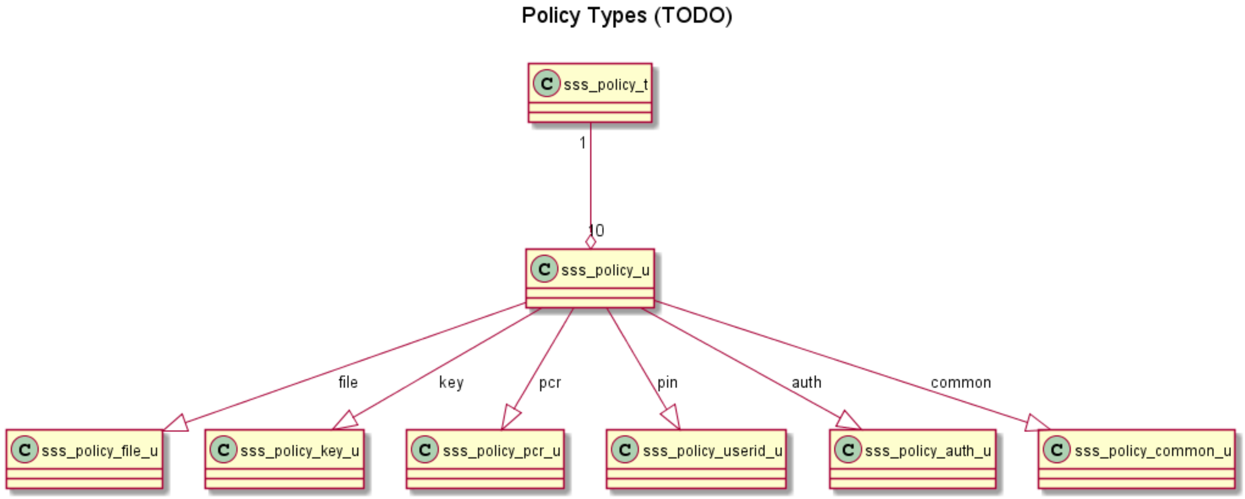
```
    kAlgorithm_SSS_ECDAA = SSS_ENUM_ALGORITHM(ECDAA, 0x01),
```

APIs

See *SSS Asymmetric types and APIs*

3.3.6 Policies

Policies can be used to restrict & control the usage of session or objects.



Policies applicable to different objects

Object Type	Applet 3.x	Applet 6.x	Applet 7.x
common	forbid_All, can_Delete, req_Sm, req_pcr_val	forbid_All, can_Delete, req_Sm, req_pcr_val	forbid_All, can_Delete, req_Sm, req_pcr_val, **can_Read**, **can_Write**
symmetric objects	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, can_Wrap, can_Desfire_Auth, can_Desfire_Dump, can_KD, **can_Write**, can_Gen	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, forbid_Derived_Output, allow_kdf_ext_rnd, can_Wrap, can_Desfire_Auth, can_Desfire_Dump, can_KD, **can_Write**, can_Gen	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, forbid_Derived_Output, can_TLS_KDF, allow_kdf_ext_rnd, can_TLS_PMS_KD, can_HKDF, can_PBKDF, can_Wrap, can_Desfire_Auth, can_Desfire_Dump, can_Desfire_KD, forbid_external_iv, can_usage_hmac_pepper
Asymmetric objects	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, can_Gen, can_KA, can_Attest, **can_Read**, **can_Write**, can_KD, can_Wrap	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, forbid_Derived_Output, can_Gen, can_KA, can_Attest, **can_Read**, **can_Write**, can_KD, can_Wrap	can_Sign, can_Verify, can_Encrypt, can_Decrypt, can_Import_Export, forbid_Derived_Output, can_Gen, can_KA, can_Attest,
User Id	can_Write	can_Write	can_Write
File policy	can_Read, can_Write	can_Read, can_Write	can_Read, can_Write
Counter policy	can_Read, can_Write	can_Read, can_Write	can_Read, can_Write
PCR policy	can_Read, can_Write	can_Read, can_Write	can_Read, can_Write

Note:

1. **can_Read** and **can_Write** polices are moved from symmetric and asymmetric object policy to common policy in applet 7.x. **PLEASE UPDATE THE APPLICATIONS ACCORDINGLY**.
2. Invalid policies on objects will be rejected at SSS software layer and only result in warning message.

Usage

Policy can be declared like below:

```
    /* Policies for key */
    const sss_policy_u key_withPol = {
        .type = KPolicy_Asym_Key,
        /*Authentication object based on SE05X_AUTH*/
```

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```
        .auth_obj_id = EX_LOCAL_OBJ_AUTH_ID,
        .policy = {
            /*Asymmetric key policy*/
            .asymmkey = {
                /*Policy for sign*/
                .can_Sign = allow_sign,
                /*Policy for verify*/
                .can_Verify = allow_verify,
                /*Policy for encrypt*/
                .can_Encrypt = 1,
                /*Policy for decrypt*/
                .can_Decrypt = 1,
                /*Policy for Key Derivation*/
                .can_KD = 1,
                /*Policy for wrapped object*/
                .can_Wrap = 1,
                /*Policy to re-write object*/
                .can_Write = 1,
                /*Policy for reading object*/
                .can_Read = 1,
                /*Policy to use object for attestation*/
                .can_Attest = 1,
            }
        }
    };

    /* Common rules */
    const sss_policy_u common = {
        .type = KPolicy_Common,
        /*Authentication object based on SE05X_AUTH*/
        .auth_obj_id = EX_LOCAL_OBJ_AUTH_ID,
        .policy = {
        .common = {
        /*Secure Messaging*/
        .req_Sm = 0,
        /*Policy to Delete object*/
        .can_Delete = 1,
        /*Forbid all operations on object*/
        .forbid_All = 0,
    }
    }
    };

    /* create policy set */
    sss_policy_t policy_for_ec_key = {
        .nPolicies = 2,
        .policies = { &key_withPol, &common }
    };
```

To create an object with that policy, usage is as below:

```
    status = sss_key_store_generate_key(
        &pCtx->ks,
        &object,
        ECC_KEY_BIT_LEN,
        &policy_for_ec_key);
```

Note: When creating a policy with *KPolicy_Common_PCR_Value*, *KPolicy_Desfire_Changekey_Auth_Id* and *KPolicy_Derive_Master_Key_Id*, set the policies to sss_policy_t variable in the following order always,

‘Common_PCR_Value‘ , ‘Desfire_Changekey_Auth_Id‘ , ‘Derive_Master_Key_Id‘

Example,

```
const sss_policy_u pcr_val_policy = {
.type = KPolicy_Common_PCR_Value, .auth_obj_id = 0,
.policy = { .common_pcr_value = {} } };

const sss_policy_u desfire_change_key_auth_id_policy = {
.type = KPolicy_Desfire_Changekey_Auth_Id, .auth_obj_id = 0,
.policy = { .desfire_auth_id = {} } };

const sss_policy_u master_key_id_policy = {
.type = KPolicy_Derive_Master_Key_Id, .auth_obj_id = 0,
.policy = { .master_key_id = {} } };

// create policy as,
sss_policy_t key_policy = { .nPolicies = 3,.policies = { &pcr_val_policy, &desfire_
↪change_key_auth_id_policy, &master_key_id_policy } };
// OR
sss_policy_t key_policy = { .nPolicies = 1,.policies = { &desfire_change_key_auth_id_
↪policy } };
// OR
sss_policy_t key_policy = { .nPolicies = 2,.policies = { &pcr_val_policy, &master_key_
↪id_policy } };
```

APIs

See *SSS Policy types and APIs*

3.3.7 Example Boot-Up

The Examples and use cases based on SSS APIs are them selves *(more or less)* Cryptosystem agnostic, how ever the platforms where they run and how they run would be very specific.

e.g. While running from PC with a Secure Element, you may need to choose and connect to specific COM Port / Socket. On the other hand, when running from different embedded platforms like FREEDOM K64F, iMX RT 1050, etc., few board specific steps are needed.

To simplify examples, them selves, the files in `sss/ex/inc` and `sss/ex/src` try to isolate such details.

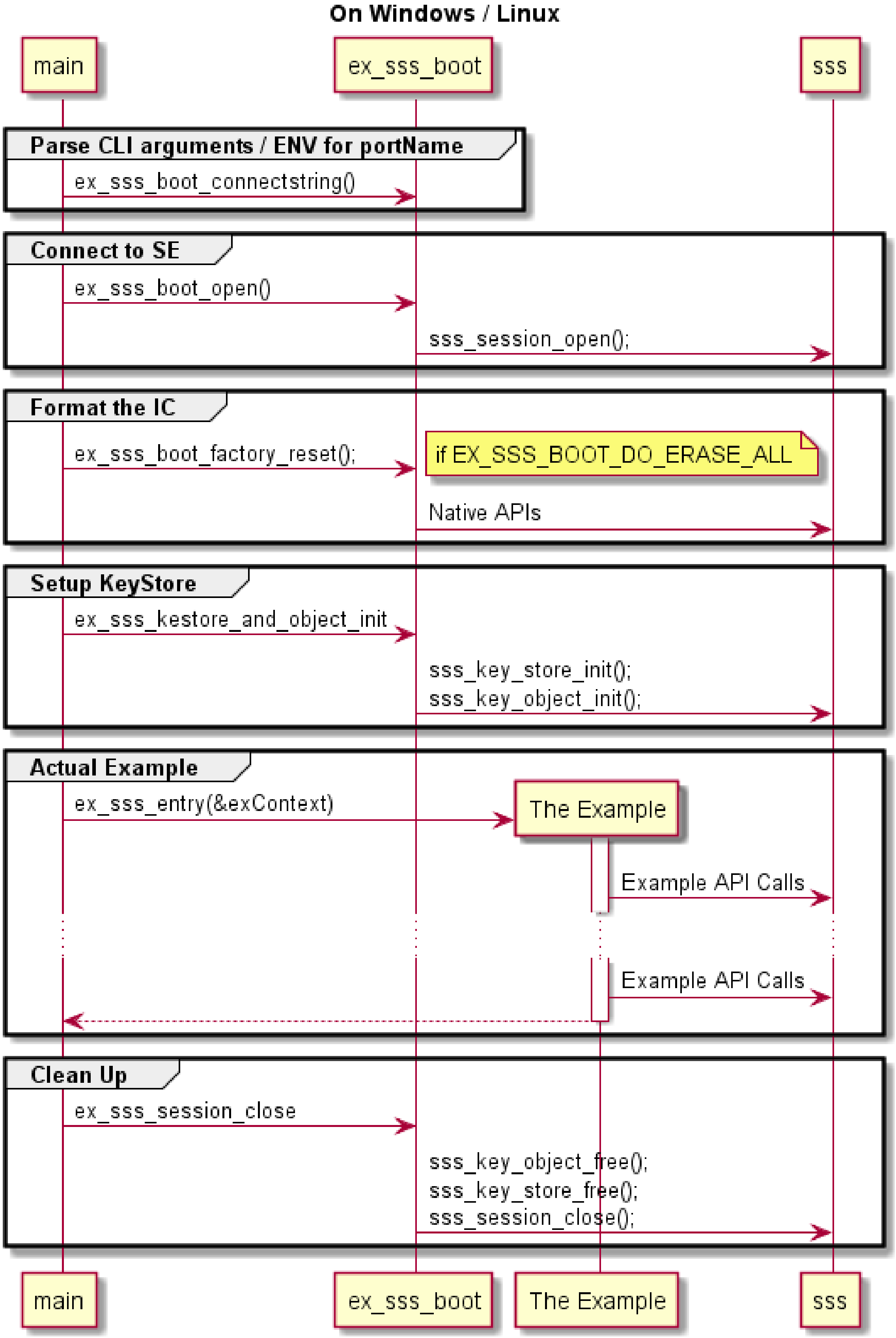
Some of the scenarios of boot up are:

Booting from Windows / Linux

In such a system, many decisions are taken at run time. e.g. COM Port for interface to the secure element, etc.

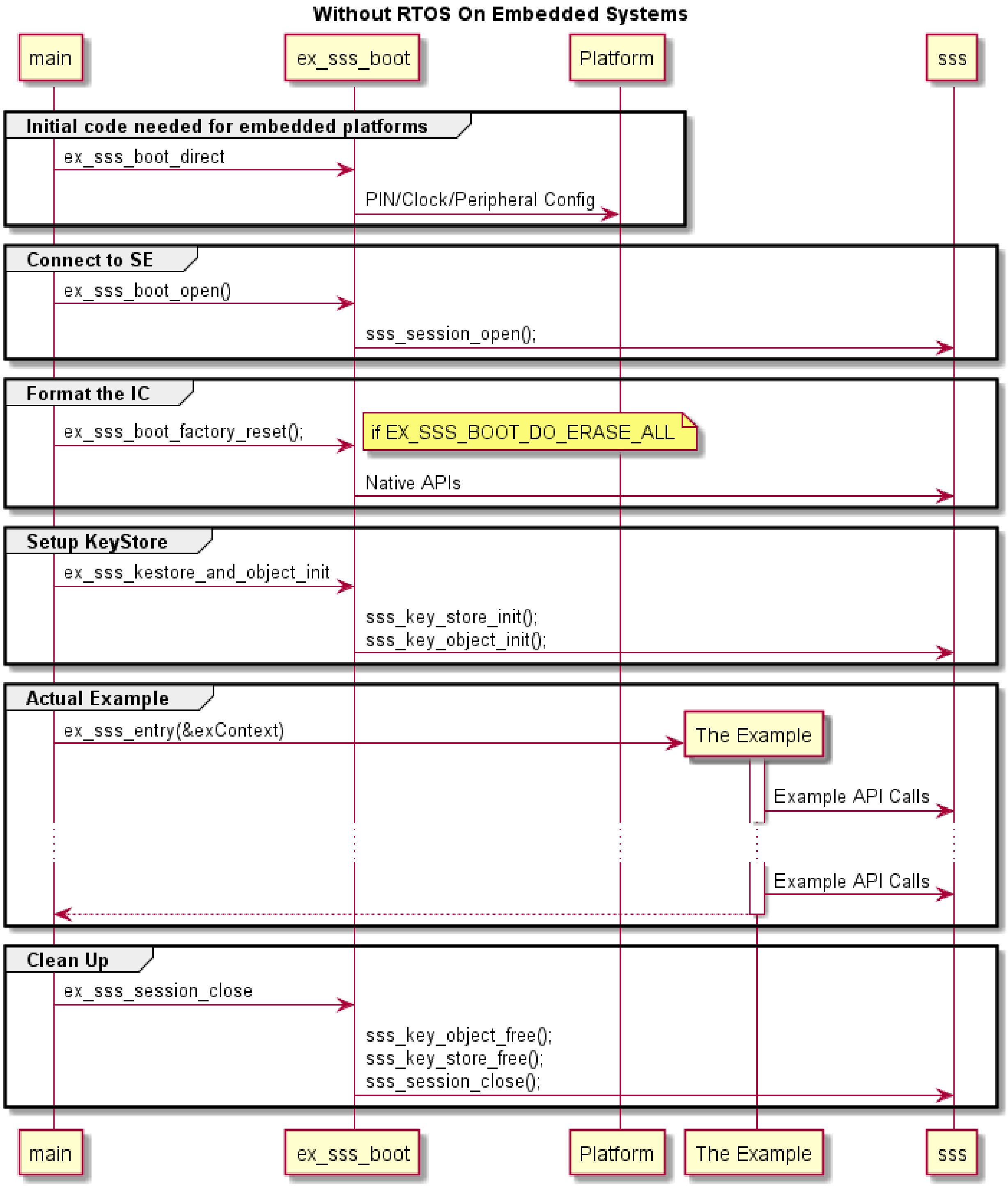
In such a system, examples also have access to command line arguments and environment variables.

Such a setup is mostly for testing and early prototyping.


On Windows / Linux
main
ex_sss_boot
sss
Parse CLI arguments / ENV for portName
ex_sss_boot_connectstring()
Connect to SE
ex_sss_boot_open()
sss_session_open();
Format the IC
ex_sss_boot_factory_reset();
if EX_SSS_BOOT_DO_ERASE_ALL
Native APIs
Setup KeyStore
ex_sss_kestore_and_object_init
sss_key_store_init();
sss_key_object_init();
Actual Example
ex_sss_entry(&exContext)
The Example
Example API Calls
Example API Calls
Clean Up
ex_sss_session_close
sss_key_object_free();
sss_key_store_free();
sss_session_close();
main
ex_sss_boot
The Example
sss

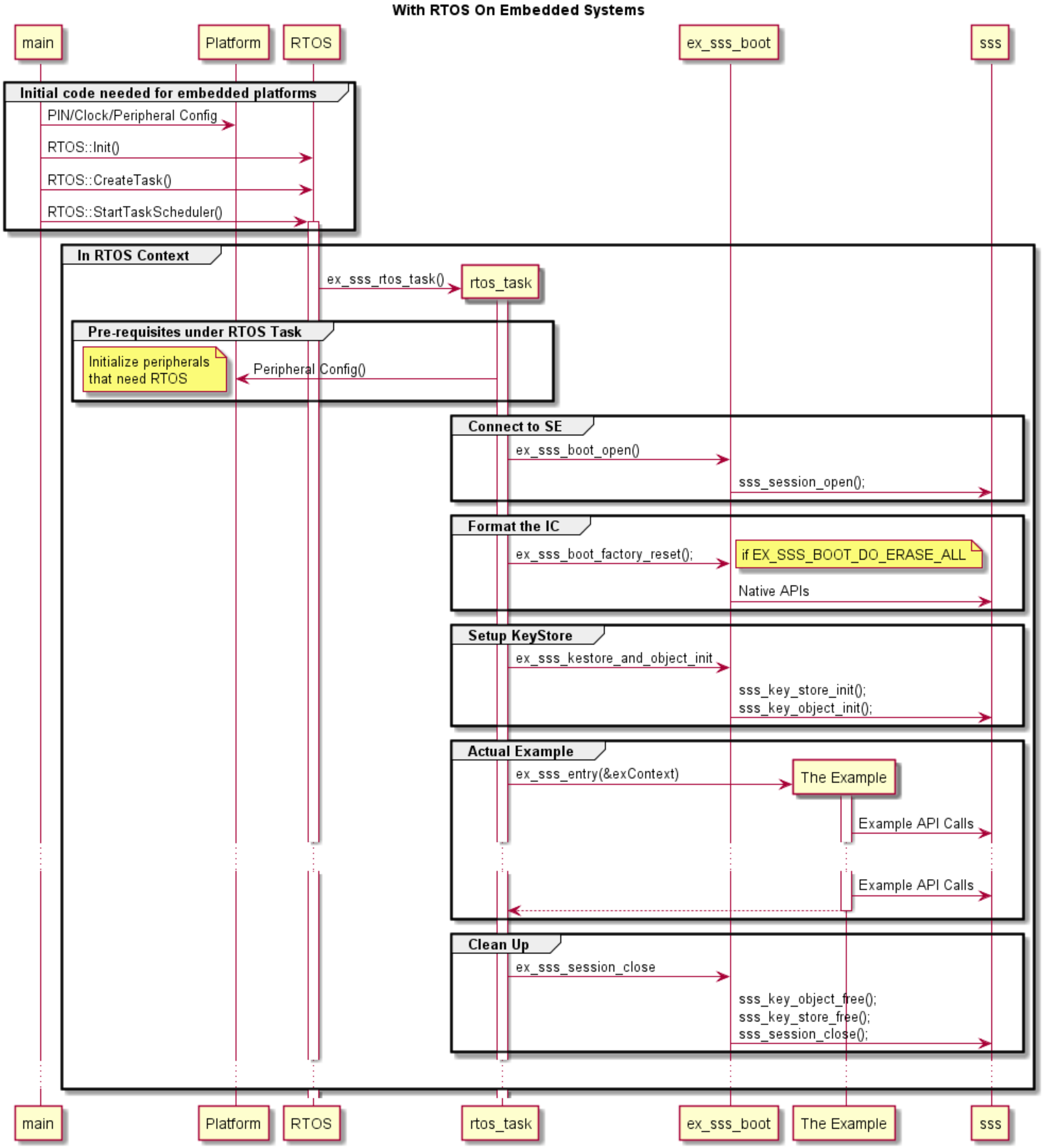
Booting from an embedded system, without any RTOS

In such a system, the example is pre-compiled for specific platform/combination. There are very less decisions to be taken at run time, and most decisions are pre-selected during build/compile time.



Booting from an embedded system, with RTOS

In such a system, the example uses RTOS. And the example itself is to be run from an RTOS Thread context.



3.3.8 SSS api key format (asymmetric keys)

NIST-P, NIST-K and BRAINPOOL ECC Keys

When passing the key pair / public key, the key should be passed DER encoded using PKCS #8 or traditional openssl format. When passing the private key alone, do not include the key header.

When retrieving the key pair as data argument from the sss_key_store_get api, the full key pair cannot be retrieved. Instead the public key value is returned in ANSI X9.62 uncompressed format.

Note: Keys, signature and shared secret key generated all follow the big endian convention.

EDWARD and MONTGOMERY ECC keys

When passing the key pair / public key, the key should be passed DER encoded using the format specified in RFC 8410. When passing the private key alone, do not include the key header.

When retrieving the key pair as data argument from the sss_key_store_get api, the full key pair cannot be retrieved. Instead the public key value is returned in ANSI X9.62 uncompressed format.

Note: Keys, signature and shared secret key generated all follow the little endian convention.

A set of examples of a X25519 keypair encoded according to RFC 8410:

```
$ dumpasn1 X25519_keypair.der
 0  81: SEQUENCE {
 2   1:   INTEGER 1
 5   5:   SEQUENCE {
 7   3:     OBJECT IDENTIFIER curveX25519 (1 3 101 110)
      :     }
12  34:   OCTET STRING, encapsulates {
14  32:     OCTET STRING
      :       58 5D B1 E3 50 0B 71 24 F6 B1 E1 41 83 54 93 12
      :       F4 4B 0C A3 44 F7 52 A1 8A 12 2F E7 DA D9 CE 52
      :     }
48  33:   [1]
      :     00 A2 8E 04 FF 1C DC 1C 3D 60 91 0F BC 98 EF 01
      :     BF 9F 0F 69 C0 B7 EF 70 61 35 34 62 F3 06 28 C7
      :     29
      :   }

$ dumpasn1 X25519_priv.pem
  0  46: SEQUENCE {
  2   1:   INTEGER 0
  5   5:   SEQUENCE {
  7   3:     OBJECT IDENTIFIER curveX25519 (1 3 101 110)
       :     }
 12  34:   OCTET STRING, encapsulates {
 14  32:     OCTET STRING
       :       58 5D B1 E3 50 0B 71 24 F6 B1 E1 41 83 54 93 12
       :       F4 4B 0C A3 44 F7 52 A1 8A 12 2F E7 DA D9 CE 52
       :     }
       :   }

$ dumpasn1 X25519_pub.pem
  0  42: SEQUENCE {
```

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```
  2   5:   SEQUENCE {
  4   3:     OBJECT IDENTIFIER curveX25519 (1 3 101 110)
       :     }
  9  33:   BIT STRING
       :     A2 8E 04 FF 1C DC 1C 3D 60 91 0F BC 98 EF 01 BF
       :     9F 0F 69 C0 B7 EF 70 61 35 34 62 F3 06 28 C7 29
       :   }
```

The X25519 keypair from the example above can be created with the asn1parse OpenSSL tool. The command line invocation is as follows:

```
openssl asn1parse -genconf key_config.txt -out X25519_keypair.der
```

The file **key_config.txt** contains the different ASN.1 components and values of the keypair to create. The resulting DER representation of the keypair is stored in the file **X25519_keypair.der**. The contents of the **key_config.txt** file is as follows:

```
asn1 = SEQUENCE:seq_section

[seq_section]

field1 = INTEGER:1
field2 = SEQUENCE:seq_section_oid
field3 = OCTWRAP,FORMAT:HEX,
↪OCT:585DB1E3500B7124F6B1E14183549312F44B0CA344F752A18A122FE7DAD9CE52
field4 = IMP:1C,
↪INT:0x00A28E04FF1CDC1C3D60910FBC98EF01BF9F0F69C0B7EF7061353462F30628C729

[seq_section_oid]

field1 = OID:X25519
```

Note: Additional information on the *asn1parse* command and the key configuration format is available under the manpages of respectively *asn1parse* and *ASN1_generate_nconf*

Set Edwards and Montgomery keys using pycli

On generting keys using openssl, pycli tool can be used to set edwards and montomory keys.

Example - Set key pair as:

```
`openssl genpkey -algorithm ed25519 -outform PEM -out test_ed25519.pem`
`ssscli set ecc pair <KEYID> test_ed25519.pem`
```

Set public key as:

```
`openssl pkey -in test_ed25519.pem -out test_ed25519_pub.pem -pubout`
`ssscli set ecc pub <KEYID> test_ed25519_pub.pem`
```

BN Curve ECC keys

When passing key pair, private key or public key do not include key header. When retrieving the key from the sss_key_store_get api, the public key value is returned without any header.

RSA keys

When passing the key pair / public key, the key should be passed DER encoded using PKCS #8 or traditional openssl format. When passing the private key alone, do not include the key header.

When retrieving the key pair as data argument from the sss_key_store_get API, the full key pair cannot be retrieved. Instead the public key value is returned in ANSI X9.62 uncompressed format.

3.3.9 List of all SSS APIs and structures

SSS Enums and Types

group **`sss_types`**

SSS Types.

Defines

`SSS_ENUM` (GROUP, INDEX)

Helper macro to set enum value

Enums

enum sss_access_permission_t

Permissions of an object

Values:

kAccessPermission_SSS_Read = (1u << 0)

Can read (applicable) contents of the key.

```
@note This is not same as @ref kAccessPermission_SSS_Use.

Without reading, the object, the key can be used.
```

kAccessPermission_SSS_Write = (1u << 1)

Can change the value of an object

kAccessPermission_SSS_Use = (1u << 2)

Can use an object

kAccessPermission_SSS_Delete = (1u << 3)

Can delete an object

kAccessPermission_SSS_ChangeAttributes = (1u << 4)

Can change permissions applicable to an object

kAccessPermission_SSS_All_Permission = 0x1F

Bitwise OR of all sss_access_permission.

enum sss_algorithm_t

Cryptographic algorithm to be applied

Values:

kAlgorithm_None

kAlgorithm_SSS_AES_ECB = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_CBC = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_CTR = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_GCM = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_CCM = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_GCM_INT_IV = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_CTR_INT_IV = SSS_ENUM_ALGORITHM(AES,)

kAlgorithm_SSS_AES_CCM_INT_IV = SSS_ENUM_ALGORITHM(AES, 0x08)

kAlgorithm_SSS_CHACHA_POLY = SSS_ENUM_ALGORITHM(CHACHA,)

kAlgorithm_SSS_DES_ECB = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES_CBC = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES_CBC_ISO9797_M1 = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES_CBC_ISO9797_M2 = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES3_ECB = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES3_CBC = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES3_CBC_ISO9797_M1 = SSS_ENUM_ALGORITHM(DES,)

kAlgorithm_SSS_DES3_CBC_ISO9797_M2 = SSS_ENUM_ALGORITHM(DES, 0x08)

kAlgorithm_SSS_SHA1 = SSS_ENUM_ALGORITHM(SHA,)

kAlgorithm_SSS_SHA224 = SSS_ENUM_ALGORITHM(SHA,)

kAlgorithm_SSS_SHA256 = SSS_ENUM_ALGORITHM(SHA,)

kAlgorithm_SSS_SHA384 = SSS_ENUM_ALGORITHM(SHA,)

kAlgorithm_SSS_SHA512 = SSS_ENUM_ALGORITHM(SHA,)

kAlgorithm_SSS_CMAC_AES = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_HMAC_SHA1 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_HMAC_SHA224 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_HMAC_SHA256 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_HMAC_SHA384 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_HMAC_SHA512 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_DES_CMAC8 = SSS_ENUM_ALGORITHM(MAC,)

kAlgorithm_SSS_DH = SSS_ENUM_ALGORITHM(DH,)

kAlgorithm_SSS_ECDH = SSS_ENUM_ALGORITHM(DH,)

kAlgorithm_SSS_DSA_SHA1 = SSS_ENUM_ALGORITHM(DSA,)

kAlgorithm_SSS_DSA_SHA224 = SSS_ENUM_ALGORITHM(DSA,)

kAlgorithm_SSS_DSA_SHA256 = SSS_ENUM_ALGORITHM(DSA,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_NO_HASH = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA1 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA224 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA256 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA384 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_V1_5_SHA512 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA1 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_MG

kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA224 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_M

kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA256 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_M

kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA384 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_M

kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA512 = SSS_ENUM_ALGORITHM(RSASSA_PKCS1_PSS_M

kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA1 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,)

kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA224 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,)

kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA256 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,)

kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA384 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,)

kAlgorithm_SSS_RSAES_PKCS1_OAEP_SHA512 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_OAEP,)

kAlgorithm_SSS_RSAES_PKCS1_V1_5 = SSS_ENUM_ALGORITHM(RSAES_PKCS1_V1_5,)

kAlgorithm_SSS_RSASSA_NO_PADDING = SSS_ENUM_ALGORITHM(RSASSA_NO_PADDING,)

kAlgorithm_SSS_ECDSA_SHA1 = SSS_ENUM_ALGORITHM(ECDSA,)

kAlgorithm_SSS_ECDSA_SHA224 = SSS_ENUM_ALGORITHM(ECDSA,)

kAlgorithm_SSS_ECDSA_SHA256 = SSS_ENUM_ALGORITHM(ECDSA,)

kAlgorithm_SSS_ECDSA_SHA384 = SSS_ENUM_ALGORITHM(ECDSA,)

kAlgorithm_SSS_ECDSA_SHA512 = SSS_ENUM_ALGORITHM(ECDSA,)

kAlgorithm_SSS_ECDAA = SSS_ENUM_ALGORITHM(ECDAA,)

enum sss_cipher_type_t
For all cipher types, key bit length is provides at the time key is inserted/generated

Values:

kSSS_CipherType_NONE

kSSS_CipherType_AES = 10

kSSS_CipherType_DES = 12

kSSS_CipherType_CMAC = 20

kSSS_CipherType_HMAC = 21

kSSS_CipherType_MAC = 30

kSSS_CipherType_RSA = 31

kSSS_CipherType_RSA_CRT = 32
RSA RAW format

kSSS_CipherType_EC_NIST_P = 40
RSA CRT format

kSSS_CipherType_EC_NIST_K = 41
Keys Part of NIST-P Family

kSSS_CipherType_EC_MONTGOMERY = 50
Keys Part of NIST-K Family Montgomery Key,

kSSS_CipherType_EC_TWISTED_ED = 51
twisted Edwards form elliptic curve public key

kSSS_CipherType_EC_BRAINPOOL = 52
Brainpool form elliptic curve public key

kSSS_CipherType_EC_BARRETO_NAEHRIG = 53
Barreto Naehrig curve

kSSS_CipherType_UserID = 70

kSSS_CipherType_Certificate = 71
Use kSSS_CipherType_Binary to store Certificate

kSSS_CipherType_Binary = 72

kSSS_CipherType_Count = 73

kSSS_CipherType_PCR = 74

kSSS_CipherType_ReservedPin = 75

enum sss_connection_type_t
Destintion connection type

Values:

kSSS_ConnectionType_Plain

kSSS_ConnectionType_Password

kSSS_ConnectionType_Encrypted

enum sss_key_object_mode_t
Persistent / Non persistent mode of a key

Values:

kKeyObject_Mode_None = 0
kKeyObject_Mode_None

kKeyObject_Mode_Persistent = 1
Key object will be persisted in memory and will retain it's value after a closed session

kKeyObject_Mode_Transient = 2
Key Object will be stored in RAM. It will lose it's contents after a session is closed

enum sss_key_part_t
Part of a key

Values:

kSSS_KeyPart_NONE

kSSS_KeyPart_Default = 1
Applicable where we have UserID, Binary Files, Certificates, Symmetric Keys, PCR, HMAC-key, counter

kSSS_KeyPart_Public = 2
Public part of asymmetric key

kSSS_KeyPart_Private = 3
Private only part of asymmetric key

kSSS_KeyPart_Pair = 4
Both, public and private part of asymmetric key

enum sss_mode_t
High level algorihtmic operations.

Augmented by sss_algorithm_t

Values:

kMode_SSS_Encrypt = 1
Encrypt.

kMode_SSS_Decrypt = 2
Decrypt.

kMode_SSS_Sign = 3
Sign.

kMode_SSS_Verify = 4
Verify.

kMode_SSS_ComputeSharedSecret = 5

kMode_SSS_Digest = 6
Message Digest.

kMode_SSS_Mac = 7
Message Authentication Code.

kMode_SSS_HKDF_ExpandOnly = 9
HKDF Expand Only (RFC 5869)

kMode_SSS_HKDF_ExtractExpand = 10
HKDF Extract and Expand (RFC 5869)

kMode_SSS_Mac_Validate = 11
MAC Validate.

enum sss_status_t
Status of the SSS APIs

Values:

kStatus_SSS_Success = 0x5a5a5a5au
Operation was successful

kStatus_SSS_Fail = 0x3c3c0000u
Operation failed

kStatus_SSS_InvalidArgument = 0x3c3c0001u
Operation not performed because some of the passed parameters were found inappropriate

kStatus_SSS_ResourceBusy = 0x3c3c0002u
Where the underlying sub-system *supports* multi-threading, Internal status to handle simultaneous access.

This status is not expected to be returned to higher layers.

enum sss_type_t
Cryptographic sub system

Values:

kType_SSS_SubSystem_NONE

kType_SSS_Software = ((0x01 << 8) | (0x00))
Software based

kType_SSS_mbedTLS = ((*kType_SSS_Software*) | (0x01))

kType_SSS_OpenSSL = ((*kType_SSS_Software*) | (0x02))

kType_SSS_HW = ((0x02 << 8) | (0x00))
HOST HW Based

kType_SSS_SECO = ((*kType_SSS_HW*) | (0x01))

kType_SSS_Isolated_HW = ((0x04 << 8) | (0x00))
Isolated HW

kType_SSS_Sentinel = ((*kType_SSS_Isolated_HW*) | (0x01))

kType_SSS_Sentinel200 = ((*kType_SSS_Isolated_HW*) | (0x02))

kType_SSS_Sentinel300 = ((*kType_SSS_Isolated_HW*) | (0x03))

kType_SSS_Sentinel400 = ((*kType_SSS_Isolated_HW*) | (0x04))

kType_SSS_Sentinel500 = ((*kType_SSS_Isolated_HW*) | (0x05))

kType_SSS_SecureElement = ((0x08 << 8) | (0x00))
Secure Element

kType_SSS_SE_A71CH = ((*kType_SSS_SecureElement*) | (0x01))
To connect to https://www.nxp.com/products/:A71CH

kType_SSS_SE_A71CL = ((*kType_SSS_SecureElement*) | (0x02))

kType_SSS_SE_SE05x = ((*kType_SSS_SecureElement*) | (0x03))
To connect to https://www.nxp.com/products/:SE050

kType_SSS_SubSystem_LAST

struct sss_ecc_point_t
#include <fsl_sss_api.h> XY Co-ordinates for ECC Curves

Public Members

uint8_t ***X**
X Point

uint8_t ***Y**
Y Point

struct sss_eccgfp_group_t
#include <fsl_sss_api.h> ECC Curve Parameter

Public Members

uint8_t ***a**
ECC parameter a

uint8_t ***b**
ECC parameter b

sss_ecc_point_t ***G**
ECC parameter G

uint8_t ***h**
ECC parameter h

uint8_t ***n**
ECC parameter n

uint8_t ***p**
ECC parameter P

SSS Session types and APIs

group **sss_session**
Manage session.

Enums

enum sss_session_prop_au8_t
Properties of session that are S32

From 0 to kSSS_SessionProp_Optional_Prop_Start, around 2^24 = 16777215 Properties are possible.

From 0 to kSSS_SessionProp_Optional_Prop_Start, around 2^24 = 16777215 Properties are possible.

Values:

`kSSS_SessionProp_au8_NA` = 0
Invalid

`kSSS_SessionProp_szName`
Name of the product, string

`kSSS_SessionProp_UID`
Unique Identifier

`kSSS_SessionProp_au8_Optional_Start` = 0x00FFFFFFu
Optional Properties Start

`kSSS_SessionProp_au8_Proprietary_Start` = 0x01FFFFFFu
Proprietary Properties Start

`enum sss_session_prop_u32_t`
Properties of session that are U32

From 0 to kSSS_SessionProp_Optional_Prop_Start, around 2^24 = 16777215 Properties are possible.

From 0 to kSSS_SessionProp_Optional_Prop_Start, around 2^24 = 16777215 Properties are possible.

Values:

`kSSS_SessionProp_u32_NA` = 0
Invalid

`kSSS_SessionProp_VerMaj`
Major version

`kSSS_SessionProp_VerMin`
Minor Version

`kSSS_SessionProp_VerDev`
Development Version

`kSSS_SessionProp_UIDLen`

`kSSS_SessionProp_u32_Optional_Start` = 0x00FFFFFFu
Optional Properties Start

`kSSS_KeyStoreProp_FreeMem_Persistant`
How much persistent memory is free

`kSSS_KeyStoreProp_FreeMem_Transient`
How much transient memory is free

`kSSS_SessionProp_u32_Proprietary_Start` = 0x01FFFFFFu
Proprietary Properties Start

Functions

void **`sss_session_close`** (*sss_session_t *session*)
Close session between application and security subsystem.

This function closes a session which has been opened with a security subsystem. All commands within the session must have completed before this function can be called. The implementation must do nothing if the input `session` parameter is NULL.

Parameters

- `session`: Session context.

sss_status_t **`sss_session_create`**(*sss_session_t *session*, sss_type_t *subsystem*, uint32_t *application_id*, sss_connection_type_t *connection_type*, void **connectionData*)

Same as sss_session_open but to support sub systems that explictily need a create before opening.

For the sake of portabilty across various sub systems, the applicaiton has to call sss_session_create before calling sss_session_open.

Parameters

- `[inout] session`: Pointer to session context
- `[in] subsystem`: See sss_session_open
- `[in] application_id`: See sss_session_open
- `[in] connection_type`: See sss_session_open
- `[in] connectionData`: See sss_session_open

void **`sss_session_delete`**(*sss_session_t *session*)

Counterpart to sss_session_create

Similar to contraint on sss_session_create, application may call sss_session_delete to explicitly release all underlying/used session specific resoures of that implementation.

sss_status_t **`sss_session_open`**(*sss_session_t *session*, sss_type_t *subsystem*, uint32_t *application_id*, sss_connection_type_t *connection_type*, void **connectionData*)

Open session between application and a security subsystem.

```
Open virtual session between application (user context) and a
security subsystem and function thereof. Pointer to session
shall be supplied to all SSS APIs as argument. Low level SSS
functions can provide implementation specific behaviour based
on the session argument.
Note: sss_session_open() must not be called concurrently from
multiple threads. The application must ensure this.
```

Return status

Parameters

- `[inout] session`: Session context.
- `[in] subsystem`: Indicates which security subsystem is selected to be used.
- `[in] application_id`: ObjectId/AuthenticationID Connecting to:
  - `application_id` == 0 => Super use / Plaform user
  - Anything else => Authenticated user
- `[in] connection_type`: How are we connecting to the system.
- `[inout] connectionData`: subsystem specific connection parameters.

sss_status_t **`sss_session_prop_get_au8`**(*sss_session_t *session*, uint32_t *property*, uint8_t **pValue*, size_t **pValueLen*)

Get an underlying property of the crypto sub system.

This API is used to get values that are numeric in nature.

Property can be either fixed value that is calculated at compile time and returned directly, or it may involve some access to the underlying system.

Return

Parameters

- `[in] session`: Session context
- `[in] property`: Value that is part of sss_session_prop_au8_t
- `[out] pValue`: Output buffer array
- `[inout] pValueLen`: Count of values thare are/must br read

sss_status_t **`sss_session_prop_get_u32`** (*sss_session_t *session*, uint32_t *property*, uint32_t **pValue*)

Get an underlying property of the crypto sub system.

This API is used to get values that are numeric in nature.

Property can be either fixed value that is calculated at compile time and returned directly, or it may involve some access to the underlying system.

For applicable properties see sss_session_prop_u32_t

Return

Parameters

- `[in] session`: Session context
- `[in] property`: Value that is part of sss_session_prop_u32_t
- `[out] pValue`:

`struct sss_session_t`

#include <fsl_sss_api.h> Root session.

This is a *singleton* for each connection (physical/logical) to individual cryptographic system.

Public Members

uint8_t **`data`**[(0 + (1 * sizeof(void *)) + (1 * sizeof(void *)) + (8 * sizeof(void *)) + 32)]

`struct` *sss_session_t*::**[anonymous]** **`extension`**

Reserved memory for implementation specific extension

sss_type_t **`subsystem`**

Indicates which security subsystem is selected.

This is set when sss_session_open is successful

SSS Keystore types and APIs

group **`sss_key_store`**

Secure storage for keys and certificates.

Enums

enum sss_key_store_prop_au8_t

properties of a Key Store that return array

Values:

kSSS_KeyStoreProp_au8_Optional_Start = 0x00FFFFFFu

Optional Properties Start

enum sss_tunnel_dest_t

Entity on the other side of the tunnel

Values:

kSSS_TunnelDest_None = 0

Default value

kSSS_TunnelType_Se05x_Iot_applet

SE05X IoT Applet

Functions

sss_status_t **sss_key_store_allocate** (*sss_key_store_t *keyStore*, uint32_t *keyStoreId*)

Get handle to key store. If the key store already exists, nothing is allocated. If the key store does not exists, new empty key store is created and initialized. Key store context structure is updated with actual information.

Parameters

- `[out] keyStore`: Pointer to key store context. Key store context is updated on function return.
- `keyStoreId`: Implementation specific ID, can be used in case security subsystem manages multiple different key stores.

void **sss_key_store_context_free** (*sss_key_store_t *keyStore*)

Destructor for the key store context.

sss_status_t **sss_key_store_context_init** (*sss_key_store_t *keyStore*, *sss_session_t *session*)

Constructor for the key store context data structure.

Parameters

- `[out] keyStore`: Pointer to key store context. Key store context is updated on function return.
- `session`: Session context.

sss_status_t **sss_key_store_erase_key** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*)

Delete / destroy allocated keyObect .

Return The sss status.

Parameters

- `keyStore`: The key store
- `keyObject`: The key object to be deleted

sss_status_t **sss_key_store_freeze_key** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*)

The referenced key cannot be updated any more.

Return The sss status.

Parameters

- `keyStore`: The key store
- `keyObject`: The key object to be locked / frozen.

sss_status_t **`sss_key_store_generate_key`** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*, size_t *keyBitLen*, void **options*)

This function generates key[] in the destination key store.

sss_status_t **`sss_key_store_get_key`** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*, uint8_t **data*, size_t **dataLen*, size_t **pKeyBitLen*)

This function exports plain key[] from key store (if constraints and user id allows reading)

sss_status_t **`sss_key_store_load`** (*sss_key_store_t *keyStore*)

Load from persistent memory to cached objects.

sss_status_t **`sss_key_store_open_key`** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*)

Access key store using one more level of encryption.

e.g. Access keys / encryption key during storage

Return The sss status.

Parameters

- `keyStore`: The key store
- `keyObject`: The key object that is to be used as a KEK (Key Encryption Key)

sss_status_t **`sss_key_store_save`** (*sss_key_store_t *keyStore*)

Save all cached persistent objects to persistent memory.

sss_status_t **`sss_key_store_set_key`** (*sss_key_store_t *keyStore*, *sss_object_t *keyObject*, **const** uint8_t **data*, size_t *dataLen*, size_t *keyBitLen*, void **options*, size_t *optionsLen*)

This function moves data[] from memory to the destination key store.

Return

Parameters

- `keyStore`: Key store context
- `keyObject`: Reference to a key and it's properties
- `data`: Data to be stored in Key. When setting ecc private key only, do not include key header.
- `dataLen`: Length of the data
- `keyBitLen`: Crypto algorithm key bit length
- `options`: Pointer to implementation specific options
- `optionsLen`: Length of the options in bytes

`struct sss_key_store_t`

#include <fsl_sss_api.h> Store for secure and non secure key objects within a cryptographic system.

- A cryptographic system may have more than partitions to store such keys.

Public Members

uint8_t **data**[(0 + (1 * sizeof(void *)) + (4 * sizeof(void *)) + 32)]

struct *sss_key_store_t*::**[anonymous] extension**
Reserved memory for implementation specific extension

sss_session_t ***session**
Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS KeyObject types and APIs

group **sss_key_object**
Low level iota of key/certificates in `SSS` domain.

Functions

sss_status_t **sss_key_object_allocate_handle** (*sss_object_t *keyObject*, uint32_t *keyId*, sss_key_part_t *keyPart*, sss_cipher_type_t *cipherType*, size_t *keyByteLenMax*, uint32_t *options*)
Allocate / pre-provision memory for new key.

```
        This API allows underlying cryptographic subsystems to perform
        preconditions of before creating any cryptographic key object.
```

Return Status of object allocation.

Parameters

- `[inout] keyObject`: The object If required, update implementation defined values inside the keyObject
- `keyId`: External Key ID. Later on this may be used by sss_key_object_get_handle
- `keyPart`: See sss_key_part_t
- `cipherType`: See sss_cipher_type_t
- `keyByteLenMax`: Maximum storage this type of key may need. For systems that have their own internal allocation table this would help
- `options`: 0 = Persistant Key (Default) or Transient Key. See sss_key_object_mode_t

void **sss_key_object_free** (*sss_object_t *keyObject*)
Destructor for the key object. The function frees key object context.

Parameters

- `keyObject`: Pointer to key object context.

sss_status_t **sss_key_object_get_access** (*sss_object_t *keyObject*, uint32_t **access*)
Check what are access restrictions on an object

Return

Parameters

- `keyObject`: Object

- `access`: What is permitted

sss_status_t **`sss_key_object_get_handle`** (*sss_object_t *keyObject*, uint32_t *keyId*)
Get handle to an existing allocated/provisioned/created Object.

```
        See @ref sss_key_object_allocate_handle.

        After calling this API, Ideally keyObject should become equivlant
        to as set after the calling of @ref
        sss_key_object_allocate_handle api.
```

Return The sss status.

Parameters

- `keyObject`: The key object
- `[in] keyId`: The key identifier

sss_status_t **`sss_key_object_get_purpose`** (*sss_object_t *keyObject*, sss_mode_t **purpose*)
Check what is purpose restrictions on an object

Return

Parameters

- `keyObject`: Object to be checked
- `purpose`: Know what is permitted.

sss_status_t **`sss_key_object_get_user`** (*sss_object_t *keyObject*, uint32_t **user*)
get attributes

sss_status_t **`sss_key_object_init`** (*sss_object_t *keyObject*, *sss_key_store_t *keyStore*)
Constructor for a key object data structure The function initializes keyObject data structure and associates it with a key store in which the plain key and other attributes are stored.

Return Status of the operation

Parameters

- `keyObject`:
- `keyStore`:

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_key_object_set_access`** (*sss_object_t *keyObject*, uint32_t *access*, uint32_t *options*)
Assign access permissions to a key object.

Parameters

- `keyObject`: the object where permission restrictions are applied
- `access`: Logical OR of read, write, delete, use, change attributes defined by enum _sss_access_permission.

- `options`: Transient or persistent update. Allows for transient update of persistent attributes.

sss_status_t **`sss_key_object_set_eccgfp_group`** (*sss_object_t *keyObject*, *sss_eccgfp_group_t *group*)

Set elliptic curve domain parameters over Fp for a key object.

When the key object is a reference to one of ECC Private, ECC Public or ECC Pair key types, this function shall be used to specify the exact domain parameters prior to using the key object for ECDSA or ECDH algorithms.

Parameters

- `keyObject`: The destination key object
- `group`: Pointer to elliptic curve domain parameters over Fp (sextuple p,a,b,G,n,h)

sss_status_t **`sss_key_object_set_purpose`** (*sss_object_t *keyObject*, sss_mode_t *purpose*, uint32_t *options*)

Assign purpose to a key object.

Parameters

- `keyObject`: the object where permission restrictions are applied
- `purpose`: Usage of the key.
- `options`: Transient or persistent update. Allows for transient update of persistent attributes.

sss_status_t **`sss_key_object_set_user`** (*sss_object_t *keyObject*, uint32_t *user*, uint32_t *options*)

Assign user to a key object.

Parameters

- `keyObject`: the object where permission restrictions are applied
- `user`: Assign User id for a key object. The user is kept in the key store along with the key data and other properties.
- `options`: Transient or persistent update. Allows for transient update of persistent attributes.

`struct sss_object_t`

#include <fsl_sss_api.h> An object (secure / non-secure) within a Key Store.

Public Members

uint32_t **`cipherType`**

cipherType type from sss_cipher_type_t

uint8_t **`data`**[(0 + (1 * sizeof(void *)) + (2 * sizeof(int)) + (4 * sizeof(void *)) + 32)]

`struct` *sss_object_t*::**[anonymous]** **`extension`**

Reserved memory for implementation specific extension

uint32_t **`keyId`**

Application specific key identifier. The keyId is kept in the key store along with the key data and other properties.

sss_key_store_t ***`keyStore`**

key store holding the data and other properties

uint32_t **`objectType`**

The type/part of object is referneced from sss_key_part_t

SSS Symmetric types and APIs

group **`sss_crypto_symmetric`**

Symmetric cryptographic operations like `AES` / `DES/etc`.

Functions

sss_status_t **`sss_cipher_crypt_ctr`** (*sss_symmetric_t *context*, **`const`** uint8_t **srcData*, uint8_t **destData*, size_t *size*, uint8_t **initialCounter*, uint8_t **lastEncryptedCounter*, size_t **szLeft*)

Symmetric AES in Counter mode in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing the input data.
- `destData`: Buffer containing the output data.
- `size`: Size of source and destination data buffers in bytes.
- `[inout] initialCounter`: Input counter (Always 16 bytes) (updates on return). When using internal IV algorithms (only encrypt) for SE051, initialCounter buffer will be filled with genereted Initial counter.
- `[out] lastEncryptedCounter`: Output cipher of last counter, for chained CTR calls. NULL can be passed if chained calls are not used.
- `[out] szLeft`: Output number of bytes in left unused in lastEncryptedCounter block. NULL can be passed if chained calls are not used.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_cipher_finish`** (*sss_symmetric_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Symmetric cipher finalize.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing final chunk of input data.
- `srcLen`: Length of final chunk of input data in bytes.
- `destData`: Buffer containing output data.
- `[inout] destLen`: Length of output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.

- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_cipher_init`** (*sss_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*)

Symmetric cipher init. The function starts the symmetric cipher operation.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_cipher_one_go`** (*sss_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*, **`const`** uint8_t **srcData*, uint8_t **destData*, size_t *dataLen*)

Symmetric cipher in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.
- `srcData`: Buffer containing the input data (block aligned).
- `destData`: Buffer containing the output data.
- `dataLen`: Size of input and output data buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_cipher_one_go_v2`** (*sss_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*, **`const`** uint8_t **srcData*, **`const`** size_t *srcLen*, uint8_t **destData*, size_t **dataLen*)

Symmetric cipher in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.

- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.
- `srcData`: Buffer containing the input data (block aligned).
- `srcLen`: Length of buffer srcData.
- `destData`: Buffer containing the output data.
- `pDataLen`: Pointer to Size of buffer destData in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_cipher_update`** (*sss_symmetric_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Symmetric cipher update. Input data does not have to be a multiple of block size. Subsequent calls to this function are possible. Unless one or more calls of this function have supplied sufficient input data, no output is generated. The cipher operation is finalized with a call to sss_cipher_finish().

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing the input data.
- `srcLen`: Length of the input data in bytes.
- `destData`: Buffer containing the output data.
- `[inout] destLen`: Length of the output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

void **`sss_symmetric_context_free`** (*sss_symmetric_t *context*)

Symmetric context release. The function frees symmetric context.

Parameters

- `context`: Pointer to symmetric crypto context.

sss_status_t **`sss_symmetric_context_init`** (*sss_symmetric_t *context*, *sss_session_t *session*, *sss_object_t *keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Symmetric context init. The function initializes symmetric context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.

- `session`: Associate SSS session with symmetric context.
- `keyObject`: Associate SSS key object with symmetric context.
- `algorithm`: One of the symmetric algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

`struct sss_symmetric_t`

#include <fsl_sss_api.h> Typedef for the symmetric crypto context.

Public Members

sss_algorithm_t **`algorithm`**

Algorithm to be applied, e.g AES_ECB / CBC

uint8_t **`data`**[(0 + (2 * sizeof(void *)) + (2 * sizeof(int)) + (2 * sizeof(void *)) + 16 + 4 + 32)]

`struct` *sss_symmetric_t*::**[anonymous]** **`extension`**

Reserved memory for implementation specific extension

sss_object_t ***`keyObject`**

Key to be used for the symmetric operation

sss_mode_t **`mode`**

Mode of operation, e.g Encryption/Decryption

sss_session_t ***`session`**

Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS Asymmetric types and APIs

group **`sss_crypto_asymmetric`**

Asymmetric cryptographic operations like `RSA` / `ECC/etc`.

Functions

void **`sss_asymmetric_context_free`** (sss_asymmetric_t **context*)

Asymmetric context release. The function frees asymmetric context.

Parameters

- `context`: Pointer to asymmetric context.

sss_status_t **`sss_asymmetric_context_init`** (sss_asymmetric_t **context*, *sss_session_t* **session*, *sss_object_t* **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Asymmetric context init. The function initializes asymmetric context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric crypto context.
- `session`: Associate SSS session with asymmetric context.
- `keyObject`: Associate SSS key object with asymmetric context.
- `algorithm`: One of the asymmetric algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_asymmetric_decrypt`**(sss_asymmetric_t **context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Asymmetric decryption The function uses asymmetric algorithm to decrypt data. Private key portion of a key pair is used for decryption.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `srcData`: Input buffer
- `srcLen`: Length of the input in bytes
- `destData`: Output buffer
- `destLen`: Length of the output in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_asymmetric_encrypt`**(sss_asymmetric_t **context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Asymmetric encryption The function uses asymmetric algorithm to encrypt data. Public key portion of a key pair is used for encryption.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `srcData`: Input buffer
- `srcLen`: Length of the input in bytes
- `destData`: Output buffer
- `destLen`: Length of the output in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_asymmetric_sign_digest`** (sss_asymmetric_t **context*, uint8_t **digest*, size_t *digestLen*, uint8_t **signature*, size_t **signatureLen*)

Asymmetric signature of a message digest The function signs a message digest.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `digest`: Input buffer containing the input message digest
- `digestLen`: Length of the digest in bytes
- `signature`: Output buffer written with the signature of the digest
- `signatureLen`: Length of the signature in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_asymmetric_verify_digest`** (sss_asymmetric_t **context*, uint8_t **digest*, size_t *digestLen*, uint8_t **signature*, size_t *signatureLen*)

Asymmetric verify of a message digest The function verifies a message digest.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `digest`: Input buffer containing the input message digest
- `digestLen`: Length of the digest in bytes
- `signature`: Input buffer containing the signature to verify
- `signatureLen`: Length of the signature in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

SSS RNG types and APIs

group **`sss_rng`**

Functions

sss_status_t **`sss_rng_context_free`** (*sss_rng_context_t *context*)
free random genertor context.

Return status

Parameters

- `context`: generator context.

sss_status_t **`sss_rng_context_init`** (*sss_rng_context_t *context*, *sss_session_t *session*)
Initialise random generator context between application and a security subsystem.

Warning API Changed

```
Earlier:
    sss_status_t sss_rng_context_init(
        sss_session_t *session, sss_rng_context_t *context);

Now: Parameters are swapped
 sss_status_t sss_rng_context_init(
     sss_rng_context_t *context, sss_session_t *session);
```

Return status

Parameters

- `session`: Session context.
- `context`: random generator context.

sss_status_t **`sss_rng_get_random`** (*sss_rng_context_t *context*, uint8_t **random_data*, size_t *dataLen*)
Generate random number.

Return status

Parameters

- `context`: random generator context.
- `random_data`: buffer to hold random data.
- `dataLen`: required random number length

`struct sss_rng_context_t`
#include <fsl_sss_api.h> Random number generator context

Public Members

`struct` *sss_rng_context_t*::**[anonymous] `context`**
Reserved memory for implementation specific extension

uint8_t **`data`**[(0 + (1 * sizeof(void *)) + (2 * sizeof(void *)) + 32)] *sss_session_t* ***session**

Pointer to the session

SSS Digest types and APIs

group **sss_crypto_digest**

Functions

void **sss_digest_context_free** (*sss_digest_t *context*)

Digest context release. The function frees digest context.

Parameters

- `context`: Pointer to digest context.

sss_status_t **sss_digest_context_init** (*sss_digest_t *context*, *sss_session_t *session*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Digest context init. The function initializes digest context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `session`: Associate SSS session with digest context.
- `algorithm`: One of the digest algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_digest_finish** (*sss_digest_t *context*, uint8_t **digest*, size_t **digestLen*)

Finish digest for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `digest`: Output message digest
- `digestLen`: Message digest byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_digest_init`** (*sss_digest_t *context*)

Init digest for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_digest_one_go`** (*sss_digest_t *context*, **`const`** uint8_t **message*, size_t *messageLen*, uint8_t **digest*, size_t **digestLen*)

Message digest in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `message`: Input message
- `messageLen`: Length of the input message in bytes
- `digest`: Output message digest
- `digestLen`: Message digest byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_digest_update`** (*sss_digest_t *context*, **`const`** uint8_t **message*, size_t *messageLen*)

Update digest for a message.

The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `message`: Buffer with a message chunk.
- `messageLen`: Length of the input buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

`struct sss_digest_t`

#include <fsl_sss_api.h> Message Digest operations

Public Members

sss_algorithm_t **algorithm**
Algorithm to be applied, e.g SHA1, SHA256

uint8_t **data**[(0 + (1 * sizeof(void *)) + (3 * sizeof(int)) + (2 * sizeof(void *)) + 32)]

size_t **digestFullLen**
Full digest length per algorithm definition. This field is initialized along with algorithm.

struct *sss_digest_t*::**[anonymous] extension**
Reserved memory for implementation specific extension

sss_mode_t **mode**
Mode of operation, e.g Sign/Verify

sss_session_t ***session**
Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS MAC types and APIs

group **sss_crypto_mac**

Functions

void **sss_mac_context_free**(*sss_mac_t *context*)
MAC context release. The function frees mac context.

Parameters

- `context`: Pointer to mac context.

sss_status_t **sss_mac_context_init**(*sss_mac_t *context*, *sss_session_t *session*, *sss_object_t *keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)
MAC context init. The function initializes mac context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `session`: Associate SSS session with mac context.
- `keyObject`: Associate SSS key object with mac context.
- `algorithm`: One of the mac algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_mac_finish** (*sss_mac_t *context*, uint8_t **mac*, size_t **macLen*)

Finish mac for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `mac`: Output message MAC
- `macLen`: Computed MAC byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_mac_init** (*sss_mac_t *context*)

Init mac for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_mac_one_go** (*sss_mac_t *context*, **const** uint8_t **message*, size_t *messageLen*, uint8_t **mac*, size_t **macLen*)

Message MAC in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `message`: Input message
- `messageLen`: Length of the input message in bytes
- `mac`: Output message MAC
- `macLen`: Computed MAC byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_mac_update** (*sss_mac_t *context*, **const** uint8_t **message*, size_t *messageLen*)

Update mac for a message.

The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `message`: Buffer with a message chunk.
- `messageLen`: Length of the input buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

struct sss_mac_t

#include <fsl_sss_api.h> Message Authentication Code.

Public Members

sss_algorithm_t **algorithm**

Algorithm to be applied, e.g. MAC/CMAC

uint8_t **data**[(0 + (2 * sizeof(void *)) + (2 * sizeof(int)) + (2 * sizeof(void *)) + 32)]

struct *sss_mac_t*::**[anonymous] extension**

Reserved memory for implementation specific extension

sss_object_t ***keyObject**

Key to be used for . . .

sss_mode_t **mode**

Mode of operation for MAC (kMode_SSS_Mac)

sss_session_t ***session**

Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS Key derivation types and APIs

group **sss_crypto_derive_key**

Derive Key.

Operations that use mutiple keys from multiple security systems and dervive and output key, e.g. Diffie Hellman exchange.

Functions

void **sss_derive_key_context_free** (*sss_derive_key_t *context*)

Derive key context release. The function frees derive key context.

Parameters

- `context`: Pointer to derive key context.

sss_status_t **sss_derive_key_context_init** (*sss_derive_key_t *context*, *sss_session_t *session*, *sss_object_t *keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Derive key context init. The function initializes derive key context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `session`: Associate SSS session with the derive key context.
- `keyObject`: Associate SSS key object with the derive key context.
- `algorithm`: One of the derive key algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_derive_key_dh**(*sss_derive_key_t *context*, *sss_object_t *otherPartyKeyObject*, *sss_object_t *derivedKeyObject*)

Asymmetric key derivation Diffie-Helmann The function cryptographically derives a key from another key. For example Diffie-Helmann.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `otherPartyKeyObject`: Public key of the other party in the Diffie-Helmann algorithm
- `[inout] derivedKeyObject`: Reference to a derived key

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_derive_key_go**(*sss_derive_key_t *context*, **const** uint8_t **saltData*, size_t *saltLen*, **const** uint8_t **info*, size_t *infoLen*, *sss_object_t *derivedKeyObject*, uint16_t *deriveDataLen*, uint8_t **hkdfOutput*, size_t **hkdfOutputLen*)

Symmetric key derivation The function cryptographically derives a key from another key. For example MIFARE key derivation, PRF, HKDF-Extract.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `saltData`: Input data buffer, typically with some random data.
- `saltLen`: Length of saltData buffer in bytes.
- `info`: Input data buffer, typically with some fixed info.
- `infoLen`: Length of info buffer in bytes.
- `[inout] derivedKeyObject`: Reference to a derived key

- `deriveDataLen`: Requested length of output
- `hkdfOutput`: Output buffer containing key derivation output
- `hkdfOutputLen`: Output containing length of hkdfOutput

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_derive_key_one_go`** (*sss_derive_key_t *context*, **`const`** uint8_t **saltData*, size_t *saltLen*, **`const`** uint8_t **info*, size_t *infoLen*, *sss_object_t *derivedKeyObject*, uint16_t *deriveDataLen*)

Symmetric key derivation (replaces the deprecated function sss_derive_key_go) The function cryptographically derives a key from another key. For example MIFARE key derivation, PRF, HKDF-Extract-Expand, HKDF-Expand. Refer to sss_derive_key_sobj_one_go in case the Salt is available as a key object.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `saltData`: Input data buffer, typically with some random data.
- `saltLen`: Length of saltData buffer in bytes.
- `info`: Input data buffer, typically with some fixed info.
- `infoLen`: Length of info buffer in bytes.
- `[inout] derivedKeyObject`: Reference to a derived key
- `[in] deriveDataLen`: Expected length of derived key.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_derive_key_sobj_one_go`** (*sss_derive_key_t *context*, *sss_object_t *saltKeyObject*, **`const`** uint8_t **info*, size_t *infoLen*, *sss_object_t *derivedKeyObject*, uint16_t *deriveDataLen*)

Symmetric key derivation (salt in key object) Refer to sss_derive_key_one_go in case the salt is not available as a key object.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context
- `saltKeyObject`: Reference to salt. The salt key object must reside in the same keystore as the derive key context.
- `[in] info`: Input data buffer, typically with some fixed info.

- `[in] infoLen`: Length of info buffer in bytes.
- `derivedKeyObject`: Reference to a derived key
- `[in] deriveDataLen`: The derive data length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

`struct sss_derive_key_t`

#include <fsl_sss_api.h> Key derivation

Public Members

sss_algorithm_t **`algorithm`**

Algorithm to be applied, e.g. . . .

uint8_t **`data`**[(0 + (2 * sizeof(void *)) + (2 * sizeof(int)) + (2 * sizeof(void *)) + 32)]

`struct` *sss_derive_key_t*::**[anonymous]** **`extension`**

Reserved memory for implementation specific extension

sss_object_t ***`keyObject`**

KeyObject used to derive key s

sss_mode_t **`mode`**

Mode of operation for . . . . e.g. . . .

sss_session_t ***`session`**

Pointer to the session

SSS AEAD types and APIs

group **`sss_crypto_aead`**

Authenticated Encryption with Additional Data.

Functions

void **`sss_aead_context_free`** (*sss_aead_t *context*)

AEAD context release. The function frees aead context.

Parameters

- `context`: Pointer to aead context.

sss_status_t **`sss_aead_context_init`** (*sss_aead_t *context*, *sss_session_t *session*, *sss_object_t *keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

AEAD context init. The function initializes aead context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.

- `session`: Associate SSS session with aead context.
- `keyObject`: Associate SSS key object with aead context.
- `algorithm`: One of the aead algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_aead_finish`** (*sss_aead_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*, uint8_t **tag*, size_t **tagLen*)

Finalize AEAD. The functions processes data that has not been processed by previous calls to sss_aead_update() as well as srcData. It finalizes the AEAD operations and computes the tag (encryption) or compares the computed tag with the tag supplied in the parameter (decryption).

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing final chunk of input data.
- `srcLen`: Length of final chunk of input data in bytes.
- `destData`: Buffer containing output data.
- `[inout] destLen`: Length of output data in bytes. Buffer length on entry, reflects actual output size on return.
- `tag`: Encryption: Output buffer filled with computed tag Decryption: Input buffer filled with received tag
- `tagLen`: Length of the computed or received tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_aead_init`** (*sss_aead_t *context*, uint8_t **nonce*, size_t *nonceLen*, size_t *tagLen*, size_t *aadLen*, size_t *payloadLen*)

AEAD init. The function starts the aead operation.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `nonce`: The operation nonce or IV. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.

- `nonceLen`: The length of nonce in bytes. For AES-GCM it must be >= 1. For AES-CCM it must be 7, 8, 9, 10, 11, 12, or 13.
- `tagLen`: Length of the computed or received tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.
- `aadLen`: Input size in bytes of AAD. Used only for AES-CCM. Ignored for AES-GCM.
- `payloadLen`: Length in bytes of the payload. Used only for AES-CCM. Ignored for AES-GCM.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_aead_one_go`** (*sss_aead_t *context*, **`const`** uint8_t **srcData*, uint8_t **destData*, size_t *size*, uint8_t **nonce*, size_t *nonceLen*, **`const`** uint8_t **aad*, size_t *aadLen*, uint8_t **tag*, size_t **tagLen*)

AEAD in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing the input data.
- `destData`: Buffer containing the output data.
- `size`: Size of input and output data buffer in bytes.
- `nonce`: The operation nonce or IV. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `nonceLen`: The length of nonce in bytes. For AES-GCM it must be >= 1. For AES-CCM it must be 7, 8, 9, 10, 11, 12, or 13.
- `aad`: Input additional authentication data AAD
- `aadLen`: Input size in bytes of AAD
- `tag`: Encryption: Output buffer filled with computed tag Decryption: Input buffer filled with received tag
- `tagLen`: Length of the tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_aead_update`** (*sss_aead_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

AEAD data update. Feeds a new chunk of the data payload. Input data does not have to be a multiple of block size. Subsequent calls to this function are possible. Unless one or more calls of this function have supplied sufficient input data, no output is generated. The integration check is done by sss_aead_finish(). Until then it is not sure if the decrypt data is authentic.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing the input data.
- `srcLen`: Length of the input data in bytes.
- `destData`: Buffer containing the output data.
- `[inout] destLen`: Length of the output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_aead_update_aad`**(*sss_aead_t *context*, **`const`** uint8_t **aadData*, size_t *aadDataLen*)

Feeds a new chunk of the AAD. Subsequent calls of this function are possible.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context
- `aadData`: Input buffer containing the chunk of AAD
- `aadDataLen`: Length of the AAD data in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

`struct sss_aead_t`

#include <fsl_sss_api.h> Authenticated Encryption with Additional Data.

Public Members

sss_algorithm_t **`algorithm`**

Algorithm to be used

uint8_t **`data`**[(0 + (5 * sizeof(void *)) + (6 * sizeof(int)) + (5 * sizeof(void *)) + 32)]

`struct` *sss_aead_t*::**[anonymous] `extension`**

Reserved memory for implementation specific extension

sss_object_t ***`keyObject`**

Key to be used for asymmetric

sss_mode_t **`mode`**

High level operation (encrypt/decrypt)

sss_session_t ***`session`**
Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS Tunnel types and APIs

group **`sss_crypto_tunnel`**
Tunnel session.

Functions

sss_status_t **`sss_tunnel`** (*sss_tunnel_t *context*, uint8_t **data*, size_t *dataLen*, *sss_object_t *keyObjects*, uint32_t *keyObjectCount*, uint32_t *tunnelType*)
Tunnelling service.

Parameters

- `[inout] context`: Pointer to tunnel context.
- `data`: Pointer to data to be send to subsystem.
- `dataLen`: Length of the data in bytes.
- `keyObjects`: Objects references used by the service.
- `keyObjectCount`: Number of key references at `keyObjects`.
- `tunnelType`: Implementation specific id of the service.

void **`sss_tunnel_context_free`** (*sss_tunnel_t *context*)
Destructor for the tunnelling service context.

Parameters

- `[out] context`: Pointer to tunnel context.

sss_status_t **`sss_tunnel_context_init`** (*sss_tunnel_t *context*, *sss_session_t *session*)
Constructor for the tunnelling service context.

```
Earlier:
    sss_status_t sss_tunnel_context_init(
        sss_session_t *session, sss_tunnel_t *context);

Now: Parameters are swapped
    sss_status_t sss_tunnel_context_init(
        sss_tunnel_t *context, sss_session_t *session);
```

Parameters

- `[out] context`: Pointer to tunnel context. Tunnel context is updated on function return.
- `session`: Pointer to session this tunnelling service belongs to.

`struct sss_tunnel_t`
#include <fsl_sss_api.h> Tunneling

Used for communication via another system.

Public Members

uint8_t **`data`**[(0 + (1 * sizeof(void *)) + (2 * sizeof(int)) + (2 * sizeof(void *)) + 32)]

`struct` *sss_tunnel_t*::**[anonymous]** **`extension`**
Reserved memory for implementation specific extension

sss_session_t ***`session`**
Pointer to the session

uint32_t **`tunnelType`**
Tunnel to which Applet (Currently unused)

SSS Policy types and APIs

group **`sss_policy`**
Policies to restrict and control sessions and objects.

Enums

`enum sss_policy_type_u`
Type of policy

Values:

`KPolicy_None`
No policy applied

`KPolicy_Session`
Policy related to session.
See sss_policy_session_u

`KPolicy_Sym_Key`
Policy related to key.
See sss_policy_key_u

`KPolicy_Asym_Key`

`KPolicy_UserID`

`KPolicy_File`

`KPolicy_Counter`

`KPolicy_PCR`

`KPolicy_Common`

`KPolicy_Common_PCR_Value`

`KPolicy_Desfire_Changekey_Auth_Id`

`KPolicy_Derive_Master_Key_Id`

`KPolicy_Internal_Sign`

`struct sss_policy_asym_key_u`
#include <fsl_sss_policy.h> Policies applicable to Asymmetric KEY

Public Members

uint8_t **`can_Attest`**
Allow to attest an object

uint8_t **`can_Decrypt`**
Allow decryption

uint8_t **`can_Encrypt`**
Allow encryption

uint8_t **`can_Gen`**
Allow to (re)generate the object

uint8_t **`can_Import_Export`**
Allow to imported or exported

uint8_t **`can_KA`**
Allow key agreement

uint8_t **`can_KD`**
Allow key derivation

uint8_t **`can_Read`**
Allow to read the object

uint8_t **`can_Sign`**
Allow signature generation

uint8_t **`can_Verify`**
Allow signature verification

uint8_t **`can_Wrap`**
Allow key wrapping

uint8_t **`can_Write`**
Allow to write the object

uint8_t **`forbid_Derived_Output`**
Forbid derived output

`struct sss_policy_common_pcr_value_u`
#include <fsl_sss_policy.h> Common PCR Value Policies for all object types

Public Members

uint8_t **`pcrExpectedValue`**[32]
Expected value of the PCR

uint32_t **`pcrObjId`**
PCR object ID

`struct sss_policy_common_u`
#include <fsl_sss_policy.h> Common Policies for all object types

Public Members

uint8_t **`can_Delete`**
Allow to delete the object

uint8_t **`can_Read`**
Allow to read the object

uint8_t **`can_Write`**
Allow to write the object

uint8_t **`forbid_All`**
Forbid all operations

uint8_t **`req_pcr_val`**
Require PCR value

uint8_t **`req_Sm`**
Require having secure messaging enabled with encryption and integrity on the command

`struct sss_policy_counter_u`
#include <fsl_sss_policy.h> All policies related to secure object type Counter

Public Members

uint8_t **`can_Read`**
Allow to read the object

uint8_t **`can_Write`**
Allow to write the object

`struct sss_policy_desfire_changekey_authId_value_u`
#include <fsl_sss_policy.h> DESFire ChangeKey - authentication key identifier.

Public Members

uint32_t **`desfire_authId`**
DESFire authentication object ID

`struct sss_policy_file_u`
#include <fsl_sss_policy.h> All policies related to secure object type File

Public Members

uint8_t **`can_Read`**
Allow to read the object

uint8_t **`can_Write`**
Allow to write the object

`struct sss_policy_internal_sign_tbs_value_u`
#include <fsl_sss_policy.h> Allow internal sign.

Public Members

uint32_t **`tbsItemList_KeyId`**
identifier of the tbsItemList Secure Object

`struct sss_policy_key_drv_master_keyid_value_u`
#include <fsl_sss_policy.h> Key Derive - Master key identifier.

Public Members

uint32_t **master_keyId**
Master key ID

struct sss_policy_pcr_u
#include <fsl_sss_policy.h> All policies related to secure object type PCR

Public Members

uint8_t **can_Read**
Allow to read the object

uint8_t **can_Write**
Allow to write the object

struct sss_policy_session_u
#include <fsl_sss_policy.h> Policy applicable to a session

Public Members

uint8_t **allowRefresh**
Whether this session can be refreshed without losing context. And also reset maxDurationOfSession_sec / maxOperationsInSession

uint8_t **has_MaxDurationOfSession_sec**
Whether maxOperationsInSession is set. This is to ensure '0 == maxDurationOfSession_sec' does not get set by middleware.

uint8_t **has_MaxOperationsInSession**
Whether maxOperationsInSession is set. This is to ensure '0 == maxOperationsInSession' does not get set by middleware.

uint16_t **maxDurationOfSession_sec**
Session can be used for this much time, in seconds

uint16_t **maxOperationsInSession**
Number of operations permitted in a session

struct sss_policy_sym_key_u
#include <fsl_sss_policy.h> Policies applicable to Symmetric KEY

Public Members

uint8_t **allow_kdf_ext_rnd**
Allow kdf(prf) external random

uint8_t **can_Decrypt**
Allow decryption

uint8_t **can_Desfire_Auth**
Allow to perform DESFire authentication

uint8_t **can_Desfire_Dump**
Allow to dump DESFire session keys

uint8_t **can_Desfire_KD**
Allow Desfire key derivation

uint8_t **can_Encrypt**
Allow encryption

uint8_t **can_Gen**
Allow to (re)generate the object

uint8_t **can_HKDF**
Allow HKDF

uint8_t **can_Import_Export**
Allow to imported or exported

uint8_t **can_KA**
Allow key agreement. Only for SE051H, key agreement is applicable for symm objects

uint8_t **can_KD**
Allow key derivation

uint8_t **can_PBKDF**
Allow PBKDF

uint8_t **can_Sign**
Allow signature generation

uint8_t **can_TLS_KDF**
Allow TLS PRF key derivation

uint8_t **can_TLS_PMS_KD**
Allow TLS PMS key derivation

uint8_t **can_usage_hmac_pepper**
Allow usage as hmac pepper

uint8_t **can_Verify**
Allow signature verification

uint8_t **can_Wrap**
Allow key wrapping

uint8_t **can_Write**
Allow to write the object

uint8_t **forbid_Derived_Output**
Forbid derived output

uint8_t **forbid_external_iv**
Forbid External iv

struct sss_policy_t
#include <fsl_sss_policy.h> An array of policies sss_policy_u

Public Members

size_t **nPolicies**
Number of policies

const *sss_policy_u* ***policies**[(10)]
Array of unique policies, this needs to be allocated based nPolicies

struct sss_policy_u
#include <fsl_sss_policy.h> Unique/individual policy. For any operation, you need array of sss_policy_u.

Public Members

sss_policy_asym_key_u **asymmkey**

uint32_t **auth_obj_id**
Auth ID for each Object Policy, invalid for session policy type == KPolicy_Session

sss_policy_common_u **common**

sss_policy_common_pcr_value_u **common_pcr_value**

sss_policy_counter_u **counter**

sss_policy_desfire_changekey_authId_value_u **desfire_auth_id**

sss_policy_file_u **file**

sss_policy_key_drv_master_keyid_value_u **master_key_id**

sss_policy_pcr_u **pcr**

sss_policy_userid_u **pin**

union *sss_policy_u*::**[anonymous] policy**
Union of applicable policies based on the type of object

sss_policy_session_u **session**

sss_policy_sym_key_u **symmkey**

sss_policy_internal_sign_tbs_value_u **tbsItemList**

sss_policy_type_u **type**
Secure Object Type

struct sss_policy_userid_u
#include <fsl_sss_policy.h> All policies related to secure object type UserID

Public Members

uint8_t **can_Write**
Allow to write the object

SSS Str log types and APIs

group **sss_str_log**

Functions

const char ***sss_cipher_type_sz** (sss_cipher_type_t *cipher_type*)
Returns string error code for sss_cipher_type_t.

Return String conversion of `cipher_type` to String.

Parameters

- `[in] status`: See sss_cipher_type_t

const char ***sss_status_sz** (sss_status_t *status*)
Returns string error code for sss_status_t.

Return String conversion of `status` to String.

Parameters

- `[in] status`: See sss_status_t

3.3.10 List of all SSS SE05x APIs and structures

SSS SE05x Enums and Types

group **`sss_sw_se05x`**

Manage session.

Defines

`se05x_auth_context_t`

deprecated : Used only for backwards compatibility

`SE05x_Connect_Ctx_t`

deprecated : Used only for backwards compatibility

`SSS_AEAD_TYPE_IS_SE05X` (context)

Are we using SE05X as crypto subsystem?

`SSS_ASYMMETRIC_TYPE_IS_SE05X` (context)

Are we using SE05X as crypto subsystem?

`SSS_DERIVE_KEY_TYPE_IS_SE05X` (context)

Are we using SE05X as crypto subsystem?

SSS_DIGEST_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

SSS_KEY_STORE_TYPE_IS_SE05X (keyStore)
Are we using SE05X as crypto subsystem?

SSS_MAC_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

SSS_OBJECT_TYPE_IS_SE05X (pObject)
Are we using SE05X as crypto subsystem?

SSS_RNG_CONTEXT_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

SSS_SESSION_TYPE_IS_SE05X (session)
Are we using SE05X as crypto subsystem?

SSS_SUBSYSTEM_TYPE_IS_SE05X (subsystem)
Are we using SE05X as crypto subsystem?

SSS_SYMMETRIC_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

SSS_TUNNEL_CONTEXT_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

SSS_TUNNEL_TYPE_IS_SE05X (context)
Are we using SE05X as crypto subsystem?

Enums

enum sss_s05x_sesion_prop_au8_t
SE050 Properties that can be represented as an array

Values:

kSSS_SE05x_SessionProp_CertUID = kSSS_SessionProp_au8_Proprietary_Start + 1

enum sss_s05x_sesion_prop_u32_t
SE050 Properties that can be represented as 32bit numbers

Values:

kSSS_SE05x_SessionProp_CertUIDLen = kSSS_SessionProp_u32_Optional_Start + 1

struct _sss_se05x_object
#include <fsl_sss_se05x_types.h> An object (secure / non-secure) within a Key Store.

Public Members

uint32_t **cipherType**
cipherType type from sss_cipher_type_t

SE05x_ECCurve_t **curve_id**
If this is an ECC Key, the Curve ID of the key

uint8_t **isPersistant**
Whether this is a persistant or tansient object

uint32_t **keyId**
Application specific key identifier. The keyId is kept in the key store along with the key data and other properties.

sss_se05x_key_store_t ***keyStore**
key store holding the data and other properties

uint32_t **objectType**
The type/part of object is referneced from sss_key_part_t

struct _sss_se05x_session
#include <fsl_sss_se05x_types.h> Root session.

This is a *singleton* for each connection (physical/logical) to individual cryptographic system.

Public Members

sss_se05x_tunnel_context_t ***ptun_ctx**
In case connection is tunneled, context to the tunnel

Se05xSession_t **s_ctx**
Connection context to SE050

sss_type_t **subsystem**
Indicates which security subsystem is selected to be used.

struct _sss_se05x_tunnel_context
#include <fsl_sss_se05x_types.h> Tunneling

Used for communication via another system.

Public Members

struct *_sss_se05x_session* ***se05x_session**
Pointer to the base SE050 SEssion

sss_tunnel_dest_t **tunnelDest**
Where exactly this tunnel terminates to

struct SE05x_Applet_Feature_Disable_t
#include <fsl_sss_se05x_types.h> Used to disable Applet Features via `sss_se05x_set_feature`

Public Members

uint8_t **EXTCFG_FORBID_AES_GCM**
Disable feature AES_GCM B8b8

uint8_t **EXTCFG_FORBID_AES_GCM_EXT_IV**
Disable feature AES_GCM_EXT_IV B8b7

uint8_t **EXTCFG_FORBID_ECDAA**
Disable feature ECDAA B2b7

uint8_t **EXTCFG_FORBID_ECDH**
Disable feature ECDH B2b8

uint8_t **EXTCFG_FORBID_HKDF_EXTRACT**
Disable feature HKDF_EXTRACT B10b7

uint8_t **EXTCFG_FORBID_RSA_LT_2K**
Disable feature RSA_LT_2K B6b8

uint8_t **EXTCFG_FORBID_RSA_SHA1**
Disable feature RSA_SHA1 B6b7

struct SE05x_Applet_Feature_t
#include <fsl_sss_se05x_types.h> Used to enable Applet Features via `sss_se05x_set_feature`

Public Members

uint8_t **AppletConfig_AES**
Writing AESKey objects

uint8_t **AppletConfig_DES**
Writing DESKey objects

uint8_t **AppletConfig_DH_MONT**
Use of curve RESERVED_ID_ECC_MONT_DH_25519

uint8_t **AppletConfig_ECDAA**
Use of curve TPM_ECC_BN_P256

uint8_t **AppletConfig_ECDSA_ECDH_ECDHE**
EC DSA and DH support

uint8_t **AppletConfig_EDDSA**
Use of curve RESERVED_ID_ECC_ED_25519

uint8_t **AppletConfig_HMAC**
Writing HMACKey objects

uint8_t **AppletConfig_I2CM**
I2C Master support (see 4.17) in APDU Spec

uint8_t **AppletConfig_MIFARE**
Mifare DESFire support (see 4.15) in APDU Spec

uint8_t **AppletConfig_PBKDF**
PBKDF2

uint8_t **AppletConfig_RFU1**
Allocated value undefined and reserved for future use

uint8_t **AppletConfig_RFU21**
RFU

uint8_t **AppletConfig_RSA_CRT**
Writing RSAKey objects

uint8_t **AppletConfig_RSA_PLAIN**
Writing RSAKey objects

uint8_t **AppletConfig_TLS**
TLS Handshake support commands (see 4.16) in APDU Spec

struct sss_se05x_aead_t
#include <fsl_sss_se05x_types.h> Authenticated Encryption with Additional Data.

Public Members

sss_algorithm_t **algorithm**
Algorithm to be used

uint8_t **cache_data**[16]
Cache in case of un-alined inputs

size_t **cache_data_len**
How much we have cached

SE05x_CryptoObjectID_t **cryptoObjectId**
Implementation specific part

sss_se05x_object_t ***keyObject**
Key to be used for asymmetric

sss_mode_t **mode**
High level operation (encrypt/decrypt)

sss_se05x_session_t ***session**
Virtual connection between application (user context) and specific security subsystem and function thereof.

struct sss_se05x_asymmetric_t
#include <fsl_sss_se05x_types.h> Asymmetric Cryptographic operations.

e.g. RSA/ECC.

Public Members

sss_algorithm_t **algorithm**
Algorithm to be applied, e.g. ECDSA

sss_se05x_object_t ***keyObject**
KeyObject used for Asymmetric operation

sss_mode_t **mode**
Mode of operation for the Asymmetric operation. e.g. Sign/Verify/Encrypt/Decrypt

sss_se05x_session_t ***session**
Pointer to root session

struct sss_se05x_derive_key_t
#include <fsl_sss_se05x_types.h> Key derivation

Public Members

sss_algorithm_t **algorithm**
Algorithm to be applied, e.g. …

sss_se05x_object_t ***keyObject**
KeyObject used to derive key s

sss_mode_t **mode**
Mode of operation for …. e.g. …

sss_se05x_session_t ***session**
Pointer to the session

struct sss_se05x_digest_t

#include <fsl_sss_se05x_types.h> Message Digest operations

Public Members

sss_algorithm_t **algorithm**

Algorithm to be applied, e.g SHA1, SHA256

SE05x_CryptoObjectID_t **cryptoObjectId**

Implementation specific part

size_t **digestFullLen**

Full digest length per algorithm definition. This field is initialized along with algorithm.

sss_mode_t **mode**

Mode of operation, e.g Sign/Verify

sss_se05x_session_t ***session**

Virtual connection between application (user context) and specific security subsystem and function thereof.

struct sss_se05x_key_store_t

#include <fsl_sss_se05x_types.h> Store for secure and non secure key objects within a cryptographic system.

- A cryptographic system may have more than partitions to store such keys.

Public Members

struct *_sss_se05x_object* ***kekKey**

In case the we are using Key Wrapping while injecting the keys, pointer to key used for wrapping

sss_se05x_session_t ***session**

Pointer to the session

struct sss_se05x_mac_t

#include <fsl_sss_se05x_types.h> Message Authentication Code.

Public Members

sss_algorithm_t **algorithm**

copydoc sss_mac_t::algorithm

SE05x_CryptoObjectID_t **cryptoObjectId**

Used crypto object ID for this operation

sss_se05x_object_t ***keyObject**

copydoc sss_mac_t::keyObject

sss_mode_t **mode**

copydoc sss_mac_t::mode

sss_se05x_session_t ***session**

copydoc sss_mac_t::session

struct sss_se05x_rng_context_t

#include <fsl_sss_se05x_types.h> Random number generator context

Public Members

sss_se05x_session_t ***session**
Pointer to the session

struct sss_se05x_symmetric_t
#include <fsl_sss_se05x_types.h> Typedef for the symmetric crypto context.

Public Members

sss_algorithm_t **algorithm**
Algorithm to be applied, e.g AES_ECB / CBC

uint8_t **cache_data**[16]
Since underlying system conly only process in fixed chunks, chache them on host to complete the operation sanely

size_t **cache_data_len**
Length of bytes cached on host

SE05x_CryptoObjectID_t **cryptoObjectId**
Used crypto object ID for this operation

sss_se05x_object_t ***keyObject**
Reference to key and it's properties.

sss_mode_t **mode**
Mode of operation, e.g Encryption/Decryption

sss_se05x_session_t ***session**
Virtual connection between application (user context) and specific security subsystem and function thereof.

SSS SE05x Session types and APIs

group **sss_se05x_session**
Manage session.

Functions

void **sss_se05x_session_close** (sss_se05x_session_t **session*)
Close session between application and security subsystem.

This function closes a session which has been opened with a security subsystem. All commands within the session must have completed before this function can be called. The implementation must do nothing if the input `session` parameter is NULL.

Parameters

- `session`: Session context.

sss_status_t **sss_se05x_session_create** (sss_se05x_session_t **session*, sss_type_t *subsystem*, uint32_t *application_id*, sss_connection_type_t *connection_type*, void **connectionData*)
Same as sss_session_open but to support sub systems that explictily need a create before opening.

For the sake of portabilty across various sub systems, the applicaiton has to call sss_session_create before calling sss_session_open.

Parameters

- `[inout] session`: Pointer to session context
- `[in] subsystem`: See sss_session_open
- `[in] application_id`: See sss_session_open
- `[in] connection_type`: See sss_session_open
- `[in] connectionData`: See sss_session_open

void **`sss_se05x_session_delete`**(sss_se05x_session_t **session*)

Counterpart to sss_session_create

Similar to contraint on sss_session_create, application may call sss_session_delete to explicitly release all underlying/used session specific resoures of that implementation.

sss_status_t **`sss_se05x_session_open`**(sss_se05x_session_t **session*, sss_type_t *subsystem*, uint32_t *application_id*, sss_connection_type_t *connection_type*, void **connectionData*)

Open session between application and a security subsystem.

```
            Open virtual session between application (user context) and a
            security subsystem and function thereof. Pointer to session
            shall be supplied to all SSS APIs as argument. Low level SSS
            functions can provide implementation specific behaviour based
            on the session argument.
            Note: sss_session_open() must not be called concurrently from
            multiple threads. The application must ensure this.
```

Return status

Parameters

- `[inout] session`: Session context.
- `[in] subsystem`: Indicates which security subsystem is selected to be used.
- `[in] application_id`: ObjectId/AuthenticationID Connecting to:
  - `application_id` == 0 => Super use / Plaform user
  - Anything else => Authenticated user
- `[in] connection_type`: How are we connecting to the system.
- `[inout] connectionData`: subsystem specific connection parameters.

sss_status_t **`sss_se05x_session_prop_get_au8`**(sss_se05x_session_t **session*, uint32_t *property*, uint8_t **pValue*, size_t **pValueLen*)

Get an underlying property of the crypto sub system.

This API is used to get values that are numeric in nature.

Property can be either fixed value that is calculated at compile time and returned directly, or it may involve some access to the underlying system.

Return

Parameters

- `[in] session`: Session context
- `[in] property`: Value that is part of sss_session_prop_au8_t

- `[out] pValue`: Output buffer array
- `[inout] pValueLen`: Count of values thare are/must br read

sss_status_t **`sss_se05x_session_prop_get_u32`** (sss_se05x_session_t **session*, uint32_t *property*, uint32_t **pValue*)

Get an underlying property of the crypto sub system.

This API is used to get values that are numeric in nature.

Property can be either fixed value that is calculated at compile time and returned directly, or it may involve some access to the underlying system.

For applicable properties see sss_session_prop_u32_t

Return

Parameters

- `[in] session`: Session context
- `[in] property`: Value that is part of sss_session_prop_u32_t
- `[out] pValue`:

SSS SE05x Keystore types and APIs

group **`sss_se05x_keystore`**

Manage session.

Functions

sss_status_t **`sss_se05x_key_store_allocate`** (*sss_se05x_key_store_t *keyStore*, uint32_t *keyStoreId*)

Get handle to key store. If the key store already exists, nothing is allocated. If the key store does not exists, new empty key store is created and initialized. Key store context structure is updated with actual information.

This API does not do anything special on SE05X.

Parameters

- `[out] keyStore`: Pointer to key store context. Key store context is updated on function return.
- `keyStoreId`: Implementation specific ID, can be used in case security subsystem manages multiple different key stores.

void **`sss_se05x_key_store_context_free`** (*sss_se05x_key_store_t *keyStore*)

Destructor for the key store context.

sss_status_t **`sss_se05x_key_store_context_init`** (*sss_se05x_key_store_t *keyStore*, sss_se05x_session_t **session*)

Constructor for the key store context data structure.

Parameters

- `[out] keyStore`: Pointer to key store context. Key store context is updated on function return.
- `session`: Session context.

sss_status_t **sss_se05x_key_store_erase_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*)

Delete / destroy allocated keyObect .

Return The sss status.

Parameters

- `keyStore`: The key store
- `keyObject`: The key object to be deleted

sss_status_t **sss_se05x_key_store_export_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, uint8_t **key*, size_t **keylen*)

Export Key from SE050 to host

Only Transient keys can be exported.

sss_status_t **sss_se05x_key_store_freeze_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*)

Not available for SE05X

sss_status_t **sss_se05x_key_store_generate_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, size_t *keyBitLen*, void **options*)

This function generates key[] in the destination key store.

sss_status_t **sss_se05x_key_store_get_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, uint8_t **data*, size_t **dataLen*, size_t **pKeyBitLen*)

This function exports plain key[] from key store (if constraints and user id allows reading)

sss_status_t **sss_se05x_key_store_import_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, uint8_t **key*, size_t *keylen*)

Re Import previously exported SE05X key from host to the SE05X

Only Transient keys can be imported.

sss_status_t **sss_se05x_key_store_load**(*sss_se05x_key_store_t *keyStore*)

Load from persistent memory to cached objects.

This API does not do anything special on SE05X.

sss_status_t **sss_se05x_key_store_open_key**(*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*)

Access key store using one more level of encryption.

e.g. Access keys / encryption key during storage

In SE05X, these keys can be used as KEK encryption key

Return The sss status.

Parameters

- `keyStore`: The key store
- `keyObject`: The key object that is to be used as a KEK (Key Encryption Key)

If `keyObject` == NULL, then subsequent key injection does not use any KEK.

Return The sss status.

sss_status_t **sss_se05x_key_store_save** (*sss_se05x_key_store_t *keyStore*)

Save all cached persistent objects to persistent memory.

This API does not do anything special on SE05X.

sss_status_t **sss_se05x_key_store_set_key** (*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, **const** uint8_t **data*, size_t *dataLen*, size_t *keyBitLen*, void **options*, size_t *optionsLen*)

This function moves data[] from memory to the destination key store.

Return

Parameters

- `keyStore`: Key store context
- `keyObject`: Reference to a key and it's properties
- `data`: Data to be stored in Key. When setting ecc private key only, do not include key header.
- `dataLen`: Length of the data
- `keyBitLen`: Crypto algorithm key bit length
- `options`: Pointer to implementation specific options
- `optionsLen`: Length of the options in bytes

SSS SE05x KeyObject types and APIs

group **sss_se05x_keyobj**

Manage session.

Functions

sss_status_t **sss_se05x_key_object_allocate_handle** (sss_se05x_object_t **keyObject*, uint32_t *keyId*, sss_key_part_t *keyPart*, sss_cipher_type_t *cipherType*, size_t *keyByteLenMax*, uint32_t *options*)

Allocate / pre-provision memory for new key.

```
This API allows underlying cryptographic subsystems to perform
preconditions of before creating any cryptographic key object.
```

On SE050, the memory get reserved only when the actual object is created and hence there is no memory reservation happening in this API call. but internally it checks if the object already exists or not . if the object is already existing it returns a failure.

Return Status of object allocation.

Parameters

- `[inout] keyObject`: The object If required, update implementation defined values inside the keyObject
- `keyId`: External Key ID. Later on this may be used by sss_key_object_get_handle
- `keyPart`: See sss_key_part_t

- `cipherType`: See sss_cipher_type_t
- `keyByteLenMax`: Maximum storage this type of key may need. For systems that have their own internal allocation table this would help
- `options`: 0 = Persistant Key (Default) or Transient Key. See sss_key_object_mode_t

void **sss_se05x_key_object_free**(sss_se05x_object_t **keyObject*)

Destructor for the key object. The function frees key object context.

On SE050, this has no impact on physical Key Object.

Parameters

- `keyObject`: Pointer to key object context.

sss_status_t **sss_se05x_key_object_get_access**(sss_se05x_object_t **keyObject*, uint32_t **access*)

Not Available for SE05X

sss_status_t **sss_se05x_key_object_get_handle**(sss_se05x_object_t **keyObject*, uint32_t *keyId*)

Get handle to an existing allocated/provisioned/created Object.

```
        See @ref sss_key_object_allocate_handle.

        After calling this API, Ideally keyObject should become equivlant
        to as set after the calling of @ref
        sss_key_object_allocate_handle api.
```

On SE05X, this API uses Se05x_API_ReadType and fetches parameters of the API.

Return The sss status.

Parameters

- `keyObject`: The key object
- `[in] keyId`: The key identifier

sss_status_t **sss_se05x_key_object_get_purpose**(sss_se05x_object_t **keyObject*, sss_mode_t **purpose*)

Not Available for SE05X

sss_status_t **sss_se05x_key_object_get_user**(sss_se05x_object_t **keyObject*, uint32_t **user*)

Not Available for SE05X

sss_status_t **sss_se05x_key_object_init**(sss_se05x_object_t **keyObject*, *sss_se05x_key_store_t *keyStore*)

Constructor for a key object data structure The function initializes keyObject data structure and associates it with a key store in which the plain key and other attributes are stored.

Return Status of the operation

Parameters

- `keyObject`:
- `keyStore`:

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_key_object_set_access**(sss_se05x_object_t **keyObject*, uint32_t *access*, uint32_t *options*)

Not Available for SE05X

sss_status_t **sss_se05x_key_object_set_eccgfp_group**(sss_se05x_object_t **keyObject*, *sss_eccgfp_group_t *group*)

Not Available for SE05X

sss_status_t **sss_se05x_key_object_set_purpose**(sss_se05x_object_t **keyObject*, sss_mode_t *purpose*, uint32_t *options*)

Assign purpose to a key object.

Parameters

- `keyObject`: the object where permission restrictions are applied
- `purpose`: Usage of the key.
- `options`: Transient or persistent update. Allows for transient update of persistent attributes.

sss_status_t **sss_se05x_key_object_set_user**(sss_se05x_object_t **keyObject*, uint32_t *user*, uint32_t *options*)

Not Available for SE05X

SSS SE05x Symmetric types and APIs

group **sss_se05x_symm**

Manage session.

Functions

sss_status_t **sss_se05x_cipher_crypt_ctr**(*sss_se05x_symmetric_t *context*, **const** uint8_t **srcData*, uint8_t **destData*, size_t *size*, uint8_t **initialCounter*, uint8_t **lastEncryptedCounter*, size_t **szLeft*)

Symmetric AES in Counter mode in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing the input data.
- `destData`: Buffer containing the output data.
- `size`: Size of source and destination data buffers in bytes.
- `[inout] initialCounter`: Input counter (Always 16 bytes) (updates on return). When using internal IV algorithms (only encrypt) for SE051, initialCounter buffer will be filled with genereted Initial counter.
- `[out] lastEncryptedCounter`: Output cipher of last counter, for chained CTR calls. NULL can be passed if chained calls are not used.

- `[out] szLeft`: Output number of bytes in left unused in lastEncryptedCounter block. NULL can be passed if chained calls are not used.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_cipher_finish`** (*sss_se05x_symmetric_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Symmetric cipher finalize.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing final chunk of input data.
- `srcLen`: Length of final chunk of input data in bytes.
- `destData`: Buffer containing output data.
- `[inout] destLen`: Length of output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_cipher_init`** (*sss_se05x_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*)

Symmetric cipher init. The function starts the symmetric cipher operation.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_cipher_one_go`** (*sss_se05x_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*, **`const`** uint8_t **srcData*, uint8_t **destData*, size_t *dataLen*)

Symmetric cipher in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.
- `srcData`: Buffer containing the input data (block aligned).
- `destData`: Buffer containing the output data.
- `dataLen`: Size of input and output data buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_cipher_one_go_v2`** (*sss_se05x_symmetric_t *context*, uint8_t **iv*, size_t *ivLen*, **`const`** uint8_t **srcData*, **`const`** size_t *srcLen*, uint8_t **destData*, size_t **pDataLen*)

Symmetric cipher in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `iv`: Buffer containing the symmetric operation Initialization Vector. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `ivLen`: Length of the Initialization Vector in bytes.
- `srcData`: Buffer containing the input data (block aligned).
- `srcLen`: Length of buffer srcData.
- `destData`: Buffer containing the output data.
- `pDataLen`: Pointer to Size of buffer destData in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_cipher_update`** (*sss_se05x_symmetric_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Symmetric cipher update. Input data does not have to be a multiple of block size. Subsequent calls to this function are possible. Unless one or more calls of this function have supplied sufficient input data, no output is generated. The cipher operation is finalized with a call to sss_cipher_finish().

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `srcData`: Buffer containing the input data.
- `srcLen`: Length of the input data in bytes.
- `destData`: Buffer containing the output data.

- `[inout] destLen`: Length of the output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

void **`sss_se05x_symmetric_context_free`** (*sss_se05x_symmetric_t *context*)

Symmetric context release. The function frees symmetric context.

Parameters

- `context`: Pointer to symmetric crypto context.

sss_status_t **`sss_se05x_symmetric_context_init`** (*sss_se05x_symmetric_t *context*, sss_se05x_session_t **session*, sss_se05x_object_t **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Symmetric context init. The function initializes symmetric context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to symmetric crypto context.
- `session`: Associate SSS session with symmetric context.
- `keyObject`: Associate SSS key object with symmetric context.
- `algorithm`: One of the symmetric algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

SSS SE05x Asymmetric types and APIs

group **`sss_se05x_asym`**

Manage session.

Functions

void **`sss_se05x_asymmetric_context_free`** (*sss_se05x_asymmetric_t *context*)

Asymmetric context release. The function frees asymmetric context.

Parameters

- `context`: Pointer to asymmetric context.

sss_status_t **sss_se05x_asymmetric_context_init**(*sss_se05x_asymmetric_t *context*, sss_se05x_session_t **session*, sss_se05x_object_t **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Asymmetric context init. The function initializes asymmetric context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric crypto context.
- `session`: Associate SSS session with asymmetric context.
- `keyObject`: Associate SSS key object with asymmetric context.
- `algorithm`: One of the asymmetric algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_asymmetric_decrypt**(*sss_se05x_asymmetric_t *context*, **const** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Asymmetric decryption The function uses asymmetric algorithm to decrypt data. Private key portion of a key pair is used for decryption.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `srcData`: Input buffer
- `srcLen`: Length of the input in bytes
- `destData`: Output buffer
- `destLen`: Length of the output in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_asymmetric_encrypt**(*sss_se05x_asymmetric_t *context*, **const** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

Asymmetric encryption The function uses asymmetric algorithm to encrypt data. Public key portion of a key pair is used for encryption.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `srcData`: Input buffer
- `srcLen`: Length of the input in bytes
- `destData`: Output buffer
- `destLen`: Length of the output in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_asymmetric_sign** (*sss_se05x_asymmetric_t *context*, uint8_t **srcData*, size_t *srcLen*, uint8_t **signature*, size_t **signatureLen*)

Similar to sss_se05x_asymmetric_sign_digest,

but hashing/digest done by SE

sss_status_t **sss_se05x_asymmetric_sign_digest** (*sss_se05x_asymmetric_t *context*, uint8_t **digest*, size_t *digestLen*, uint8_t **signature*, size_t **signatureLen*)

Asymmetric signature of a message digest The function signs a message digest.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `digest`: Input buffer containing the input message digest
- `digestLen`: Length of the digest in bytes
- `signature`: Output buffer written with the signature of the digest
- `signatureLen`: Length of the signature in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_asymmetric_verify** (*sss_se05x_asymmetric_t *context*, uint8_t **srcData*, size_t *srcLen*, uint8_t **signature*, size_t *signatureLen*)

Similar to sss_se05x_asymmetric_verify_digest, but hashing/digest done by SE

sss_status_t **sss_se05x_asymmetric_verify_digest** (*sss_se05x_asymmetric_t *context*, uint8_t **digest*, size_t *digestLen*, uint8_t **signature*, size_t *signatureLen*)

Asymmetric verify of a message digest The function verifies a message digest.

Return Status of the operation

Parameters

- `context`: Pointer to asymmetric context.
- `digest`: Input buffer containing the input message digest
- `digestLen`: Length of the digest in bytes
- `signature`: Input buffer containing the signature to verify
- `signatureLen`: Length of the signature in bytes

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

SSS SE05x RNG types and APIs

group **`sss_se05x_rng`**

Manage session.

Functions

sss_status_t **`sss_se05x_rng_context_free`** (*sss_se05x_rng_context_t *context*)

free random genertor context.

Return status

Parameters

- `context`: generator context.

sss_status_t **`sss_se05x_rng_context_init`** (*sss_se05x_rng_context_t *context*, sss_se05x_session_t **session*)

Initialise random generator context between application and a security subsystem.

Warning API Changed

```
Earlier:
    sss_status_t sss_rng_context_init(
        sss_session_t *session, sss_rng_context_t *context);

Now: Parameters are swapped
 sss_status_t sss_rng_context_init(
     sss_rng_context_t *context, sss_session_t *session);
```

Return status

Parameters

- `session`: Session context.
- `context`: random generator context.

sss_status_t **`sss_se05x_rng_get_random`** (*sss_se05x_rng_context_t *context*, uint8_t **random_data*, size_t *dataLen*)

Generate random number.

Return status

Parameters

- `context`: random generator context.
- `random_data`: buffer to hold random data.
- `dataLen`: required random number length

SSS SE05x Digest types and APIs

group **`sss_se05x_md`**

Manage session.

Functions

void **`sss_se05x_digest_context_free`** (*sss_se05x_digest_t *context*)

Digest context release. The function frees digest context.

Parameters

- `context`: Pointer to digest context.

sss_status_t **`sss_se05x_digest_context_init`** (*sss_se05x_digest_t *context*, sss_se05x_session_t **session*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Digest context init. The function initializes digest context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `session`: Associate SSS session with digest context.
- `algorithm`: One of the digest algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_digest_finish`** (*sss_se05x_digest_t *context*, uint8_t **digest*, size_t **digestLen*)

Finish digest for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `digest`: Output message digest

- `digestLen`: Message digest byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_digest_init`** (*sss_se05x_digest_t *context*)

Init digest for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_digest_one_go`** (*sss_se05x_digest_t *context*, **`const`** uint8_t **message*, size_t *messageLen*, uint8_t **digest*, size_t **digestLen*)

Message digest in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `message`: Input message
- `messageLen`: Length of the input message in bytes
- `digest`: Output message digest
- `digestLen`: Message digest byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_digest_update`** (*sss_se05x_digest_t *context*, **`const`** uint8_t **message*, size_t *messageLen*)

Update digest for a message.

The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to digest context.
- `message`: Buffer with a message chunk.
- `messageLen`: Length of the input buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.

- `kStatus_SSS_Fail`: The operation has failed.

SSS SE05x MAC types and APIs

group **`sss_se05x_mac`**

Manage session.

Functions

void **`sss_se05x_mac_context_free`** (*sss_se05x_mac_t *context*)

MAC context release. The function frees mac context.

Parameters

- `context`: Pointer to mac context.

sss_status_t **`sss_se05x_mac_context_init`** (*sss_se05x_mac_t *context*, sss_se05x_session_t **session*, sss_se05x_object_t **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

MAC context init. The function initializes mac context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `session`: Associate SSS session with mac context.
- `keyObject`: Associate SSS key object with mac context.
- `algorithm`: One of the mac algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_mac_finish`** (*sss_se05x_mac_t *context*, uint8_t **mac*, size_t **macLen*)

Finish mac for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `mac`: Output message MAC
- `macLen`: Computed MAC byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_se05x_mac_init** (*sss_se05x_mac_t *context*)

Init mac for a message. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_se05x_mac_one_go** (*sss_se05x_mac_t *context*, **const** uint8_t **message*, size_t *messageLen*, uint8_t **mac*, size_t **macLen*)

Message MAC in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `message`: Input message
- `messageLen`: Length of the input message in bytes
- `mac`: Output message MAC
- `macLen`: Computed MAC byte length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_se05x_mac_update** (*sss_se05x_mac_t *context*, **const** uint8_t **message*, size_t *messageLen*)

Update mac for a message.

The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to mac context.
- `message`: Buffer with a message chunk.
- `messageLen`: Length of the input buffer in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_se05x_mac_validate_one_go** (*sss_se05x_mac_t *context*, **const** uint8_t **message*, size_t *messageLen*, uint8_t **mac*, size_t *macLen*)

MAC Validate

SSS SE05x Key derivation types and APIs

group **`sss_se05x_keyderive`**

Manage session.

Functions

void **`sss_se05x_derive_key_context_free`** (*sss_se05x_derive_key_t *context*)

Derive key context release. The function frees derive key context.

Parameters

- `context`: Pointer to derive key context.

sss_status_t **`sss_se05x_derive_key_context_init`** (*sss_se05x_derive_key_t *context*, sss_se05x_session_t **session*, sss_se05x_object_t **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

Derive key context init. The function initializes derive key context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `session`: Associate SSS session with the derive key context.
- `keyObject`: Associate SSS key object with the derive key context.
- `algorithm`: One of the derive key algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_derive_key_dh`** (*sss_se05x_derive_key_t *context*, sss_se05x_object_t **otherPartyKeyObject*, sss_se05x_object_t **derivedKeyObject*)

Asymmetric key derivation Diffie-Helmann The function cryptographically derives a key from another key. For example Diffie-Helmann.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `otherPartyKeyObject`: Public key of the other party in the Diffie-Helmann algorithm
- `[inout] derivedKeyObject`: Reference to a derived key

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.

- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_derive_key_go`** (*sss_se05x_derive_key_t *context*, **`const`** uint8_t **saltData*, size_t *saltLen*, **`const`** uint8_t **info*, size_t *infoLen*, sss_se05x_object_t **derivedKeyObject*, uint16_t *deriveDataLen*, uint8_t **hkdfOutput*, size_t **hkdfOutputLen*)

Symmetric key derivation The function cryptographically derives a key from another key. For example MIFARE key derivation, PRF, HKDF-Extract.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `saltData`: Input data buffer, typically with some random data.
- `saltLen`: Length of saltData buffer in bytes.
- `info`: Input data buffer, typically with some fixed info.
- `infoLen`: Length of info buffer in bytes.
- `[inout] derivedKeyObject`: Reference to a derived key
- `deriveDataLen`: Requested length of output
- `hkdfOutput`: Output buffer containing key derivation output
- `hkdfOutputLen`: Output containing length of hkdfOutput

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_derive_key_one_go`** (*sss_se05x_derive_key_t *context*, **`const`** uint8_t **saltData*, size_t *saltLen*, **`const`** uint8_t **info*, size_t *infoLen*, sss_se05x_object_t **derivedKeyObject*, uint16_t *deriveDataLen*)

Symmetric key derivation (replaces the deprecated function sss_derive_key_go) The function cryptographically derives a key from another key. For example MIFARE key derivation, PRF, HKDF-Extract-Expand, HKDF-Expand. Refer to sss_derive_key_sobj_one_go in case the Salt is available as a key object.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context.
- `saltData`: Input data buffer, typically with some random data.
- `saltLen`: Length of saltData buffer in bytes.
- `info`: Input data buffer, typically with some fixed info.
- `infoLen`: Length of info buffer in bytes.

- `[inout] derivedKeyObject`: Reference to a derived key
- `[in] deriveDataLen`: Expected length of derived key.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_derive_key_sobj_one_go`** (*sss_se05x_derive_key_t *context*, sss_se05x_object_t **saltKeyObject*, **`const`** uint8_t **info*, size_t *infoLen*, sss_se05x_object_t **derivedKeyObject*, uint16_t *deriveDataLen*)

Symmetric key derivation (salt in key object) Refer to sss_derive_key_one_go in case the salt is not available as a key object.

Return Status of the operation

Parameters

- `context`: Pointer to derive key context
- `saltKeyObject`: Reference to salt. The salt key object must reside in the same keystore as the derive key context.
- `[in] info`: Input data buffer, typically with some fixed info.
- `[in] infoLen`: Length of info buffer in bytes.
- `derivedKeyObject`: Reference to a derived key
- `[in] deriveDataLen`: The derive data length

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

SSS SE05x AEAD types and APIs

group **`sss_se05x_aead`**

Manage session.

Functions

void **`sss_se05x_aead_context_free`** (*sss_se05x_aead_t *context*)

AEAD context release. The function frees aead context.

Parameters

- `context`: Pointer to aead context.

sss_status_t **sss_se05x_aead_context_init** (*sss_se05x_aead_t *context*, sss_se05x_session_t **session*, sss_se05x_object_t **keyObject*, sss_algorithm_t *algorithm*, sss_mode_t *mode*)

AEAD context init. The function initializes aead context with initial values.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `session`: Associate SSS session with aead context.
- `keyObject`: Associate SSS key object with aead context.
- `algorithm`: One of the aead algorithms defined by sss_algorithm_t.
- `mode`: One of the modes defined by sss_mode_t.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_aead_finish** (*sss_se05x_aead_t *context*, **const** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*, uint8_t **tag*, size_t **tagLen*)

Finalize AEAD. The functions processes data that has not been processed by previous calls to sss_aead_update() as well as srcData. It finalizes the AEAD operations and computes the tag (encryption) or compares the computed tag with the tag supplied in the parameter (decryption).

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing final chunk of input data.
- `srcLen`: Length of final chunk of input data in bytes.
- `destData`: Buffer containing output data.
- `[inout] destLen`: Length of output data in bytes. Buffer length on entry, reflects actual output size on return.
- `tag`: Encryption: Output buffer filled with computed tag Decryption: Input buffer filled with received tag
- `tagLen`: Length of the computed or received tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **sss_se05x_aead_init** (*sss_se05x_aead_t *context*, uint8_t **nonce*, size_t *nonceLen*, size_t *tagLen*, size_t *aadLen*, size_t *payloadLen*)

AEAD init. The function starts the aead operation.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `nonce`: The operation nonce or IV. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `nonceLen`: The length of nonce in bytes. For AES-GCM it must be >= 1. For AES-CCM it must be 7, 8, 9, 10, 11, 12, or 13.
- `tagLen`: Length of the computed or received tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.
- `aadLen`: Input size in bytes of AAD. Used only for AES-CCM. Ignored for AES-GCM.
- `payloadLen`: Length in bytes of the payload. Used only for AES-CCM. Ignored for AES-GCM.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **sss_se05x_aead_one_go** (*sss_se05x_aead_t *context*, **const** uint8_t **srcData*, uint8_t **destData*, size_t *size*, uint8_t **nonce*, size_t *nonceLen*, **const** uint8_t **aad*, size_t *aadLen*, uint8_t **tag*, size_t **tagLen*)

AEAD in one blocking function call. The function blocks current thread until the operation completes or an error occurs.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing the input data.
- `destData`: Buffer containing the output data.
- `size`: Size of input and output data buffer in bytes.
- `nonce`: The operation nonce or IV. When using internal IV algorithms (only encrypt) for SE051, iv buffer will be filled with genereted Initialization Vector.
- `nonceLen`: The length of nonce in bytes. For AES-GCM it must be >= 1. For AES-CCM it must be 7, 8, 9, 10, 11, 12, or 13.
- `aad`: Input additional authentication data AAD
- `aadLen`: Input size in bytes of AAD
- `tag`: Encryption: Output buffer filled with computed tag Decryption: Input buffer filled with received tag
- `tagLen`: Length of the tag in bytes. For AES-GCM it must be 4,8,12,13,14,15 or 16. For AES-CCM it must be 4,6,8,10,12,14 or 16.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sss_se05x_aead_update`** (*sss_se05x_aead_t *context*, **`const`** uint8_t **srcData*, size_t *srcLen*, uint8_t **destData*, size_t **destLen*)

AEAD data update. Feeds a new chunk of the data payload. Input data does not have to be a multiple of block size. Subsequent calls to this function are possible. Unless one or more calls of this function have supplied sufficient input data, no output is generated. The integration check is done by sss_aead_finish(). Until then it is not sure if the decrypt data is authentic.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context.
- `srcData`: Buffer containing the input data.
- `srcLen`: Length of the input data in bytes.
- `destData`: Buffer containing the output data.
- `[inout] destLen`: Length of the output data in bytes. Buffer length on entry, reflects actual output size on return.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

sss_status_t **`sss_se05x_aead_update_aad`** (*sss_se05x_aead_t *context*, **`const`** uint8_t **aadData*, size_t *aadDataLen*)

Feeds a new chunk of the AAD. Subsequent calls of this function are possible.

Return Status of the operation

Parameters

- `context`: Pointer to aead crypto context
- `aadData`: Input buffer containing the chunk of AAD
- `aadDataLen`: Length of the AAD data in bytes.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.
- `kStatus_SSS_InvalidArgument`: One of the arguments is invalid for the function to execute.

SSS SE05x Tunnel types and APIs

group **`sss_se05x_tunnel`**

Manage session.

Functions

sss_status_t **`sss_se05x_tunnel`** (sss_se05x_tunnel_context_t **context*, uint8_t **data*, size_t *dataLen*, sss_se05x_object_t **keyObjects*, uint32_t *keyObjectCount*, uint32_t *tunnelType*)

Tunneling

Used for communication via another system.

void **`sss_se05x_tunnel_context_free`** (sss_se05x_tunnel_context_t **context*)

Destructor for the tunnelling service context.

Parameters

- `[out] context`: Pointer to tunnel context.

sss_status_t **`sss_se05x_tunnel_context_init`** (sss_se05x_tunnel_context_t **context*, sss_se05x_session_t **session*)

Constructor for the tunnelling service context.

```
Earlier:
    sss_status_t sss_tunnel_context_init(
        sss_session_t *session, sss_tunnel_t *context);

Now: Parameters are swapped
    sss_status_t sss_tunnel_context_init(
        sss_tunnel_t *context, sss_session_t *session);
```

Parameters

- `[out] context`: Pointer to tunnel context. Tunnel context is updated on function return.
- `session`: Pointer to session this tunnelling service belongs to.

SSS SE05x I2C Master types and APIs

group **`se050_i2cm`**

I2C Master APIs in SE050 for secure sensor.

Enums

`enum SE05x_I2CM_Baud_Rate_t`

Configuration for I2CM

Values:

`kSE05x_I2CM_Baud_Rate_100Khz` = 0

`kSE05x_I2CM_Baud_Rate_400Khz`

`enum SE05x_I2CM_securityReq_t`

Additional operation on data read by I2C

Values:

`kSE05x_Security_None` = 0

`kSE05x_Sign_Request`

`kSE05x_Sign_Enc_Request`

enum SE05x_I2CM_status_t

Status of I2CM Transaction

Values:

kSE05x_I2CM_Success = 0x5A

kSE05x_I2CM_I2C_Nack_Fail = 0x01

kSE05x_I2CM_I2C_Write_Error = 0x02

kSE05x_I2CM_I2C_Read_Error = 0x03

kSE05x_I2CM_I2C_Time_Out_Error = 0x05

kSE05x_I2CM_Invalid_Tag = 0x11

kSE05x_I2CM_Invalid_Length = 0x12

kSE05x_I2CM_Invalid_Length_Encode = 0x13

kSE05x_I2CM_I2C_Config = 0x21

enum SE05x_I2CM_TAG_t

I2C Master micro operation.

Values:

kSE05x_TAG_I2CM_Config = 0x01

kSE05x_TAG_I2CM_Write = 0x03

kSE05x_TAG_I2CM_Read = 0x04

enum SE05x_I2CM_TLV_type_t

Types of entries in an I2CM Transaction

Values:

kSE05x_I2CM_None = 0

Do nothing

kSE05x_I2CM_Configure

Configure the address, baudrate

kSE05x_I2CM_Write = 3

Write to I2C Slave

kSE05x_I2CM_Read

Read from I2C Slave

kSE05x_I2CM_StructuralIssue = 0xFF

Response from SE05x that there is something wrong

Functions

smStatus_t **Se05x_i2c_master_attst_txn** (*sss_session_t *sess*, *sss_object_t *keyObject*, SE05x_I2CM_cmd_t **p*, uint8_t **random_attst*, size_t *random_attstLen*, SE05x_AttestationAlgo_t *attst_algo*, *sss_se05x_attst_comp_data_t *pattest_data*, uint8_t **rspbuffer*, size_t **rspbufferLen*, uint8_t *noOftags*)

Se05x_i2c_master_attst_txn.

I2CM Read With Attestation

Pre p describes I2C master commands.

Post p contains execution state of I2C master commands, the I2C master commands can be overwritten to report on execution failure.

Parameters

- `[in] sess`: session identifier
- `[in] keyObject`: Keyobject which contains 4 byte attestaion KeyId
- `[inout] p`: Array of structure type capturing a sequence of i2c master cmd/rsp transactions.
- `[in] random_attst`: 16-byte freshness random
- `[in] random_attstLen`: length of freshness random
- `[in] attst_algo`: 1 byte attestationAlgo
- `[out] ptimeStamp`: timestamp
- `[out] timeStampLen`: Length for timestamp
- `[out] freshness`: freshness (random)
- `[out] pfreshnessLen`: Length for freshness
- `[out] chipId`: unique chip Id
- `[out] pchipIdLen`: Length for chipId
- `[out] signature`: signature
- `[out] psignatureLen`: Length for signature
- `[in] noOftags`: Amount of structures contained in `p`

smStatus_t **`Se05x_i2c_master_txn`**(*sss_session_t *sess*, SE05x_I2CM_cmd_t **cmds*, uint8_t *cmdLen*)

Se05x_i2c_master_txn.

I2CM Transaction

Pre p describes I2C master commands.

Post p contains execution state of I2C master commands, the I2C master commands can be overwritten to report on execution failure.

Parameters

- `[in] sess`: session identifier
- `[inout] cmds`: Array of structure type capturing a sequence of i2c master cmd/rsp transactions.
- `[in] cmdLen`: Amount of structures contained in cmds

`struct _SE05x_I2CM_cmd`

#include <fsl_sss_se05x_types.h> Individual entry in array of TLV commands, with type

Se05x_i2c_master_txn would expect an array of these.

Public Members

SE05x_I2CM_INS_type_t **`cmd`**

Individual entry in array of TLV commands.

SE05x_I2CM_TLV_type_t **type**

struct SE05x_I2CM_configData_t

#include <fsl_sss_se05x_types.h> Data Configuration for I2CM

Public Members

uint8_t **I2C_addr**

7 Bit address of I2C slave

SE05x_I2CM_Baud_Rate_t **I2C_baudRate**

What baud rate

SE05x_I2CM_status_t **status**

return status of the config operation

union SE05x_I2CM_INS_type_t

#include <fsl_sss_se05x_types.h> Individual entry in array of TLV commands.

Public Members

SE05x_I2CM_configData_t **cfg**

Data Configuration for I2CM

SE05x_I2CM_structuralIssue_t **issue**

Used to report error response, not for outgoing command

SE05x_I2CM_readData_t **rd**

Read to I2CM from I2C Slave

SE05x_I2CM_securityData_t **sec**

Security Configuration for I2CM.

SE05x_I2CM_writeData_t **w**

Write From I2CM to I2C Slave.

struct SE05x_I2CM_readData_t

#include <fsl_sss_se05x_types.h> Read to I2CM from I2C Slave

Public Members

uint8_t ***rdBuf**

Output. rdBuf will point to Host buffer.

SE05x_I2CM_status_t **rdStatus**

[Out] status of the operation

uint16_t **readLength**

How many bytes to read

struct SE05x_I2CM_securityData_t

#include <fsl_sss_se05x_types.h> Security Configuration for I2CM.

Public Members

uint32_t **keyObject**

object used for the operation

SE05x_I2CM_securityReq_t **operation**
Additional operation on data read by I2C

struct SE05x_I2CM_structuralIssue_t
#include <fsl_sss_se05x_types.h> Used to report error response, not for outgoing command

Public Members

SE05x_I2CM_status_t **issueStatus**
[Out] In case there is any structural issue

struct SE05x_I2CM_writeData_t
#include <fsl_sss_se05x_types.h> Write From I2CM to I2C Slave.

Public Members

uint8_t ***writebuf**
Buffer to be written

uint8_t **writeLength**
How many bytes to write

SE05x_I2CM_status_t **wrStatus**
[Out] status of the operation

SSS SE05x Attestation types and APIs

group **se05x_attest**

Functions

sss_status_t **sss_se05x_key_store_get_key_attst** (*sss_se05x_key_store_t *keyStore*, sss_se05x_object_t **keyObject*, uint8_t **key*, size_t **keylen*, size_t **pKeyBitLen*, sss_se05x_object_t **keyObject_attst*, sss_algorithm_t *algorithm_attst*, uint8_t **random_attst*, size_t *randomLen_attst*, *sss_se05x_attst_data_t *attst_data*)
Read with attestation

struct sss_se05x_attst_comp_data_t
#include <fsl_sss_se05x_types.h> Attestation data

Public Members

uint8_t **attribute**[**MAX_POLICY_BUFFER_SIZE** + 15]
Attributes

size_t **attributeLen**
Length of Attribute

uint8_t **chipId**[**SE050_MODULE_UNIQUE_ID_LEN**]
Uinquie ID of SE050

size_t **chipIdLen**

Lenght of the Unique ID

uint8_t **outrandom**[16]

Random used during attestation

size_t **outrandomLen**

length of outrandom

uint8_t **signature**[512]

Signature for attestation

size_t **signatureLen**

Length of signature

SE05x_TimeStamp_t **timeStamp**

time stamp

size_t **timeStampLen**

Length of timeStamp

struct sss_se05x_attst_data_t

#include <fsl_sss_se05x_types.h> Data to be read with attestation

Public Members

sss_se05x_attst_comp_data_t **data**[**SE05X_MAX_ATTST_DATA**]

Whle reading RSA Objects, modulus and public exporent get attested separately,

uint8_t **valid_number**

How many entries to attest

SSS SE05x Other types and APIs

group **se05x_other**

Functions

sss_status_t **sss_se05x_set_feature** (sss_se05x_session_t **session*, *SE05x_Applet_Feature_t feature*, *SE05x_Applet_Feature_Disable_t disable_features*)

Set features of the Applet.

See Se05x_API_SetAppletFeatures

See also Section 5.2.1 *SSS API Examples*

3.4 SSS APIs: SE051 vs SE050

SSS API name	SE051	SE050
`sss_session_open()`	Available	Available
`sss_session_close()`	Available	Available
`sss_key_store_set_key()`	POLICY_OBJ_FORBID_DERIVED_OUTPUT can be set to a SymmKey object	Available

Continued on next page

Table 1 – continued from previous page

SSS API name	SE051	SE050
`sss_key_store_generate_key()`	Available	Available
`sss_key_store_get_key()`	Available	Available
`sss_key_store_open_key()`	Available	Available
`sss_key_store_erase_key()`	Available	Available
`sss_key_store_context_free()`	Available	Available
`sss_key_object_init()`	Available	Available
`sss_key_object_allocate_handle()`	Available	Available
`sss_key_object_get_handle()`	Available	Available
`sss_key_object_free()`	Available	Available
`sss_symmetric_context_init()`	Available	Available
`sss_cipher_one_go()`	Available	Available
`sss_cipher_init()`	Available	Available
`sss_cipher_update()`	Available	Available
`sss_cipher_finish()`	Available	Available
`sss_cipher_crypt_ctr()`	Available	Available
`sss_symmetric_context_free()`	Available	Available
`sss_aead_context_init()`	Available	NA
`sss_aead_one_go()`	Available	NA
`sss_aead_init()`	Available	NA
`sss_aead_update_aad()`	Available	NA
`sss_aead_update()`	Available	NA
`sss_aead_finish()`	Available	NA
`sss_aead_context_free()`	Available	NA
`sss_digest_context_init()`	Available	Available
`sss_digest_one_go()`	Available	Available
`sss_digest_init()`	Available	Available
`sss_digest_update()`	Available	Available
`sss_digest_finish()`	Available	Available
`sss_digest_context_free()`	Available	Available
`sss_mac_context_init()`	Available	Available
`sss_mac_one_go()`	Available	Available
`sss_mac_init()`	Available	Available
`sss_mac_update()`	Available	Available
`sss_mac_finish()`	Available	Available
`sss_mac_context_free()`	Available	Available
`sss_asymmetric_context_init()`	Available	Available
`sss_asymmetric_encrypt()`	Available	Available
`sss_asymmetric_decrypt()`	Available	Available
`sss_asymmetric_sign_digest()`	Available	Available
`sss_asymmetric_verify_digest()`	Available	Available
`sss_asymmetric_context_free()`	Available	Available
`sss_derive_key_context_init()`	Available	Available
`sss_derive_key_go()`	Deprecated	Deprecated
`sss_derive_key_one_go()`	Derived Key object can be stored in Secure Element	Available
`sss_derive_key_sobj_one_go()`	Derived Key object can be stored in Secure Element	Available
`sss_derive_key_dh()`	Derived Key object can be stored in Secure Element	Available

Continued on next page

Table 1 – continued from previous page

SSS API name	SE051	SE050
sss_derive_key_context_free()	Available	Available
sss_rng_context_init()	Available	Available
sss_rng_get_random()	Available	Available
sss_rng_context_free()	Available	Available

3.5 Parameter Check & Conventions

3.5.1 Parameter Convention

APIs for which a buffer is input. e.g.:

```
smStatus_t Se05x_API_VerifySessionUserID(
    pSe05xSession_t session_ctx,
    const uint8_t *userId,
    size_t userIdLen);
```

In the above case `userId` is a buffer input. It is assumed that the lengh as set in `userIdLen` is same as that pointed to by `userId`. This parameter is used as is and any mistake by the calling API will have unpredictable errors.

APIs for which a buffer is input. e.g.:

```
smStatus_t Se05x_API_ReadObject(
    pSe05xSession_t session_ctx,
    uint32_t objectID,
    uint16_t offset,
    uint16_t length,
    uint8_t *data,
    size_t *pdataLen);
```

In the above case `data` is a buffer output and `pdataLen` is both input and output. It is assumed that the lengh as set in `pdataLen` is set to the maximum as available to the pointer pointed by `data`. This parameter is used as is and any mistake by the calling API will have unpredictable errors.

PCSC/CCID Interface and 64 Byte packet

See the note “USB 64 byte boundary” at `hostlib\\hostLib\\libCommon\\smCom\\smComPCSC.c`

3.5.2 Helper Macros

Helper macros are available as a part of the stack to capture warnings if some parameters are not as expected.

During debug builds, it is recommended to enable the logging to capture mistakes during integration.

During Retail/Release builds, they may be kept silent.

3.5.3 Apis

group **`param_check`**

Parameter Checks.

nxEnsure.h: Helper parameter assertion check macros.

Pre Condition: The source file must have included nxLog header file.

Project: SecureIoTMW

Defines

ENSURE_OR_BREAK (CONDITION)

If condition fails, break.

Sample Usage:

```
int SomeAPI()
{
    ...

    do {
        status = Operation1();
        ENSURE_OR_BREAK(0 == status);

        status = Operation2();
        ENSURE_OR_BREAK(0 == status);

        ...

    } while(0);

    return status;
}
```

ENSURE_OR_EXIT_WITH_STATUS_ON_ERROR (CONDITION, STATUS, RETURN_VALUE)

If condition fails, goto quit with return value status updated.

```
int SomeAPI()
{
    int status = 0;
    ...

    value = Operation1();
    ENSURE_OR_QUIT_WITH_STATUS_ON_ERROR(0 == value, status, ERR_FAIL);

    value = Operation2();
    ENSURE_OR_QUIT_WITH_STATUS_ON_ERROR(0 == value, status, ERR_NOT_ENOUGH_
↪SPACE);

    ...
quit:
    return status;
}
```

Warning This macro introduces system of mutliple returns from a function which is not easy to debug/trace through and hence not recommended.

ENSURE_OR_GO_CLEANUP (CONDITION)

If condition fails, goto :cleanup label

```
{
    ...
```

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```
    status = Operation1();
    ENSURE_OR_GO_CLEANUP(0 == status);

    status = Operation2();
    ENSURE_OR_GO_CLEANUP(0 == status);

    ...

cleanup:
    return status;
}
```

`ENSURE_OR_GO_EXIT`(CONDITION)
If condition fails, goto :exit label

```
{
    ...

    status = Operation1();
    ENSURE_OR_GO_EXIT(0 == status);

    status = Operation2();
    ENSURE_OR_GO_EXIT(0 == status);

    ...

exit:
    return status;
}
```

`ENSURE_OR_RETURN`(CONDITION)
If condition fails, return

```
void SomeAPI()
{
    ...

    status = Operation1();
    ENSURE_OR_RETURN(0 == status);

    status = Operation2();
    ENSURE_OR_RETURN(0 == status);

    ...

    return;
}
```

Warning This macro introduces system of mutliple returns from a function which is not easy to debug/trace through and hence not recommended.

`ENSURE_OR_RETURN_ON_ERROR`(CONDITION, RETURN_VALUE)
If condition fails, return

```
int SomeAPI()
{
    ...

    status = Operation1();
    ENSURE_OR_RETURN_ON_ERROR(0 == status, ERR_FAIL);

    status = Operation2();
    ENSURE_OR_RETURN_ON_ERROR(0 == status, ERR_NOT_ENOUGH_SPACE);

    ...

    return 0;
}
```

Warning This macro introduces system of mutliple returns from a function which is not easy to debug/trace through and hence not recommended.

NX_ENSURE_DO_LOG_MESSAGE
Build time over-ride if we want to enable/disable Warning Prints

During debug builds, it makes sense to print them, During retail builds, such loggings would be of any use and remove and reduce code size.

NX_ENSURE_MESSAGE (strCONDITION)
Waring print of the parameter `strCONDITION`

Warning NX_ENSURE_MESSAGE is an internal message/API to this file. Do not use directly.

NX_ENSURE_MESSAGE (strCONDITION)
Waring print of the parameter `strCONDITION`

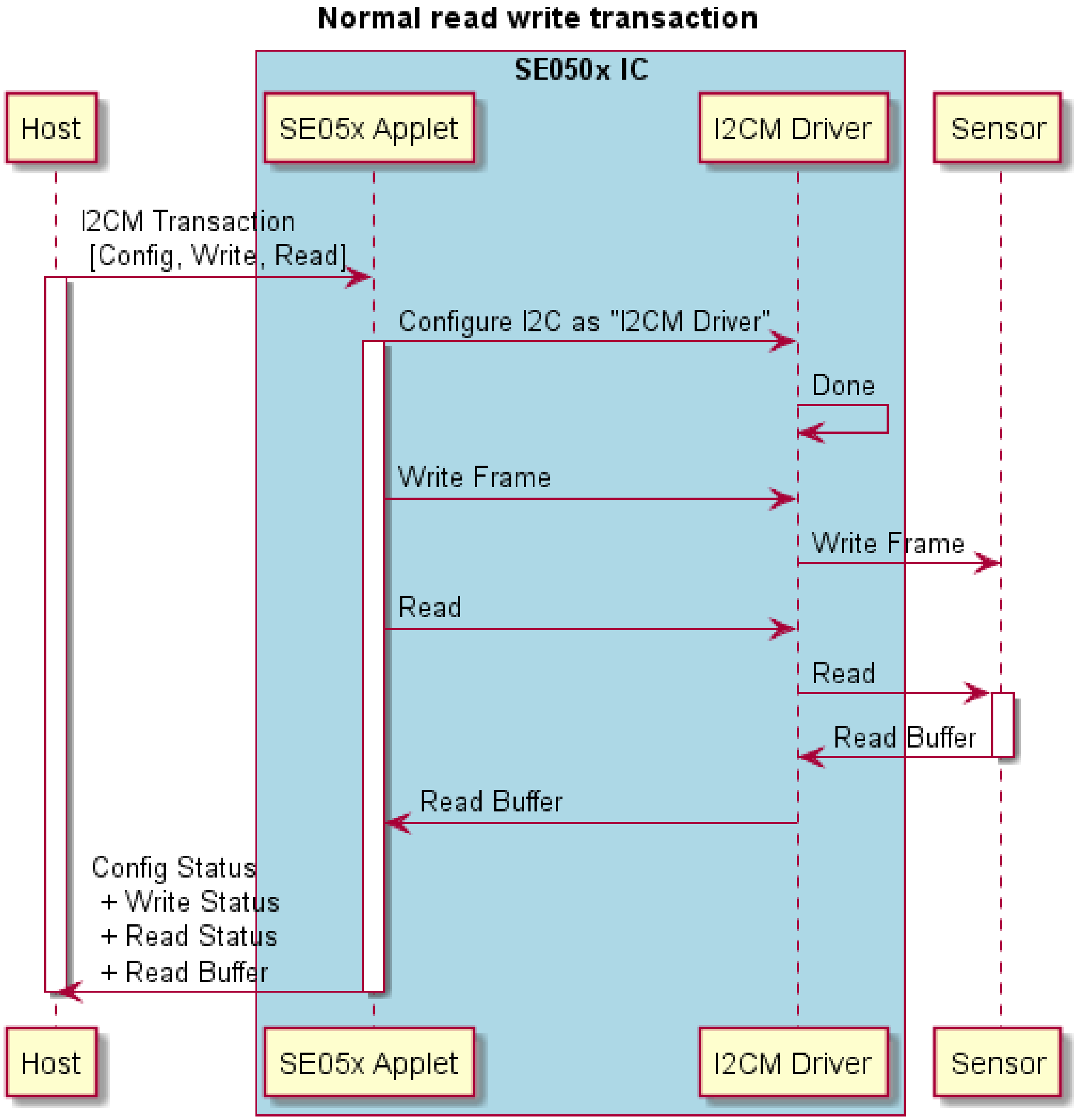
Warning NX_ENSURE_MESSAGE is an internal message/API to this file. Do not use directly.

3.6 I2CM / Secure Sensor

For an example regarding this, see Section 5.7.7 *I2C Master Example*

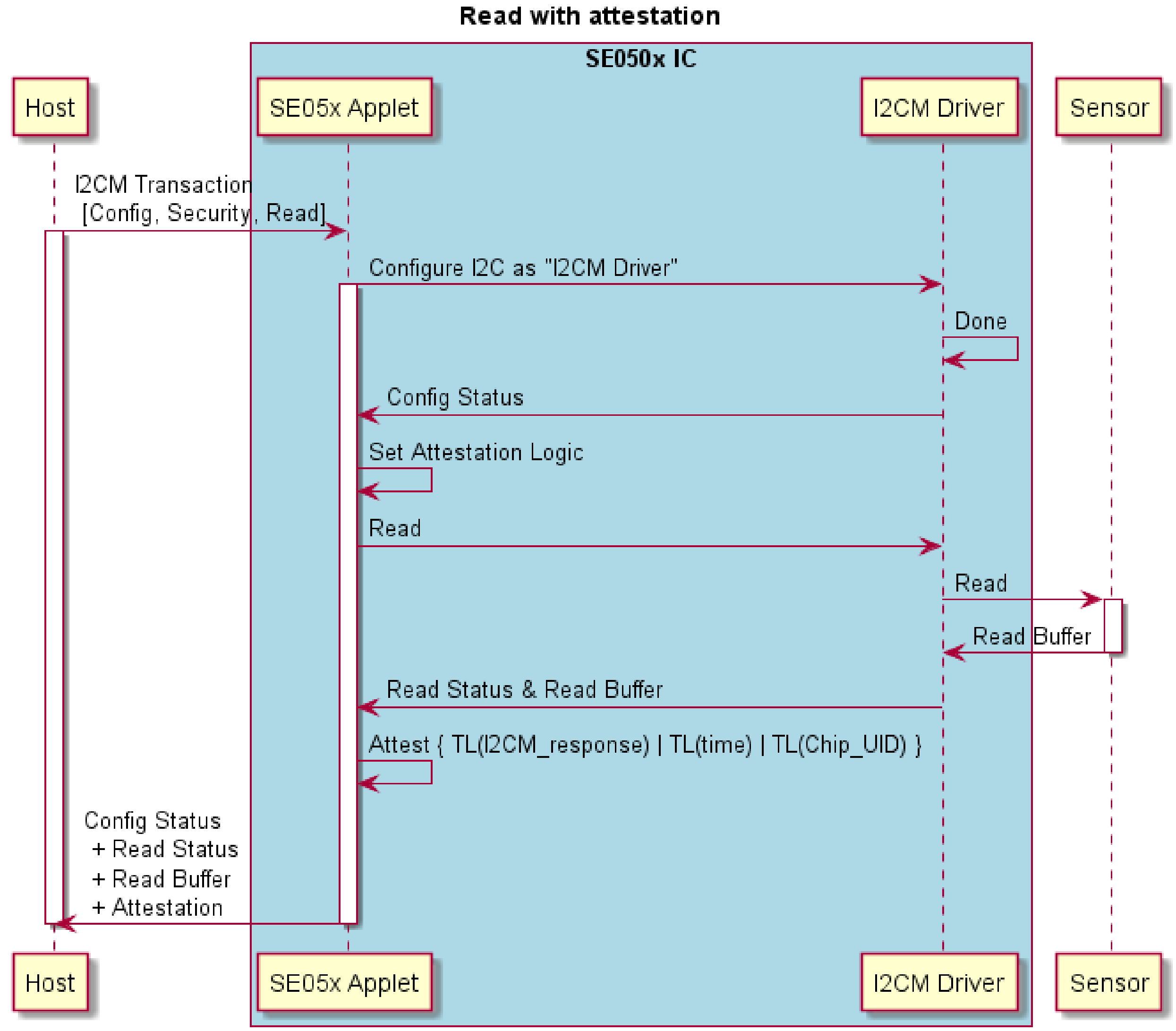
3.6.1 Normal Read/Write

The sequence to read from I2CM Sensor is as below:



3.6.2 Attested Read

The sequence to read with attestation from I2CM Sensor is as below:



3.6.3 Transaction

A sample I2CM Transaction can be performed as below:

Code:

3.6.4 Read with Attestation

A sample I2CM read with Attestation can be performed as below:

Code:

3.6.5 I2C Master APIs

See *SSS SE05x I2C Master types and APIs*

3.7 Logging

In order to efficiently debug and diagnose the Plug & Trust Middleware and its supported use-cases and examples, it supports logging. The logging Framework is written in such a way that embedded platforms are kept in mind and at priority. The choice of logging is done at compile time and not at run time like other high-level languages. Logging library `mwlog` is compiled and linked to all projects.

3.7.1 Logging level

The logging is divided into following levels:

Error Some kind of unrecoverable or unexpected error has happened and the behaviour from this point on is most likely to be out of specifications/expectations. The suffix for this in *Logging APIs* is **E**.

Warn Whatever happened is unexpected but not fatal, the severity of the warning requires the judgement of the user. The suffix for this in *Logging APIs* is **W**.

Info This is information for the user. The suffix for this in *Logging APIs* is **I**.

Debug These are verbose low level diagnostic debug messages and not to be used/enabled in normal circumstances. The suffix for this in *Logging APIs* is **D**.

3.7.2 Adding log messages into the source code

1) Add one of *Logging Header Files* to the `C` source code.

> **Warning:** Only for `C` source code. Never add the logging files to header files, only add them to `C` source code.

2) Call applicable *Logging APIs* at respective *Logging level*
3) Re-compile and re-run the software.

3.7.3 Logging APIs

The following are the loggings APIs to be called from the source code.

LOG_I(...) Log any value. C language format specifiers and values can be used if needed.

LOG_X8_I(VALUE) Log a HEX number 8 bits wide

LOG_U8_I(VALUE) Log an unsigned decimal number 8 bits wide

LOG_X16_I(VALUE) Log a HEX number 16 bits wide

LOG_U16_I(VALUE) Log a unsigned decimal number 16 bits wide

LOG_X32_I(VALUE) Log a HEX number 32 bits wide

LOG_U32_I(VALUE) Log an unsigned number 32 bits wide

LOG_AU8_I(ARRAY, LEN) Log an array of 8bits of length LEN

LOG_MAU8_I(MESSAGE, ARRAY, LEN) Same as `LOG_AU8_I`, but use MESSAGE.

- The logging APIs effectively use preprocessor directives like `#` and `##` and therefore, if the variable names are verbose enough, API calls like `LOG_X16_I(statusOfDeleteKey)` are enough to log response with relevent information, and efficient for the developer to add a logging instruction.
- The suffix `_I` can be replaced with `_E`, `_W` or `_D` based on *Logging level*. The convention of logging remains the same.
- Use HEX Values to log enums and other hexadecimal numbers. For items that are not treated as HEX (e.g. length), use the decimal logging APIs.

For example, the APIs can be called as below.

```
retStatus = DoAPDUTxRx_Case3( /* ..., */
    rspbuf,
    &rspbufLen);
LOG_X16_D(retStatus);
LOG_AU8_D(rspbuf, rspbufLen);
```

If needed, the same can be made more verbose as below.

```
LOG_D("Sending FOO Command");
retStatus = DoAPDUTxRx_Case3( /* ..., */
    rspbuf,
    &rspbufLen);

LOG_D("FOO retStatus=0x04X", rtStatus);
LOG_MAU8_D("FOO Command", rspbuf, rspbufLen);
```

Logging - Information

Code:

```
uint32_t xu32val=0x12341234u;
uint8_t xu8val=0x44;

LOG_I("Values are xu32val=0x%08X xu8val=0x%02X", xu32val, xu8val);
```

Output:

```
       App:INFO :Values are xu32val=0x12341234 xu8val=0x44
```

Logging - Variable Names

Code:

```
    uint32_t xu32val=0x12341234u;
    uint8_t xu8val=0x44;
    unsigned int some_int_value = 783;
    unsigned char some_byte_value = 96;

    LOG_I("Values are:");
    LOG_X8_I(xu8val);
    LOG_U8_I(some_byte_value);
    LOG_X16_I(xu8val);
    LOG_U16_I(some_byte_value);
```

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```
    LOG_X32_I(xu32val);
    LOG_U32_I(some_int_value);

    /* Logging that will be mis-intepreted */
    LOG_X16_I(some_byte_value);
```

Output:

```
       App:INFO :Values are:
       App:INFO :xu8val=0x44
       App:INFO :some_byte_value=96
       App:INFO :xu8val=0x0044
       App:INFO :some_byte_value=96
       App:INFO :xu32val=0x12341234
       App:INFO :some_int_value=783
       App:INFO :some_byte_value=0x0060
```

Logging - Arrays

Code:

```
    const uint8_t some_array[] = {
        0x5A,   0x5B,   0x5C,   0x5D,
        0x5E,   0x5F,   0x60,   0x61,
        0x62,   0x63,   0x64,   0x65,
        0x66,   0x67,   0x68,   0x69,
        0x6A,   0x6B,   0x6C,   0x6D};
    const uint8_t buffer[] = {
        0x2A,   0x2B,   0x2C,   0x2D,
        0x2E,   0x2F,   0x30,   0x31,
        0x32,   0x33,   0x34,   0x35,
        0x36,   0x37,   0x38,   0x39,
        0x3A,   0x3B,   0x3C,   0x3D,
        0x3E,   0x3F,   0x40,   0x41,
        0x42,   0x43,   0x44,   0x45};
    LOG_AU8_I(some_array, ARRAY_SIZE(some_array));
    LOG_MAU8_I("meaningful name", buffer, ARRAY_SIZE(buffer));
```

Output:

```
       App:INFO :some_array (Len=20)
        5A 5B 5C 5D      5E 5F 60 61      62 63 64 65      66 67 68 69
        6A 6B 6C 6D
       App:INFO :meaningful name (Len=28)
        2A 2B 2C 2D      2E 2F 30 31      32 33 34 35      36 37 38 39
        3A 3B 3C 3D      3E 3F 40 41      42 43 44 45
```

Logging - Levels

Code:

```
    uint32_t xu32val=0x12341234u;
    LOG_X32_D(xu32val);
```

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```
    LOG_X32_I(xu32val);
    LOG_X32_W(xu32val);
    LOG_X32_E(xu32val);
```

Output:

```
        App:INFO :xu32val=0x12341234
        App:WARN :xu32val=0x12341234
        App:ERROR:xu32val=0x12341234
```

3.7.4 Logging Header Files

Some of the header files for logging are as under.

nxLog_UseCases.h	High level use cases.
nxLog_App.h	Applications and tools.
nxLog_VCOM.h	Logging specifically for VCOM Layer.
nxLog_sss.h	Logging specifically for SSS Layer.
nxLog_hostLib.h	Logging specifically for Host Library Layer.
nxLog_smCom.h	Communication and common layer.

They can be found at `hostlib/hostLib/libCommon/log`. These files are machine generated and hence is is not recommended to hand edit them.

3.7.5 Changing logging level

To change the level of logging, the following approaches are valid and based on the need of the problem, they can and should be used.

Full source-code

`hostlib/hostLib/libCommon/log/nxLog_DefaultConfig.h` can be modified to change logging level. `nxLog_DefaultConfig.h` is self documented.

```
/* See Plug & Trust Middleware Docuemntation --> stack --> Logging
   for more information */

/*
 * - 1 => Enable Debug level logging - for all.
 * - 0 => Disable Debug level logging.  This has to be
 *        enabled individually by other logging
 *        header/source files */
#define NX_LOG_ENABLE_DEFAULT_DEBUG 0

/* Same as NX_LOG_ENABLE_DEFAULT_DEBUG but for Info Level */
#define NX_LOG_ENABLE_DEFAULT_INFO 1

/* Same as NX_LOG_ENABLE_DEFAULT_DEBUG but for Warn Level */
#define NX_LOG_ENABLE_DEFAULT_WARN 1
```

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```
/* Same as NX_LOG_ENABLE_DEFAULT_DEBUG but for Error Level.
 * Ideally, this shoudl alwasy be kept enabled */
#define NX_LOG_ENABLE_DEFAULT_ERROR 1


/* Release - retail build */
#ifdef FLOW_SILENT
#undef NX_LOG_ENABLE_DEFAULT_DEBUG
#undef NX_LOG_ENABLE_DEFAULT_INFO
#undef NX_LOG_ENABLE_DEFAULT_WARN
#undef NX_LOG_ENABLE_DEFAULT_ERROR

#define NX_LOG_ENABLE_DEFAULT_DEBUG 0
#define NX_LOG_ENABLE_DEFAULT_INFO 0
#define NX_LOG_ENABLE_DEFAULT_WARN 0
#define NX_LOG_ENABLE_DEFAULT_ERROR 0
#endif
```

Logging at component level

For example, changing logging level of `App`, `hostlib/hostLib/libCommon/log/nxLog_App.h` can be updated. As shown below, in `nxLog_App.h`, the values of `NX_LOG_ENABLE_APP_INFO`, etc. can be updated.

```
/* If source file, or nxLog_Config.h has not set it, set these defines
 *
 * Do not #undef these values, rather set to 0/1. This way we can
 * jump to definition and avoid plain-old-text-search to jump to
 * undef. */

#ifndef NX_LOG_ENABLE_APP_DEBUG
#   define NX_LOG_ENABLE_APP_DEBUG (NX_LOG_ENABLE_DEFAULT_DEBUG)
#endif
#ifndef NX_LOG_ENABLE_APP_INFO
#   define NX_LOG_ENABLE_APP_INFO (NX_LOG_ENABLE_APP_DEBUG + NX_LOG_ENABLE_DEFAULT_
↪INFO)
#endif
#ifndef NX_LOG_ENABLE_APP_WARN
#   define NX_LOG_ENABLE_APP_WARN (NX_LOG_ENABLE_APP_INFO + NX_LOG_ENABLE_DEFAULT_
↪WARN)
#endif
#ifndef NX_LOG_ENABLE_APP_ERROR
#   define NX_LOG_ENABLE_APP_ERROR (NX_LOG_ENABLE_APP_WARN + NX_LOG_ENABLE_DEFAULT_
↪ERROR)
#endif
```

Individual files

Rather than applying logging levels to full stack, if the need is to set the logging level in individual files, the individual source file can set required defined before including the respective log file.

e.g. The below lines will set log level to maximum:

```
#define NX_LOG_ENABLE_APP_DEBUG 1
#include <nxLog_App.h>
```

e.g. The below lines will set log level to just error:

```
#define NX_LOG_ENABLE_APP_DEBUG 0
#define NX_LOG_ENABLE_APP_INFO 0
#define NX_LOG_ENABLE_APP_WARN 0
#define NX_LOG_ENABLE_APP_ERROR 1
#include <nxLog_App.h>
```

`nxLog_App.h` and `_APP_` needs to be replaced with respective names as per the list in *Logging Header Files*.

3.8 Feature File - `fsl_sss_ftr.h`

The Plug & Trust Middleware uses a feature file to select/detect used/enabled features Within the middleware stack. When using CMake this file is automatically generated into the generated and used build directory. when not using CMake (e.g. using demo/example from the MCUExpresso KSDK package, this file is kept at the root of the source folder.

3.8.1 When Using CMake

Please be careful that when you’re using C Make this file is overwritten every time CMake is invoked or it re-generates the make files.

You do not have to hand modify `fsl_sss_ftr.h` feature file. Selections from CMake edit cache would automatically make relevant updates into the generated feature file.

This file is auto generated from `simw-top\sss\inc\fsl_sss_ftr.h.in`

3.8.2 When Using MCUXpresso IDE

As mentioned in above sections this file is kept in the root folder of the imported project. The file is filled with checks and balances so that at compile time some of the invalid selections are handled up front

3.8.3 `fsl_sss_ftr_default.h`

There is also provision to use a default fall-back file in case this feature file is not generated.

In the relevant parts the Middleware uses the following snippet to select the main or fall-back feature file:

```
#if defined(SSS_USE_FTR_FILE)
#include "fsl_sss_ftr.h"
#else
#include "fsl_sss_ftr_default.h"
#endif
```

It must be obvious that if the macro `SSS_USE_FTR_FILE` is not defined by the build system, default feature file gets used. In the reference demos and use cases from the Middleware, `SSS_USE_FTR_FILE` is always defined and only `fsl_sss_ftr.h` is used.

3.8.4 Using feature file to reduce code size

By setting below items to `0`, either in CMake or the `fsl_sss_ftr.h` relevant sections of the code is removed from compilation and thereby reducing the code consumption.

3.8.5 SSS_HAVE_APPLET_A71CH

When we set to `1` can compile with this applet support(A71CH-ECC)

3.8.6 SSS_HAVE_APPLET_SE05X_A

When we set to `1` can compile with this applet support(SE050 Type A (ECC))

3.8.7 SSS_HAVE_APPLET_SE05X_B

When we set to to `1` can compile with SE05X_B applet support(SE050 Type A (RSA))

3.8.8 SSS_HAVE_APPLET_SE05X_C

When we set to `0` cannot compile with this applet support (SE050 (Super set of A + B))

Enable at-least one of 'PTMW_Applet' Not more than `1`

SSSFTR_SW_TESTCOUNTERPART

For some of the demos we use cryptography both from the secure element and the host. For example, this makes an easy check for comparison where use comparison where we ask the host crypto to encrypt something and the secure element to do the counterpart (in this case encrypt) decrypt. Similarly for sign, verify.

Setting this to Zero, removes the implementation of counterpart.

SSSFTR_SW_ECC

When we set to 1, this feature exposes the asymmetric cryptography from the host for ECC. When using ECKey Authentication (See *Auth Objects : ECKey*) this feature needs to be enabled. Please note that `SSSFTR_SW_AES` also needs to be enabled for ECKey Authentication

SSSFTR_SW_RSA

When we set to `0`, RSA related implementation from the host SW is removed.

Symmetric cryptography on Host

If for some reason there is no cryptography used at all on the host side then these macros can also be set to `0` to remove relevant code from the host.

- `SSSFTR_SW_AES`
- `SSSFTR_SW_KEY_GET`

- `SSSFTR_SW_KEY_SET`

`SSSFTR_SE05X_AuthECKey`

When set to `0` the authentication using (See *Auth Objects : ECKey*) mode is disabled from the Host.

`SSSFTR_SE05X_AuthSession`

When set to `0` then only Platform SCP or default session can be used to talk to the secure element.

`SSSFTR_SE05X_AES`

When set to `0` then the symmetric cryptography related APIs from the Secure Element is removed from compilation.

`SSSFTR_SE05X_CREATE_DELETE_CRYPTOOBJ`

When we set to zero the host never creates new crypto objects or neither delete them. under such situation crypto objects should already be created once in the lifetime of the secure element explicitly.

`SSSFTR_SE05X_ECC`

Feature related to various elliptic curves is removed when we set to `0`.

`SSSFTR_SE05X_KEY_GET`

When there is no use case to fetch a key from the secure element to the host via the SSS APIs, this can be set to `0`.

`SSSFTR_SE05X_KEY_SET`

When there is no use case to inject a key into the secure element from the host this can be set to `0`. note that the keys can still be provisioned remotely for authenticated sessions this just removes the code from the host Middleware.

`SSSFTR_SE05X_RSA`

Removes the code related to RSA features of the secure element from the Middleware when we set to `0`.

`SSS_HAVE_ECC`

When we set to `1`, this feature exposes the ECC asymmetric cryptography. When we set to `0` the feature will Disable.

`SSS_HAVE_RSA`

When we set to `1`, this feature exposes the RSA asymmetric cryptography. When we set to `0` the feature will Disable.

`SSS_HAVE_TPM_BN`

When we set to `0` TPM BARRETO_NAEHRIG Curve is Disabled. If we set to `1` the curve will be Enabled.

`SSS_HAVE_EC_ED`

When we set to `0` Edwards curve is Disabled. If we set to `1` curve will be Enabled.

`SSS_HAVE_EC_MONT`

when we set to `0` Montgomery Curve is Disabled. If we set to `1` the curve will be Enabled.

`SSS_HAVE_MIFARE_DESFIRE`

When we set to `0` MIFARE DESFire is Disabled. If we set to `1` MIFARE_DESFIRE will be Enabled.

`SSS_HAVE_PBKDF2`

When we set to `0` PBKDF2 will be Disabled. If we set to `1` PBKDF2 will be Enabled.

`SSS_HAVE_TLS_HANDSHAKE`

When we set to `0` TLS handshake APIs will be Disabled. If we set to `1` TLS handshake APIs will be Enabled.

`SSS_HAVE_IMPORT`

when we set to `0` import and export keys are Disabled. If we set `1` import export key are Enabled.

`SSS_PFSCP_ENABLE`

See Section 3.9.1 *Configuring for OEF specific Platform SCP keys*

3.9 Platform SCP03 Authentication

3.9.1 MW Configuration

Configuring for OEF specific Platform SCP keys

File `sss/inc/fsl_sss_ftr.h.in` allows to configure the Plug & Trust MW to use Platform SCP keys for a specific OEF. Macros `SSS_PFSCP_ENABLE_*` are added for this. These macros can be used to configure the MW for PlatformSCP03 keys based on an OEF configuration. By default these remain disabled and default configuration is made based on `PTMW_SE05X_Ver` CMake option. For version `03_XX`, we use `SE050_DEVKIT` configuration, else we use `SE050E_0001A921` configuration.

Enabling any one of these macros would override the default configuration and enable the Platform SCP keys for that OEF. Also, macro `SSS_PFSCP_ENABLE_OTHER` allows the user to configure the MW in case user-defined Platform SCP keys are provisioned on the secure element. In that case, correct keys need to be updated in `ex_sss_tp_scp03_keys.h` before running the MW.

3.9.2 Using Platform SCP Keys from File System

Warning: Keeping keys in plain on file system is not secure. This mechanism is just to test quick prototyping / testing.

Note:

- This is valid only for hosts with filesystem access e.g. : Windows/Linux
- *CLI Tool* does not use this mechanism.

Using this mechanism, pre-compiled windows/linux demo examples can pick up platform SCP Keys from file system.

1) Create a file as set by `EX_SSS_SCP03_FILE_PATH`

   You can over-ride value for this variable in `sss/ex/inc/ex_sss_scp03_keys.h`

   For Android

   For Linux

   For Windows

2) Let us assume the Platform SCP03 keys provisioned in SE050 are as follows

   - ENC is `35C256458958A34F6136155F8209D6CD`
   - MAC is `AF177D5DBDF7C0D5C10A05B9F1607F78`
   - DEK is `A1BC8438BF77935B361A4425FE79FA29`

   The format of a reference file is as below:

```
# This is a comment, empty lines and comment lines allowed.
ENC 35C256458958A34F6136155F8209D6CD # Trailing comment
MAC AF177D5DBDF7C0D5C10A05B9F1607F78 # Optional trailing comment
DEK A1BC8438BF77935B361A4425FE79FA29 # Optional trailing comment
```

The Default Platform SCP keys for ease of use configurations are present in https://www.nxp.com/docs/en/application-note/AN12436.pdf

How to Run examples with Platform SCP03 keys

Once the `plain_scp.txt` file is filled with the correct SCP keys for the sample, run any example e.g.: *ECC Example*. The example will automatically pick up the keys from the file at this location, if the file exists. If the file does not exist, it uses keys from pre-compiled values in the example.

3.10 Auth Objects

There are 3 types of Auth Objects:

- *Auth Objects : UserID* : Sometimes referred to as Identifier or password
- *Auth Objects : AESKey* : Uses AES Key as authentication
- *Auth Objects : ECKey* : Uses ECC Key for authentication

These are needed to have an authenticated session to the Applet. Also, in SE05X, access to many objects can be controlled via policies. Many of these polices are related to which Auth Object was used for the session to the SE05X.

3.11 Auth Objects : UserID

As user ID is kind of Symmetric Identifier that is used to authenticate a session.

3.11.1 User ID - Provisioning / Injection

To *provision* / *inject* the key, the process is like this:

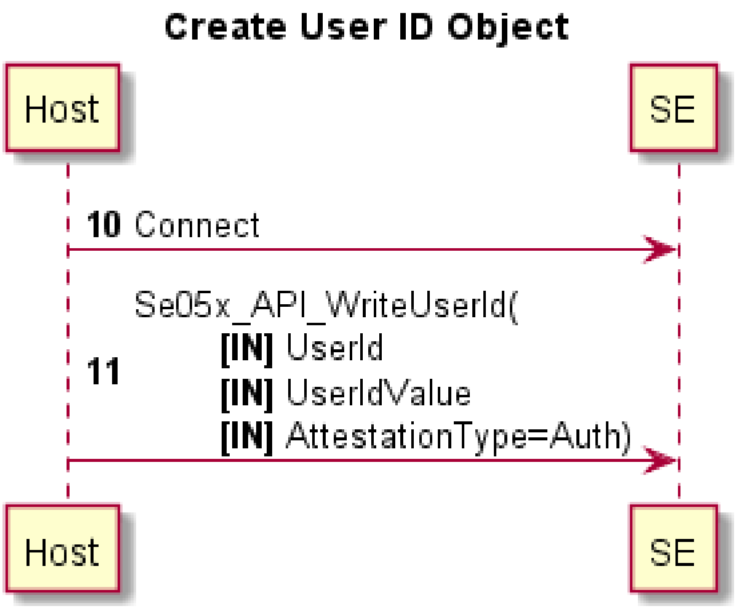

Table 2: Steps to provision

Step	Operation
10	We establish physical connection to SE
11	We create a UserId object, *Attestation Type* is `Auth`

3.11.2 User ID - Use for connection / authentication

To *use* the key, the process is like this:

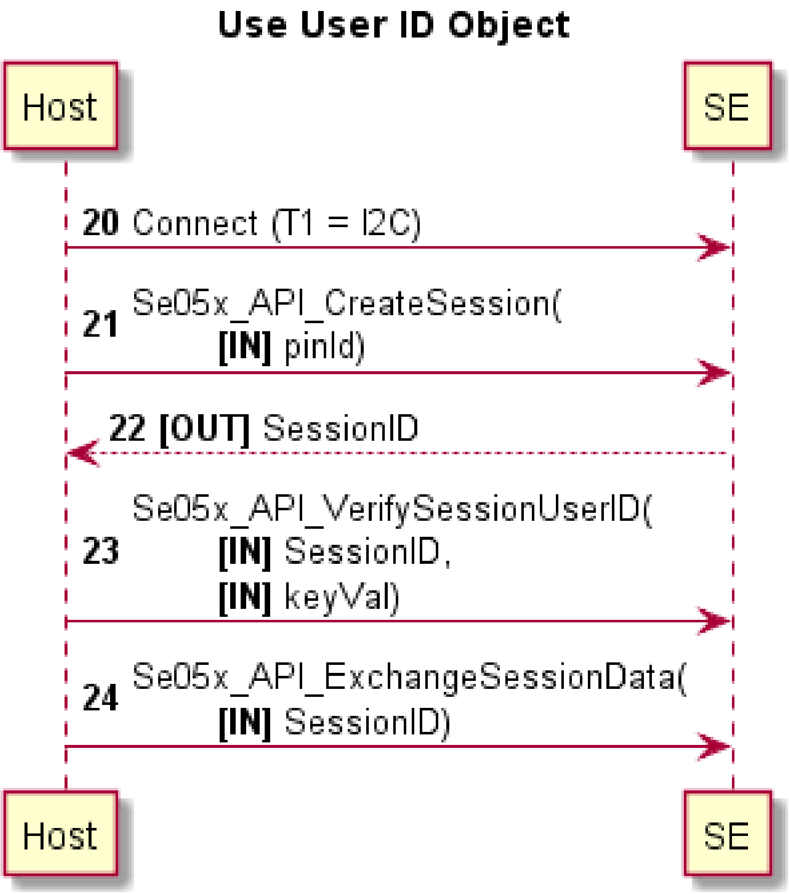

Table 3: Steps

Step	Operation
20	Host establishes physical connection to SE
21	Host calls *`Se05x_API_CreateSession()`* and use the 32bit id of UserId that we are going to use.
22	As a part of *`Se05x_API_CreateSession()`* API, Applet returns an 8 byte Session ID. We use this in future communication with the SE.
23	Host calls *`Se05x_API_VerifySessionUserID()`*. At this point, we pass the Value that we are going to use. (Host must already know the value of the PIN that is used/chosen in step 21.)
24	Finally, Host calls *`Se05x_API_ExchangeSessionData()`* API

3.11.3 User ID - Applet Spec Notes

From SE050 APDU Spec:

```
3.2.1.9 UserID

A UserID object is a byte array that holds a value that is linked to a
user.

UserID objects can only be created as Authentication object. By default,
```

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```
the maximum number of allowed authentication attempts is set to 255.

Length = 1 up to 16 bytes
```

From SE051 APDU Spec:

```
3.3.1.9 UserID

A User ID object is a value which is used to logically group secure objects. UserID
objects can only be created as Authentication objects (see Section 3.3.3). They cannot
be updated once created (i.e. the value of an existing UserID can not be changed).
A session that is opened by a UserID Authentication Object is not applying secure
messaging (so no encrypted or MACed communication).

By default, the maximum number of allowed authentication attempts is set to infinite.␣
↪Its
length is 4 up to 16 bytes. It is intended for use cases where a trusted operating␣
↪system
on a host MCU/MPU is isolating applications based e.g. on application ID.
```

3.12 Auth Objects : AESKey

Applet SCP03 is applet level secure channel protocol, which involved single symmetric key as static ENC, MAC, DEC key. First applet scp session is created using auth object provisioned in the SE, and then it follows the standard SCP03 protocol — Initialized Update and External Authenticate.

3.13 Auth Objects : ECKey

ECKey is secure channel protocol tailored for secured authentication and communication between a Host and a connected SE.

Please contact NXP CAS/FAE for the specification of ECKey.

The Secure Channel Protocol consists of two logical phases:

1) Authentication phase
2) Secure messaging phase

3.13.1 ECKey - Keys Used

The table below gives an overview of the required keys and their presence at SE and Host as required for the ECKey setup, authentication phase

Table 4: Auth Keys

key	SE	Host	Purpose
SK.SE.ECKA	Yes		Static SE key pair for Key Agreement Private key
PK.SE.ECKA	Yes	Yes	Static SE key pair for Key Agreement Public key
SK.Host.ECDSA		Yes	Host signing key pair Private key
PK.Host.ECDSA	Yes		Host signing key pair Private key
eSK.Host.ECKA		Yes	Ephemeral private key of the Host used for key agreement
ePK.Host.ECKA		Yes	Ephemeral public key of the Host used for key agreement

3.13.2 ECKey - Use for connection / authentication

Authentication Phase:

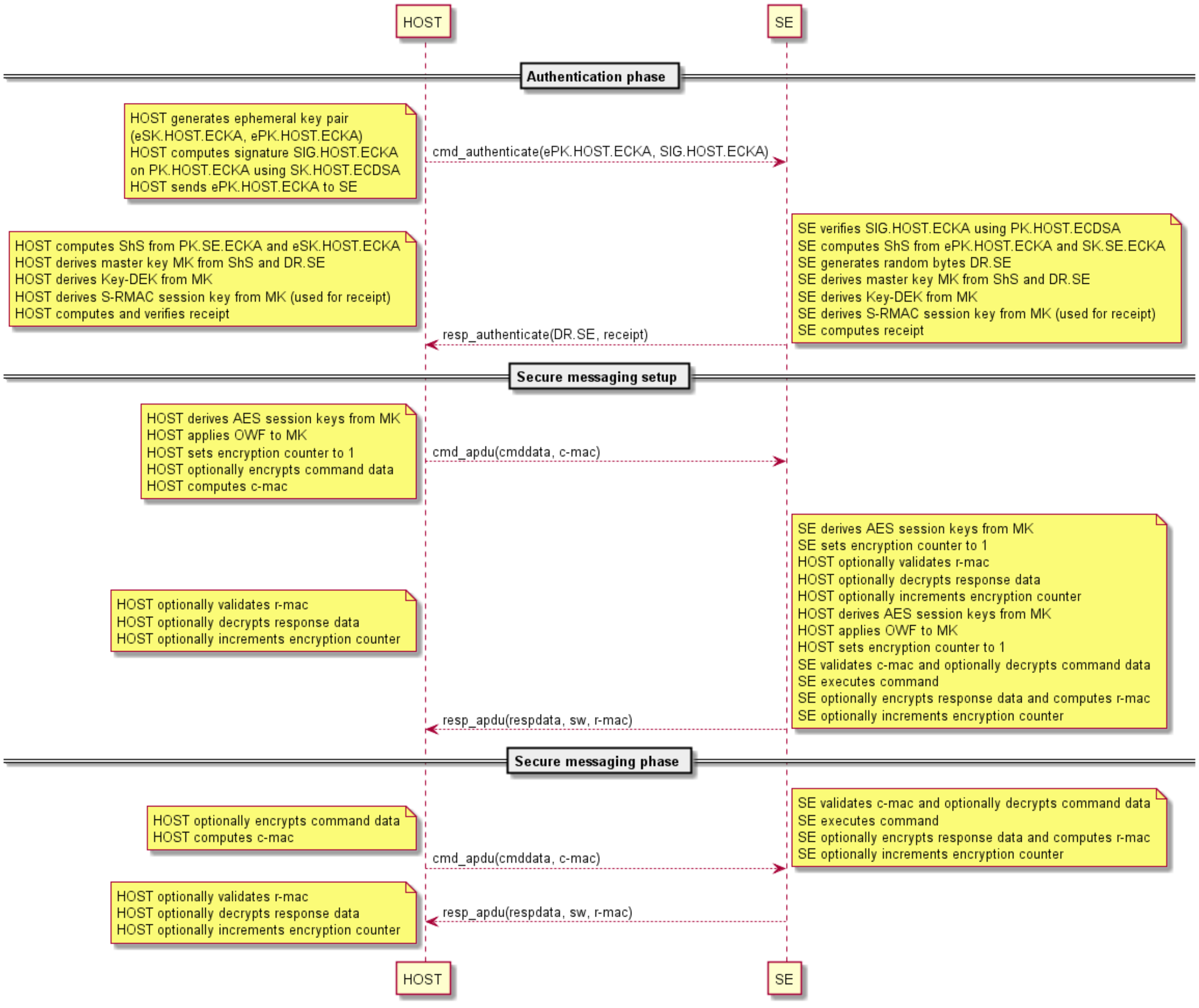
1) In the Secure Channel authentication phase, a Host-generated ephemeral key pair, the static SE key pair and SE-generated random data are used to compute a shared master secret
2) The Host generates an ephemeral ECC key pair and exchanges the public key component ePK.Host.ECKA with the SE. The ePK.Host.ECKA is signed to prove its authenticity.
3) Both the Host and the SE compute the shared secret ShS from (eSK.Host.ECKA , PK.SE.ECKA) and (SK.SE.ECKA, ePK.Host.ECKA) respectively.
4) The SE generates random bytes DR.SE and exchanges this with the Host.
5) Both the Host and the SE compute the shared master secret MK from the shared secret ShS and random bytes DR.SE.
6) **Optionally:**
    A) Both Host and SE compute the Key-DEK.
    B) Both Host and SE compute the S-RMAC session key (used for the receipt).
    C) Both Host and SE compute the receipt.
    D) The Host verifies the receipt.

Secure Messaging phase:

1) In the Secure Channel secure messaging phase, first a setup is performed, where the shared master secret is used to compute the AES session keys (S-ENC, S-MAC and S-RMAC) and initialize the encryption counter
2) Both the Host and the SE compute the AES session keys from MK.
3) Both the Host and the SE apply an OWF to MK. Note that this is performed after the validation of the command's C-MAC (to exclude DOS attacks on the SE).
4) Both the Host and the SE initialize the encryption counter to 1 for the first command/response with C-DECRYPTION or R-ENCRYPTION.
5) After the secure messaging setup has been performed, the AES session keys are employed to realize SCP03 secure messaging between Host and SE
6) Command APDUs are MACed.
7) Response APDUs are optionally MACed.

8) Command and response APDUs are optionally encrypted. For each command/response with C-DECRYPTION or R-ENCRYPTION, the encryption counter is incremented.

The phases inclusive the optional Key-DEK and receipt are shown in the figure below


HOST
SE
Authentication phase
HOST generates ephemeral key pair
(eSK.HOST.ECKA, ePK.HOST.ECKA)
HOST computes signature SIG.HOST.ECKA
on PK.HOST.ECKA using SK.HOST.ECDSA
HOST sends ePK.HOST.ECKA to SE
cmd_authenticate(ePK.HOST.ECKA, SIG.HOST.ECKA)
SE verifies SIG.HOST.ECKA using PK.HOST.ECDSA
SE computes ShS from ePK.HOST.ECKA and SK.SE.ECKA
SE generates random bytes DR.SE
SE derives master key MK from ShS and DR.SE
SE derives Key-DEK from MK
SE derives S-RMAC session key from MK (used for receipt)
SE computes receipt
HOST computes ShS from PK.SE.ECKA and eSK.HOST.ECKA
HOST derives master key MK from ShS and DR.SE
HOST derives Key-DEK from MK
HOST derives S-RMAC session key from MK (used for receipt)
HOST computes and verifies receipt
resp_authenticate(DR.SE, receipt)
Secure messaging setup
HOST derives AES session keys from MK
HOST applies OWF to MK
HOST sets encryption counter to 1
HOST optionally encrypts command data
HOST computes c-mac
cmd_apdu(cmddata, c-mac)
SE derives AES session keys from MK
SE sets encryption counter to 1
HOST optionally validates r-mac
HOST optionally decrypts response data
HOST optionally increments encryption counter
HOST derives AES session keys from MK
HOST applies OWF to MK
HOST sets encryption counter to 1
SE validates c-mac and optionally decrypts command data
SE executes command
SE optionally encrypts response data and computes r-mac
SE optionally increments encryption counter
HOST optionally validates r-mac
HOST optionally decrypts response data
HOST optionally increments encryption counter
resp_apdu(respdata, sw, r-mac)
Secure messaging phase
HOST optionally encrypts command data
HOST computes c-mac
cmd_apdu(cmddata, c-mac)
SE validates c-mac and optionally decrypts command data
SE executes command
SE optionally encrypts response data and computes r-mac
SE optionally increments encryption counter
HOST optionally validates r-mac
HOST optionally decrypts response data
HOST optionally increments encryption counter
resp_apdu(respdata, sw, r-mac)
HOST
SE

3.14 Key Id Range and Purpose

These key ranges are used as a convention by the Middleware. Functionally (from applet point of view) they are the same. Only the “Applet reserved” keys have a special functionality as defined in the APDU specification of the secure element.

Purpose		Range
Customer keys	Start	0x00000001
	End	0x7BFFFFFF
AKM Dynamic	Start	0x7C000000
	End	0x7CFFFFFF
Middleware Use Cases and Demos	Start	0x7D000000
	End	0x7DFFFFFF
Applet Reserved	Start	0x7FFF0000
	End	0x7FFFFFFF
Managed by EdgeLock 2GO for different cloud onboarding	Start	0x80000000
	End	0xEEFFFFFF
Middleware testing	Start	0xEF000000
	End	0xEFFFFFFF
Required for EdgeLock 2GO	Start	0xF0000000
	End	0xFFFFFFFF

3.15 Authentication Keys

Authentication object type	KeyID
UserID	0x7DA00001
UserID	0x7DA00011
AESKey	0x7DA00002
AESKey	0x7DA00012
ECKey	0x7DA00003
ECKey	0x7DA00013

Note: These authentication objects are used by the examples listed in Section 5 — *Demo and Examples* and are used as default authentication objects by the Middleware examples in case an applet session authentication is configured in the build options (See Section 4.7.11 *PTMW_SE05X_Auth*)

3.16 ECDAA Keys For Random Number

A random number(r) is reuqired when doing ECDAA sign. EC private key(key-r) is used to hold r. To reduce NVM operation, MW will not generate new key-r for each ECDAA sign. On the contrary, it will generate a specific key for each session. All the ECDAA sign operations in the same session will share the same key-r. Key ID 0x7DB0,0000 - 0x7DB0,FFFF is reserved for key-r. These keys are used internally by MW and can't be generated or set by SSS API.

The mapping between session and key-r is calculated as following:

- Default session will use Key-r ID 0x7DB00000

- Applet session: Key-r ID = 0x7DB00001 + (Session Authentication ID) % 65535

Session Authentication ID	Random Key ID	
Default session(session less)	0x7DB00000	
0x00000001	0x7DB00001	
0x00000002	0x7DB00002	
…	…	
0x0000FFFE	0x7DB0FFFE	
0x0000FFFF	0x7DB0FFFF	
0x00010000	0x7DB00001	
0x00010001	0x7DB00002	
…	…	

Note: The reserved Key-r ID should be enough for most use cases. But in some corner case, 2 session may mapped to same Key-r(e.g., session auth ID 0x00000001 and 0x00010000 both are mapped to key 0x7DB00001). If that is the case, user can define their own mapping by changing `sss_se05x_get_ecdaa_random_key_id()`.

3.17 Trust provisioned KeyIDs

The secure element gets as well trust provisioned with further keys and certificates which are ready to be used. The below table lists the usually used ones. Not all keys and certificates are available on all types, for a complete definition refer to “AN12436 SE050 Configurations” respectively “AN12973 SE051 configurations (1.0)”

Trust Provisioned object type	KeyID
ECC-256	
Device Key	0xF0000100
Device Certificate	0xF0000101
Gateway Key	0xF0000102
Gateway Certificate	0xF0000103
RSA-2K	
Device Key	0xF0000110
Device Certificate	0xF0000111
Gateway Key	0xF0000112
Gateway Certificate	0xF0000113
RSA-4K	
Device Key	0xF0000120
Device Certificate	0xF0000121
Gateway Key	0xF0000122
Gateway Certificate	0xF0000123

3.18 SCP03 with PUF

To keep Platform SCP03 keys secure, on the LPC55S e.g. PUF can be used. PUF will have the actual keys stored and we can perform cryptographic operations with it using HashCrypt block.

3.18.1 Activation Code

The Activation Code (AC) is a 1192-byte code used to start PUF. The AC is generated during `PUF_Enroll` operation. This must be generated once for the lifetime of the device and stored in PFR region of flash.

Each PUF has a different AC and cannot be used with any other device.

Note: For testing, we use pre-compiled activation code from `ex_scp03_puf.h` instead of reading from PFR. In actual use case, it **MUST** be stored and read from PFR.

3.18.2 Key Code

For every key stored in PUF, we get a Key Code (KC) which is used to access the key. Hardware keys stored in PUF cannot be exported. SCP03 keys must be stored as hardware keys.

3.18.3 Using with LPC55S

PUF is integrated with *`sss_session_open()`* in the supplied LPC55S example. Use the following CMake configurations to compile with PUF on LPC55S:

- `Host=lpcxpresso55s_s`
- `SCP=SCP03_SSS`
- `SE05X_Auth=PlatfSCP03`

When we compile any application on LPC55S secure zone, it will try to read HW keys provisioned in PUF. If in case the keys are not provisioned in PUF, the implementation will fallback on software implementation.

Note: You need to pass keyCodes in connectionData to `sss_session_open` instead of actual keys provisioned in PUF.

Only the static SCP03 keys are injected inside the PUF. Dynamic keys are derived from the static keys using CMAC operations with Hashcrypt module.

For example on how to enroll PUF and store SCP03 keys, refer *Key Injection to PUF*.

3.19 SSS Heap Management

For effective heap management, macros `SSS_MALLOC`, `SSS_CALLOC` and `SSS_FREE` are available in `sss/port/ksdk/fsl_sss_types.h` for embedded build and in `sss/port/default/fsl_sss_types.h` for PC/Linux build.

```
#if defined(USE_RTOS) && USE_RTOS == 1
#include "FreeRTOS.h"

void *pvPortCalloc(size_t num, size_t size); /*Calloc for Heap3/Heap4.*/

#ifndef SSS_MALLOC
#define SSS_MALLOC pvPortMalloc
#endif // SSS_MALLOC
```

(continues on next page)

(continued from previous page)

```
#ifndef SSS_FREE
#define SSS_FREE vPortFree
#endif // SSS_FREE

#ifndef SSS_CALLOC
#define SSS_CALLOC pvPortCalloc
#endif // SSS_CALLOC

#else // !USE_RTOS

#include <stdlib.h>

#ifndef SSS_MALLOC
#define SSS_MALLOC malloc
#endif // SSS_MALLOC

#ifndef SSS_FREE
#define SSS_FREE free
#endif // SSS_FREE

#ifndef SSS_CALLOC
#define SSS_CALLOC calloc
#endif // SSS_CALLOC

#endif // USE_RTOS
```

These macros are used for heap management operations in middleware and examples. All malloc/calloc/free calls should redirect to the same implementation. The same macro is also used for mbedTLS so that we are consistent across all malloc/free calls. In case of CMake configuration `RTOS=FreeRTOS`, we define the macros to use FreeRTOS implementation.

Warning: Not using same implementation across the solution could lead to memory corruption.

It is recommended that these macros should be used for all applications. The user can also define their own implementation of heap APIs as platform dependent calls to malloc, calloc and free.

3.20 Secure Boot

In this section we describe the process of secure boot followed by Secondary Bootloader (SBL) to initialize SE05X and MCU for secure binding and communication.

3.20.1 Secure Boot flow

1) LPC55S ROM Bootloader verifies Secondary Bootloader (SBL) image (see AN12283) and hands over control to SBL
2) SBL performs Secure Binding and opens session to SE05X
3) SBL uses pre-provisioned key `K_PUB_OEM` in SE05X to verify secure application image
4) After successful verification, SBL loads verified image

5) (Optional) Secure Application can perform further initialization, non-secure image verification, hand over control to Non-Secure applications, or use SE050 with provided credentials (Secure Binding)

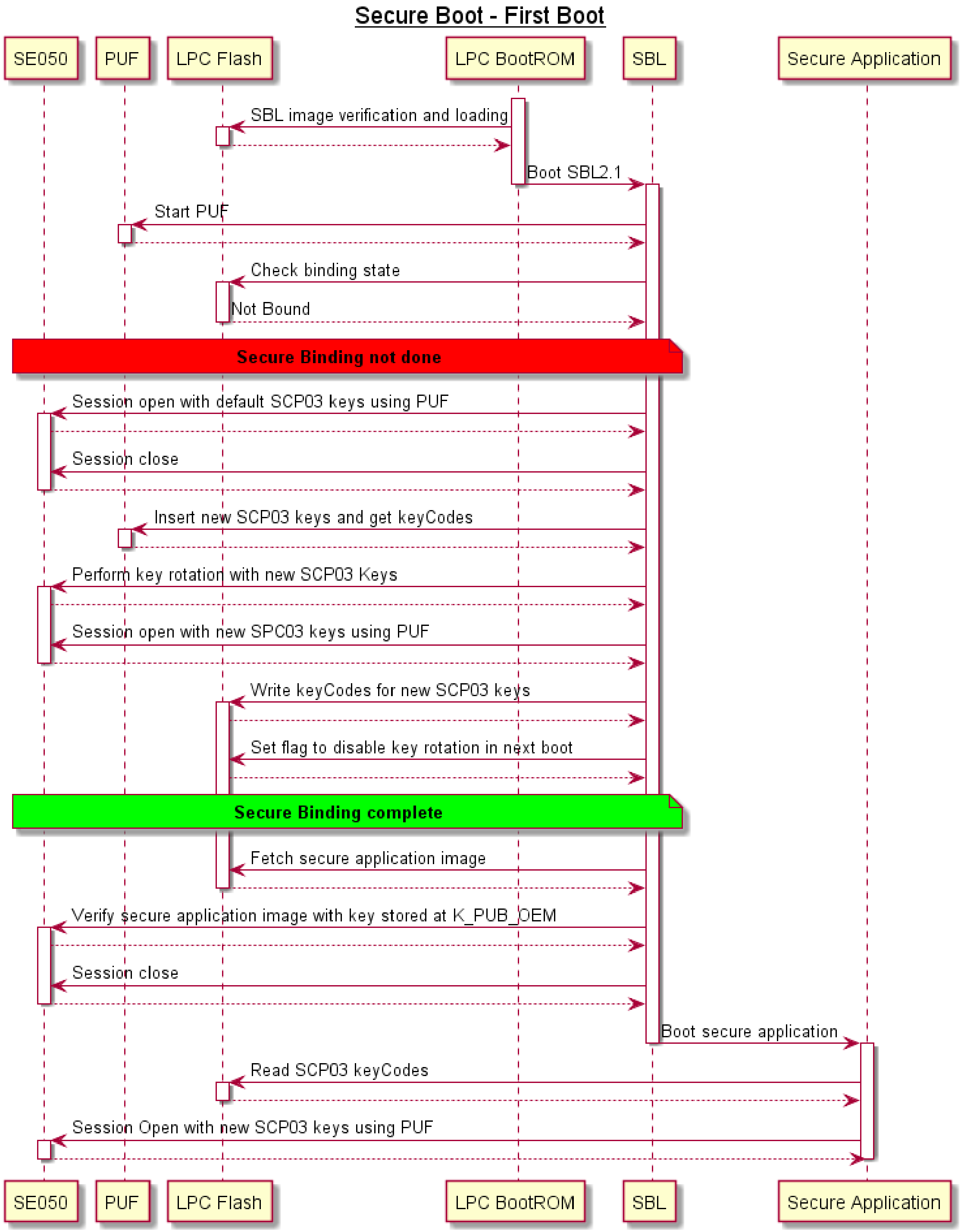
3.20.2 Secondary Bootloader

Secondary Bootloader (SBL) performs the following tasks to enable secure boot:

- **Secure Binding: Preparing SE05X for PlatformSCP**
    - Establish a pairing between the host MCU and the SE
    - MCU is only able to use services offered by the paired SE
    - SE is only able to provide services to the paired MCU
    - Mutually authenticated, encrypted SCP03 channel
- **Preparing host MCU for PlatformSCP session**
    - Securely storing PlatformSCP keys in PUF, protected by keyCodes
- **Verifying secure application**
    - Check the signature of secure application to verify that it is signed by a trusted key
- **KeyCode handover to secure application**
    - Handing over reference to ENC and MAC keyCodes prepared by SBL to secure application to open PlatformSCP session

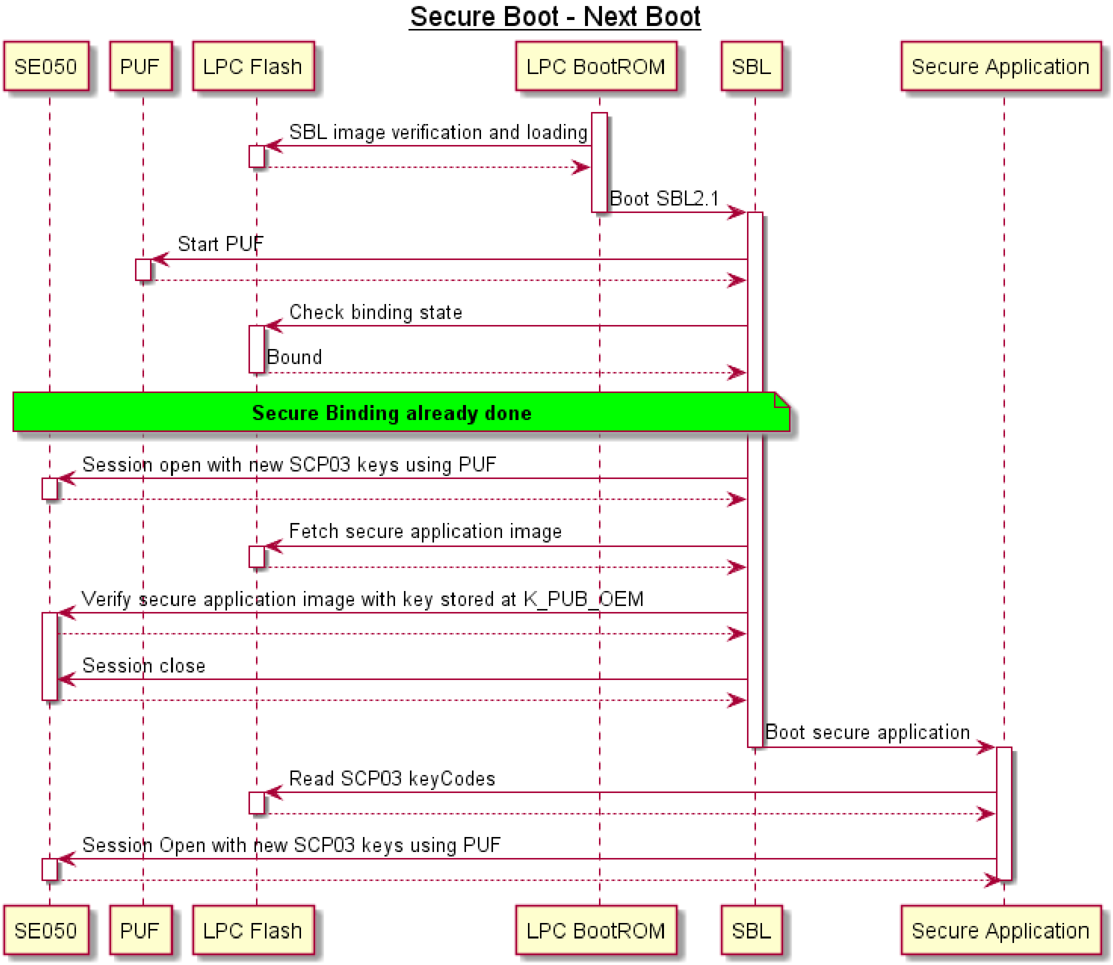
3.20.3 Secure Binding

1) **First boot**
    - SBL performs key rotation of the PlatformSCP key
    - PlatformSCP keys are stored in PUF
    - KeyCodes stored in flash to be used in subsequent boots
    - Flag set in flash to disable key rotation in subsequent boots
    - Verifies secure application


Secure Boot - First Boot
SE050
PUF
LPC Flash
LPC BootROM
SBL
Secure Application
SBL image verification and loading
Boot SBL2.1
Start PUF
Check binding state
Not Bound
Secure Binding not done
Session open with default SCP03 keys using PUF
Session close
Insert new SCP03 keys and get keyCodes
Perform key rotation with new SCP03 Keys
Session open with new SPC03 keys using PUF
Write keyCodes for new SCP03 keys
Set flag to disable key rotation in next boot
Secure Binding complete
Fetch secure application image
Verify secure application image with key stored at K_PUB_OEM
Session close
Boot secure application
Read SCP03 keyCodes
Session Open with new SCP03 keys using PUF
SE050
PUF
LPC Flash
LPC BootROM
SBL
Secure Application

2) **Next boot**

- Checks for flag to disable key rotation
- Uses keyCodes from flash to verify secure application


Secure Boot - Next Boot
SE050
PUF
LPC Flash
LPC BootROM
SBL
Secure Application
SBL image verification and loading
Boot SBL2.1
Start PUF
Check binding state
Bound
Secure Binding already done
Session open with new SCP03 keys using PUF
Fetch secure application image
Verify secure application image with key stored at K_PUB_OEM
Session close
Boot secure application
Read SCP03 keyCodes
Session Open with new SCP03 keys using PUF

Also see *Secure Boot Demo*

CHAPTER

FOUR

BUILDING / COMPILING

The Plug & Trust Middleware uses *CMake* for compiling / building.

4.1 Windows Build

Building the Plug & Trust MW on Windows enables to explore the MW stack and examples in a rich IDE. Only the low level communication to the secure element is done on a connected host as interface to the secure element. This process and the hardware setup to connect to SE05x is shown in AN12398 Quick start guide se05x Visual Studio Project examples.

4.1.1 Prerequisite

- Visual studio installed
- Python 3 32 bit installed

Refer https://www.nxp.com/docs/en/application-note/AN12398-Quick_start_guide_se050_vs_projects.pdf for more details on prerequisite installation steps.

4.1.2 Create Build files

- **Use `<SE05X_root_folder>/simw-top/scripts/create_cmake_projects.py` to** generate the build files, Run as

  ```
  @REM Setup environment variables and PATH
  call env_setup.bat

  @REM Use CMake to generate .sln files
  python create_cmake_projects.py
  ```

  Note: There should not be any spaces in **SE05X_root_folder**

- Build files are generated at `<SE05X_root_folder>/simw-top_build/`
- Use the visual studio solution at `<SE05X_root_folder>/simw-top_build/se_x86/PlugAndTrustMW.sln` to build sample examples and demo examples

Note: In case of using powershell, use *env_setup.ps1* script to set environment variables.

4.1.3 SSS Examples

- Sample examples can be found at `<SE05X_root_folder>/simw-top_build/se_x86/bin`
- Run the example as

```
<example_name>.exe <COM_PORT>
```

Refer *Demo and Examples* for details on these examples and for running cloud/tls demo applications

4.2 Import MCUXPresso projects from SDK

With Plug & Trust middleware, MCUXPresso SDKs are supplied for supported boards. Projects can be imported/executed from these SDKs.

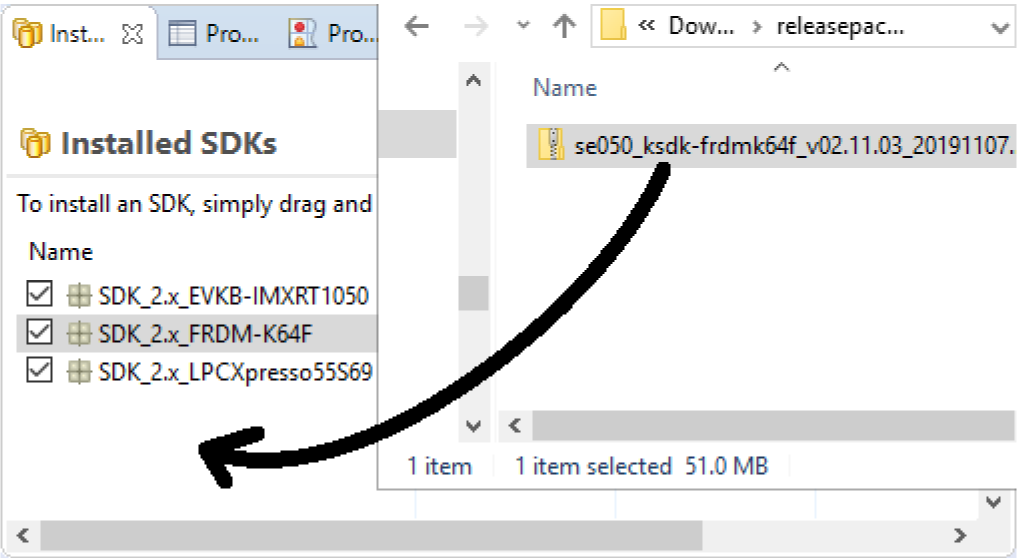
For more details refer - https://www.nxp.com/docs/en/application-note/AN12396-Quick_start_guide_kinetis_k64.pdf

4.2.1 Prerequisite

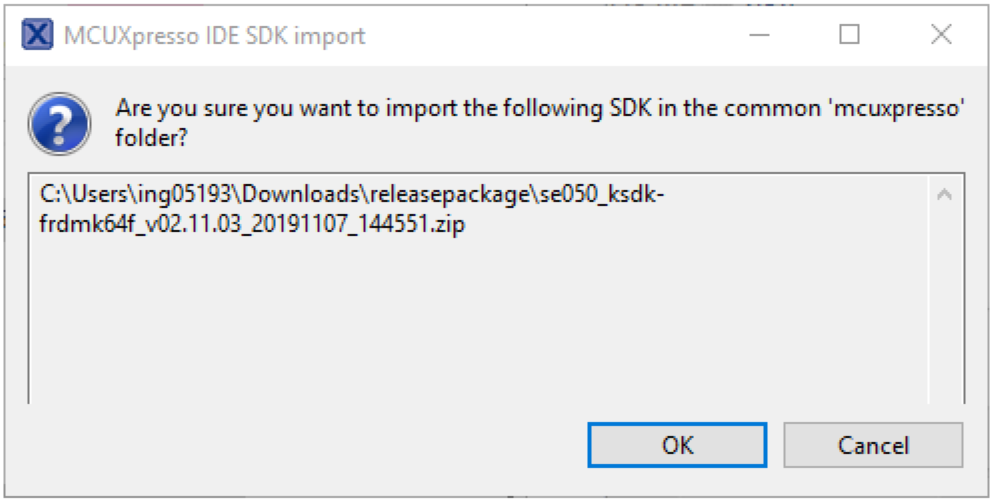
- MCUXpresso installed. Refer to *Setting up MCUXPresso IDE* for details on installation
- Plug & Trust Middleware SE050 MCUXPresso SDK Package is downloaded and available

4.2.2 Importing an example

- Drag and drop SDK to "Install SDKs" windows of MCUXPresso. Even if you have older SDK, you can drag and drop. MCUXPresso will take the latest SDK based on version number.



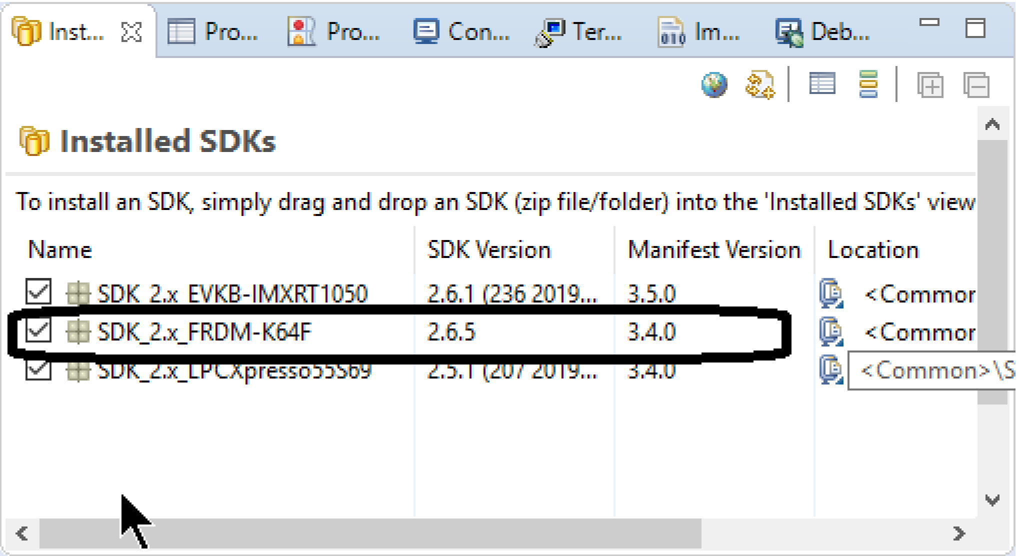
- Accept the request to import the SDK.



Are you sure you want to import the following SDK in the common 'mcuxpresso' folder?

C:\Users\ing05193\Downloads\releasepackage\se050_ksdk-frdmk64f_v02.11.03_20191107_144551.zip

- You should see a new / updated entry. In this case version 2.6.5. Based on the release, this version may change. If you have Newer version of SDK, and you would like to use this version, you must delete the old SDK.

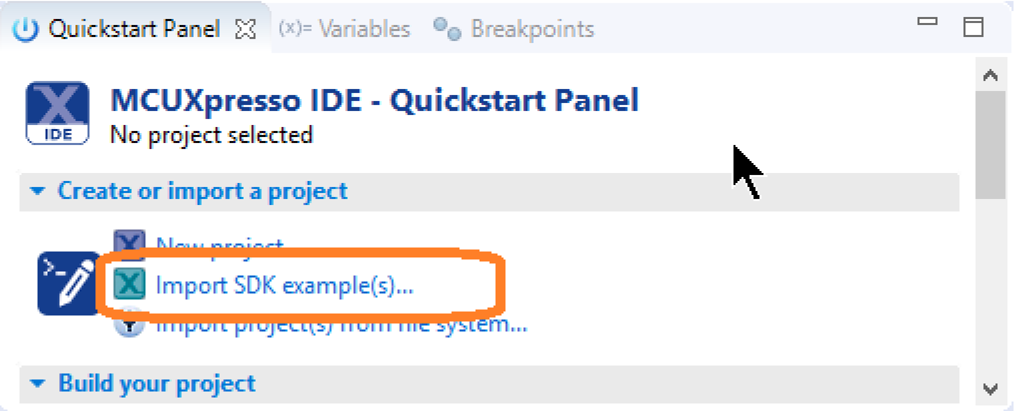


Installed SDKs

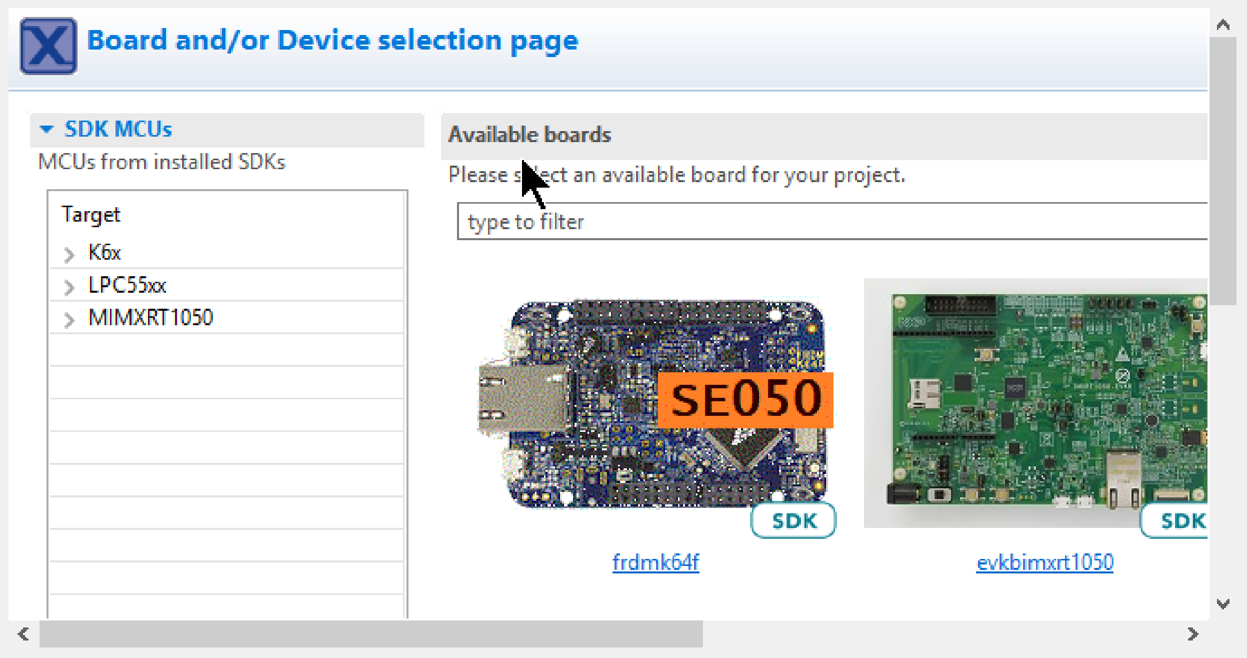
To install an SDK, simply drag and drop an SDK (zip file/folder) into the 'Installed SDKs' view

Name	SDK Version	Manifest Version	Location
☑ SDK_2.x_EVKB-IMXRT1050	2.6.1 (236 2019...	3.5.0	<Commor
☑ SDK_2.x_FRDM-K64F	2.6.5	3.4.0	<Commor
☑ SDK_2.x_LPCXpresso55S69	2.5.1 (207 2019...	3.4.0	<Common>\S

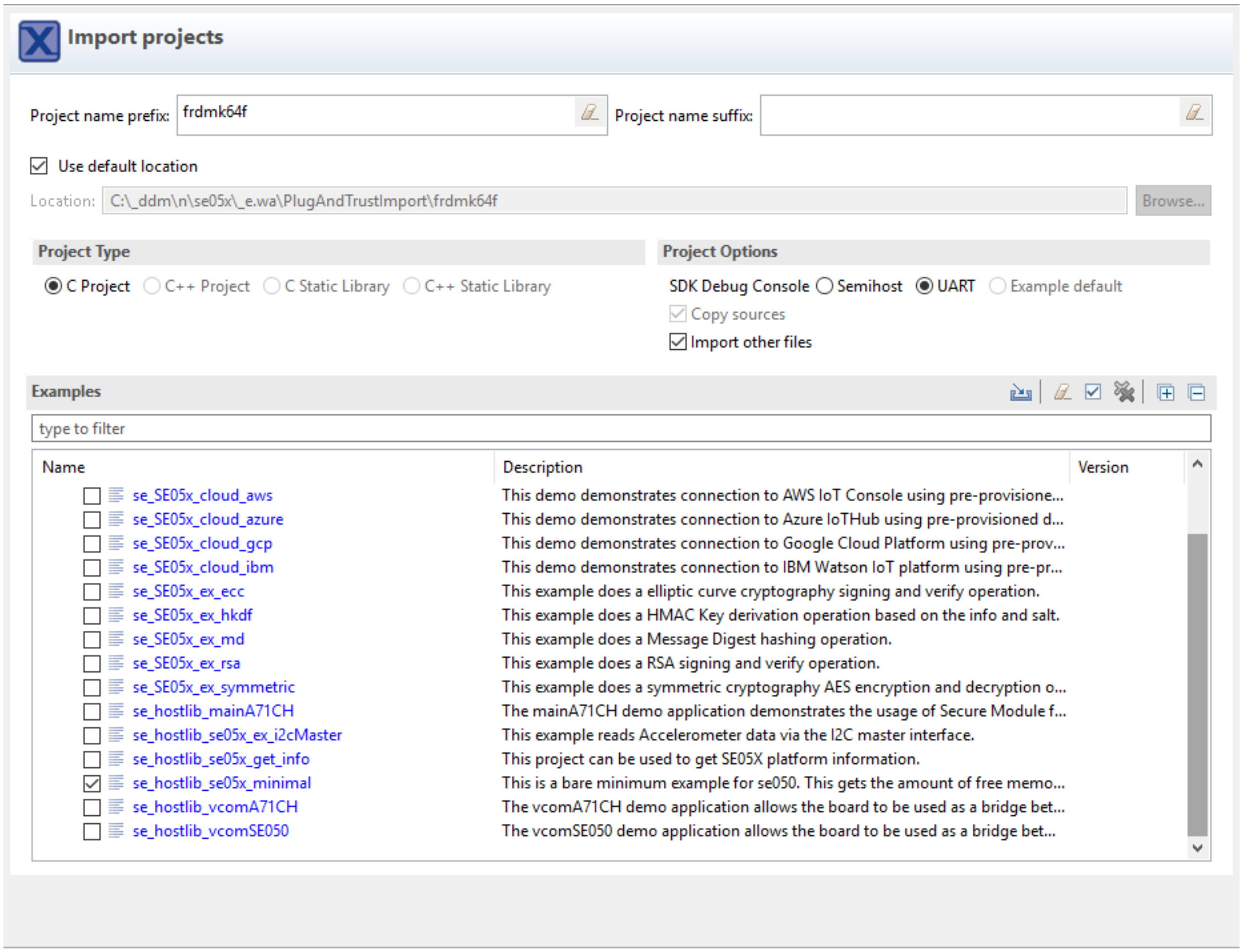
- From the "Quickstart Panel" –> "Import SDK Example(s)"



- You must see K64F with SE050 marked. For other SDKs, same convention follows. If you do not see SE050 there, it means you have newer version of the SDK and you must delete them.



- When you import and click next, you will see support examples for that board.
- Select the example you would like to run/test. In this case, we go for "minimal"



Import projects

Project name prefix: frdmk64f
Project name suffix:

☑ Use default location

Location: C:_ddm\n\se05x_e.wa\PlugAndTrustImport\frdmk64f

Project Type

● C Project ○ C++ Project ○ C Static Library ○ C++ Static Library

Project Options

SDK Debug Console ○ Semihost ● UART ○ Example default

☑ Copy sources

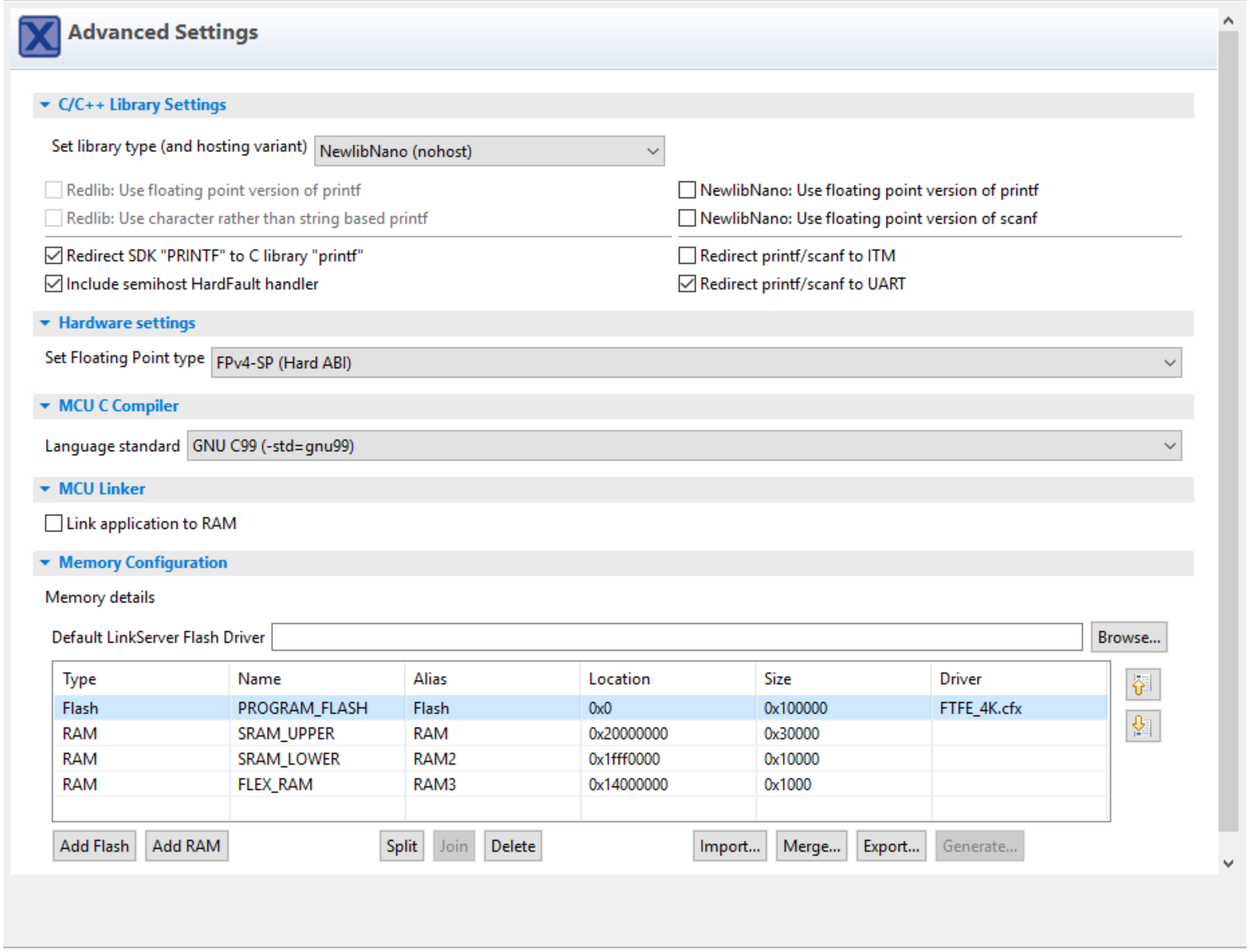
☑ Import other files

Examples

type to filter

	Name	Description	Version
☐	se_SE05x_cloud_aws	This demo demonstrates connection to AWS IoT Console using pre-provisione...	
☐	se_SE05x_cloud_azure	This demo demonstrates connection to Azure IoTHub using pre-provisioned d...	
☐	se_SE05x_cloud_gcp	This demo demonstrates connection to Google Cloud Platform using pre-prov...	
☐	se_SE05x_cloud_ibm	This demo demonstrates connection to IBM Watson IoT platform using pre-pr...	
☐	se_SE05x_ex_ecc	This example does a elliptic curve cryptography signing and verify operation.	
☐	se_SE05x_ex_hkdf	This example does a HMAC Key derivation operation based on the info and salt.	
☐	se_SE05x_ex_md	This example does a Message Digest hashing operation.	
☐	se_SE05x_ex_rsa	This example does a RSA signing and verify operation.	
☐	se_SE05x_ex_symmetric	This example does a symmetric cryptography AES encryption and decryption o...	
☐	se_hostlib_mainA71CH	The mainA71CH demo application demonstrates the usage of Secure Module f...	
☐	se_hostlib_se05x_ex_i2cMaster	This example reads Accelerometer data via the I2C master interface.	
☐	se_hostlib_se05x_get_info	This project can be used to get SE05X platform information.	
☑	se_hostlib_se05x_minimal	This is a bare minimum example for se050. This gets the amount of free memo...	
☐	se_hostlib_vcomA71CH	The vcomA71CH demo application allows the board to be used as a bridge bet...	
☐	se_hostlib_vcomSE050	The vcomSE050 demo application allows the board to be used as a bridge bet...	

- You can choose different settings if you like to as supported by MCUXPresso



Advanced Settings

C/C++ Library Settings

Set library type (and hosting variant): NewlibNano (nohost)

☐ Redlib: Use floating point version of printf
☐ Redlib: Use character rather than string based printf
☐ NewlibNano: Use floating point version of printf
☐ NewlibNano: Use floating point version of scanf
☑ Redirect SDK "PRINTF" to C library "printf"
☑ Include semihost HardFault handler
☐ Redirect printf/scanf to ITM
☑ Redirect printf/scanf to UART

Hardware settings

Set Floating Point type: FPv4-SP (Hard ABI)

MCU C Compiler

Language standard: GNU C99 (-std=gnu99)

MCU Linker

☐ Link application to RAM

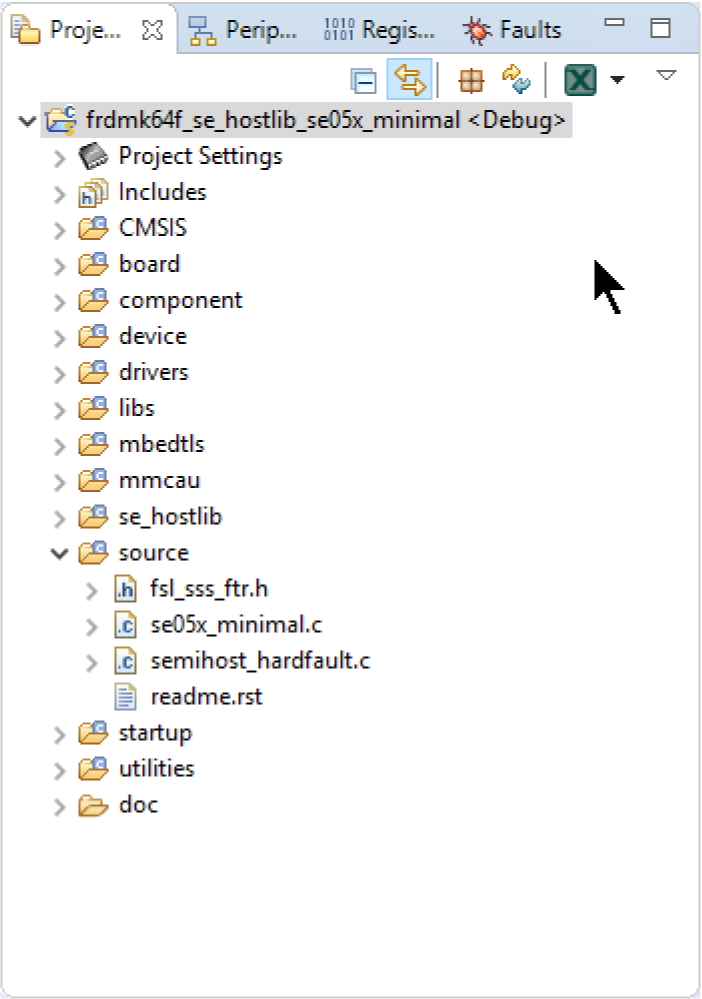
Memory Configuration

Memory details

Default LinkServer Flash Driver:

Type	Name	Alias	Location	Size	Driver
Flash	PROGRAM_FLASH	Flash	0x0	0x100000	FTFE_4K.cfx
RAM	SRAM_UPPER	RAM	0x20000000	0x30000	
RAM	SRAM_LOWER	RAM2	0x1fff0000	0x10000	
RAM	FLEX_RAM	RAM3	0x14000000	0x1000	

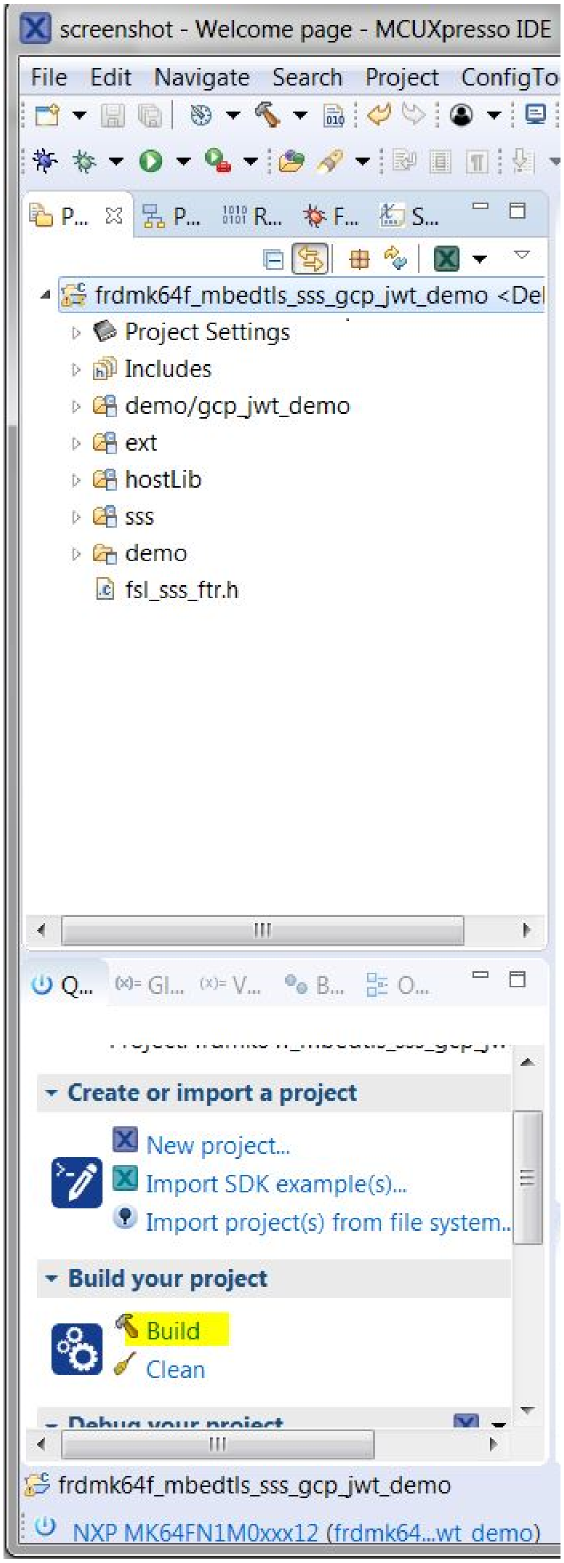
- Now the examples are ready to be tested.



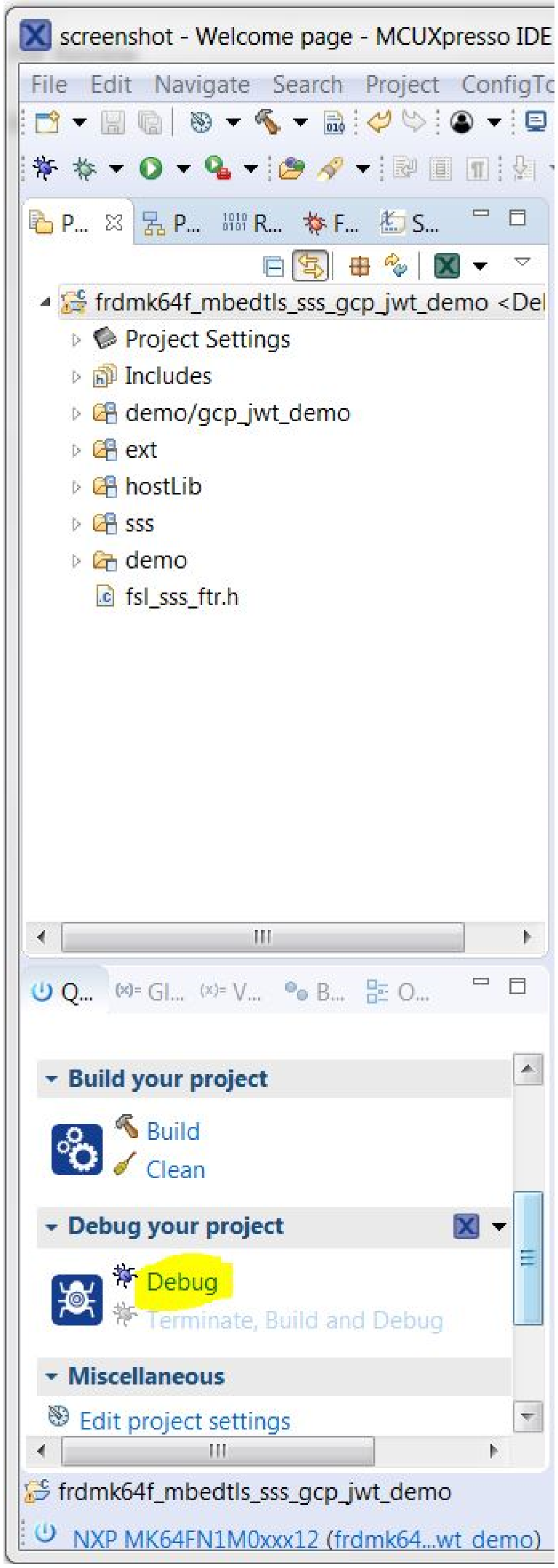
- frdmk64f_se_hostlib_se05x_minimal <Debug>
  - Project Settings
  - Includes
  - CMSIS
  - board
  - component
  - device
  - drivers
  - libs
  - mbedtls
  - mmcau
  - se_hostlib
  - source
    - fsl_sss_ftr.h
    - se05x_minimal.c
    - semihost_hardfault.c
    - readme.rst
  - startup
  - utilities
  - doc

4.2.3 Running / Debugging example

- Click on Build to compile and generate the executables

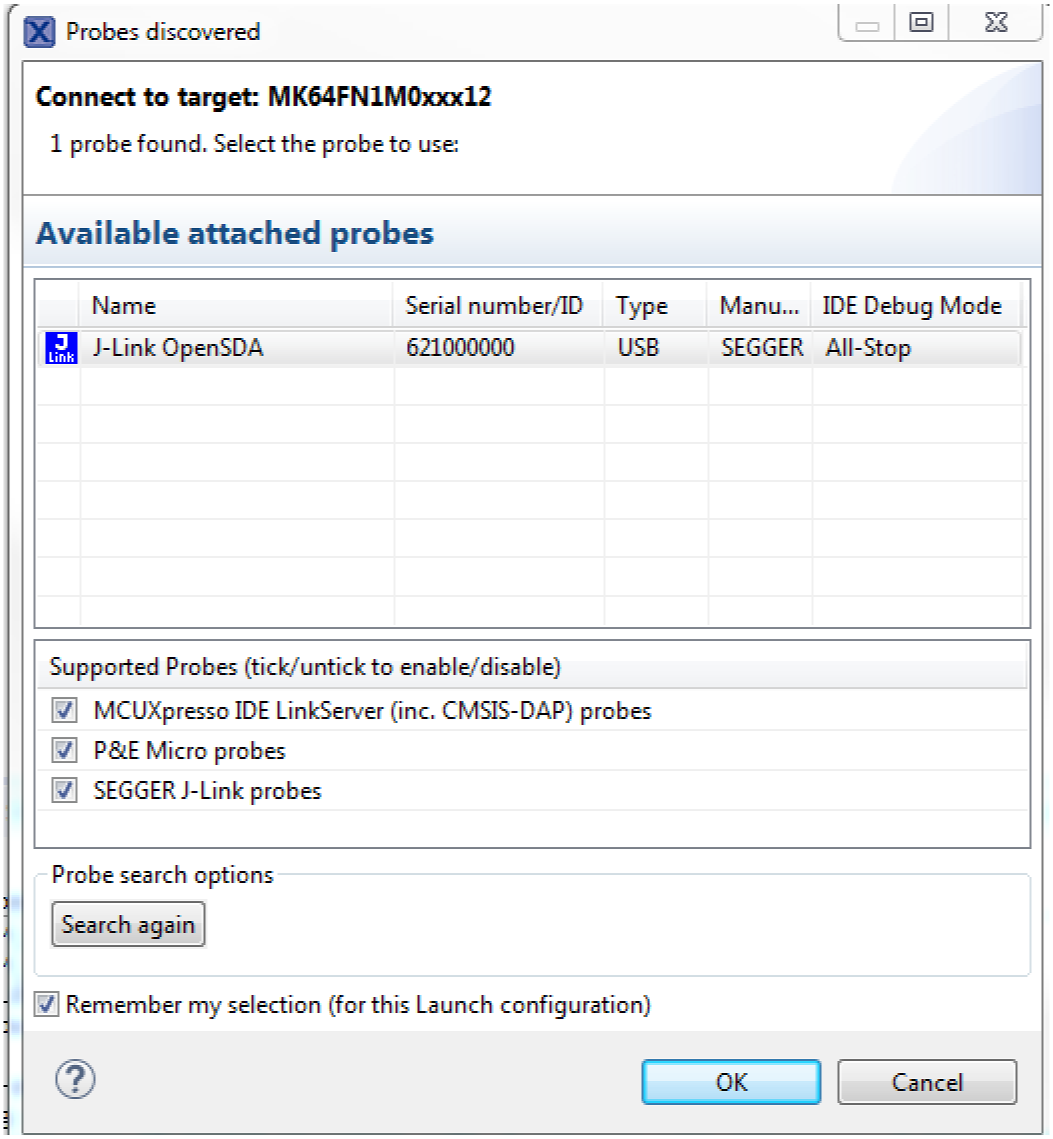

screenshot - Welcome page - MCUXpresso IDE
File Edit Navigate Search Project ConfigTo
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo <Del
Project Settings
Includes
demo/gcp_jwt_demo
ext
hostLib
sss
demo
fsl_sss_ftr.h
Q... Gl... V... B... O...
Create or import a project
New project...
Import SDK example(s)...
Import project(s) from file system...
Build your project
Build
Clean
Debug your project
frdmk64f_mbedtls_sss_gcp_jwt_demo
NXP MK64FN1M0xxx12 (frdmk64...wt_demo)

- Click on debug to program the binary into the device


screenshot - Welcome page - MCUXpresso IDE
File Edit Navigate Search Project ConfigTo
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo <Del
Project Settings
Includes
demo/gcp_jwt_demo
ext
hostLib
sss
demo
fsl_sss_ftr.h
Q... Gl... V... B... O...
Build your project
Build
Clean
Debug your project
Debug
Terminate, Build and Debug
Miscellaneous
Edit project settings
frdmk64f_mbedtls_sss_gcp_jwt_demo
NXP MK64FN1M0xxx12 (frdmk64...wt_demo)

- Select J-Link OpenSDA and click on OK. For more details on OpenSDA, refer to

https://www.nxp.com/support/developer-resources/run-time-software/kinetis-developer-resources/ides-for-kinetis-mcus/opensda-serial-and-debug-adapter:OPENSDA



Probes discovered

Connect to target: MK64FN1M0xxx12

1 probe found. Select the probe to use:

Available attached probes

Name	Serial number/ID	Type	Manu...	IDE Debug Mode
J-Link OpenSDA	621000000	USB	SEGGER	All-Stop

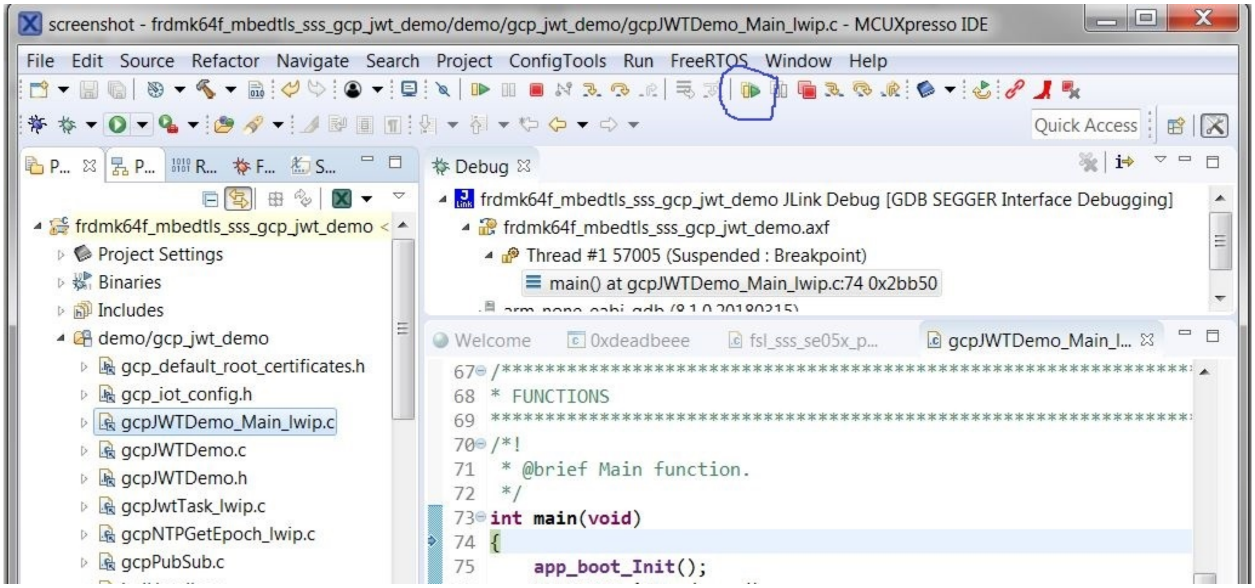
Supported Probes (tick/untick to enable/disable)

☑ MCUXpresso IDE LinkServer (inc. CMSIS-DAP) probes
☑ P&E Micro probes
☑ SEGGER J-Link probes

Probe search options

☑ Remember my selection (for this Launch configuration)

- Click on the Resume button to start program execution


screenshot - frdmk64f_mbedtls_sss_gcp_jwt_demo/demo/gcp_jwt_demo/gcpJWTDemo_Main_lwip.c - MCUXpresso IDE
File Edit Source Refactor Navigate Search Project ConfigTools Run FreeRTOS Window Help
Quick Access
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo
Project Settings
Binaries
Includes
demo/gcp_jwt_demo
gcp_default_root_certificates.h
gcp_iot_config.h
gcpJWTDemo_Main_lwip.c
gcpJWTDemo.c
gcpJWTDemo.h
gcpJwtTask_lwip.c
gcpNTPGetEpoch_lwip.c
gcpPubSub.c
Debug
frdmk64f_mbedtls_sss_gcp_jwt_demo JLink Debug [GDB SEGGER Interface Debugging]
frdmk64f_mbedtls_sss_gcp_jwt_demo.axf
Thread #1 57005 (Suspended : Breakpoint)
main() at gcpJWTDemo_Main_lwip.c:74 0x2bb50
Welcome
0xdeadbeee
fsl_sss_se05x_p...
gcpJWTDemo_Main_l...

```
/*******************************************************************
 * FUNCTIONS
 ******************************************************************
/*!
 * @brief Main function.
 */
int main(void)
{
    app_boot_Init();
```

4.2.4 Logging on console

For UART, a serial terminal application(for e.g Tera Term) on PC for serial device needs to be configured as follows (in Tera Term goto `Setup` –> `Serial port`)

- 115200 baud rate
- 8 data bits
- No parity
- One stop bit
- No flow control

Once the program execution begins, logs are printed on the terminal(e.g. Tera Term) indicating the status of execution and test results. The ATR and the various module versions are printed followed by a SELECT-DONE after which the respective test logs are printed.

4.3 Freedom K64F Build (CMake - Advanced)

For the advanced users and users who are aware of CMake / want to use true potential of CMake, the plug and trust MW supports build system where developers can run exactly the same example on PC/Windows/Linux and embedded targets.

e.g. Using this, developer can develop/extend example on a Windows Machine with visual studio which supports multiple break points, watch points, etc. and then recompile same example for K64F and test it there.

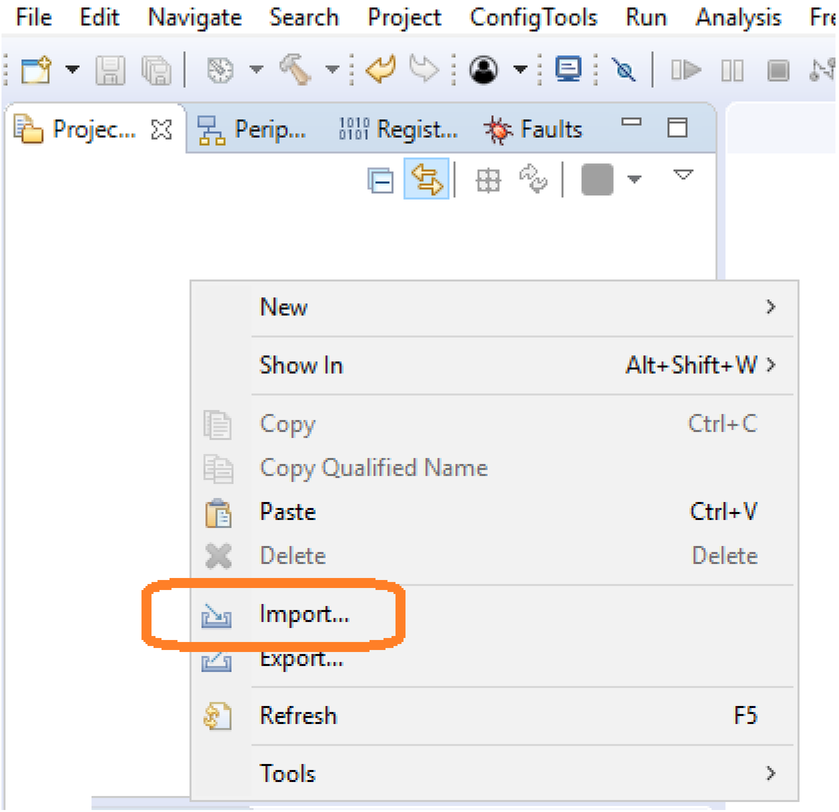
4.3.1 Prerequisite

- MCUXpresso installed and version correctly updated in `scripts/env_setup.bat` Refer to *Setting up MCUXPresso IDE* for details on installation
- CMake is installed .
- Python is installed and projects are created using `scripts/create_cmake_projects.py`

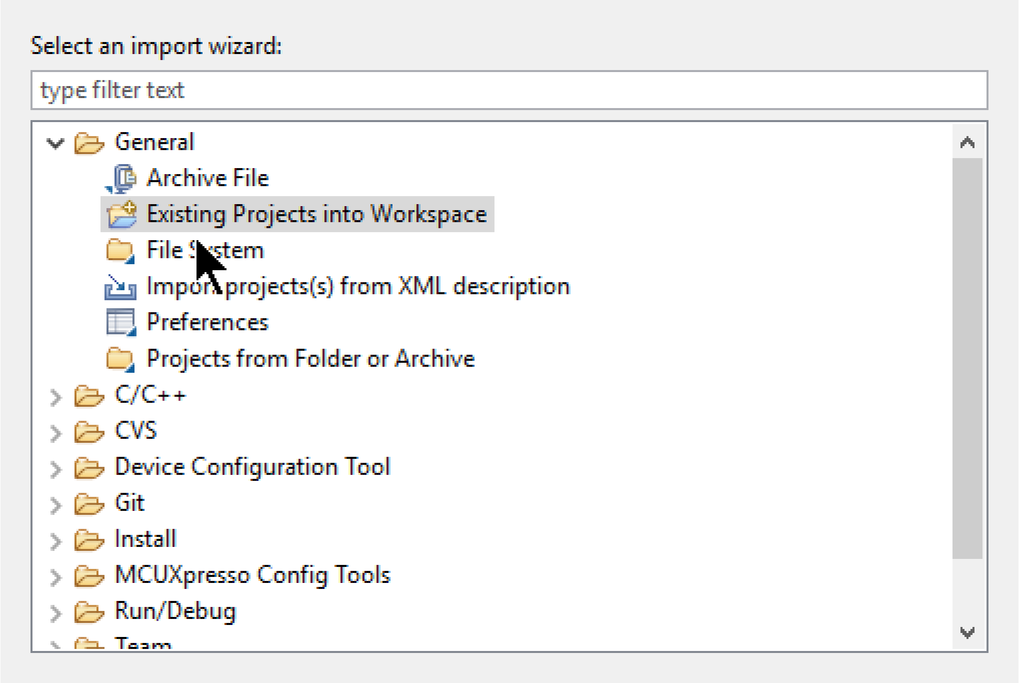
Refer https://www.nxp.com/docs/en/application-note/AN12396-Quick_start_guide_kinetis_k64.pdf for more details on Prerequisite installation steps.

4.3.2 Importing the Project

- Import a project using the option provided by MCUXPresso. Do not use the "Quickstart Panel" to import project.



- Import existing projects into Workspace



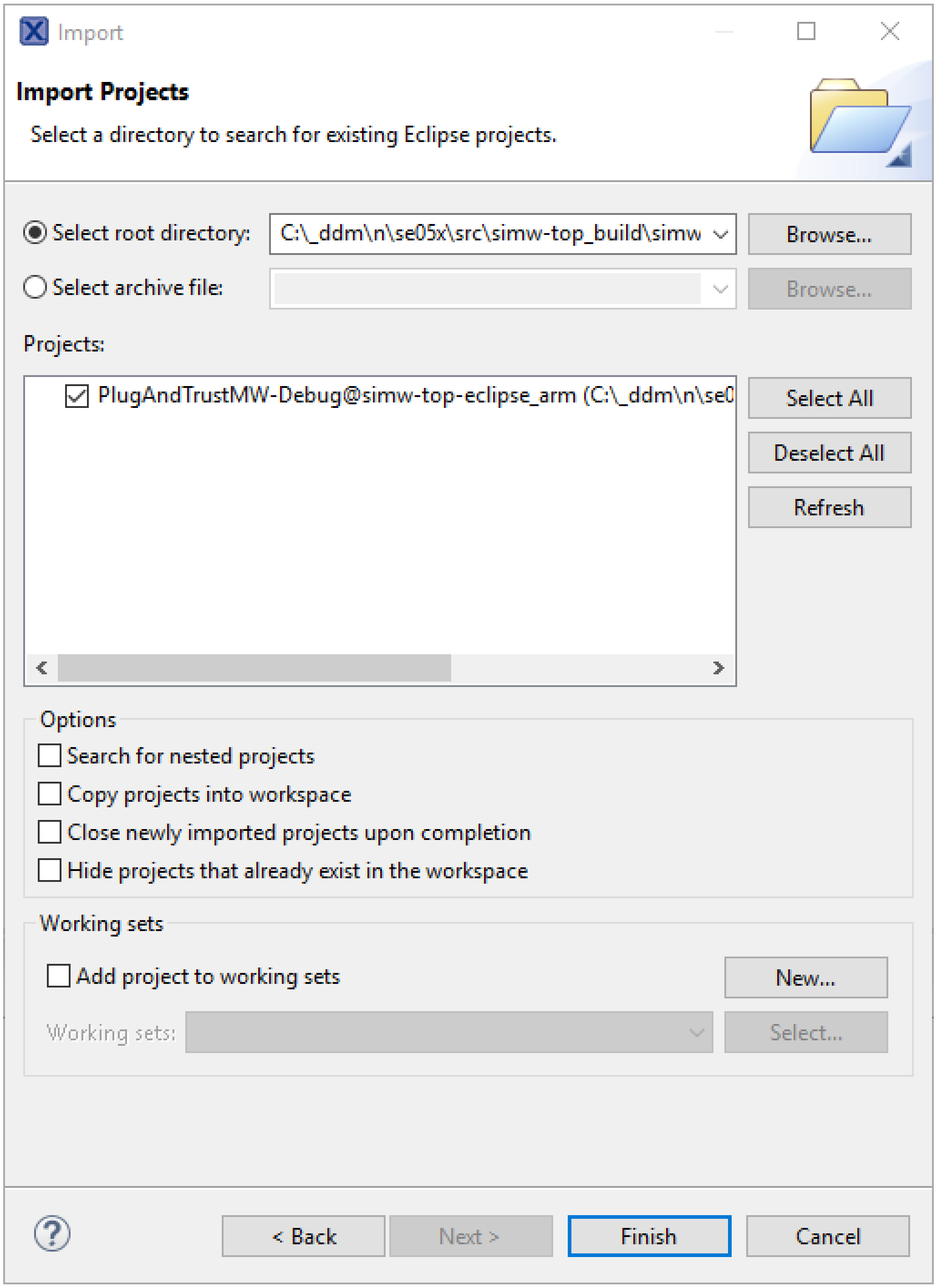
Select an import wizard:

type filter text

- General
  - Archive File
  - Existing Projects into Workspace
  - File System
  - Import projects(s) from XML description
  - Preferences
  - Projects from Folder or Archive
- C/C++
- CVS
- Device Configuration Tool
- Git
- Install
- MCUXpresso Config Tools
- Run/Debug
- Team

- First import the project generated by `scripts/create_cmake_projects.py`. We are going to use that workarea to build the examples.

  Never select "Copy projects into workspace" for this CMake configuration.



Import Projects

Select a directory to search for existing Eclipse projects.

● Select root directory: C:_ddm\n\se05x\src\simw-top_build\simw

○ Select archive file:

Projects:

☑ PlugAndTrustMW-Debug@simw-top-eclipse_arm (C:_ddm\n\se0

Options

☐ Search for nested projects

☐ Copy projects into workspace

☐ Close newly imported projects upon completion

☐ Hide projects that already exist in the workspace

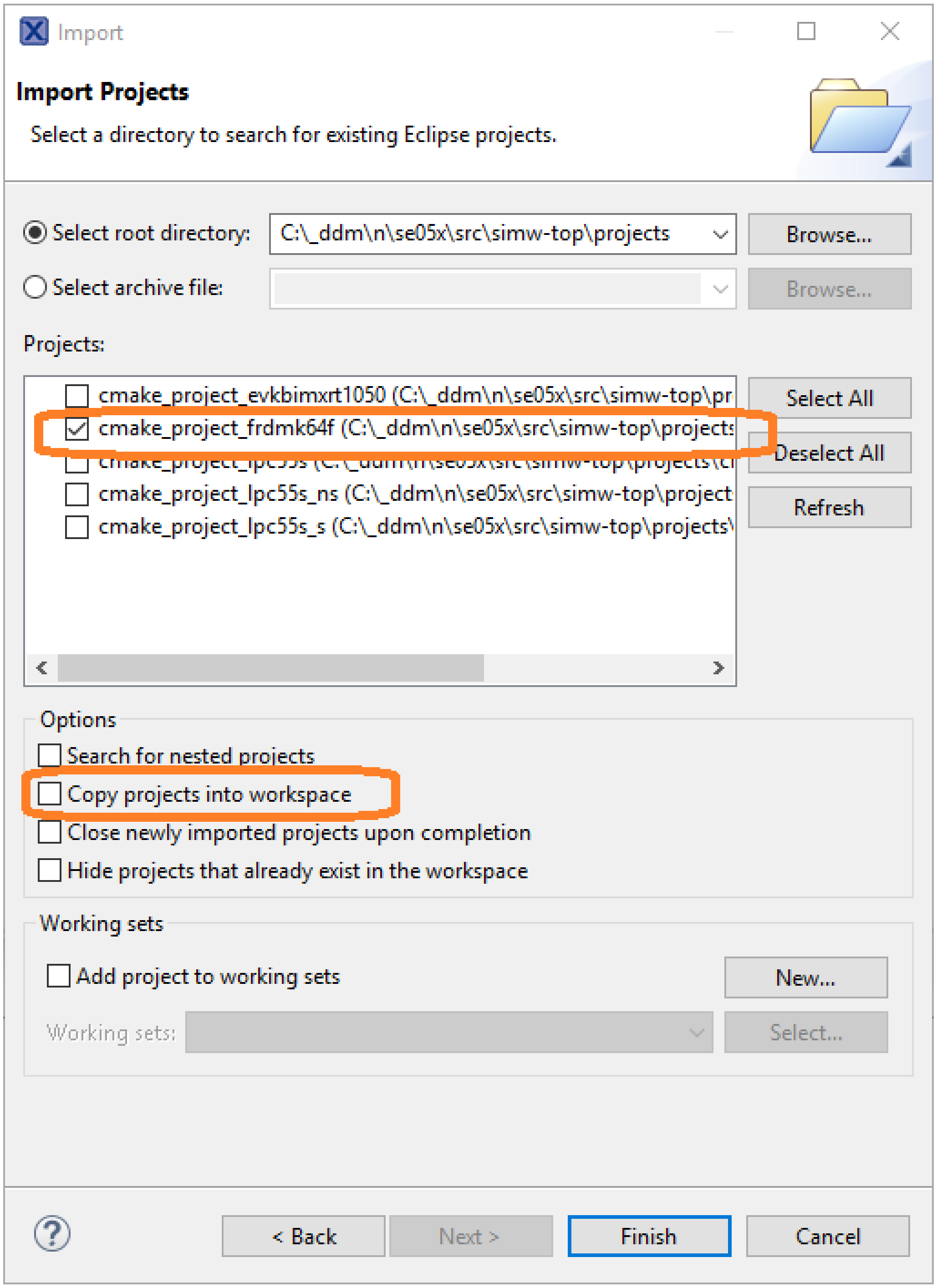
Working sets

☐ Add project to working sets

Working sets:

- Then import the project from “projects” directory. Import only the project for your board. In this case we import `cmake_project_XXXX`, where **XXXX** is the board name. This project is used to *debug* and *download* to the target. It’s a manually maintained project.

  Never select “Copy projects into workspace” for this CMake configuration.



Import Projects

Select a directory to search for existing Eclipse projects.

● Select root directory: C:_ddm\n\se05x\src\simw-top\projects

○ Select archive file:

Projects:

- ☐ cmake_project_evkbimxrt1050 (C:_ddm\n\se05x\src\simw-top\pr
- ☑ cmake_project_frdmk64f (C:_ddm\n\se05x\src\simw-top\projects
- ☐ cmake_project_lpc55s (C:_ddm\n\se05x\src\simw-top\projects\c
- ☐ cmake_project_lpc55s_ns (C:_ddm\n\se05x\src\simw-top\project
- ☐ cmake_project_lpc55s_s (C:_ddm\n\se05x\src\simw-top\projects\

Options

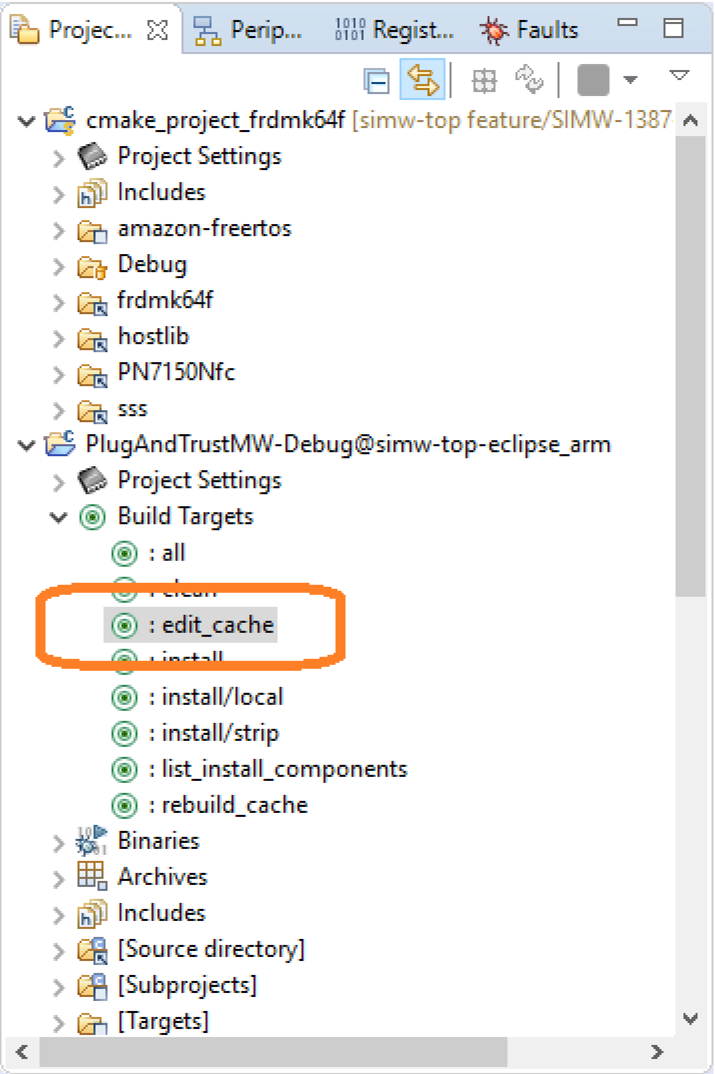
- ☐ Search for nested projects
- ☐ Copy projects into workspace
- ☐ Close newly imported projects upon completion
- ☐ Hide projects that already exist in the workspace

Working sets

- ☐ Add project to working sets

Working sets:

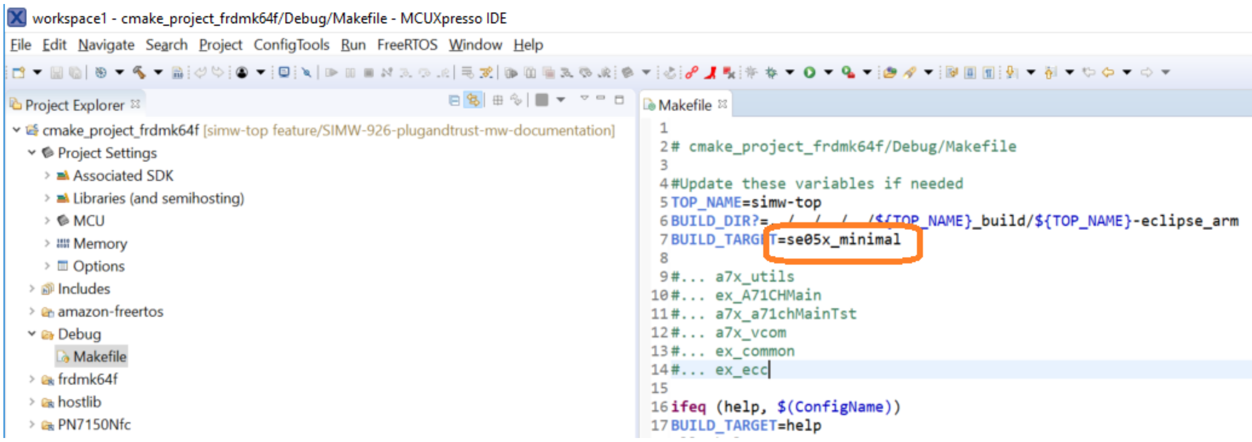
- You may have to run cmake's `edit_cache` to change the configuration of your example. e.g. choice of RTOS, Applet, Board, optimization level, etc.



- You would mostly have to change the target that you want to build and download. Modify `cmake_project_XXXX/Debug/Makefile`.

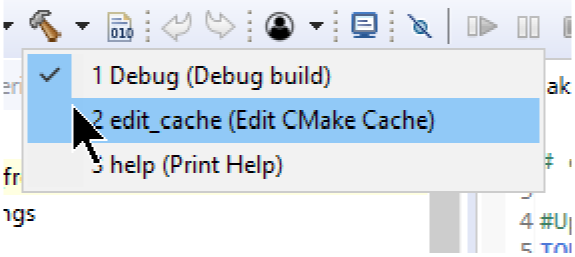
  As you can see, the default selection is `se05x_Minimal`.

  You can run the help target of this project a shown in next image to see which projects are supported.



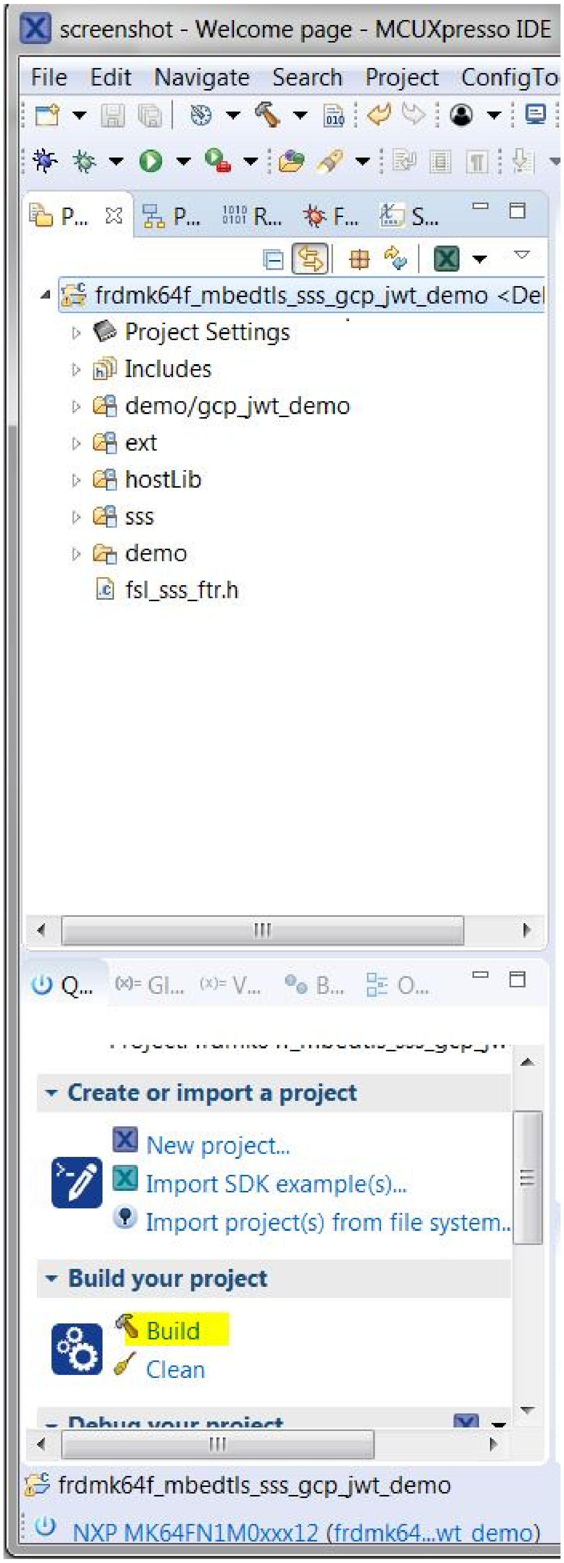
```

# cmake_project_frdmk64f/Debug/Makefile

#Update these variables if needed
TOP_NAME=simw-top
BUILD_DIR?=../../../../${TOP_NAME}_build/${TOP_NAME}-eclipse_arm
BUILD_TARGET=se05x_minimal

#... a7x_utils
#... ex_A71CHMain
#... a7x_a71chMainTst
#... a7x_vcom
#... ex_common
#... ex_ecc

ifeq (help, $(ConfigName))
BUILD_TARGET=help
```

- `cmake_project_XXXX` project's settings also supports helpful target to edit_cache or list supported projects by that configuration.

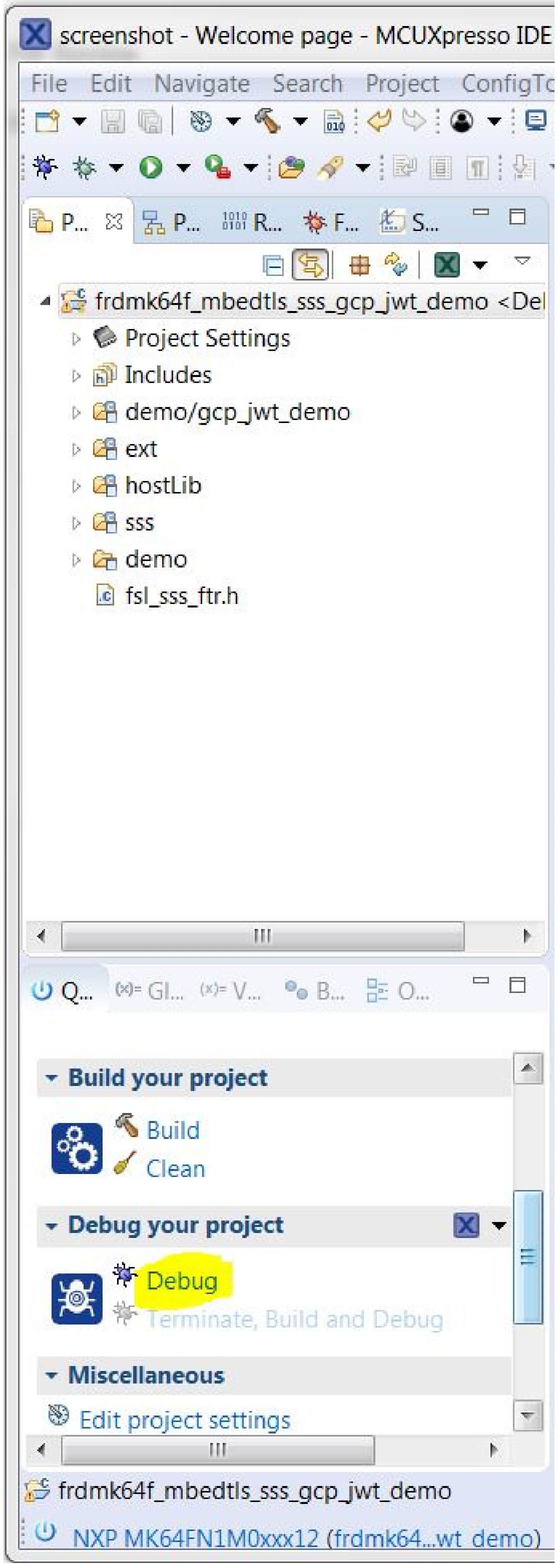


4.3.3 Running / Debugging example

- Click on Build to compile and generate the executables

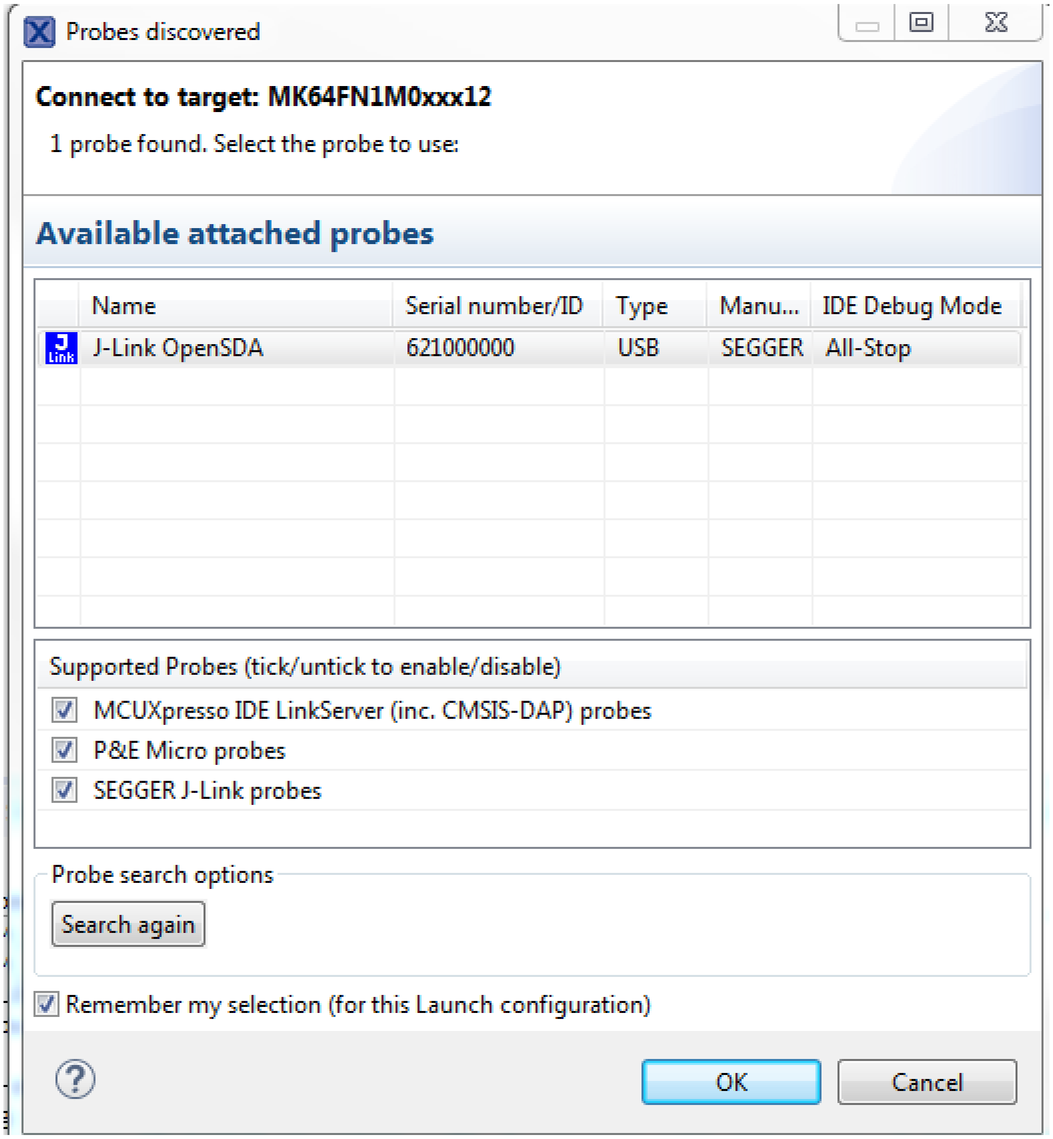

screenshot - Welcome page - MCUXpresso IDE
File Edit Navigate Search Project ConfigTo
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo <Del
Project Settings
Includes
demo/gcp_jwt_demo
ext
hostLib
sss
demo
fsl_sss_ftr.h
Q... Gl... V... B... O...
Create or import a project
New project...
Import SDK example(s)...
Import project(s) from file system...
Build your project
Build
Clean
frdmk64f_mbedtls_sss_gcp_jwt_demo
NXP MK64FN1M0xxx12 (frdmk64...wt_demo)

- Click on debug to program the binary into the device


screenshot - Welcome page - MCUXpresso IDE
File Edit Navigate Search Project ConfigTo
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo <Del
Project Settings
Includes
demo/gcp_jwt_demo
ext
hostLib
sss
demo
fsl_sss_ftr.h
Q... Gl... V... B... O...
Build your project
Build
Clean
Debug your project
Debug
Terminate, Build and Debug
Miscellaneous
Edit project settings
frdmk64f_mbedtls_sss_gcp_jwt_demo
NXP MK64FN1M0xxx12 (frdmk64...wt_demo)

- Select J-Link OpenSDA and click on OK. For more details on OpenSDA, refer to

https://www.nxp.com/support/developer-resources/run-time-software/kinetis-developer-resources/ides-for-kinetis-mcus/opensda-serial-and-debug-adapter:OPENSDA



Connect to target: MK64FN1M0xxx12

1 probe found. Select the probe to use:

Available attached probes

Name	Serial number/ID	Type	Manu...	IDE Debug Mode
J-Link OpenSDA	621000000	USB	SEGGER	All-Stop

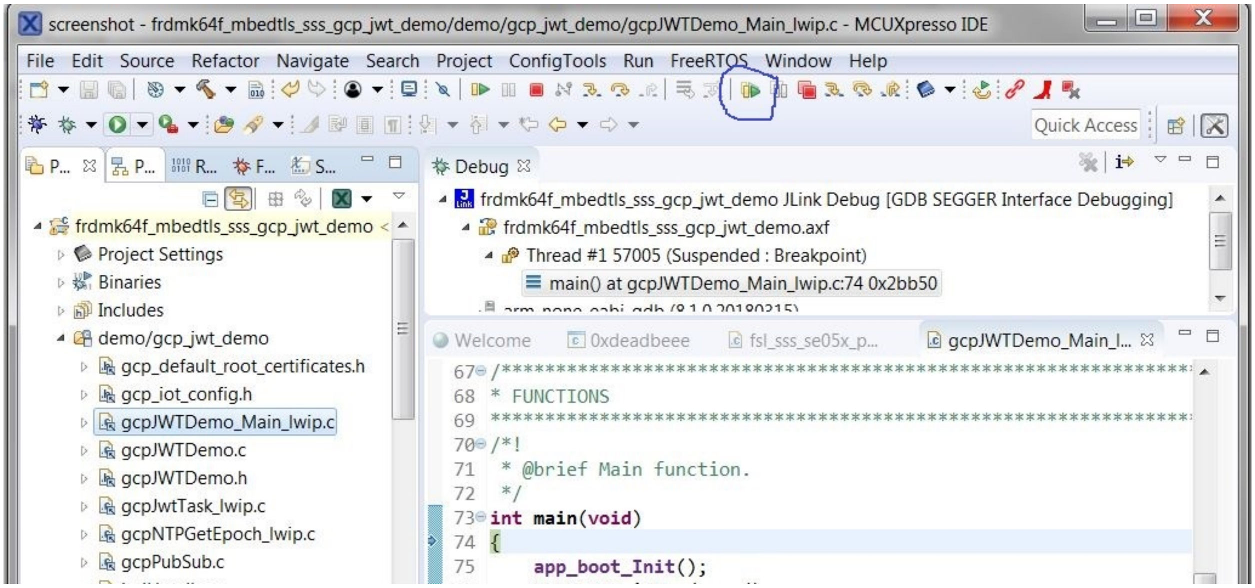
Supported Probes (tick/untick to enable/disable)

☑ MCUXpresso IDE LinkServer (inc. CMSIS-DAP) probes
☑ P&E Micro probes
☑ SEGGER J-Link probes

Probe search options

☑ Remember my selection (for this Launch configuration)

- Click on the Resume button to start program execution


screenshot - frdmk64f_mbedtls_sss_gcp_jwt_demo/demo/gcp_jwt_demo/gcpJWTDemo_Main_lwip.c - MCUXpresso IDE
File Edit Source Refactor Navigate Search Project ConfigTools Run FreeRTOS Window Help
Quick Access
P... P... R... F... S...
frdmk64f_mbedtls_sss_gcp_jwt_demo
Project Settings
Binaries
Includes
demo/gcp_jwt_demo
gcp_default_root_certificates.h
gcp_iot_config.h
gcpJWTDemo_Main_lwip.c
gcpJWTDemo.c
gcpJWTDemo.h
gcpJwtTask_lwip.c
gcpNTPGetEpoch_lwip.c
gcpPubSub.c
Debug
frdmk64f_mbedtls_sss_gcp_jwt_demo JLink Debug [GDB SEGGER Interface Debugging]
frdmk64f_mbedtls_sss_gcp_jwt_demo.axf
Thread #1 57005 (Suspended : Breakpoint)
main() at gcpJWTDemo_Main_lwip.c:74 0x2bb50
Welcome
0xdeadbeee
fsl_sss_se05x_p...
gcpJWTDemo_Main_l...

```
/*********************************************************************
 * FUNCTIONS
 *********************************************************************
/*!
 * @brief Main function.
 */
int main(void)
{
    app_boot_Init();
```

4.3.4 Logging on console

For UART, a serial terminal application(for e.g Tera Term) on PC for VCOM serial device needs to be configured as follows (in Tera Term goto `Setup` –> `Serial port`)

- 115200 baud rate
- 8 data bits
- No parity
- One stop bit
- No flow control

Once the program execution begins, logs are printed on the terminal(e.g. Tera Term) indicating the status of execution and test results. The ATR and the various module versions are printed followed by a SELECT-DONE after which the respective test logs are printed.

4.4 i.MX Linux Build

4.4.1 Prerequisite

Linux should be running on e.g. the MCIMX8M-EVK or MCIMX6UL-EVK development board. Refer to *Setup i.MX 8MQuad - MCIMX8M-EVK* for details on preparing the platform.

4.4.2 Build Instructions

1) Copy the plug and trust middleware package to the i.MX file system
2) Execute the below commands to build and install the se05x libraries on the system:

```
cd simw-top
python scripts/create_cmake_projects.py # invoke this only once
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

Default cmake options are shown below:

```
Applet                              SE050_C
Host                                iMXLinux
HostCrypto                          OPENSSL
IOT                                 GCP
OpenSSL                             1_1_1
RTOS                                Default
SCP                                 None
SE05X_Auth                          None
SMCOM                               T1oI2C
WithCodeCoverage                    OFF
WithNXPNFCRdLib                     OFF
WithSSS_TestCounterPart             ON
WithSharedLIB                       OFF
mbedTLS_ALT                         None
```

To get the list of enabled cmake options, execute the following command from the build area:

```
cmake -L .
```

3) If required cmake options can be changed and libraries can be rebuilt and installed. Refer to *CMake*

```
cd simw-top_build/imx_native_se050_t1oi2c
ccmake .
```

ccmake (i.e. a text-ui to cmake) is not available by default on the Yocto distribution for i.MX.

An alternative approach to change cmake options is to set them on the command line.

Explicitly overruling cmake options (in this case changing SE05X_Auth to UserID):

```
cd simw-top_build/imx_native_se050_t1oi2c
cmake -DSE05X_Auth=UserID .
cmake --build .
```

An easier approach is to use the script `simw-top/scripts/cmake_options` to enable command line completion of the available cmake options. First source the convenience script (`simw-top/scripts/cmake_options`). In the fragment below the SW is built with the same SE05X_Auth option as above:

```
cd simw-top
source scripts/cmake_options.sh
cd simw-top_build/imx_native_se050_t1oi2c
echo ${do # type double tab to enable command line completion hints

${doPTMW_Applet_A71CH_ON}                 ${doPTMW_Host_evkmimxrt1060_ON}
${doPTMW_SE05X_Auth_AESKey_ON}            ${doPTMW_SE05X_Auth_None_ON}
${doPTMW_Applet_A71CL_ON}                 ${doPTMW_Host_frdmk64f_ON}
...
...
${doPTMW_Host_Win10IoT_ON}                ${doPTMW_SCP_SCP03_SSS_ON}
```

(continues on next page)

(continued from previous page)

```
cmake ${doPTMW_SE05X_Auth_UserID_ON} .
cmake --build .
```

Note: The SW package also includes an install script (`scripts/imx/se05x_mw_install.sh`) that assists in installing the Plug&Trust MW on the iMX:

- Copy the Plug&Trust MW zip file into directory `/home/root/install`
- Copy the install script `scripts/imx/se05x_mw_install.sh` into directory `/home/root/install`
- Execute:

```
cd /home/root/install
chmod 755 se05x_mw_install.sh
./se05x_mw_install.sh <Plug&Trust>.zip
```

4.4.3 SSS Examples

Above build steps will also create a few examples that illustrate the usage of se05x. Location - `simw-top_build/imx_native_se050_t1oi2c/bin` A subset of these examples is installed (upon executing `make install`) in `/usr/local/bin`.

Refer to *Demo and Examples* for details on these examples and for running cloud/tls demo applications

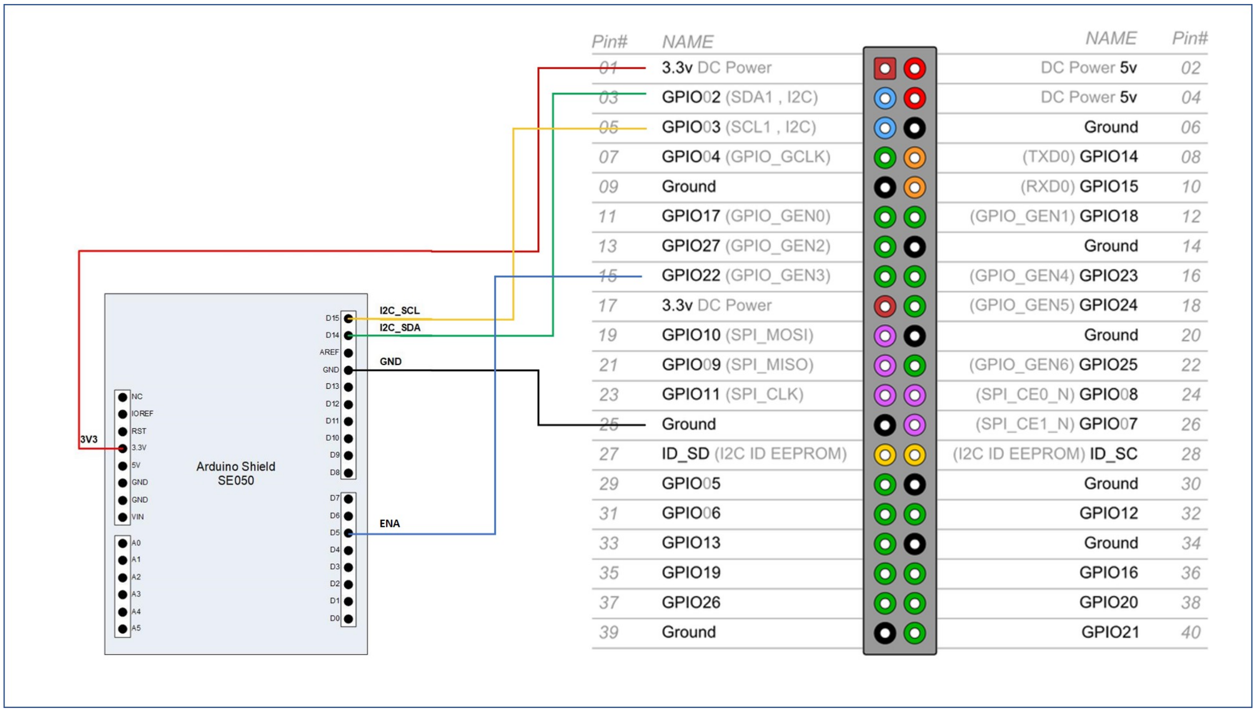
4.5 Raspberry Pi Build

Also Refer - https://www.nxp.com/docs/en/application-note/AN12570.pdf

4.5.1 Prerequisite

Linux should be running on the Raspberry Pi development board, the release was tested with Raspbian Buster (4.19.75-v7l+)

4.5.2 Connecting SE05X with RaspberryPi



4.5.3 Enable Pin configuration for SE05X

Connect GPIO22 (P1_15) to enable pin of SE05X as indicated in the image above.

4.5.4 Build Instructions

1) Copy the Plug & Trust middleware package to the raspberry pi file system
2) Install required build tools, if the image does not have them already
3) Enable I2C if not yet enabled on your board. If `ls /sys/bus/i2c/devices` does not list `i2c-1`,

   I2C needs to be enabled for your board..

   - Run `sudo raspi-config`
   - Use the down arrow to select `Interfacing Options`.
   - Follow instructions and Enable I2C
4) Install extra build tools. e.g. on `2019-07-10-raspbian-buster-lite.img`, following packages are also required:

```
sudo apt-get install cmake cmake-curses-gui cmake-gui libssl-dev libsystemd-dev
```

5) Execute the below commands to build and install the se05x libraries to the system

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/raspberrypi_native_se050_t1oi2c
```

(continues on next page)

(continued from previous page)

```
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: If autodetection of RaspberryPi fails run the command with arguement `python scripts/create_cmake_projects.py rpi`

Default cmake options are shown below:

```
Applet                            SE050_C
 CMAKE_BUILD_TYPE                  Debug
CMAKE_INSTALL_PREFIX              /usr/local
Host                              Raspbian
HostCrypto                        OPENSSL
IOT                               GCP
Log                               Verbose
NXPInternal                       ON
OpenSSL                           1_1_1
RTOS                              Default
SCP                               None
SE05X_Auth                        None
SMCOM                             VCOM
SSS_HAVE_FIPS                     0
WithCodeCoverage                  OFF
WithNXPNFCRdLib                   OFF
WithSSS_TestCounterPart           ON
WithSharedLIB                     OFF
mbedTLS_ALT                       None
```

6) If required cmake options can be changes and libraries can be rebuilt and installed. Refer *CMake*

```
cd simw-top_build/raspberrypi_native_se050_t1oi2c

# With Gui
cmake-gui .
```

The `cmake-gui` will bring up CMake GUI that can set up command with bring up the CMake UI using which options like logging level, etc. can be changed.

If you are connected to Raspberry PI over a command line terminal, (which does not have GUI), you can use `ccmake .` instead of `cmake-gui .`

4.5.5 SSS Examples

Above build steps will also build few sample examples for se05x test. Location: `simw-top_build/raspberrypi_native_se050_t1oi2c/bin`

Refer *Demo and Examples* for details on these examples and for running cloud/tls demo applications

4.6 CMake

CMake is an open-source, cross-platform family of tools designed to build, test and package software. CMake is used to control the software compilation process using simple platform and compiler independent configuration files, and generate native makefiles and workspaces that can be used in the compiler environment of your choice. (From https://cmake.org/). CMake can be downloaded from https://cmake.org/download/.

4.6.1 Reference Commands

We recommend to use out of the source build of Cmake and run it from other directory.

A reference command to compiling for SE050_C from Windows PC is:

```
cd <ROOT_DIR>
mkdir ..\build_se050
cd ..\build_se050
cmake ..\<ROOT_DIR> -DApplet=SE050_C -DHost=PCWindows
```

A helper python script `scripts\create_cmake_projects.py` is available as a part of the project.

Sample usage on Windows is:

```
call <ROOT_DIR>\scripts\env_setup.bat
python scripts\create_cmake_projects.py
```

Sample usage on Linux/POSIX is:

```
. <ROOT_DIR>/scripts/env_setup.sh
python scripts/create_cmake_projects.py
```

This will create a `<ROOT_DIR>_build` directory with some reference CMake projects.

Warning: It is recommend to keep `<ROOT_DIR>` to:

- A small path as much as possible. i.e. Closer to top most directory of the drive, instead of a deep long path.
- Is kept in a path that does not have spaces in it. This avoids issues faced with building some times.

Note: For sample paths of installation tools, please see `scripts\env_setup.bat` and `scripts/env_setup.sh`

4.6.2 CMake - Cross compiling

CMake can also be used for cross compiling for non native platforms. For that tool-chain files have to be used. As part of the Plug & Trust Middleware the following files are used.

Android `$NDK_ROOT/build/cmake/android.toolchain.cmake`

iMX6 `scripts/ToolchainFile_imx6.cmake`

FRDM K64F `scripts/armgcc_force_cpp.cmake`

`NDK_ROOT` is the environment variable set by Android Build system.

4.7 CMake Options

4.7.1 PTMW_Applet

`PTMW_Applet`

The Secure Element Applet

You can compile host library for different Applets listed below. Please note, some of these Applets may be for NXP Internal use only.

`-DPTMW_Applet=None`: Compiling without any Applet Support

`-DPTMW_Applet=A71CH`: A71CH (ECC)

`-DPTMW_Applet=SE05X_A`: SE050 Type A (ECC)

`-DPTMW_Applet=SE05X_B`: SE050 Type B (RSA)

`-DPTMW_Applet=SE05X_C`: SE050 (Super set of A + B)

`-DPTMW_Applet=SE051_H`: SE051 with SPAKE Support

`-DPTMW_Applet=AUTH`: AUTH

`-DPTMW_Applet=SE050_E`: SE050E

4.7.2 PTMW_SE05X_Ver

`PTMW_SE05X_Ver`

SE05X Applet version.

Selection of Applet version 03_XX enables SE050 features. Selection of Applet version 06_00 enables SE051 features.

`-DPTMW_SE05X_Ver=03_XX`: SE050

`-DPTMW_SE05X_Ver=06_00`: SE051

`-DPTMW_SE05X_Ver=07_02`: SE051

4.7.3 PTMW_Host

`PTMW_Host`

Host where the software stack is running

e.g. Windows, PC Linux, Embedded Linux, Kinetis like embedded platform

`-DPTMW_Host=Darwin`: OS X / Macintosh

`-DPTMW_Host=PCLinux32`: PC/Laptop Linux with 32bit libraries

`-DPTMW_Host=PCLinux64`: PC/Laptop Linux with 64bit libraries

`-DPTMW_Host=PCWindows`: PC/Laptop Windows

`-DPTMW_Host=Cygwin`: Using Cygwin

`-DPTMW_Host=frdmk64f`: Embedded Kinetis Freedom K64F

`-DPTMW_Host=evkmimxrt1060`: Embedded Kinetis i.MX RT 1060

`-DPTMW_Host=evkmimxrt1170`: Embedded Kinetis i.MX RT1170

`-DPTMW_Host=lpcxpresso55s`: Embedded LPCXpresso55s (No demarcation of secure/non-secure world)

`-DPTMW_Host=lpcxpresso55s_ns`: Non Secure world of LPCXpresso55s

`-DPTMW_Host=lpcxpresso55s_s`: Secure world of LPCXpresso55s

`-DPTMW_Host=iMXLinux`: Embedded Linux on i.MX

`-DPTMW_Host=Raspbian`: Embedded Linux on RaspBerry PI

`-DPTMW_Host=Android`: Android

4.7.4 PTMW_SMCOM

`PTMW_SMCOM`

Communication Interface

How the host library communicates to the Secure Element. This may be directly over an I2C interface on embedded platform. Or sometimes over Remote protocol like JRCP_V1 / JRCP_V1_AM / JRCP_V2 / VCOM from PC.

`-DPTMW_SMCOM=None`: Not using any Communication layer

`-DPTMW_SMCOM=JRCP_V2`: Socket Interface New Implementation

`-DPTMW_SMCOM=JRCP_V1`: Socket Interface Old Implementation. This is the interface used from Host PC when when we run jrcpv1_server from the linux PC.

`-DPTMW_SMCOM=JRCP_V1_AM`: JRCP_V1 extended with Access manager features

`-DPTMW_SMCOM=VCOM`: Virtual COM Port

`-DPTMW_SMCOM=SCI2C`: Smart Card I2C for A71CH and A71CH

`-DPTMW_SMCOM=T1oI2C`: T=1 over I2C for SE050

`-DPTMW_SMCOM=PCSC`: CCID PC/SC reader interface

4.7.5 PTMW_HostCrypto

`PTMW_HostCrypto`

Counterpart Crypto on Host

What is being used as a cryptographic library on the host. As of now only OpenSSL / mbedTLS is supported

`-DPTMW_HostCrypto=MBEDTLS`: Use mbedTLS as host crypto

`-DPTMW_HostCrypto=OPENSSL`: Use OpenSSL as host crypto

`-DPTMW_HostCrypto=User`: User Implementation of Host Crypto e.g. Files at `sss/src/user/crypto` have low level AES/CMAC primitives. The files at `sss/src/user` use those primitives. This becomes an example for users with their own AES Implementation This then becomes integration without mbedTLS/OpenSSL for SCP03 / AESKey.

Note: ECKey abstraction is not implemented/available yet.

`-DPTMW_HostCrypto=None`: NO Host Crypto Note, this is unsecure and only provided for experimentation on platforms that do not have an mbedTLS PORT Many *Feature Control* have to be disabled to have a valid build.

4.7.6 PTMW_RTOS

`PTMW_RTOS`

Choice of Operating system

Default would mean nothing special. i.e. Without any RTOS on embedded system, or default APIs on PC/Linux

`-DPTMW_RTOS=Default`: No specific RTOS. Either bare matal on embedded system or native linux or Windows OS

`-DPTMW_RTOS=FreeRTOS`: Free RTOS for embedded systems

4.7.7 PTMW_mbedTLS_ALT

`PTMW_mbedTLS_ALT`

ALT Engine implementation for mbedTLS

When set to None, mbedTLS would not use ALT Implementation to connect to / use Secure Element. This needs to be set to SSS for Cloud Demos over SSS APIs

`-DPTMW_mbedTLS_ALT=SSS`: Use SSS Layer ALT implementation

`-DPTMW_mbedTLS_ALT=A71CH`: Legacy implementation

`-DPTMW_mbedTLS_ALT=PSA`: Enable TF-M based on PSA as ALT

`-DPTMW_mbedTLS_ALT=None`: Not using any mbedTLS_ALT

> When this is selected, cloud demos can not work with mbedTLS

4.7.8 PTMW_SCP

`PTMW_SCP`

Secure Channel Protocol

In case we enable secure channel to Secure Element, which interface to be used.

`-DPTMW_SCP=None`

`-DPTMW_SCP=SCP03_SSS`: Use SSS Layer for SCP. Used for SE050 family.

`-DPTMW_SCP=SCP03_HostCrypto`: Use Host Crypto Layer for SCP03. Legacy implementation. Used for older demos of A71CH Family.

4.7.9 PTMW_FIPS

`PTMW_FIPS`

Enable or disable FIPS

This selection mostly impacts tests, and generally not the actual Middleware

`-DPTMW_FIPS=None`: NO FIPS

`-DPTMW_FIPS=SE050`: SE050 IC FIPS

4.7.10 PTMW_SBL

`PTMW_SBL`

Enable/Disable SBL Bootable support

This option is to enable/disable boot from SBL by switching linker address

`-DPTMW_SBL=None`: Not SBL bootable

`-DPTMW_SBL=SBL_LPC55S`: SE050 based LPC55S SBL bootable

4.7.11 PTMW_SE05X_Auth

`PTMW_SE05X_Auth`

SE050 Authentication

This settings is used by examples to connect using various options to authenticate with the Applet. The SE05X_Auth options can be changed for KSDK Demos and Examples. To change SE05X_Auth option follow below steps. Set flag `SSS_HAVE_SCP_SCP03_SSS` to 1 and Reset flag `SSS_HAVE_SCP_NONE` to 0. To change SE05X_Auth option other than `None` and `PlatfSCP03`, execute se05x_Delete_and_test_provision.exe in order to provision the Authentication Key. To change SE05X_Auth option to `ECKey` or `ECKey_PlatfSCP03`, Set additional flag `SSS_HAVE_HOSTCRYPTO_ANY` to 1.

`-DPTMW_SE05X_Auth=None`: Use the default session (i.e. session less) login

`-DPTMW_SE05X_Auth=UserID`: Do User Authentication with UserID

`-DPTMW_SE05X_Auth=PlatfSCP03`: Use Platform SCP for connection to SE

`-DPTMW_SE05X_Auth=AESKey`: Do User Authentication with AES Key Earlier this was called AppletSCP03

`-DPTMW_SE05X_Auth=ECKey`: Do User Authentication with EC Key Earlier this was called FastSCP

`-DPTMW_SE05X_Auth=UserID_PlatfSCP03`: UserID and PlatfSCP03

`-DPTMW_SE05X_Auth=AESKey_PlatfSCP03`: AESKey and PlatfSCP03

`-DPTMW_SE05X_Auth=ECKey_PlatfSCP03`: ECKey and PlatfSCP03

4.7.12 PTMW_A71CH_AUTH

`PTMW_A71CH_AUTH`

A71CH Authentication

This settings is used by SSS-API based examples to connect using either plain or authenticated to the A71CH.

`-DPTMW_A71CH_AUTH=None`: Plain communication, not authenticated or encrypted

`-DPTMW_A71CH_AUTH=SCP03`: SCP03 enabled

4.7.13 PTMW_Log

`PTMW_Log`

Logging

`-DPTMW_Log=Default`: Default Logging

`-DPTMW_Log=Verbose`: Very Verbose logging

`-DPTMW_Log=Silent`: Totally silent logging

4.7.14 CMAKE_BUILD_TYPE

`CMAKE_BUILD_TYPE`

See https://cmake.org/cmake/help/latest/variable/CMAKE_BUILD_TYPE.html

For embedded builds, this choices sets optimization levels. For MSVC builds, build type is selected from IDE As well

`-DCMAKE_BUILD_TYPE=Debug`: For developer

`-DCMAKE_BUILD_TYPE=Release`: Optimization enabled and debug symbols removed

`-DCMAKE_BUILD_TYPE=RelWithDebInfo`: Optimization enabled but with debug symbols

`-DCMAKE_BUILD_TYPE=`: Empty Allowed

4.7.15 Feature Control

Using these options, you can enable/disable individual features.

See Section 3.8.4 *Using feature file to reduce code size* for details on it's usage and relevance.

`SSSFTR_SE05X_AES`

SE05X Secure Element : Symmetric AES

`SSSFTR_SE05X_ECC`

SE05X Secure Element : Elliptic Curve Cryptography

`SSSFTR_SE05X_RSA`

SE05X Secure Element : RSA

`SSSFTR_SE05X_KEY_SET`

SE05X Secure Element : KEY operations : SET Key

`SSSFTR_SE05X_KEY_GET`

SE05X Secure Element : KEY operations : GET Key

`SSSFTR_SE05X_AuthECKey`

SE05X Secure Element : Authenticate via ECKey

`SSSFTR_SE05X_AuthSession`

SE05X Secure Element : Allow creation of user/authenticated session.

If the intended deployment only uses Platform SCP Or it is a pure session less integration, this can save some code size.

`SSSFTR_SE05X_CREATE_DELETE_CRYPTOOBJ`

SE05X Secure Element : Allow creation/deletion of Crypto Objects

If disabled, new Crytpo Objects are neither created and old/existing Crypto Objects are not deleted. It is assumed that during provisioning phase, the required Crypto Objects are pre-created or they are never going to be needed.

`SSSFTR_SW_AES`

Software : Symmetric AES

`SSSFTR_SW_ECC`

Software : Elliptic Curve Cryptography

`SSSFTR_SW_RSA`

Software : RSA

SSSFTR_SW_KEY_SET
Software : KEY operations : SET Key

SSSFTR_SW_KEY_GET
Software : KEY operations : GET Key

SSSFTR_SW_TESTCOUNTERPART
Software : Used as a test counterpart

e.g. Major part of the mebdTLS SSS layer is purely used for testing of Secure Element implementation, and can be avoided fully during many production scenarios.

4.7.16 Deprecated Defines

Keept and for time being for backwards compatibility. They will be removed in some future release.

WithNXPNFCRdLib

- Compile in NXP NFC RdLib support
- Default is OFF
- Use NXP NFC RdLib. This is used mainly for RC663 + SAM Use Cases. Package available under NDA is needed to use this feature

WithOPCUA_open62541

- Compile With open62541 Support
- Default is OFF
- Compile with OPC UA. By default it is disabled from compilation.

WithSharedLIB

- Create and use shared libraries
- Default is OFF
- Create shared libraries. Applicable for Engine DLL and other use cases.

WithAccessMgr_UnixSocket

- Compile Access Manager with UNIX socket support (Default is STREAM sockets).
- Default is OFF
- Compile Access Manager with unix socket support.

4.7.17 NXP Internal Options

These options are not supported outside NXP.

NXPInternal

- NXP Internal
- Default is OFF. (ON only within NXP)

Note: For deliveries outside NXP, this option is disabled.

WithCodeCoverage

- Compile with Code Coverage
- Default is OFF

4.7.18 Other Variables

`WithExtCustomerTPMCode`

- Include code from ../customer/tpm2
- Default is OFF
- Include code from external tpm2 folder. This way, TPM code can be included in build from outside the simw-top repository.

`SIMW_INSTALL_INC_DIR`

- Location where library header files are installed for linux based targets. (Used for iMX Linux)
- Default location is `</usr/local/>include/se05x`

`SIMW_INSTALL_SHARE_DIR`

- Location where miscellaneous scripts get copiled for linux based targets. (Used for iMX Linux)
- e.g. `cmake_options.mak` which has current cmake build settings.
- Default location is `</usr/local/>share/se05x`

CHAPTER

FIVE

DEMO AND EXAMPLES

Some of the examples below can be run on windows or raspberry-pi with optional connection string (VCOM or I2C address) as command line argument. When running examples on raspberry pi connection string of secured element should be passed in the format `<i2c_port>:<i2c_addr>`

Example Raspberry Pi:

```
./ex_ecc "/dev/i2c-1:0x48"
```

On Windows with VCOM:

```
ex_ecc.exe COM1
```

5.1 Demo List

5.1.1 DEMO List

Platforms List

KSDK Embedded platforms like FRDM K64F, i.MX RT1060, LPC55S

KSDK-CLOUD Embedded platforms like FRDM K64F, i.MX RT1060, LPC55S, that can connect to cloud.

LINUX Linux based platforms/systems like iMX6, iMX8, Raspberry Pi

PC Windows PC

ALL **KSDK**, **LINUX**, **PC**

SSS APIs Examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.2.1	*ECC Example* Inject ECC Key and use it for sign and verify operation	**ALL**	SE05X (A and C), A71CH	
Section 5.2.1	*RSA Example* Generate RSA key and use it for signin and verify operation	**ALL**	SE05X (B and C)	
Section 5.2.1	*Symmetric AES Example* Inject AES key, encrypt and decrypt data with it	**ALL**	SE05X	
Section 5.2.1	*HKDF Example* HMAC Key derivation operation based on the info and salt. Inject HMAC key into SE and derive a key using HMAC from the SE into the host keystore	**ALL**	SE05X, A71CH	
Section 5.2.1	*Message Digest Example* Message Digest hashing operation. Calculate SHA256 over data.	**ALL**	SE05X, A71CH	
Section 5.2.1	*HMAC Example* Inject HMAC key and calculate a HMAC	**ALL**	SE05X, A71CH	
Section 5.2.1	*ECDH Example* Inject ECC key into SE and derive a key using ECDH from the SE into the host keystore.	**ALL**	SE05X, A71CH	
Section 5.2.1	*ECDAA Example* Generate ECC Barreto-Naehrig key into SE and perform sign operation (ECDAA).	**ALL**	SE05X (A and C)	

Cloud connectivity Examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.3.1	*AWS Demo for KSDK* Connect to Amazon Web Services IoT Core	**KSDK-CLOUD**	SE05X, A71CH	
Section 5.3.2	*AWS Demo for iMX Linux / RaspberryPi* Connect to Amazon Web Services	**LINUX**	SE05X, A71CH	
Section 5.3.3	*GCP Demo for KSDK* Connect to Google Cloud	**KSDK-CLOUD**	SE05X, A71CH	
Section 5.3.4	*GCP Demo for iMX Linux / Raspberry Pi* Connect to Google Cloud	**LINUX**	SE05X, A71CH	
Section 5.3.5	*IBM Watson Demo for KSDK* Connect to IBM Watson	**KSDK-CLOUD**	SE05X, A71CH	
Section 5.3.6	*IBM Watson Demo for iMX Linux / Raspberry Pi* Connect to IBM Watson	**LINUX**	SE05X, A71CH	
Section 5.3.7	*Azure Demo for KSDK* Connect to Microsoft Azure	**KSDK-CLOUD**	SE05X, A71CH	
Section 5.3.8	*Azure Demo for iMX Linux / Raspberry Pi* Connect to Microsoft Azure	**LINUX**	SE05X, A71CH	
Section 5.4.1	*Greengrass Demo for Linux* Connect as AWS Greengrass Core	**Raspberry PI**	SE05X	

OpenSSL Engine Examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.4.2	*OpenSSL Engine: TLS Client example for iMX/Rpi3* Setting up a TLS Link using OpenSSL Engine	**LINUX**	SE05X, A71CH	

mbedTLS Examples

Demos regarding the mbedTLS ALT implementation. See *Introduction on mbedTLS ALT Implementation*

Demo	Description	Platforms supported	SE supported	Authentication required
SSL2 Client	Use extended SSL Client 2 & SSL Server 2 from mbedTLS	**PC**	SE05X, A71CH	
DTLS Client	Use extended dtls_client & dtls_server from mbedTLS	**PC**	SE05X, A71CH	

OPC UA Examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.5.1	*OPC UA (Open62541) Demo* OPC UA Server	**PC**, **iMX6**	SE05X	

PSA / TF-M Examples

Demo	Description	Platforms supported	Authentication required
Section 5.6.1	*PSA Non Secure Example* PSA Secure Non-secure example	**LPC55S**	

SE05X Specific Examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.7.1	*SE05X Minimal example* Showcase usage of SE05X low level APIs	**ALL**	SE05X	
Section 5.7.2	*SE05X Get Info example* Showcase Platform details of SE05X	**ALL**	SE05X	
Section 5.7.3	*APDU Player Demo* Send RAW APDUs to SE050	**PC**, **LINUX**	SE05X	None / PlatformSCP03
Section 5.7.4	*Using policies for secure objects* Showcase usage of policies	**ALL**	SE05X	
Section 5.7.5	*Get Certificate from the SE* Read the certificate from the SE and store it on the file system.	**ALL** (With mbedTLS Only)	SE05X	
Section 5.7.6	*SE05X Rotate PlatformSCP Keys Demo* Showcase Rotation of SE05X PlatformSCP03 Keys	**ALL**	SE05X	PlatformSCP03
Section 5.7.7	*I2C Master Example* Showcase usage of I2CM interface of SE050	**ALL**	SE05X	
Section 5.7.8	*SE05X WiFi KDF Example* Showcase usage of PBKDF	**ALL**	SE05X	
Section 5.7.9	*SE05X Export Transient objects* Export transient objects	**PC**, **LINUX**	SE05X	
Section 5.7.10	*SE05X Import Transient objects* Import transient objects	**PC**, **LINUX**	SE05X	
Section 5.7.11	*Import External Object Prepare* Create ImportExternlObject raw APDU	**PC**, **LINUX**	SE05X	ECKey
Section 5.7.12	*SE05X Mandate SCP example*	**ALL**	SE05X	
Section 5.7.13	*Read object with Attestation* Demonstrate how to read object with attestation	**ALL**	SE05X	
Section 5.7.14	*SE05X Transport Lock example* Show transport lock feature	**PC**, **LINUX**	SE05X	None / PlatformSCP03
Section 5.7.15	*SE05X Transport UnLock example* Show transport unlock feature	**PC**, **LINUX**	SE05X	None / PlatformSCP03
Section 5.7.16	*SE05X Timestamp* Demonstrate increment of timestamp inside SE	**ALL**	SE05X	
Section 5.7.17	*SE05X PCR example* Demonstrate PCR feature as Policy	**ALL**	SE05X	
Section 5.7.18	*Configuring Applet Features* Demonstrate how to configure applet features	**PC**, **LINUX**	SE05X	ECKey / ECKey-PlatformSCP03 (FEATURE ID)
Section 5.7.19	*Write APDU to buffer* Demonstrate how to write APDU to buffer	**ALL**	SE05X	
Section 5.7.20	*Inject Certificate into SE* Example to showcase injection of certificates into SE	**ALL**	SE05X	
Section 5.7.21	*SE05X Read State example* Example to Read the LockState, RestrictMode and PlatformSCPRequest of SE	**ALL**	SE051	
Section 5.7.22	*SE05X Personalization Remove RSA Key Generation Module* Example to showcase to delete rsa key	**ALL**	SE051	

Examples that use OpenSSL

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.8.1	*Tool to create Reference key file* Native example to generate refKeys. (Only for NIST-P256 curve).	**LINUX**, **PC**	SE05X, A71CH	
Section 5.8.2	*Building a self-signed certificate* Create self signed certificates	**LINUX**, **PC**	SE05X	

NFC (DESFire) Examples

Demos that interact with DESFire card via RC663. These examples can be run from:

- From **KSDK** with RC663
- From PC with FRDM-K64F & RC663

> **Warning:** These examples are only included in a separate MW package (including nxpnfcrdlib). Please contact your NXP FAE or sales for access

Demo	Description	Authentication required
Section 5.10.1	*MIFARE DESFire EV2 : Prepare Secure Element* Prepare/Provision SE050 with reference Keys. This example does not use RC663	
Section 5.10.2	*MIFARE DESFire EV2 : Prepare MFDFEV2* Prepare/Provision DESFireEv2 with reference Keys. This example does not use SE050.	
Section 5.10.4	*MIFARE DESFire EV2 : Authentication* Authenticate MIFARE DESFire EV2 using SE050 & RC663	
Section 5.10.5	*MIFARE DESFire EV2 : Change Key* MIFARE DESFire EV2 Change Key using SE050 & RC663	
Section 5.10.6	*MIFARE DESFire EV2 : Diversified Change Key* MIFARE DESFire EV2 Diversified Change Key using SE050 & RC663	

Ease of Use Configuration Examples

Seps for using the Ease Of Use Configuration of SE050.

Number	Description
Section 5.11.1	*Ease of Use configuration - IBM Watson*
Section 5.11.2	*Ease of Use configuration - Google Cloud Platform*
Section 5.11.3	*Ease of Use configuration - Azure IoT Hub*
Section 5.11.4	*Ease of Use configuration - AWS IoT Console*

SEMS Demos

See *PTMW_Applet*. You need to compile with `-DSE05X_Ver=06_00 -DSE05X_Auth=None`

Demo	Description	Platforms supported	SE Supported
Section 5.12.1	*SEMS Lite Agent Demo (sems_lite_ex_update)*	**ALL**	SE051
Section 5.12.2	*SEMS Lite CLI APP*	**PC**, **LINUX**	SE051

LPC55S-PUF Based examples

Demo	Description	Platforms supported	SE supported	Authentication required
Section 5.13.1	*Key Injection to PUF* Example to demonstrate inject PlatformSCP keys into PUF	**LPC55S**	SE05X	
Section 5.13.2	*Key Rotation using PUF* Example to demonstrate PlatformSCP key rotation using PUF	**LPC55S**	SE05X	PlatformSCP03
Section 5.13.3	*Secure Boot Demo* Example to demonstrate Secure Binding with LPC55S and SE05X using PUF	**LPC55S**	SE05X	PlatformSCP03

EdgeLock 2GO Agent example

Demo	Description	Platforms supported	SE supported	Authentication required
Section 6.8	*EdgeLock 2GO Agent Examples* Example of usage of the EdgeLock 2GO Client	**PC**, **iMX6**, **iMX8**, **FRDM K64F**, **LPC55S**	SE05X	None / PlatformSCP03

5.2 SSS API Examples

5.2.1 SSS API Examples

ECC Example

This project demonstrates Elliptic Curve Cryptography sign and verify operation using SSS APIs

Refer - `simw-top/sss/ex/ecc/ex_sss_ecc.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a elliptic curve cryptography signing and verify operation.

It uses the following APIs and data types:

- *`sss_asymmetric_context_init()`*
- `kAlgorithm_SSS_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Sign` from `sss_mode_t`
- *`sss_asymmetric_sign_digest()`*
- `kMode_SSS_Verify` from `sss_mode_t`
- *`sss_asymmetric_verify_digest()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running Elliptic Curve Cryptography Example ex_sss_ecc.c
App   :INFO :Do Signing
App   :INFO :digest (Len=32)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
App   :INFO :signature (Len=72)
      30 46 02 21    00 C8 4C 40    74 35 42 D7    37 64 03 D9
      B1 1B 9C 0B    44 50 DC 70    1E 92 07 92    78 BC 0E C5
      A4 07 FC 95    09 02 21 00    CA 70 02 36    13 65 47 72
      0F 60 78 59    EA 59 81 82    DF 80 FD 89    2D FC 3E 7D
      B2 FC 51 17    30 9B C4 15
App   :INFO :Signing Successful !!!
App   :INFO :Do Verify
App   :INFO :digest (Len=32)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
App   :INFO :signature (Len=72)
      30 46 02 21    00 C8 4C 40    74 35 42 D7    37 64 03 D9
      B1 1B 9C 0B    44 50 DC 70    1E 92 07 92    78 BC 0E C5
      A4 07 FC 95    09 02 21 00    CA 70 02 36    13 65 47 72
      0F 60 78 59    EA 59 81 82    DF 80 FD 89    2D FC 3E 7D
      B2 FC 51 17    30 9B C4 15
App   :INFO :Verification Successful !!!
App   :INFO :ex_sss_ecc Example Success !!!...
App   :INFO :ex_sss Finished
```

RSA Example

This project demonstrates RSA sign and verify operations using SSS APIs.

Refer - `simw-top/sss/ex/rsa/ex_sss_rsa.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a RSA signing and verify operation.

It uses the following APIs and data types:

- *`sss_asymmetric_context_init()`*
- `kAlgorithm_SSS_RSASSA_PKCS1_PSS_MGF1_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Sign` from `sss_mode_t`
- `kSSS_CipherType_RSA` from :cpp:enumerator: *sss_cipher_type_t*
- *`sss_asymmetric_sign_digest()`*
- `kMode_SSS_Verify` from `sss_mode_t`
- *`sss_asymmetric_verify_digest()`*

Note: This example tries to delete key first. Deletion would be successful, if the key already exists. Otherwise it would return an error message which is perfectly alright and the example could be successfully executed.

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running RSA Example ex_sss_rsa.c
sss   :WARN :nxEnsure:'ret == SM_OK' failed. At Line:5612 Function:sss_se05x_TXn
sss   :WARN :Could not delete Key id EF000046
App   :INFO :Delete key succeeds only if key exists, ignore error message if any
App   :INFO :Do Signing
App   :INFO :digest (Len=32)
      00 01 02 03    04 05 06 07    08 09 0A 0B    0C 0D 0E 0F
      10 11 12 13    14 15 16 17    18 19 1A 1B    1C 1D 1E 1F
App   :INFO :Signing successful !!!
App   :INFO :signature (Len=512)
      60 64 F1 3B    DE 72 F7 91    05 29 A4 1D    AC 48 47 D6
      25 E6 D4 35    67 32 78 37    45 90 03 56    1E B4 97 F5
      2A 09 26 CE    9A 81 4E 24    07 31 1E B4    18 04 BD B8
      88 42 6F 95    C6 3A 8A 6F    09 7B 80 35    4A F6 1D 9F
      19 6F 99 66    F9 61 47 6E    D0 52 8F 80    C5 E4 D3 F6
      A2 37 B0 3A    8B 34 32 A0    00 2D 0D B7    BA 10 19 C9
      58 EB 7D D0    7E E9 47 4E    E1 E7 2C 96    44 0E D5 BF
      4A F4 16 4A    8E BB C0 1C    8F A5 AD C4    64 3A 13 89
      B0 08 03 00    19 1C BD 7C    E1 4A 69 AC    C7 1D B2 A9
      DB 80 68 34    EA B9 96 1C    D8 DE F0 E2    09 CA A0 4D
      35 38 6B FC    88 A3 A2 B8    E9 15 18 7B    5D 81 B4 C6
      53 2D 92 12    5E 7D 84 D1    7A 2E C1 C4    72 6D 5F 29
      95 4E 21 EE    47 AC 29 80    4E D4 03 DE    98 1B 6C 82
      55 D2 61 47    29 CD D1 AE    B8 C4 89 85    89 FB 3E BE
      20 30 BE A7    AB DA 5B 42    1C 10 F8 3B    5E 8A C9 23
      4F DE 8F 3A    01 D1 ED 4C    79 CF D8 2A    47 4D FD 7E
      12 20 D4 B1    49 4A 27 A9    3A 72 34 B7    35 39 4F 87
      0D C8 C2 D1    91 E7 93 E5    54 D3 1B 0D    D6 30 97 CD
      56 33 9F 54    03 43 E9 44    0A 22 4D D2    27 5C 42 BD
      82 40 F7 D8    83 3E 10 A8    31 43 A2 0D    8A 1F 27 FE
```

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```
            66 7A 12 63     2F DC F5 9F     6C 83 B1 C3     AC F1 A9 2F
            96 EE 94 00     5C 57 9D AB     D3 3F A0 EB     F0 6B E1 33
            95 AB 14 5D     07 87 C0 14     18 70 51 A2     EF 0E 1B C4
            92 07 CC 18     3F 0F 48 80     FA 85 55 BD     B9 86 F3 C2
            DC 61 84 A6     84 19 4E 9D     60 99 2A A9     84 43 38 42
            08 61 5E 53     43 06 C4 BB     72 42 8D 41     A3 3D 64 3D
            22 2B 11 1D     13 88 1D CF     03 9C C2 C7     71 DB 4A FA
            58 B1 AF 13     8C 86 55 16     3E 15 BB EF     CD 2F EC CD
            A8 CA F7 7C     E9 B4 1B ED     FE A1 89 A3     AF 03 7B 38
            2F B5 AE 30     0F 88 41 D4     2A E1 F8 4E     25 88 4C B2
            2B FD 6A 98     60 B9 F8 A9     A3 5E A2 68     A1 C9 11 F1
            BB 06 67 2F     8E B0 5A A6     55 C7 1E 3A     FC 71 CC 1A
App     :INFO :Do Verification
App     :INFO :Verification successful !!!
App     :INFO :ex_sss_RSA Example Success !!!...
App     :INFO :ex_sss Finished
```

Symmetric AES Example

This project demonstrates symmetric cryptography - AES encryption and decryption operations.

Refer - `simw-top/sss/ex/symmetric/ex_sss_symmetric.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a symmetric cryptography AES encryption and decryption operation.

It uses the following APIs and data types:

- *`sss_symmetric_context_init()`*
- `kAlgorithm_SSS_AES_CBC` from `sss_algorithm_t`
- `kSSS_CipherType_AES` from `sss_cipher_type_t`
- `kMode_SSS_Encrypt` from `sss_mode_t`
- *`sss_cipher_one_go()`*
- `kMode_SSS_Decrypt` from `sss_mode_t`

Console output

If everything is successful, the output will be similar to:

```
App     :INFO :Running AES symmetric Example ex_sss_symmetric.c
App     :INFO :Do Encryption
App     :INFO :iv (Len=16)
            00 00 00 00     00 00 00 00     00 00 00 00     00 00 00 00
App     :INFO :srcData (Len=16)
```

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```
      48 45 4C 4C    4F 48 45 4C    4C 4F 48 45    4C 4C 4F 31
App   :INFO :Encryption successful !!!
App   :INFO :encrypted data (Len=16)
      32 A6 04 88    C5 B3 FF 40    50 AF 56 A5    68 AE D1 05
App   :INFO :Do Decryption
App   :INFO :iv (Len=16)
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
App   :INFO :Encrypted data (Len=16)
      32 A6 04 88    C5 B3 FF 40    50 AF 56 A5    68 AE D1 05
App   :INFO :Decryption successful !!!
App   :INFO :decrypted data (Len=16)
      48 45 4C 4C    4F 48 45 4C    4C 4F 48 45    4C 4C 4F 31
App   :INFO :ex_sss_symmetric Example Success !!!...
App   :INFO :ex_sss Finished
```

HKDF Example

This project demonstrates an HMAC Key derivation operation based on info and salt using SSS APIs.

Refer - `simw-top/sss/ex/hkdf/ex_sss_hkdf.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a HMAC Key derivation operation based on the info and salt.

It uses the following APIs and data types:

- *`sss_derive_key_context_init()`*
- `kAlgorithm_SSS_HMAC_SHA256` from `sss_algorithm_t`
- `kMode_SSS_ComputeSharedSecret` from `sss_mode_t`
- `kSSS_CipherType_HMAC` from `sss_cipher_type_t`
- *`sss_derive_key_go()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running HMAC Key Derivation Function Example ex_sss_hkdf.c
App   :INFO :Do Key Derivation
App   :INFO :salt (Len=32)
      AA 1A 2A E3    B2 76 15 4D    67 F9 D8 4C    B9 35 54 56
      BB 1B 2B 03    04 05 06 07    08 09 0A 0B    0C 0D 0E 0F
App   :INFO :info (Len=192)
      00 01 02 03    04 05 06 07    08 09 0A 0B    0C 0D 0E 0F
      10 11 12 13    14 15 16 17    18 19 1A 1B    1C 1D 1E 1F
```

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```
      20 21 22 23    24 25 26 27    28 29 2A 2B    2C 2D 2E 2F
      30 31 32 33    34 35 36 37    38 39 3A 3B    3C 3D 3E 3F
      40 41 42 43    44 45 46 47    48 49 4A 4B    4C 4D 4E 4F
      50 51 52 53    54 55 56 57    58 59 5A 5B    5C 5D 5E 5F
      60 61 62 63    64 65 66 67    68 69 6A 6B    6C 6D 6E 6F
      70 71 72 73    74 75 76 77    78 79 7A 7B    7C 7D 7E 7F
      80 81 82 83    84 85 86 87    88 89 8A 8B    8C 8D 8E 8F
      90 91 92 93    94 95 96 97    98 99 9A 9B    9C 9D 9E 9F
      A0 A1 A2 A3    A4 A5 A6 A7    A8 A9 AA AB    AC AD AE AF
      B0 B1 B2 B3    B4 B5 B6 B7    B8 B9 BA BB    BC BD BE BF
App   :INFO : Key Derivation successful !!!
App   :INFO :hkdfOutput (Len=128)
      6E 69 25 DB    1D D7 37 64    3C 9F F5 02    0D 54 B1 0A
      97 FF 80 78    36 A6 86 80    6D B5 77 5C    89 DD 61 53
      E3 69 58 67    6B 41 EB 4A    8B 10 01 F6    BB 67 7C A4
      26 F7 87 DE    03 A1 18 B1    D3 ED 11 38    CA 0A AA 02
      0A C2 A0 B1    65 7D 80 83    23 7C 8B EA    58 EE E4 DF
      DF 17 49 59    8B 66 62 7F    C7 EE 63 87    5A 1A F4 C3
      BB 97 3F 35    47 06 4A EA    15 DA 15 21    5B 87 DA AA
      81 1F 1F B0    D7 95 4E F4    25 5D C6 75    34 2B 0C 40
App   :INFO :ex_sss_hkdf Example Success !!!...
App   :INFO :ex_sss Finished
```

Message Digest Example

This project demonstrates a Message Digest / hashing operation using SSS APIs.

Refer - `simw-top/sss/ex/md/ex_sss_md.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a Message Digest hashing operation.

It uses the following APIs and data types:

- *`sss_digest_context_init()`*
- `kAlgorithm_SSS_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Digest` from `sss_mode_t`
- *`sss_digest_one_go()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running Message Digest Example ex_sss_md.c
App   :INFO :Do Digest
App   :INFO :input (Len=10)
      48 65 6C 6C    6F 57 6F 72    6C 64
App   :INFO :Message Digest successful !!!
App   :INFO :digest (Len=32)
      87 2E 4E 50    CE 99 90 D8    B0 41 33 0C    47 C9 DD D1
      1B EC 6B 50    3A E9 38 6A    99 DA 85 84    E9 BB 12 C4
App   :INFO :ex_sss_digest Example Success !!!...
App   :INFO :ex_sss Finished
```

HMAC Example

This project demonstrates a HMAC operation on a message using SSS APIs.

Refer - `simw-top/sss/ex/hmac/ex_sss_hmac.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a HMAC operation on input data.

It uses the following APIs and data types:

- *`sss_mac_context_init()`*
- `kAlgorithm_SSS_HMAC_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Mac` from `sss_mode_t`
- *`sss_mac_one_go()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running HMAC (SHA256) Example ex_sss_hmac.c
App   :INFO :Do HMAC
App   :INFO :input (Len=10)
      48 65 6C 6C    6F 57 6F 72    6C 64
App   :INFO :hmac key (Len=16)
      48 65 6C 6C    6F 48 65 6C    6C 6F 48 65    6C 6C 6F 48
App   :INFO :HMAC (SHA256) successful !!!
App   :INFO :hmac (Len=32)
      68 7A 26 95    49 67 9D 6E    FA 11 19 5E    96 CB BA C2
      6B 50 A5 09    10 8A D1 48    B5 FC A0 94    2C BD 10 21
App   :INFO :ex_sss_hmac Example Success !!!...
App   :INFO :ex_sss Finished
```

ECDH Example

This project demonstrates generating a ECDH key using SSS APIs.

Refer - `simw-top/sss/ex/ecdh/ex_sss_ecdh.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example generates a ECDH key.

It uses the following APIs and data types:

- *`sss_derive_key_context_init()`*
- `kAlgorithm_SSS_ECDH` from `sss_algorithm_t`
- `kMode_SSS_ComputeSharedSecret` from `sss_mode_t`
- *`sss_derive_key_dh()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running ECDH Example ex_sss_ecdh.c
App   :INFO :ECDH successful !!!
App   :INFO :ECDH derive Key (Len=32)
      C2 EA 1C 13    7D 30 F7 DA    65 1E B3 DB    7A F1 CF 42
      DF 38 B2 E6    22 41 2B 5B    BB DC F5 10    8E D5 69 CB
App   :INFO :ex_sss_ecdh Example Success !!!...
App   :INFO :ex_sss Finished
```

ECDAA Example

This project demonstrates Elliptic Curve Cryptography ECDAA sign operation using SSS APIs.

Refer - `simw-top/sss/ex/ecdaa/ex_sss_ecdaa.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a elliptic curve cryptography signing and verify operation.

It uses the following APIs and data types:

- *`sss_asymmetric_context_init()`*

- `kAlgorithm_SSS_ECDAA` from `sss_algorithm_t`
- `kMode_SSS_Sign` from `sss_mode_t`
- *`sss_asymmetric_sign_digest()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running Elliptic Curve Cryptography Example ex_sss_ecdaa.c
App   :INFO :Do Signing
App   :INFO :digest (Len=32)
      00 01 02 03    04 05 06 07    08 09 0A 0B    0C 0D 0E 0F
      10 11 12 13    14 15 16 17    18 19 1A 1B    1C 1D 1E 1F
App   :INFO :signature (Len=70)
      30 44 02 20    00 01 02 03    04 05 06 07    08 09 0A 0B
      0C 0D 0E 0F    10 11 12 13    14 15 16 17    18 19 1A 1B
      1C 1D 1E 1F    02 20 C7 2B    67 E4 09 FA    22 0E E5 9C
      22 3B CB 2C    E2 9C 78 76    DB 1D F3 C3    4B E4 83 D4
      42 79 92 50    74 39
App   :INFO :Signing Successful !!!
App   :INFO :ex_sss_ecdaa Example Success !!!...
App   :INFO :ex_sss Finished
```

ECC NIST256 Key Attestation Example

This project demonstrates ecc nist256 key attestation and verification with another ecc nist256 key using SSS API

Refer - `simw-top/sss/ex/attest_ecc/ex_sss_ecc_attest.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example reads a nist256 public key with attestation.

It uses the following APIs and data types:

- *`sss_key_store_set_key()`*
- *`sss_key_store_generate_key()`*
- *`sss_se05x_key_store_get_key_attst()`*
- `kAlgorithm_SSS_ECDSA_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Verify` from `sss_mode_t`
- *`sss_asymmetric_verify_digest()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running ECC key attestation example ex_sss_attest_ecc.c
App   :INFO :Inject ECC key pair - 'ecc_key'
App   :INFO :Create a attestation ECC key pair - 'attestation_ecc_key'
App   :INFO :Read public key from ECC key pair 'ecc_key' with attestation
App   :INFO :Attested Key -->
App   :INFO :Public Key (Len=91)
      30 59 30 13    06 07 2A 86    48 CE 3D 02    01 06 08 2A
      86 48 CE 3D    03 01 07 03    42 00 04 ED    A7 E9 0B F9
      20 CF FB 9D    F6 DB CE F7    20 E1 23 8B    3C EE 84 86
      D2 50 E4 DF    30 11 50 1A    15 08 A6 2E    D7 49 52 78
      63 6E 61 E8    5F ED B0 6D    87 92 0A 04    19 14 FE 76
      63 55 DF BD    68 61 59 31    8E 68 7C
App   :INFO :Attribute (Len=17)
      EF 00 00 92    01 01 00 00    00 00 00 00    00 00 01 00
      00
App   :INFO :Time Stamp (Len=12)
      00 00 00 0F    FF FF FF FA    00 01 2C C8
App   :INFO :Out Random Value (Len=16)
      01 02 03 04    05 06 07 08    09 01 02 03    04 05 06 07
App   :INFO :Chip Id (Len=18)
      04 0D 0F 00    39 67 C2 C1    CE 41 1B 9A    76 F5 B7 AB
      D0 CD
App   :INFO :Signature (Len=71)
      30 45 02 21    00 8E 09 C2    BD 27 45 7B    0A 6E 2C 70
      48 00 B0 D7    AC 7D FA 70    03 7B 21 A5    BF 0B 40 8B
      C8 99 76 B0    03 02 20 6F    F0 22 37 24    43 22 0C 7B
      99 2A DA DA    0D D6 BF AD    A6 B3 09 81    0A 2D 0A BD
      5D 59 17 39    EC 24 93
App   :INFO :Verify attestation signature using 'attestation_ecc_key' key
App   :INFO :Verification success
App   :INFO :ex_sss_attest_ecc Example Success !!!...
App   :INFO :ex_sss Finished
```

ECC MONTGOMERY-25519 Key Attestation Example

This project demonstrates ecc montogomery25519 key attestation and verification with ecc nist256 key using SSS API. Signing on montgomery public key is done with key in the big endian format inside secure element.

Refer - `simw-top/sss/ex/attest_mont/ex_sss_mont_attest.c`

Note: For twisted edward curve and montgomery 448 curve also the attestation signing is done with public key in big endian format.

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example reads a montgomery-25519 public key with attestation.

It uses the following APIs and data types:

- *`sss_key_store_set_key()`*
- *`sss_key_store_generate_key()`*
- *`sss_se05x_key_store_get_key_attst()`*
- `kAlgorithm_SSS_ECDSA_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Verify` from `sss_mode_t`
- *`sss_asymmetric_verify_digest()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running ECC key attestation example ex_sss_attest_mont.c
App   :INFO :Inject ECC Montgomery key pair - 'ecc_mont_key'
sss   :WARN :nxEnsure:'ret == SM_OK' failed. At Line:5621 Function:sss_se05x_TXn
App   :INFO :Create a attestation ECC key pair - 'attestation_ecc_key'
App   :INFO :Read public key from ECC key pair 'ecc_key' with attestation
App   :INFO :Attested Key -->
App   :INFO :Public Key (Little endian format) (Len=44)
      30 2A 30 05    06 03 2B 65    6E 03 21 00    85 20 F0 09
      89 30 A7 54    74 8B 7D DC    B4 3E F7 5A    0D BF 3A 0D
      26 38 1A F4    EB A4 A9 8E    AA 9B 4E 6A
App   :INFO :Attribute (Len=17)
      EF 00 00 8A    01 01 00 00    00 00 00 00    00 00 01 00
      00
App   :INFO :Time Stamp (Len=12)
      00 00 00 18    FF FF FF ED    00 01 30 B0
App   :INFO :Out Random Value (Len=16)
      01 02 03 04    05 06 07 08    09 01 02 03    04 05 06 07
App   :INFO :Chip Id (Len=18)
      04 0D 0F 00    39 67 C2 C1    CE 41 1B 9A    76 F5 B7 AB
      D0 CD
App   :INFO :Signature (Len=71)
      30 45 02 20    7A F8 E5 21    E7 0D 01 A9    9A AC 99 2A
      AA 36 3A 89    C0 A7 CE 43    2B 85 CC FB    6E 98 A1 9C
      2A E8 BC 4B    02 21 00 E7    0F 82 DD F2    43 C3 B2 CD
      54 26 61 F0    06 AE 98 5B    2C 95 89 D7    A2 F3 4A 6E
      13 12 A4 82    23 FF BD
App   :INFO :Verify attestation signature using 'attestation_ecc_key' key
App   :INFO :Singing is done on public key without header and with key in big endian␣
↪format
App   :INFO :Covert the key to big endian format for verification of signature
App   :INFO :Verification success
App   :INFO :ex_sss_attest_mont Example Success !!!...
App   :INFO :ex_sss Finished
```

EDDSA Example

This project demonstrates EDDSA sign and verify operation using SSS APIs. Sign and Verify operations using edwards key should to be performed on plain data. Use *sss_se05x_asymmetric_sign* and *sss_se05x_asymmetric_verify* apis.

Refer - `simw-top/sss/ex/eddsa/ex_sss_eddsa.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

About the Example

This example does a elliptic curve cryptography signing and verify operation.

It uses the following APIs and data types:

- *`sss_asymmetric_context_init()`*
- `kAlgorithm_SSS_SHA256` from `sss_algorithm_t`
- `kMode_SSS_Sign` from `sss_mode_t`
- *`sss_se05x_asymmetric_sign()`*
- `kMode_SSS_Verify` from `sss_mode_t`
- *`sss_se05x_asymmetric_verify()`*

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running EDDSA Example ex_sss_eddsa.c
App   :INFO :Do Signing
App   :INFO :Source Data (Len=50)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00
App   :INFO :signature (Len=64)
      7E 88 E2 90    3A 2E 58 2B    40 30 1E D9    E6 38 D7 D1
      C4 E3 43 AF    1D F5 6B A4    FF CE 38 9A    92 EB 39 F6
      E9 8E F8 AD    54 51 B8 76    58 5D 2D 94    2F 46 EB B6
      58 E3 32 BC    84 C2 A3 14    49 C8 F5 1A    C9 98 3D 0E
App   :INFO :Signing Successful !!!
App   :INFO :Do Verify
App   :INFO :Source Data (Len=50)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00
App   :INFO :signature (Len=64)
      7E 88 E2 90    3A 2E 58 2B    40 30 1E D9    E6 38 D7 D1
      C4 E3 43 AF    1D F5 6B A4    FF CE 38 9A    92 EB 39 F6
```

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```
      E9 8E F8 AD    54 51 B8 76    58 5D 2D 94    2F 46 EB B6
      58 E3 32 BC    84 C2 A3 14    49 C8 F5 1A    C9 98 3D 0E
App   :INFO :Verification Successful !!!
App   :INFO :ex_sss_ecc Example Success !!!...
App   :INFO :ex_sss Finished
```

5.3 Cloud Demos

5.3.1 AWS Demo for KSDK

This demo demonstrates connection to AWS IoT Console using pre-provisioned device credentials and publish/subscribe procedure using MQTT.

Prerequisites

- Active AWS account
- MCUXpresso installed (for running aws demo on K64F)
- Any Serial communicator
- Flash VCOM binary on the device. VCOM binary can found under `<PROJECT>binariesMCU` folder.
- Refer to *CLI Tool* for ssscli tool setup
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Using WiFi with LPC55S

WiFi shield CMWC1ZZABR-107-EVB by muRata is supported with LPCS55S. Mount the WiFi shield on to the mikroBUS stackable headers.

Creating a device on AWS account

Refer - https://docs.aws.amazon.com/iot/latest/developerguide/iot-gs-first-thing.html

Creating and updating device keys and certificates to SE

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) Check the vcom port number
3) To create certificates on windows and provision, go to `simw-top/pycli` directory and call:

```
call venv\Scripts\activate.bat
cd Provisioning
python GenerateAWSCredentials.py <COM_PORT>
python ResetAndUpdate_AWS.py <COM_PORT>
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

---

4) Certificates and Keys are generated at `simw-top/pycli/Provisioning/aws`

Building the Demo

1) Open cmake project found under `<SIMW-TOP>projects` in MCUXPRESSO IDE
2) **Update cmake options::**
    - `RTOS=FreeRTOS`
    - `mbedTLS_ALT=SSS`
3) **Update the build target in make file**
    - Project:`cloud_aws`

Running the Demo

1) Open a serial terminal on PC for OpenSDA serial device with these settings:

```
- 115200 baud rate
- 8 data bits
- No parity
- One stop bit
- No flow control
- change Setup->Terminal->New-line->Receive->AUTO
```

2) Connect the boards's RJ45 to network with Internet access (IP address to the board is assigned by the DHCP server). Make sure the connection on port 8883 is not blocked.
3) Download the program to the target board.
4) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo.
5) The BLUE LED is turned ON during boot
6) Persistent RED LED ON indicates error
7) **First time during connection, the device certificate needs to be**
    - Activated
    - Attached with a policy that allows usage of this certificate
8) All lights off along with the following message indicates readiness to subscribe messages from AWS:

```
Subscribing...
-->sleep
-->sleep
Publish done
```

In AWS IOT shadow, the following indicates the state of the LED:

```
{
    "desired": {
    "COLOR": "RED",
    "MODE": "OFF"
    }
}
```

MODE can be ON or OFF and COLOR can be RED, GREEN or BLUE

5.3.2 AWS Demo for iMX Linux / RaspberryPi

This demo demonstrates connection to AWS IoT Console using pre-provisioned device credentials and publish/subscribe procedure using MQTT.

Prerequisites

- AWS account
- SD Card image with SE050 Middleware pre-installed. The application is built on the iMX platform.
- IMX6UL-EVK platform or Raspberry pi connected to the Internet

Preparing the credentials and Provisioning the secure element

Use ssscli tool from iMX/Rpi platform

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) To create certificates on imx and Raspberry Pi, call:

```
cd simw-top/pycli/Provisioning/
python3 GenerateAWSCredentials.py
python3 ResetAndUpdate_AWS.py
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

3) Certificates and Keys are generated at `simw-top/pycli/Provisioning/aws`

Build the OpenSSL engine [Optional]

Note: This step is optional in case you are using a prepared SD card image from NXP.

The OpenSSL engine uses the sss abstraction layer to access the crypto services of the secure element, the implementation remains dependent on the secure element attached. The following illustrates compiling the OpenSSL engine for SE050 connected over I2C.

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: Replace `imx_native_se050_t1oi2c` with `raspbian_native_se050_t1oi2c` when building for Raspberry Pi.

Run the example

1) Clone the Code

```
cd /simw-top/demos/linux/aws/
git clone https://github.com/aws/aws-iot-device-sdk-cpp.git
```

Note: If curl is not installed - run `sudo apt-get install libcurl4-openssl-dev`

1) Modify the `CMakeLists.txt` file under `samples/PubSub` so it ensures `OPENSSL_LOAD_CONF` is defined (see excerpt below):

```
if (UNIX AND NOT APPLE)
    ADD_DEFINITIONS(-DOPENSSL_LOAD_CONF)
    # Prefer pthread if found
    set(THREADS_PREFER_PTHREAD_FLAG ON)
    set(CUSTOM_COMPILER_FLAGS "-fno-exceptions -Wall -Werror")
elseif (APPLE)
    set(CUSTOM_COMPILER_FLAGS "-fno-exceptions -Wall -Werror")
elseif (WIN32)
    set(CUSTOM_COMPILER_FLAGS "/W4")
endif ()
```

1) Use ‘buildScript.sh’ script at simw-top/demos/linux/aws/ to build the mqtt application for aws call:

```
./buildScript.sh
```

1) **Adapt the PubSub example specific configuration file so that it refers to the reference key and the device certificate.**

   - Update the endpoint to match your AWS account
   - Ensure the AmazonRootCA1.pem certificate is in place (it is used by the iMX/rpi to validate the AWS IoT counterpart
   - Update the configuration file (/simw-top/demos/linux/aws/aws-iot-device-sdk-cpp/build/bin/config/SampleConfig.json) with endpoint, device_certificate_relative_path, device_private_key_relative_path (Ensure the value for “endpoint” matches your setup, you must replace “xxxxiukfoyyyy-ats.iot.eu-central-1.amazonaws.com”)
   - Sample Json file

```
{
  "endpoint": "xxxxiukfoyyyy-ats.iot.eu-central-1.amazonaws.com",
  "mqtt_port": 8883,
  "https_port": 443,
  "greengrass_discovery_port": 8443,
  "root_ca_relative_path": "certs/AmazonRootCA1.pem",
  "device_certificate_relative_path": "<UID>_device_certificate.crt",
  "device_private_key_relative_path": "<UID>_device_reference_key.pem",
  "tls_handshake_timeout_msecs": 60000,
  "tls_read_timeout_msecs": 2000,
  "tls_write_timeout_msecs": 2000,
  "aws_region": "",
  "aws_access_key_id": "",
  "aws_secret_access_key": "",
  "aws_session_token": "",
  "client_id": "CppSDKTesting",
  "thing_name": "CppSDKTesting",
  "is_clean_session": true,
  "mqtt_command_timeout_msecs": 20000,
  "keepalive_interval_secs": 600,
  "minimum_reconnect_interval_secs": 1,
  "maximum_reconnect_interval_secs": 128,
  "maximum_acks_to_wait_for": 32,
  "action_processing_rate_hz": 5,
  "maximum_outgoing_action_queue_length": 32,
  "discover_action_timeout_msecs": 300000
}
```

1) Search for *default_algorithms* in `/simw-top/demos/linux/common/openssl_sss_se050.cnf` file and set it as

```
default_algorithms = RSA,RAND,ECDSA,ECDH    ----- For openssl 1.0.0
default_algorithms = RSA,RAND,EC            ----- For openssl 1.1.1
```

1) Set the openssl config path as call:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/openssl_sss_se050.cnf
```

2) Upload the root certificate (/simw-top/pycli/Provisioning/aws/rootCA_certificate.cer) to AWS account. Refer *Creating a device on AWS account*

3) Run the application:

```
cd /simw-top/demos/linux/aws/aws-iot-device-sdk-cpp/build/bin
./pub-sub-sample
```

Note:

1) Export the OpenSSL conf path to the exact location of the file. The above example is for illustrative purpose

5.3.3 GCP Demo for KSDK

This demo demonstrates connection to Google Cloud Platform using pre-provisioned device credentials and publish/subscribe procedure using MQTT.

Prerequisites

- Active gcp account
- MCUXpresso installed (for running gcp demo on K64F)
- Any Serial communicator
- Flash VCOM binary on the device. VCOM binary can found under `<PROJECT>binariesMCU` folder.
- Refer to *CLI Tool* for ssscli tool setup
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Using WiFi with LPC55S

WiFi shield CMWC1ZZABR-107-EVB by muRata is supported with LPCS55S. Mount the WiFi shield on to the mikroBUS stackable headers.

Creating and updating device keys and certificates to SE

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) Check the vcom port number
3) To create certificates on windows and provision, go to `simw-top/pycli` directory and call:

```
call venv\Scripts\activate.bat
cd Provisioning
python GenerateGCPCredentials.py <COM_PORT>
python ResetAndUpdate_GCP.py <COM_PORT>
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

4) Certificates and Keys are generated at `simw-top/pycli/Provisioning/gcp`

Preparing the Cloud

1) Updating cloud over command line. Set up `gcloud` command line utility availabe at https://cloud.google.com/pubsub/docs/quickstart-cli

- Assuming the project name is `pgh-cloud-iot` the following commands sets up the code.

  Create a new events pub/sub topic:

```
,----
|
| gcloud pubsub topics create a71ch-demo-events \
|     --project=pgh-cloud-iot
|
`----
```

- Create a registry:

```
,----
|
| gcloud iot registries create nxp-se-demo-reg \
|     --project=pgh-cloud-iot \
|     --region=us-central1 \
|     --event-notification-config=topic=projects/pgh-cloud-iot/topics/a71ch-demo-
↪events \
|
`----
```

- Create a device and attach the certificate `tls_client.cer`:

```
,----
|
| gcloud iot devices create nxp-ecc-dev-01 \
|     --project=pgh-cloud-iot \
|     --region=us-central1 \
|     --registry=nxp-se-demo-reg \
|     --public-key=path=/simw-top/pycli/Provisioning/gcp/<UID>_device_certificate.
↪cer,type=es256-pem
|
`----
```

2) Updating cloud using the Web Interface
    A) Sign up for Google Cloud Platform - IoT (If you have not done that already)
    B) Create Registry & Device in the cloud platform.
    C) Copy For the device, add public key in ES256_X509 format Copy hostLibmbedtlssecctls_client.cer and paste in the web-dialogue box.

Building the Demo

1) Open cmake project found under `<SIMW-TOP>projects` in MCUXPRESSO IDE
2) **Update cmake options::**
    - `RTOS=FreeRTOS`
    - `mbedTLS_ALT=SSS`
3) **Update the build target in make file**
    - Project:`cloud_gcp`

Running the Demo

1) Build the project and flash the binary on FRDM-K64F board
2) Connect your board to open network
3) **Open a serial terminal on PC for OpenSDA serial device with these settings:**
    - 115200 baud rate
    - 8 data bits
    - No parity
    - One stop bit

   - No flow control
   - change Setup->Terminal->New-line->Receive->AUTO

4) Console output - If everything is setup correctly the output would be as follows

```
,----
|
| GCP JWT NXP Secure Element example
|
| selectResponseDataLen: 2
| 0x01:0x31:
| Associating ECC key-pair '0'.
| Connecting to network
| Getting IP address from DHCP ...
|
|  IPv4 Address     : 192.168.1.55
| DHCP OK
| Current EPOCH = 1520599186
| Using ECC key '0' for signing.
| JWT TOKEN = eyJhbGciOiJFUzI1NiIsInR5cCI6IkpXVCJ9.
↪eyJhdWQiOiJwZ2gtY2xvdWQtaW90IiwiaWF0IjoxNTIwNTk5MTg2LCJleHAiOjE1MjA2MzUxODZ9.
↪pZK9NjzD2rMdsU9H6bLPHNTsjHE77zHTMNhxVDVR3fYo39ttM2gYrhvJBR2Ct-9a2o8FwFqWjR8YY_
↪lDwGjYyg
| GAE subscribe publish example
|
| Connecting...
| Associating ECC key-pair '0'.
| Using ECC key '0' to compute shared secret.
| Subscribing...
| -->sleep
| -->sleep
| Publish done
|
| Subscribe callback
|
| ...
| ...
|
`----
```

5) You can update device config with following messages to toggle on-board keys. Using the below command, we can toggle LEDs:

```
,----
|
| gcloud iot devices configs update \
|     --project=pgh-cloud-iot \
|     --region=us-central1 \
|     --registry=nxp-se-demo-reg \
|     --device=nxp-ecc-dev-01 \
|     --config-data='{"red": "off"}'
|
`----
```

User can toggle individual LEDs:

```
,----
| {"green": "toggle", "user": "test1"}
```

(continues on next page)

(continued from previous page)

```
| {"green": "on",     "user": "test1"}
| {"red":   "off",    "user": "test1"}
`----
```

For DOS Batch files, the commands can be like below (with escaping):

```
,----
|
| gcloud iot devices configs update ^
|     --project=pgh-cloud-iot ^
|     --region=us-central1 ^
|     --registry=nxp-se-demo-reg ^
|     --device=nxp-ecc-dev-01 ^
|     --config-data=^"{""red"":""on"",""blue"":""off"",""green"":""off""}^"
|
| gcloud iot devices configs update ^
|     --project=pgh-cloud-iot ^
|     --region=us-central1 ^
|     --registry=nxp-se-demo-reg ^
|     --device=nxp-ecc-dev-01 ^
|     --config-data=^"{""red"":""off"",""blue"":""on"",""green"":""off""}^"
|
| gcloud iot devices configs update ^
|     --project=pgh-cloud-iot ^
|     --region=us-central1 ^
|     --registry=nxp-se-demo-reg ^
|     --device=nxp-ecc-dev-01 ^
|     --config-data=^"{""red"":""off"",""blue"":""off"",""green"":""on""}^"
|
`----
```

Appendix

1. For more information, refer to https://github.com/GoogleCloudPlatform/cpp-docs-samples/tree/master/iot/mqtt-ciotc

5.3.4 GCP Demo for iMX Linux / Raspberry Pi

This demo demonstrates connection to Google Cloud Platform using pre-provisioned device credentials and publish/subscribe procedure using MQTT.

Prerequisites

- GCP account
- SD Card image with SE050 Middleware pre-installed. The application is built on the iMX platform.
- IMX6UL-EVK/RPi platform connected to the Internet
- Install autoconf and libtool. Execute - `sudo apt-get install autoconf libtool`

For additional information:

- Refer to *Development Platforms* for hardware setup and iMX setup

- Refer to *CLI Tool* for ssscli tool setup

Preparing the credentials and Provision the SE

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) To create certificates on imx and Raspberry Pi, call:

```
cd simw-top/pycli/Provisioning
python3 GenerateGCPCredentials.py
python3 ResetAndUpdate_GCP.py
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

3) Certificates and Keys are generated at `simw-top/pycli/Provisioning/gcp`

Build the OpenSSL engine [Optional]

Note: This step is optional in case you are using a prepared SD card image from NXP.

The OpenSSL engine uses the sss abstraction layer to access the crypto services of the secure element, the implementation remains dependent on the secure element attached. The following illustrates compiling the OpenSSL engine for SE050 connected over I2C.

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: Replace `imx_native_se050_t1oi2c` with `raspbian_native_se050_t1oi2c` when building for Raspberry Pi.

Building the application

1) Use ‘buildScript.sh’ script at simw-top/demos/linux/gcp/ to download all dependencies and build the mqtt application for gcp call:

```
cd /simw-top/demos/linux/gcp/
./buildScript.sh
```

Note: Demo is tested with GCP client code with commit - *6b003f5ad945fdfd3788af275174a8bcb3aab095*. ‘buildScript.sh’ will download the same.

1) Search for *default_algorithms* in `/simw-top/demos/linux/common/openssl_sss_se050.cnf` file and set it as

```
default_algorithms = RSA,RAND,ECDSA,ECDH    ----- For openssl 1.0.0
default_algorithms = RSA,RAND,EC            ----- For openssl 1.1.1
```

2) Set the openssl config path. Skip if already done:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/openssl_sss_se050.cnf
```

3) Upload the root certificate (/simw-top/pycli/Provisioning/gcp/rootCA_certificate.cer) and device certificate (/simw-top/pycli/Provisioning/gcp/<UID>_device_certificate.cer) to GCP account. Refer *Preparing the Cloud*. Skip if already done.

4) Run the application call:

```
cd /simw-top/demos/linux/gcp/gcp/cpp-docs-samples/iot/mqtt-ciotc
$ ./mqtt_ciotc --deviceid "nxp-ecc-dev-01" --region "us-central1" --registryid␣
↪"nxp-se-demo-reg" --projectid "pgh-cloud-iot" --keypath /simw-top/pycli/
↪Provisioning/gcp/<UID>_device_reference_key.pem --rootpath /simw-top/demos/
↪linux/gcp/keys/roots.pem --algorithm ES256
```

Note:

1. The above example is for illustrative purpose
2. Export the open ssl conf path to the exact location of the file.
3. While executing the application, use the appropriate values for registryid, projectid, keypath, rootpath and algorithm

---

Appendix

1. For more information, refer to https://github.com/GoogleCloudPlatform/cpp-docs-samples/tree/master/iot/mqtt-ciotc

5.3.5 IBM Watson Demo for KSDK

This demo demonstrates connection to IBM Watson IoT platform using pre-provisioned device credentials and publish/subscribe procedure using MQTT

Prerequisites

- Active IBM Watson account
- MCUXpresso installed (for running IBM demo on K64F)
- Any Serial communicator
- Flash VCOM binary on the device. VCOM binary can found under `<PROJECT>binariesMCU` folder.
- Refer to *CLI Tool* for ssscli tool setup
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Using WiFi with LPC55S

WiFi shield CMWC1ZZABR-107-EVB by muRata is supported with LPCS55S. Mount the WiFi shield on to the mikroBUS stackable headers.

Setting up IBM Watson IoT Platform

1. Create an IBM ID which enables you to create an service instance for the Watson IoT platform (https://idaas.iam.ibm.com/idaas/mtfim/sps/authsvc?PolicyId=urn:ibm:security:authentication:asf:basicldapuser)
2. Create an instance of Internet of Things Platform in the Watson IoT after logging in.
3. Register the Root CA certificate (and Intermediate CA certificates if applicable) by following the below link https://console.bluemix.net/docs/services/IoT/reference/security/set_up_certificates.html#set_up_certificates
    i) Click on 'Launch' button to access to the IoT dashboard
    ii) Click on 'Settings' tab
    iii) Click on 'CA Certificates'
    iv) Click on 'Add Certificate'
    v) A new pop-up appears. Click on 'Select a file' option and select the certificate
    vi) Click on 'Save'
4. Configure the security policies of the service by following steps
    i) Click on 'Security' tab
    ii) Click on the pencil of 'Connection Security' to edit the preferences
    iii) A new window is loaded, 'Connection Security'. In the Security Level field, select 'TLS with Client Certificate Authentication'.
    iv) click on 'Save'
5. Register Device type
    i) In the service, Click on 'Devices' tab and 'Device Types'
    ii) Click on 'Add device type.
    iii) Select the 'Device' type and write a name. Device type shall be registered as 'NXP-SE050-EC-D' and Optionally, add a description.
    iv) Click 'Next'
    v) Optionally, add information to the rest of the fields. In this guide all the fields have been intentionally left empty. Finally, click 'Done'.
    vi) For more information, refer to https://console.bluemix.net/docs/services/IoT/ iotplatform_task.html#iotplatform_task
6. Register device
    i) Click on 'Devices' tab.
    ii) Click on 'Add Device'
    iii) In the 'Identity' tab, select as 'Device Type' the one created in 'Register Device type' and the 'Device ID' the one retrieved using the pycli tool (UID of the device)
    iv) Click on 'Next' button

   v) Click Done button to create the device

7. Configure the application.

   i) In the 'watson_iot_config.h' file, update the org details in the macro "WATSONIOT_MQTT_BROKER_ENDPOINT" which we get from the URL of the dashboard https://org_id.internetofthings.ibmcloud.com/dashboard/#/overview

   ii) update the org details and UID of the device in the macro 'WatsonechoCLIENT_ID' which is available in 'watson_iot_config.h'

8. Configuring the publish application

   Create API key and authentication pair token

   i) In the Watson IoT Platform dashboard, go to Apps > API Keys.

   ii) Click Generate API Key.

   Note: Important: Make a note of the API key and token pair. Authentication tokens are non-recoverable. If you lose or forget this token, you will need to re-register the API key to generate a new authentication token.

   An example of an API key is `a-organization_id-a84ps90Ajs`

   An example of a token is `MP$08VKz!8rXwnR-Q*`

   iii) Add a comment to identify the API key in the dashboard, for example: Key to connect my application.

   iv) Click Finish

Creating and updating device keys and certificates to SE

1) Complete Section 9.3 *Steps needed before running ssscli tool*

2) Check the vcom port number

3) To create certificates on windows and provision, go to `simw-top/pycli` directory and call:

```
call venv\Scripts\activate.bat
cd Provisioning
python GenerateIBMCredentials.py <COM_PORT>
python ResetAndUpdate_IBM.py <COM_PORT>
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

4) Certificates and Keys are generated at `simw-top/pycli/Provisioning/ibm`

Building the Demo

1) Open cmake project found under `<SIMW-TOP>projects` in MCUXPRESSO IDE

2) **Update cmake options::**

   - `RTOS=FreeRTOS`
   - `mbedTLS_ALT=SSS`

3) **Update the build target in make file**
    - Project:`cloud_ibm_watson`

Running the Demo

1. In the ‘watson_iot_config.h’ file, update the org details in the macro “WATSONIOT_MQTT_BROKER_ENDPOINT” which we get from the URL of the dashboard https://org_id.internetofthings.ibmcloud.com/dashboard/#/overview
2. Update the org details and UID of the device in the macro ‘WatsonechoCLIENT_ID’ which is available in ‘watson_iot_config.h’
3. In OrgDetails.cfg file, update the Org details which we got from the previous step in the ‘org’ section
4. In OrgDetails.cfg file, update the auth-key which we got from the above sections in to the ‘auth-key’ section
5. Upate the UID of the device in the application test.py (at Line 40)
6. Build the project and flash the binary on FRDM-K64F board
7. Connect your board to open network
8. **Open a serial terminal on PC for OpenSDA serial device with these settings:**
    - 115200 baud rate
    - 8 data bits
    - No parity
    - One stop bit
    - No flow control
    - change Setup–>Terminal–>New-line–>Receive–>AUTO
9. Press reset button on the board
10. To see the event coming in to device and event going out of the device, login to the Watson IoT platform and launch the service: i) Click ‘Devices’ #) Click the registered device id #) Click ‘Recent Events’ #) Events will be displayed in portal
11. Persistent RED LED ON indicates error
12. All lights off along with the following message indicates readiness to subscribe messages fromAWS:

    ```
    Subscribing...
    -->sleep
    -->sleep
    Publish done
    ```

13. Run the Publish application to publish events to the device.

    To do that, run:

    ```
    python test.py OrgDetails.cfg GREEN ON
    ```

    The above command ensures that the green LED is turned ON. Similarly RED and BLUE LED can be turned ON and OFF
14. Events that are published shall be verified in the Watson Platform Dashboard(Refer to section 15)

Appendix

1. For more information, refer to https://cloud.ibm.com/docs/services/IoT?topic=iot-platform-about_iotplatform

5.3.6 IBM Watson Demo for iMX Linux / Raspberry Pi

This demo demonstrates connection to IBM Watson IoT platform using pre-provisioned device credentials and publish/subscribe procedure using MQTT

Prerequisites

- IBM Cloud account
- SD Card image with SE050 Middleware pre-installed. The application is built on the iMX platform.
- IMX6UL-EVK platform connected to the Internet

For additional information:

- Refer to *Development Platforms* for hardware setup and iMX setup
- Refer to *CLI Tool* for ssscli tool setup

Preparing the credentials

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) To create certificates on imx and Raspberry Pi, call:

```
cd simw-top/pycli/Provisioning
python3 GenerateIBMCredentials.py
python3 ResetAndUpdate_IBM.py
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

3) Certificates and Keys are generated at `simw-top/pycli/Provisioning/ibm`

- The subject and subject alternative name of the device certificate must adhere to specific conventions. Both subject and subject alternative name contain the 10 byte UID value. In addition the Subject Alternative Name contains the device type.

Build the OpenSSL engine [Optional]

Note: This step is optional in case you are using a prepared SD card image from NXP.

The OpenSSL engine uses the sss abstraction layer to access the crypto services of the secure element, the implementation remains dependent on the secure element attached. The following illustrates compiling the OpenSSL engine for SE050 connected over I2C.

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: Replace `imx_native_se050_t1oi2c` with `raspbian_native_se050_t1oi2c` when building for Raspberry Pi.

Running the Demo on iMX/Raspberry Pi

1) Use 'buildScript.sh' script at `<MW_SRC_DIR>/simw-top/demos/linux/ibm_watson_iot` to download all dependencies and build the mqtt application for ibm_watson call:

```
cd /simw-top/demos/linux/ibm_watson_iot
./buildScript.sh
```

2) Based on OpenSSL version and applicable Secure Element, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

```
openssl11_sss_a71ch.cnf   ----- OpenSSL 1.1.1 and A71CH
openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
openssl_sss_a71ch.cnf     ----- OpenSSL 1.0.0 and A71CH
openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
```

3) Set the openssl config path. Skip if already done:

```
$ export OPENSSL_CONF=<MW_SRC_DIR>/simw-top/demos/linux/common/<appropriate-cnf-
↪file>
```

4) Upload the root certificate (<MW_SRC_DIR>/simw-top/pycli/Provisioning/ibm/rootCA_certificate.crt) to your IBM account. Refer to *Setting up IBM Watson IoT Platform* for instructions on uploading the Root CA certificate and registering the device. Skip if already done.

5) Run the application in either of the following two ways:

   - Parameters via commandline:

     ```
     ./watson_imx_linux --org <ORG> --keypath <MW_SRC_DIR>/simw-top/pycli/
     ↪Provisioning/ibm/<UID>_device_reference_key.pem --devcert simw-top/pycli/
     ↪Provisioning/ibm/<UID>_device_certificate.cer --topic␣
     ↪"iot-2/evt/status/fmt/json" --payload ""{\"d\"\ :\
     ↪{\"SensorID\":\ \"Test\"\,\ \"Reading\":\ 7\ }}""
     ```

     where *ORG* is the organization ID, *keypath* is the path to reference key corresponding to the device key and *devcert* is the path to device certificate.

   - Parameters via json file:

     ```
     ./watson_imx_linux --json <input.txt>
     ```

     Sample JSON file:

```
{
  "hostname": "orgID.messaging.internetofthings.ibmcloud.com",
  "protocol": "MQTTS",
  "port": "8443",
  "devcert":␣
↪"cert_0000000000000000000000000000000000000000000000000000000000000092.pem",
  "keypath":␣
↪"keyref_0000000000000000000000000000000000000000000000000000000000000092.pem",
↪
  "payload": "HelloMessage",
  "topic": "iot-2/evt/status/fmt/string",
  "rootpath": "rootCA.pem"
}
```

Note:

1) The above example invocation is for illustrative purpose.
2) Export the open ssl conf path to the exact location of the file.
3) While executing the application, use the appropriate values for org, keypath and devcert.

Appendix

1. For more information, refer to https://cloud.ibm.com/docs/services/IoT?topic=iot-platform-about_iotplatform
2. <MW_SRC_DIR> is a placeholder for the path to the Plug & Trust MW. It would typically be /home/root/se050_mw_v02.08.00 (or a later version) on i.MX.

5.3.7 Azure Demo for KSDK

This demo demonstrates connection to Azure IoTHub using pre-provisioned device credentials and demonstrates publish/subscribe procedure using MQTT.

Prerequisites

- Active azure account with iot hub created
- MCUXpresso installed (for running azure demo on K64F)
- Any Serial communicator
- Flash VCOM binary on the device. VCOM binary can found under `<PROJECT>/binariesMCU` folder.
- Refer to *CLI Tool* for ssscli tool setup
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Using WiFi with LPC55S

WiFi shield CMWC1ZZABR-107-EVB by muRata is supported with LPCS55S. Mount the WiFi shield on to the mikroBUS stackable headers.

Creating a device on azure IoT Hub portal

1. Navigate to the Dashboard –> <Your IoT Hub> –> “IoT Devices”
2. Add a new device (e.g. device1), and for its authentication type choose X.509 CA Signed

> **Note:** Creating a new device For large deployment of device, creating a device on azure iot hub can be done using Azure IoT service SDK

Creating and updating device keys and certificates to SE

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) Check the vcom port number
3) To create certificates on windows and provision, go to `simw-top/pycli` directory and call:

```
call venv\Scripts\activate.bat
cd Provisioning
python GenerateAZURECredentials.py <COM_PORT>
python ResetAndUpdate_AZURE.py <COM_PORT>
```

> **Note:** Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

4) Certificates and Keys are generated at `simw-top/pycli/Provisioning/azure`

Uploading root certificates to IoT Hub

1) On Azure IoT Hub portal, Navigate to `Dashboard --> <Your IoT Hub> --> Certificates`. Click on Add
2) Enter a friendly name and upload the root certificate created in the previous step. Location - `simw-top/pycli/Provisioning/azure/RootCA.cer` -> Save
3) Your certificate will show in the Certificate Explorer list. Click on certificate added
4) In Certificate Details, click Generate Verification Code
5) The provisioning service creates a Verification Code that you can use to validate the certificate ownership. Copy the code to your clipboard
6) Use the verification_certificate.py to generate a verify certificate (verifyCert4.cer)

```
cd simw-top/pycli/Provisioning
python verification_certificate.py <RootCA_Certificate> <RootCA_Keypair>
↪<Verification Code>
```

7) On `Azure portal -> Certificate Details`, upload the verifyCert4.cer file generated and click Verify.

   STATUS of your certificate should change to `Verified` in the Certificate Explorer list

Building the Demo

1) Open cmake project found under `<SIMW-TOP>projects` in MCUXPRESSO IDE
2) **Update cmake options::**
    - `RTOS=FreeRTOS`
    - `mbedTLS_ALT=SSS`
3) **Update the build target in make file**
    - Project:`cloud_azure`

Running the Demo

1) Update `AZURE_IOT_HUB_NAME` and `AZURE_DEVICE_NAME` in `<PROJECT>\demo\azure_demo\azure_iot_confi` `h` with your details
2) Build the project and flash the binary on FRDM-K64F board
3) Connect your board to open network
4) **Open a serial terminal on PC for OpenSDA serial device with these settings**
    - 115200 baud rate
    - 8 data bits
    - No parity
    - One stop bit
    - No flow control
    - change Setup->Terminal->New-line->Receive->AUTO
5) Console Output

- Press reset button on the board If everything is setup correctly, the output would be as follows:

```
,----
|
| Connecting to network
| Getting IP address from DHCP ...
|
| IPv4 Address     : 192.168.0.68
| DHCP OK
| MQTT attempting to connect to 'dev2'...
|
| Signing using key 1X
| MQTT Echo demo subscribed to devices/dev2/messages/devicebound/#
| -->sleepEcho successfully published
| Echo successfully published
| -->sleepEcho successfully published
| Echo successfully published
|
|   ...
|   ...
|
`----
```

- You can use device explorer tool to control the on-board LEDs. Open device explorer tool and update the IoT Hub connection string to connect to azure IoT hub, IoT Hub connection string is found at Azure IoT Hub -> Shared access policies -> iothubowner -> Connection String Primary key
- In the "Message To Devices" tab, select the device and send the message as:

```
,----
| {"green": "toggle"}, {"green": "on"}, {"red": "off"}
`----
```

Appendix

1. for more inforation, refer to https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-mqtt-support

5.3.8 Azure Demo for iMX Linux / Raspberry Pi

This demo demonstrates connection to Azure IoTHub using pre-provisioned device credentials and demonstrates publish/subscribe procedure using MQTT.

Prerequisites

- Azure account
- SD Card image with SE050 Middleware pre-installed. The application is built on the iMX platform.
- IMX6UL-EVK platform or Raspberry pi connected to the Internet

Preparing the credentials and Provisioning the secure element

Use ssscli tool from iMX/Rpi platform

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) To create certificates on imx and Raspberry Pi, call:

```
cd simw-top/pycli/Provisioning
python3 GenerateAZURECredentials.py
python3 ResetAndUpdate_AZURE.py
```

Note: Provisioning of the keys is done with default policies. Refer - Section 9.9 to change the scripts to add required policies.

3) Certificates and Keys are generated at `simw-top/pycli/Provisioning/azure`

Registering Device

To register the device onto the IoT Hub portal, we can either upload Root credentials manually or we can register an individual device using `azure_imx_register` application. If you wish to upload Root credentials, skip the next steps and proceed to *Uploading root certificates to IoT Hub*.

Create device enrollment in azure IoT Hub portal

This step is only for individual device enrollment.

Prerequisite: Azure IOT hub and Azure IOT HUB DPS account which are linked.

Refer: https://docs.microsoft.com/en-us/azure/iot-dps/tutorial-set-up-cloud

https://docs.microsoft.com/en-us/azure/iot-dps/quick-setup-auto-provision

Once required accounts exist we can enroll the devices. For this we only need device certificate which we created in above steps.

Follow the steps to enroll the device: https://docs.microsoft.com/en-us/azure/iot-dps/tutorial-provision-device-to-hub

Note: When creating device certificates be sure to use only lower-case alphanumerics and hyphens in your device name.

Run `azure_imx_register` application to register the device onto your IoT Hub.

`azure_imx_register` application can take parameters either via JSON file or via command line. The required parameters are:

- registerid: Registration id of the device (common name of device certificate)
- keypath: Path to reference key pem file
- devcert: Path to device certificate
- rootpath: Path to azure root CA certificate
- idscope: IDScope (can found in Azure IoT-DPS account - Overview)

Run via command line as:

```
./azure_imx_register --registerid test-device --keypath keyref.pem --rootpath␣
↪azureRootCA.pem --devcert cert.pem --idscope 0ne00068F95
```

Or pass JSON file as:

```
./azure_imx_register --json json_register_config.json
```

Sample JSON file:

```
{
  "devcert": "cert.pem",
  "keypath": "keyref.pem",
  "id_scope": "0ne00068F95",
  "registration_id": "test-device",
  "rootpath": "azureRootCA.pem"
}
```

Upon successful registration, “DeviceID”.txt file is created with DeviceID, assigned hub along with keyref, device certificate and root certificate path. This file can be given as input to connect to device and send messages.

The device is now registered and appears on IoT Azure hub under devices tab

We can pass this JSON file to `azure_imx_connect` application to connect to IoT Hub. You can skip the next step and proceed to *Build the OpenSSL engine [Optional]*.

Uploading root certificates to IoT Hub

1) On Azure IoT Hub portal, Navigate to `Dashboard --> <Your IoT Hub> --> Certificates`. Click on Add
2) Enter a friendly name and upload the root certificate created in the previous step. Location - `simw-top/pycli/Provisioning/azure/RootCA.cer` -> Save
3) Your certificate will show in the Certificate Explorer list. Click on certificate added
4) In Certificate Details, click Generate Verification Code
5) The provisioning service creates a Verification Code that you can use to validate the certificate ownership. Copy the code to your clipboard
6) Use the verification_certificate.py to generate a verify certificate (verifyCert4.cer)

   ```
   cd simw-top/pycli/Provisioning
   python verification_certificate.py <RootCA_Certificate> <RootCA_Keypair>
   ↪<Verification Code>
   ```

7) On `Azure portal -> Certificate Details`, upload the verifyCert4.cer file generated and click Verify.

   STATUS of your certificate should change to `Verified` in the Certificate Explorer list

Build the OpenSSL engine [Optional]

Note: This step is optional in case you are using a prepared SD card image from NXP.

The OpenSSL engine uses the sss abstraction layer to access the crypto services of the secure element, the implementation remains dependent on the secure element attached. The following illustrates compiling the OpenSSL engine for SE050 connected over I2C.

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: Replace `imx_native_se050_t1oi2c` with `raspbian_native_se050_t1oi2c` when building for Raspberry Pi.

Run the example

1) Use 'buildScript.sh' script at simw-top/demos/linux/azure/ to download all dependencies and build the mqtt application for azure call:

   ```
   cd /simw-top/demos/linux/azure
   ./buildScript.sh
   ```

2) Based on OpenSSL version and applicable Secure Element, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

```
openssl11_sss_a71ch.cnf   ----- OpenSSL 1.1.1 and A71CH
openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
openssl_sss_a71ch.cnf     ----- OpenSSL 1.0.0 and A71CH
openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
```

3) Set the openssl config path as call:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/<appropriate-cnf-file>
```

4) To run the application, call:

```
$ ./azure_imx_connect --deviceid "<device_name>" --keypath simw-top/pycli/
↪Provisioning/azure/<UID>_device_reference_key.pem --rootpath simw-top/demos/
↪linux/azure/azureRootCA.pem --devcert simw-top/pycli/Provisioning/azure/<UID>_
↪device_certificate.cer --hubname <IotHubName>.azure-devices.net --username
↪<IotHubName> --payload "<MESSAGE>"
```

Or pass JSON file as:

```
./azure_imx_connect --json json_connect_config.json
```

Sample json_connect_config.json:

```
{
  "assignedHub": "ABCD.azure-devices.net",
  "deviceId": "test-device",
  "registration_id": "test-device",
  "status": "assigned",
  "keypath": "keyref.pem",
  "devcert": "cert.pem",
  "rootpath": "azureRootCA.pem",
  "payload": "hello message from device test-device"
}
```

Note: If you have used `azure_imx_register` application, `json_connect_config.json` is same as `"DeviceID".txt`

Note:

1) Export the OpenSSL conf path to the exact location of the file. The above example is for illustrative purpose
2) While executing the application, use the appropriate values for device cert, Device id, Path, hubname and username

5.4 Linux Specific Demos

5.4.1 Greengrass Demo for Linux

AWS IoT Greengrass is a software provided by AWS to extend cloud capabilities to locally connected devices. This allows local devices to publish/subscribe to a topic even if there is no connectivity with AWS IoT console. A Greengrass group consists of a Greengrass core, multiple Greengrass devices connected to that core, and lambda functions and other services running on that core. In this, the Greengrass core performs the functions of AWS IoT console.

Also see What Is AWS IoT Greengrass for more details about AWS IoT Greengrass.

This demo is to demonstrate how to integrate SE050 with AWS IoT Greengrass core and RaspberryPi as hardware security to store core specific credentials for IoT client and MQTT server.

Note: Hardware security feature is available only for AWS IoT Greengrass Core v1.7 and later. We have used Greengrass core v1.10.0 for integration

Prerequisites

- AWS Greengrass account (Also see supported regions for Greengrass)
- RaspberryPi 3 Model B+ or Model B. The architecture of your Pi must be armv7l or later
- Raspbian Buster operating system
- Python 2.7
- ssscli Tool. Refer to *CLI Tool*

Preparing the Greengrass group

1) Follow the modules 1 and 2 as described in Environment Setup for Greengrass to set up Greengrass group and Greengrass core.

   Note: In Module 2, if you choose Easy Group Creation, AWS will create credentials for Greengrass IoT core and provision in the registry. Skip the next step if you choose Easy Group Creation. You could otherwise create your own credentials and provision AWS registry as explained in the next step.

2) If you wish to use your own credentials, upload the your RootCA and verification certificate in `Secure->CAs` tab under IoT Core.
   - While creating Greengrass group, choose `Advanced group creation`.
   - You can either assign IAM role or skip it for later.
   - Under Set up your security, choose `Advanced setup` and then choose `Use my certificate`.
   - Select your active RootCA certificate and upload corresponding device certificate
3) If you used your own credentials, download sample `config.json` file for greengrass available at AWS IoT Greengrass Core Configuration File

   After completing Module 2, store your device certificate under certs directory where you have extracted AWS IoT Greengrass core software (by default `/greengrass` directory) and the downloaded `config.json` under config directory.

4) Do **NOT** run the daemon yet.

Provisioning SE050 and Building PKCS#11 library

1) Before running the Greengrass daemon, you would need to provision your SE050 and build PKCS#11 library.
2) Complete Section 9.3 *Steps needed before running ssscli tool* for ssscli tool setup
3) Run the following steps to provision your SE050 with Greengrass core keypair:

```
ssscli connect se050 t1oi2c none
ssscli se05x reset
ssscli set ecc pair 0x20181001 <path-to-core-keypair>
ssscli disconnect
```

Note: Greengrass uses labels to address objects on tokens. To make the PKCS#11 library use a specific keyID, the label should start with `sss:` followed by 32-bit keyID in hexadecimal format (little endian). For example, the label for the command used above would be `sss:01101820`.

4) Build and install PKCS#11 library for Greengrass core. Refer to Section 8.7 *PKCS#11 Standalone Library* .. note:: Disable cmake option `WithSharedLIB` while building the PKCS#11 library

Updating Greengrass configuration

If you have successfully completed *Preparing the Greengrass group*, you would have `config.json` under config directory of AWS IoT Greengrass core software (by default as `/greengrass` directory). A sample of `config.json` is:

```
{
  "coreThing" : {
    "caPath" : "root.ca.pem",
    "certPath" : "hash.cert.pem",
    "keyPath" : "hash.private.key",
    "thingArn" : "arn:partition:iot:region:account-id:thing/core-thing-name",
    "iotHost" : "host-prefix-ats.iot.region.amazonaws.com",
    "ggHost" : "greengrass-ats.iot.region.amazonaws.com",
    "keepAlive" : 600
  },
  "runtime" : {
    "cgroup" : {
      "useSystemd" : "yes"
    }
  },
  "managedRespawn" : false,
  "crypto" : {
    "principals" : {
      "SecretsManager" : {
        "privateKeyPath" : "file:///greengrass/certs/hash.private.key"
      },
      "IoTCertificate" : {
        "privateKeyPath" : "file:///greengrass/certs/hash.private.key",
        "certificatePath" : "file:///greengrass/certs/hash.cert.pem"
      }
    },
    "caPath" : "file:///greengrass/certs/root.ca.pem"
  }
}
```

Remove the `caPath`, `certPath`, and `keyPath` values from the `coreThing` object.

Update the `certificatePath` property of `IoTCertificate` object to the path of device certificate.

Note: Currently AWS IoT Greengrass core does not support loading certificates from hardware. These have to be provided as a path to a file on filesystem.

Update the values of `privateKeyPath` under `SecretsManager` and `IoTCertificate` objects with *pkcs11:object=sss:01101820;type=private*.

Add the following `MQTTServerCertificate` object under `principals` object:

```
"MQTTServerCertificate": {
    "privateKeyPath": "pkcs11:object=sss:01101820;type=private"
}
```

Add the following `PKCS11` object under `crypto` object:

```
"PKCS11": {
    "P11Provider": "/path/to/libsss_pkcs11.so",
    "slotLabel": "SSS_PKCS11",
    "slotUserPin": "1234"
}
```

Add commas where needed to create a valid JSON document.

In this file, we have used a shared key for `MQTTServerCertificate`, `IoTCertificate` and `SecretsManager` components. In `PKCS11` object, we specify which PKCS#11 module to load and which slot to use in that module. All PKCS#11 objects specified for different components will refer to the same token.

Running Greengrass Core

Start the Greengrass daemon by running the following command in `ggc/core` directory under AWS IoT Greengrass core software directory:

```
sudo ./greengrassd start
```

The Daemon should start successfully. If you face any problem while starting the Greengrass daemon, refer to Troubleshooting section below. Also see runtime logs under `/greengrass/ggc/var/log/system` directory.

Connecting Devices to Greengrass Core

Follow steps mentioned from Module 3 to test Greengrass connectivity: Lambda Functions on AWS IoT Greengrass

Over-The-Air (OTA) Updates

To configure your device for OTA updates, you also need additional PKCS#11 engine for OpenSSL. You can use OpenSC's `libp11` as the engine. It is recommended that you build the engine manually.

Run the following commands:

```
git clone https://github.com/OpenSC/libp11.git
cd libp11
sudo apt install pkgconf libssl-dev libtool
autoreconf --verbose --install --force
./configure && make && sudo make install
```

This will build the PKCS#11 engine for OpenSSL. Next, you have to specify the paths to the engine in your OpenSSL configuration file. Instead of editing default OpenSSL configuration file, you can maintain two separate files.

Place this line at the top, before any sections are defined:

```
openssl_conf = openssl_init
```

At the end of the file add the following configuration:

```
[openssl_init]
engines=engine_section

[engine_section]
pkcs11 = pkcs11_section

[pkcs11_section]
engine_id = pkcs11
dynamic_path = /usr/lib/arm-linux-gnueabihf/engines-1.1/pkcs11.so
MODULE_PATH = /usr/local/lib/libsss_pkcs11.so
init = 0
```

Here, `dynamic_path` is the path to PKCS#11 engine *.so* file. This is installed in `/usr/lib/arm-linux-gnueabihf/` directory. This path will also be printed out while installing `libp11` library.

`MODULE_PATH` is the path to the PKCS#11 library installed in Section 8.7 *PKCS#11 Standalone Library*.

You can also test if OpenSSL is able to load the PKCS#11 library by executing the following command:

```
openssl engine dynamic -pre SO_PATH:/usr/lib/arm-linux-gnueabihf/engines-1.1/pkcs11.
↪so -pre ID:pkcs11 -pre LOAD -pre MODULE_PATH:/usr/local/lib/libsss_pkcs11.so
```

You should be able to see the following output:

```
(dynamic) Dynamic engine loading support
[Success]: SO_PATH:/usr/lib/arm-linux-gnueabihf/engines-1.1/pkcs11.so
[Success]: ID:pkcs11
[Success]: LOAD
[Success]: MODULE_PATH:/usr/local/lib/libsss_pkcs11.so
Loaded: (pkcs11) pkcs11 engine
```

Follow the steps listed in OTA Updates of AWS IoT Greengrass Core Software to configure the backend for OTA updates.

Troubleshooting

1) Error message **greengrass deployment failed too many levels of symbolic links**

   Check if your linux supports OverlayFS. Also confirm that the Raspberry Pi image version matches the version specified in Setting Up a Raspberry Pi. Currently, AWS IoT Greengrass Core has been tested on **2019-07-10-raspbian-buster** image. Greengrass core might not work with other images like Raspbian Stretch.

2) Error message **connection reset by peer**.

   Add properties `iotHttpPort` and `ggHttpPort` to `coreThing` object as:

   ```
   "iotHttpPort" : 443,
   "ggHttpPort" : 443
   ```

If you face any other issue, refer to Troubleshooting AWS IoT Greengrass.

5.4.2 OpenSSL Engine: TLS Client example for iMX/Rpi3

- DocRevision : 0.94
- Date : 2020-01-14

This section explains how to set-up a TLS link using the SE050 OpenSSL Engine on the client side. A note at the bottom of this page (Section 5.4.2) highlights the changes in case one uses an A71CH secure element.

Summary

The TLS demo demonstrates setting up a mutually authenticated and encrypted link between a client and a server system. The keypair used to identify the client is stored in the Secure Element. The keypair used to identify the server is simply available as a pem file.

The public keys associated with the respective key pairs are contained in respectively a client and a server certificate.

The CA is a self-signed certificate. The same CA is used to sign client and server certificate.

One can choose the keymaterial (CA, Client and Server) to be either RSA (4096 CA - 2048 client/server) or EC (prime256v1).

The TLS demo comes in two flavours:

1. **Flavour-A:** The standard OpenSSL tools *s_server* and *s_client* are used to set-up and demonstrate the TLS link. The certificates used are simply stored on the file system of the host. The client uses the keypair stored inside the SE050.
2. **Flavour-B:** A TLS client program - included in source code (tlsSe050Client.cpp) - retrieves the client certificate from the SE050 and uses the keypair stored inside the SE050. It establishes a TLS connection with the server process *s_server*.

Steps in Section 5.4.2 to Section 5.4.2 are identical for the two demo flavours.

Credential preparation (execute once) [Optional]

```
> cd demos/linux/tls_client
> ./scripts/createTlsCredentials_Optional.sh <ECC|RSA>
```

Note: The Host SW package comes bundled with the required credentials. The *createTlsCredentials_Optional.sh* script will re-create equivalent credentials (but with new/different keypairs)

The script creates all demo required client and server credentials on the client platform. One must transfer the server credentials to the server platform.

Secure Element preparation (client side)

For the purpose of the demo one MUST inject the TLS client key pair and certificate into the Secure Element and create a reference pem file referring to the provisioned key pair:

```
> cd demos/linux/tls_client/scripts
> python3 provisionTlsClient.py --key_type <ecc|rsa>
```

Further details on using these scripts can be found in the following:

provisionTlsClient.py

usage: provisionTlsClient.py [-h] –key_type KEY_TYPE [–connection_data CONNECTION_DATA] [–connection_type CONNECTION_TYPE] [–subsystem SUBSYSTEM]

Provision attached secure element with ECC/RSA keys

Preconditions:

- Secure element attached
- Virtual environment should be activated (not for iMX platform. Refer ssscli installation steps: Plug & Trust MW, Section 8.3 *Steps needed before running ssscli tool*)

Postconditions:

- Key pair injected on id referred by KEYPAIR_INDEX_CLIENT_PRIVATE variable
- Ref pem created
- Client certificate injected on id referred by CERTIFICATE_INDEX variable.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `ecc`, `rsa`

optional arguments:

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--subsystem SUBSYSTEM Supported subsystem => `se050`, `a71ch`. Default: `se050`

Example invocation:

```
python provisionTlsClient.py --key_type ecc
python provisionTlsClient.py --key_type ecc --connection_data 169.254.0.1:8050
python provisionTlsClient.py --key_type rsa --connection_data 127.0.0.1:8050 --
↪connection_type jrcpv2
python provisionTlsClient.py --key_type rsa --connection_data COM3
python provisionTlsClient.py --key_type ecc --subsystem a71ch
```

Server side preparation

Note: The Host SW package comes bundled with the required server credentials.

Ensure the default server credentials or those created under (Section 5.4.2) are available on the server platform.

Start up the server

Note: The server can run e.g. on a PC. The server must be reacheable over the TCP/IP network for the Client. Choose either a server using EC based credentials or a server using RSA based credentials.

Execute the following command on the server platform to use the EC based server credentials, make a note on the IP address of the server:

```
> cd demos/linux/tls_client/scripts
> ./tlsServer.sh <ECDHE|ECDHE_SHA256|max>
```

Execute the following command on the server platform to use the RSA based server credentials, make a note on the IP address of the server:

```
> cd demos/linux/tls_client/scripts
> ./tlsServer.sh RSA
```

Establish a TLS link from the client to the server

The client process establishing the TLS connection comes in two flavours: either *s_client* or a program provided in source code (tlsSe050Client.cpp). Invoke either example through a bash shell script.

Using s_client

Invoke the script using the IP address of the server as the first argument and ECDHE or ECDHE_SHA256 as the second argument (ECDHE corresponding to ECDH ephemeral) when connecting to a server using EC based credentials:

```
> ./tlsSeClient.sh <server-IP-address> <ECDHE|ECDHE_256>
```

Invoke the script using the IP address of the server as the first argument and RSA as the second argument when connecting to a server using RSA based credentials:

```
> ./tlsSeClient.sh <server-IP-address> RSA
```

In case OpenSSL 1.1.1 is available on *both* Client (i.MX or Raspberry Pi) and Server side, it's possible to request the usage of the TLS1.3 protocol (by default TLS1.2 is used). This is achieved by setting the environment variable REQ_TLS to tls1_3:

```
> REQ_TLS=tls1_3 ./tlsSeClient.sh <server-IP-address> ECDHE
```

Using tlsSe050Client.cpp

First compile the client program. Ensure all required SE050 specific libraries and header files have been installed on the linux system. By default this example links to static libraries:

```
> cd demos/linux/tls_client/build
> cmake ../.
> cmake --build .
```

Invoke the script using the IP address of the server as argument:

```
> ./tlsExtendedSeClient.sh <server-IP-address> <EC|RSA>
```

Note: The environment variable REQ_TLS is not applicable to this example. In case OpenSSL 1.1.1 is available on the client, the actual TLS protocol version used will be negotiated to the highest version supported by both client and server. Otherwise TLS1.2 will be used.

TLS client example using A71CH

Introduction

The TLS client example can also be used in combination with an A71CH secure element (in EC mode only). The following steps are different:

```
- secure element preparation
- client program invocation
```

Secure Element preparation (client side)

Specify an additional option `--subsystem a71ch`:

```
> python3 provisionTlsClient.py --key_type ecc --subsystem a71ch
```

Invocation of client program

Set the environment variable `REQ_SE` to `a71ch` when invoking the client program:

```
> REQ_SE=a71ch ./tlsSeClient.sh 192.168.1.190 ECDHE
> ... or ...
> REQ_SE=a71ch ./tlsExtendedSeClient.sh 192.168.1.190 EC
```

5.4.3 Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet

- DocRevision : 0.93
- Date : 2020-10-20

Summary

The Access Manager supports concurrent access from multiple linux processes to an SE05x IoT applet. The Access Manager can establish a connection to the SE05x either as a plain connection or as an SCP03 platform connection. Client processes connect over the JRCPv1 protocol to the accessManager. Refer to *Concepts & Features* for more details.

Note: When using multiple clients with user authentication, build client applications with `-DPTMW_SMCOM:STRING=JRCP_V1_AM` option. This will ensure the user session is established in an atomic way per client connect.

Usage

```
The accessManager takes two optional arguments 'plain' & 'any'
        'accessManager':
                Platform SCP03: ON.
                Incoming connection: localhost.
        'accessManager plain':
                Platform SCP03: OFF.
                Incoming connection: localhost.
        'accessManager any':
                Platform SCP03: ON.
                Incoming connection: any supported address.
        'accessManager plain any':
                Platform SCP03: OFF.
                Incoming connection: any supported address.

Note:
        Product Deployment => Enable Platform SCP03 & restrict incoming connection to␣
↪localhost
```

In case STREAM sockets are used client processes must connect to port 8040.

As an example:

- The Access Manager is running on iMX and opens a listening STREAMING socket. Incoming connections can be restricted to client processes connecting over localhost.

  Example invocation. Notice that the Platform SCP03 keys are passed through an environment variable:

  ```
  root@imx8mqevk:~/mnt/git/simw-top_build_imx8_5_4_24/imx_native_se050_t1oi2c# \
    EX_SSS_BOOT_SCP03_PATH=/home/root/plain_scp03.txt bin/accessManager
  Starting accessManager (Rev.0.9).
    Protect Link between accessManager and SE: YES.
  accessManager JRCPv1 (T1oI2C SE side)
  ******************************************************************************
  Server: waiting for connections on port 8040.
  Server: only localhost based processes can connect.
  ```

- client process connects via JRCPv1 to 127.0.0.1:8040

  Example invocation. Notice that the server address is set through an environment variable. In a product deployment the default server:port address can also be hard-coded to the proper value:

  ```
  root@imx8mqevk:~/home/root# EX_SSS_BOOT_SSS_PORT=127.0.0.1:8040 se05x_
  ↪ConcurrentEcc
  ```

Build

- The Access Manager must be built as a statically linked executable as its communication and authentication layer is different from the client processes that connect to it.
- Access manager will send "READY=1" start up notification to service manager. This is disabled by default. To enable, uncomment below lines in `simw-top/hostlib/hostLib/accessManager/CMakeLists.txt` file

  ```
  ADD_DEFINITIONS(-DENABLE_SD_NOTIFY)
  TARGET_LINK_LIBRARIES(${PROJECT_NAME} systemd)
  ```

Note: To build access manager on RaspberryPi with *ENABLE_SD_NOTIFY* enabled, install systemd-dev lib as `sudo apt-get install libsystemd-dev`

Build settings to support access to SE05x on iMX host platform (to be applied on top of a configured host build area):

```
cmake -DPTMW_SCP:STRING=SCP03_SSS -DPTMW_SE05X_Auth:STRING=PlatfSCP03 -DPTMW_
↪SMCOM:STRING=T1oI2C \
  -DWithSharedLIB:BOOL=OFF -DPAHO_BUILD_SHARED:BOOL=FALSE -DPAHO_BUILD_
↪STATIC:BOOL=TRUE .
cmake --build . --target accessManager
```

- The client processes that connect to the Access Manager must be built in a separate build environment. All session authentication mechanisms are supported, platform SCP03 must be off (platform SCP03 is handled by the Access Manager).

  Build settings for client processes connecting via Access Manager, in the example no session authentication is used (to be applied on top of a configured host build area):

```
cmake -DPTMW_SE05X_Auth:STRING=None -DPTMW_SMCOM:STRING=JRCP_V1 .
cmake --build .
```

Demo: concurrent access from 2 processes using OpenSSL engine

- The example requires an embedded Linux platform (e.g. an iMX8) with an attached SE05X. Interaction with the iMX8 is over 3 different shells. These shells can e.g. be established via ssh from a PC on the same network.
- Build the Access Manager in a dedicated workarea, follow build instructions as above. Select static linking, enable Platform SCP03 and use T1oI2C as communication protocol.
- Build the Plug&Trust package in a dedicated workarea, follow build instructions as above. Select None as authentication mode and use JRCPv1 as communication protocol.
- Start the Access Manager from a dedicated shell (to simplify the demo, Platform SCP03 is not enabled):

```
./accessManager plain
```

- Open another shell and configure the attached Secure Element once using the ssscli tool (ensure the installed ssscli tool uses JCRPv1 as communication protocol, refer to *Communication interface (cmake SMCOM setting)*):

```
cd <plug_and_trust>/simw-top/sss/plugin/openssl/scripts
python3 openssl_provisionEC.py --key_type prime256v1 --connection_data 127.0.0.
↪1:8040
```

- From the same shell invoke the OpenSSL Engine to perform various sign/verify operations using the provisioned EC key pairs:

```
python3 openssl_EccSign.py --key_type prime256v1 --connection_data 127.0.0.1:8040
```

- Open another shell and invoke the OpenSSL Engine to perform various sign/verify operations using the provisioned EC key pairs:

```
cd <plug_and_trust>/simw-top/sss/plugin/openssl/scripts
python3 openssl_EccSign.py --key_type prime256v1 --connection_data 127.0.0.1:8040␣
↪ --output_dirname output3
```

- The respective ‘openssl_EccSign.py’ invocations can be repeated, ensure both process invocations run in parallel.

Example programs prepared for concurrent access

The demo folder of the Plug&Trust MW package contains two SSS API based example programs that are compatible with concurrent access requirements like:

- ability to select a specific (optional) authentication object ID
- provisioned content of secure element is not erased at project start-up

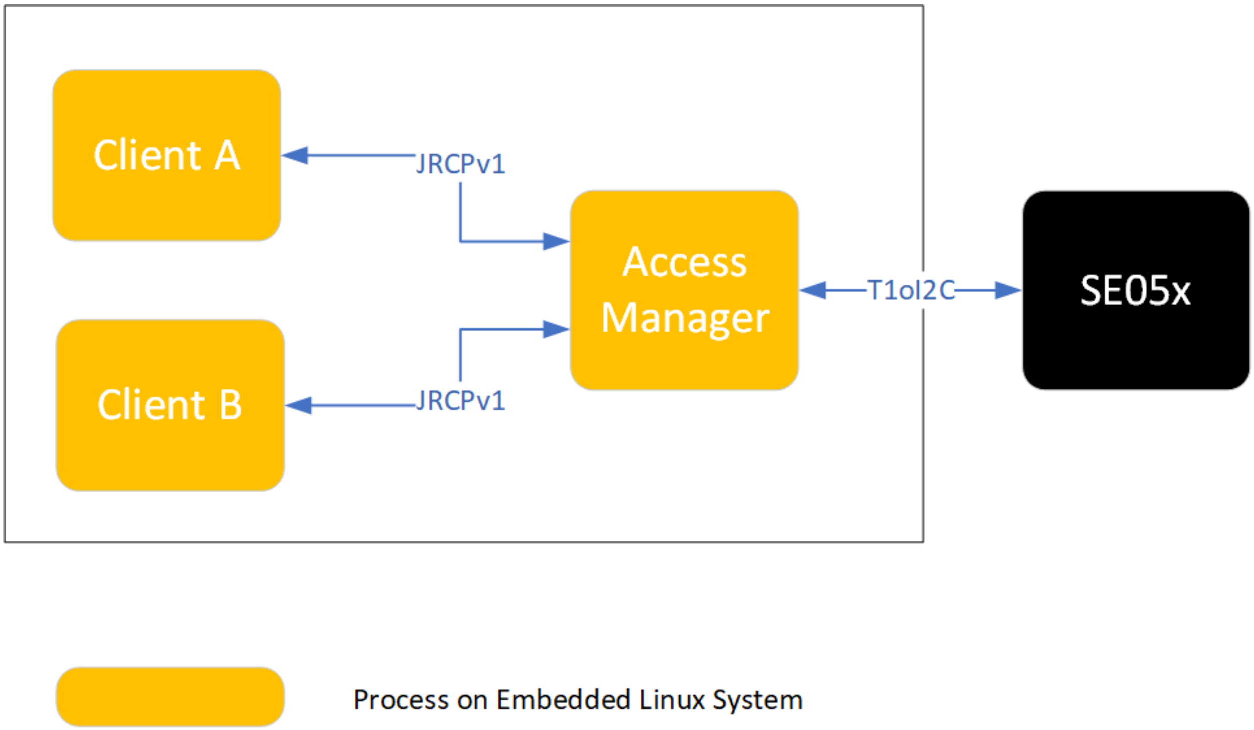
For more details on these examples refer to:

- Section 5.7.26 *ECC Concurrent Example*
- Section 5.7.27 *Symmetric Multi Step Concurrent Example*

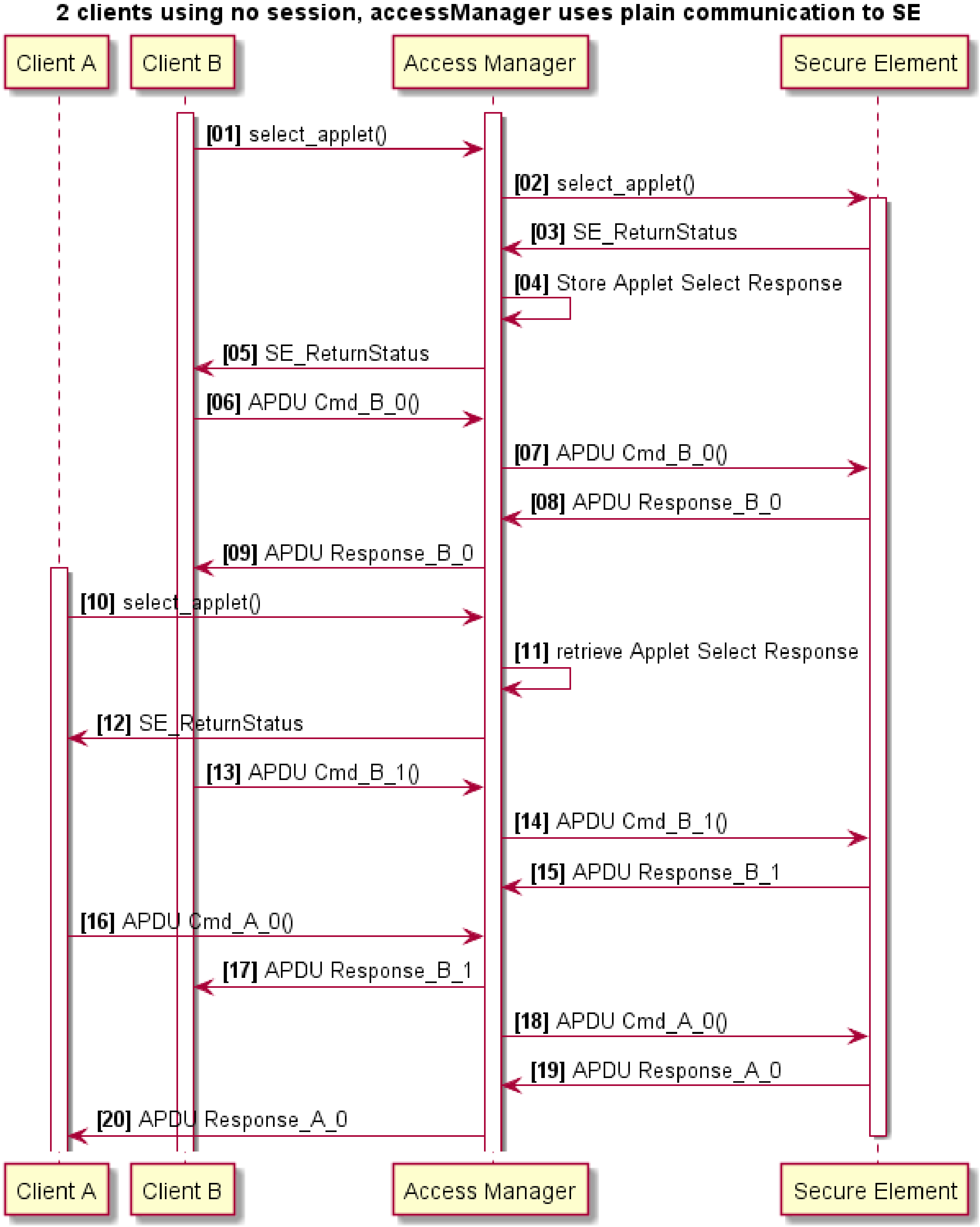
Concepts & Features

- The Access Manager uses plain communication or platform SCP03 in the communication with the SE. Select the mode at start-up.
- Client processes connect to the accessManager using the JRCPv1 protocol
- The user session authentication type is determined at the client build time. User session authentication is transparent to the Access Manager.
- The Access Manager ensures APDU command / response pairs associated with a client process are executed without interference from another client process.
- The Access Manager does not connect to the SE05x at start up. It waits until a client process initiates a connection.
- When a client process selects the SE05x IoT applet the applet response is cached by the Access Manager, a subsequent SE05x IoT applet select by a client process will simply return the cached applet response.
- A card manager select command is intercepted by the Access Manager and a pre-cooked response is provided to the initiating client process. No interaction with the secure element takes place.

The following figure illustrates the Access Manager is an independent process on the Embedded System providing indirect access to the Secure Element for client processes.



The following sequence diagram illustrates two processes connecting through the Access Manager to the Secure Element.


2 clients using no session, accessManager uses plain communication to SE
Client A
Client B
Access Manager
Secure Element
[01] select_applet()
[02] select_applet()
[03] SE_ReturnStatus
[04] Store Applet Select Response
[05] SE_ReturnStatus
[06] APDU Cmd_B_0()
[07] APDU Cmd_B_0()
[08] APDU Response_B_0
[09] APDU Response_B_0
[10] select_applet()
[11] retrieve Applet Select Response
[12] SE_ReturnStatus
[13] APDU Cmd_B_1()
[14] APDU Cmd_B_1()
[15] APDU Response_B_1
[16] APDU Cmd_A_0()
[17] APDU Response_B_1
[18] APDU Cmd_A_0()
[19] APDU Response_A_0
[20] APDU Response_A_0
Client A
Client B
Access Manager
Secure Element

Restrictions

- Each user session needs to have a different authentication object; i.e. one Authentication Object cannot be used to open multiple sessions in parallel. This limitation is inherent to the SE05x user session concept.
- The SE05x does not support more than two active user sessions (based upon either a User ID, AES Key or EC Key authentication object). The Access Manager does not and - conceptually - cannot monitor the number of active user sessions.
- The Access Manager only supports concurrent access to the SE05x IoT applet. Do not access other applets than the SE05x applet through the Access Manager.
- The Access Manager does not attempt to re-establish a broken connection to the SE05x. To recognize and recover from a broken connection, a system integrator must monitor failure to communicate to the Secure Element by the client processes. As and if required the Access Manager must be restarted and the affected client processes must reconnect to the Access Manager.
- A client process establishing a user session with the SE05x applet must always close the user session prior to disconnecting from the Access Manager.
- Selecting another applet than the SE05x IoT applet is possible but strongly discouraged and not supported.
- The Access Manager **does not** :
  - Handle power management
  - Keep track of Secure Element resources
- In a typical deployment the Access Manager and client processes are controlled by another – product specific - entity on the Embedded System:
  - In case of an applet update, the Access Manager must be shut down and control of the secure element must be handed over to the SEMS Lite update manager.
  - A credential update must be coordinated between the consuming processes and the updating process. Such coordination is out-of-scope of the Access Manager
- Transparent usage of the OpenSSL Engine from different applications implies either no user session (Auth=None) or using the OpenSSL Engine from isolated environments (with different authentication settings). This restriction does not apply to applications built directly on top of the SSS API.
- The SSS layer's implementation of multistep symmetric ciphers does not allow concurrent execution of ciphers with the same cipher mode (e.g. twice kAlgorithm_SSS_AES_CBC).

Session open retry in client processes (Only for SE05X)

Session open retries can be enabled in client processes if required. (Only with `-DPTMW_SMCOM:STRING=JRCP_V1_AM` build option)

Set env variable `EX_SSS_SESSION_OPEN_RETRY_CNT` to number of retries required. (Default - 1. Max - 50).

Set env variable `EX_SSS_SESSION_OPEN_RETRY_DLY` to delay between each retries. (Default - 1 second. Max - 10 seconds).

Build options for A71CH in Access Manager

Scope of A71CH support in Access Manager is limited to the concurrent usage of the SSS based OpenSSL engine.

Build settings to support access to A71CH on iMX host platform (to be applied on top of a configured host build area):

```
cmake -DPTMW_SCP:STRING=SCP03_HostCrypto -DPTMW_A71CH_AUTH:STRING=SCP03 -DPTMW_
↪SMCOM:STRING=SCI2C \
  -DWithSharedLIB:BOOL=OFF -DPAHO_BUILD_SHARED:BOOL=FALSE -DPAHO_BUILD_
↪STATIC:BOOL=TRUE .
cmake --build . --target accessManager
```

Build settings for A71CH client processes connecting via Access Manager, in the example no session authentication is used (to be applied on top of a configured host build area):

```
cmake -DPTMW_A71CH_AUTH:STRING=None -DPTMW_SMCOM:STRING=JRCP_V1_AM .
cmake --build .
```

When using access manager with SCP03 connection, A71CH needs to be provisioned with SCP03 keys first. This can be done using A71CH config tool.

Note: A71CH config tool has to be used only in direct connection with A71CH (SMCOM = SCI2C). It cannot be used in combination with access manager.

Build settings to build A71CH config tool on iMX host platform (to be applied on top of a configured host build area):

```
cmake -DPTMW_A71CH_AUTH:STRING=None -DPTMW_SMCOM:STRING=SCI2C .
cmake --build . --target A71CHConfigTool
```

Provision A71CH with SCP03 keys using config tool as

```
./A71CHConfigTool scp put -h 21 -k simw-top/hostlib/hostLib/accessManager/doc/
↪scp03KeyFile.txt
./A71CHConfigTool scp auth -h 21 -k simw-top/hostlib/hostLib/accessManager/doc/
↪scp03KeyFile.txt
```

Note: Product Deployment => File used to provision SCP03 keys should to be protected on file system.

FILE USED ABOVE IS ONLY FOR DEMONSTRATION PURPOSE. DO NOT USE THE SAME IN PRODUCT DEPLOYMENT.

Example invocation of access manager for A71CH. Notice that the Platform SCP03 keys are passed through an environment variable:

```
A71CH_SCP03_PATH_ENV=simw-top/hostlib/hostLib/accessManager/doc/scp03KeyFile.txt bin/
↪accessManager
Starting accessManager (Rev.0.9).
  Protect Link between accessManager and SE: YES.
accessManager JRCPv1 (T1oI2C SE side)
******************************************************************************
Server: waiting for connections on port 8040.
Server: only localhost based processes can connect.
```

Note: 1) A71CH supports some command which can be transmitted without SCP transformation even when SCP is setup. But, Access manager with SCP channel cannot be used to pass any such commands without SCP transformation.

2) Debug reset command cannot be passed via access manager to A71CH. Access manager will ignore the command and send pre-cooked success response. To issue debug reset command, use A71CH config tool with direct access to A71CH.

3) Use A71CHConfigTool to execute debug reset, before running any sss example.

Access Manager with Unix sockets

By default stream sockets are enabled for access manager. To enable Unix sockets in access manager, build using below option (to be applied on top of a configured host build area):

```
cmake -DWithAccessMgr_UnixSocket:BOOL=ON .
cmake --build . --target accessManager
```

Access manager on start up will create unix socket file at - */var/run/am*.

When using access manager with Unix sockets, build client applications also with WithAccessMgr_UnixSocket:BOOL=ON option

Note: Product Deployment => Assign the access permissions of **/var/run/am** accordingly.

Note: Product Deployment => If you wish to change the unix socket file location of access manager, modify the define 'UNIX_SOCKET_FILE' in `simw-top/hostlib/hostLib/accessManager/inc/accessManager.h`.

Also change the default socket port for client applications by changing - *EX_SSS_BOOT_SSS_SOCKETPORT_DEFAULT* in `simw-top/sss/ex/inc/ex_sss_ports.h`

5.5 OPC-UA Example

5.5.1 OPC UA (Open62541) Demo

Note: The example here is only for demostration of SE05x integration. Do not use the same in product deployment.

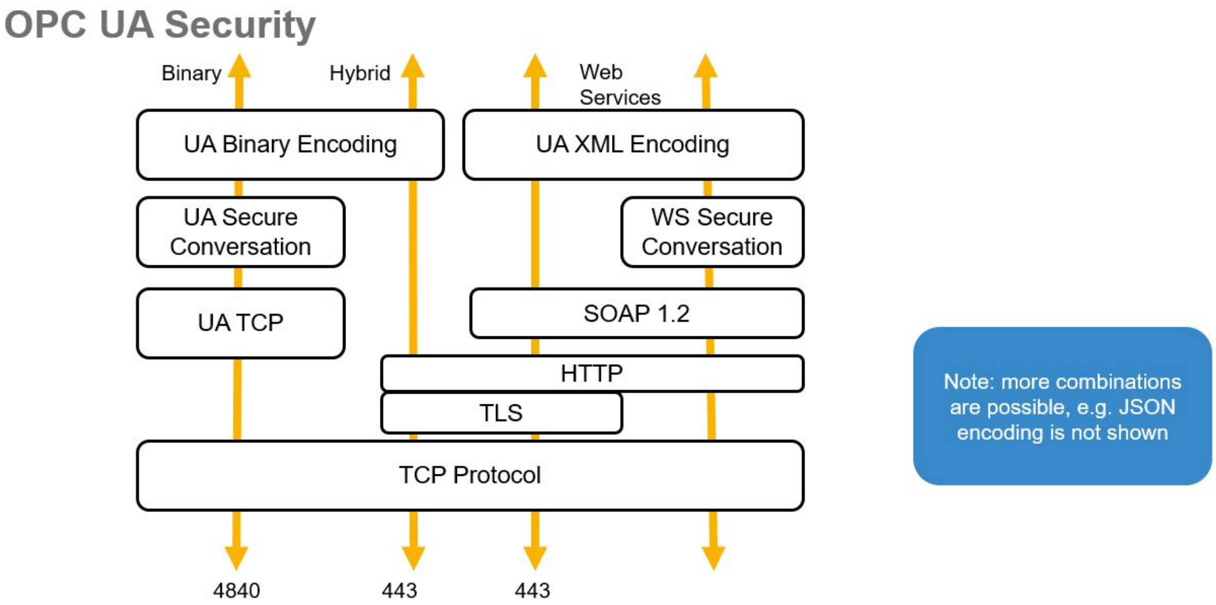
Supported Platforms

- Server Platform
  - Windows – JRCPv2 – SE050
  - iMX6 / RaspberryPi - t1oi2c – SE050
- Client Platform
  - UaExpert on Windows
  - Open62541 client on Windows
  - Open62541 client on iMX6 / RaspberryPi

Introduction

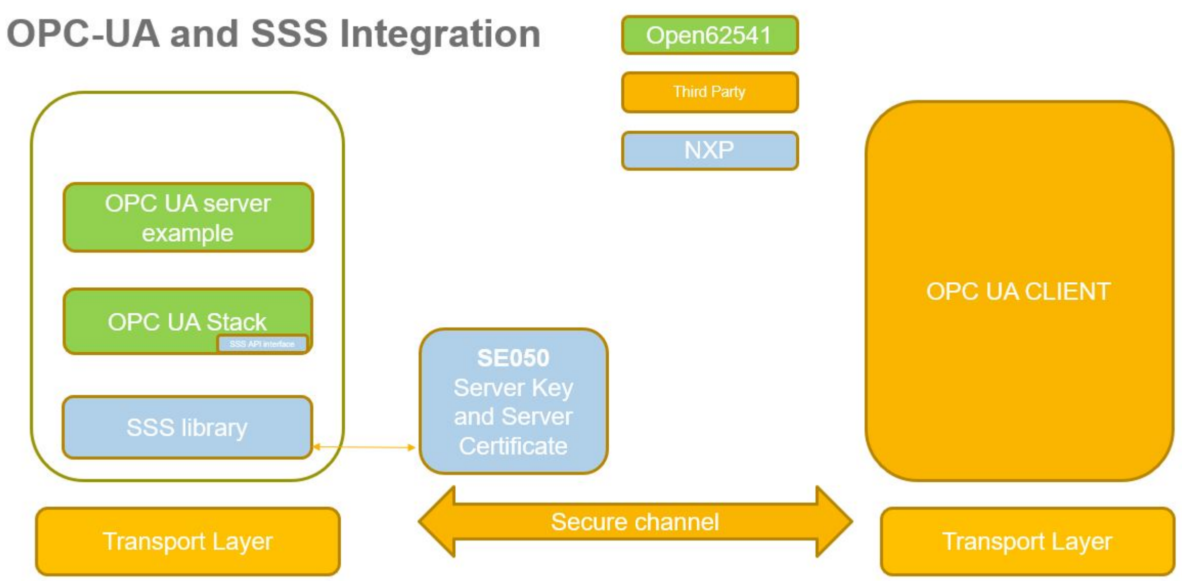
OPC UA (Open Platform Communications Unified Architecture) is an application layer protocol specific to Industrial IoT. It can run on top of TCP, TCP + Web services or TCP + HTTPS. In this client - server demo, the Open62541 open source OPC UA stack is used for integration with SE050. The server certificate and key are provisioned inside the SE050, the access to the SE050 is is performed using the SSS APIs. The OPC UA server example source code is available in directory `demos\opc_ua\opc_ua_server`. The Open62541 specific adaptation layer to the SE050 is available in directory `sss\plugin\open62541`. The source code of the Open62541 stack is available in directory `ext\open62541`.

OPC UA stack:



In reference to the above image the demo matches the left arrow:

- UA binary encoding is used
- UA Secure conversation with security policy `Basic256Sha256` and `Sign and Encrypt mode`
- on top of TCP



The crypto functionality (as defined by `Basic256Sha256`) is handled as follows:

- AsymmetricSignatureAlgorithm_RSA-PKCS15-SHA2-256: RSA Sign operation done by SE050
- AsymmetricEncryptionAlgorithm_RSA-OAEP-SHA: RSA Decrypt operation done by SE050
- Symmetric crypto operations are handled by the OPC UA stack on the host micro

Build Open62541 server and client examples

1) Build server and client example

```
cd simw-top
python3 scripts/create_cmake_projects.py
cd ../simw-top_build/imx_native_se050_t1oi2c
cmake -DWithOPCUA_open62541:BOOL=ON -DHostCrypto:STRING=MBEDTLS -
↪DWithSharedLIB:BOOL=OFF .
cmake --build .
make install
ldconfig /usr/local/lib
```

Note: Replace `imx_native_se050_t1oi2c` with `raspbian_native_se050_t1oi2c` when building for Raspberry Pi.

1) Server and client binaries are copied to the simw-top/tools folder

Test Open62541 server and client examples

1) Client/Server keys are available in `simw-top\demos\opc_ua\credentials\`. Optionally you can re-generate the client/server keys with the following command

```
cd simw-top/demos/opc_ua/scripts
python3 createOPCUACredentials_Optional.py
```

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```

OPU UA mandates the host name to be part of the subjectAltName in the server␣
↪certificate.
The default server certificate provided with the package uses hostname 'localhost
↪'.
To create a completely new set of credentials with a specific server hostname /␣
↪ip-address run
createOPCUACredentials_Optional.py script as

python3 createOPCUACredentials_Optional.py <server_hostname>    # Default <server_
↪hostname> = localhost
```

2) Refer to *CLI Tool* for ssscli tool setup. Using ssscli tool, provision server certificate and key into SE050 and create a reference pem file for server key

```
cd simw-top/demos/opc_ua/scripts

python3 provisionOPCUAServer.py 127.0.0.1:8050 jrcpv2   #On Windows
OR
python3 provisionOPCUAServer.py                         #On iMX6 / RaspberryPi
```

3) Start opc ua server

```
cd simw-top/demos/opc_ua/scripts

python3 open62541Server.py jrcpv2 127.0.0.1:8050 <certificate>  #On Windows
OR
python3 open62541Server.py <certificate>                        #On iMX6 /␣
↪RaspberryPi

When using Open62541 client:
    <certificate> is located at simw-top\demos\opc_ua\credentials\open62541_
↪client_cert.der
When using UAexpert client:
    <certificate> is located at uaexpert\PKI\own\certs\uaexpert.der

Passing "none" for <certificate>, will make the server accept all client␣
↪certificates.
```

4) Start opc ua client

```
cd simw-top/demos/opc_ua/scripts
python3 open62541Client.py opc.tcp://127.0.0.1:4840

On successful connection, value of the object "Sensor1" is read from server and␣
↪displayed.
```

5) UaExpert client can also be used to test the Open62541 server.

- For testing with UaExpert client, root certificate needs to be copied to UaExpert trusted list of certificates,
- Go to UaExpert -> Settings -> Manage Certificates -> Trusted (Tab) -> Open Certificate Location and copy the file `simw-top\demos\opc_ua\credentials\open62541_rootCA_cert.der`
- **Also disable following errors in UaExpert configurations.**

    i. UaExpert -> Settings -> Configure UaExpert -> General.DisableError.CertificateIssuerRevocationUnknown -> true

   ii. UaExpert -> Settings -> Configure UaExpert -> General.DisableError.CertificateRevocationUnknown -> true

- **Add the server details to connect. UaExpert -> Server -> Add -> Advanced (Tab). Add details in**
   i. EndPoint Url (opc.tcp://<SERVER_IP>:4840/)
   ii. Security Policy as Basic256Sha256
   iii. Message Security Mode as Sign & Encrypt
- Added server will appear in project tab. Right click on server -> Connect.
- On successful connection, the client objects should appear in UaExpert address space.
- To change the value of object "Sensor1", select the object "Sensor1" in address space. In the Attribute section, select "value" attribute and enter the new value.

Known Limitations

1) Client certificates are self signed certificates. Not tested with root ca signed.
2) No root certificate can be given as input to command line Open62541 client. So any server certificate is accepted.

5.6 ARM PSA Example

5.6.1 PSA Non Secure Example

This example is to demonstrate how to use PSA library APIs to perform a Sign/Verify operations.

Pre-requisites

You need to build PSA-ALT library for TrustZone before compiling this application code.

Refer to Section 8.3 *Platform Security Architecture*.

PSA Operation Examples

- Generating asymmetric keys.

```
psa_key_id_t key_id              = PSA_ALT_ITS_SE_FLAG | 0x00181001;
psa_key_attributes_t attributes = PSA_KEY_ATTRIBUTES_INIT;
psa_set_key_usage_flags(&attributes,
    PSA_KEY_USAGE_ENCRYPT | PSA_KEY_USAGE_DECRYPT | PSA_KEY_USAGE_EXPORT | PSA_
↪KEY_USAGE_SIGN_HASH |
        PSA_KEY_USAGE_VERIFY_HASH);
psa_set_key_algorithm(&attributes, alg);
psa_set_key_type(&attributes, PSA_KEY_TYPE_RSA_KEY_PAIR);
psa_set_key_bits(&attributes, key_bits);
psa_set_key_lifetime(&attributes, lifetime);
psa_set_key_id(&attributes, key_id);

LOG_I("Generating RSA-%d key", key_bits);

status = psa_generate_key(&attributes, &key_handle);
```

- Performing Sign-Verify operations.

```
uint8_t hash[32]       = {1};
size_t hashLen         = sizeof(hash);
uint8_t signature[256] = {0};
size_t sigLen          = sizeof(signature);

status = psa_sign_hash(
    key_handle, PSA_ALG_RSA_PKCS1V15_SIGN(PSA_ALG_SHA_256), hash, hashLen,␣
↪signature, sizeof(signature), &sigLen);
if (status != 0) {
    LOG_E("Signing failed");
    goto cleanup;
}
else {
    LOG_I("Signing success");
}

status = psa_verify_hash(key_handle, PSA_ALG_RSA_PKCS1V15_SIGN(PSA_ALG_SHA_256),␣
↪hash, hashLen, signature, sigLen);
if (status != 0) {
    LOG_E("Verification failed");
    goto cleanup;
}
else {
    LOG_I("Verification success");
}
```

Building Example

This example would run in normal world and must link with the secure world PSA library so that definitions for veneer APIs can be found. Build this example with the following CMake configurations:

- `Host=lpcxpresso55s_ns`
- `HostCrypto=MBEDTLS`
- `mbedTLS_ALT=PSA`
- `RTOS=Default`
- `SMCOM=T1oI2C`
- `PROJECT=psa_nonsecure`

5.7 SE05X Examples

5.7.1 SE05X Minimal example

This project gets available memory from secure element. This is a good starting point to work with SE05X at low level.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

- Project: `se05x_Minimal`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_Minimal.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_Minimal
```

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :mem=32767
App   :INFO :ex_sss Finished
```

5.7.2 SE05X Get Info example

This project can be used to get SE05X platform information with or without applet installed.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_GetInfo`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_GetInfo.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_GetInfo
```

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :PlugAndTrust_v04.02.00_20220524
App   :INFO :Running C:\_ddm\simw-top_build\se_x86\bin\Debug\se05x_GetInfo.exe
App   :INFO :If you want to over-ride the selection, use ENV=EX_SSS_BOOT_SSS_PORT or␣
↪pass in command line arguments.
App   :WARN :#####################################################
App   :INFO :uid (Len=18)
      A0 A1 A2 A3    A4 A5 A6 A7    A8 A9 AA AB    AC AD AE AF
      B0 B1
App   :INFO :Running C:\_ddm\simw-top_build\se_x86\bin\Debug\se05x_GetInfo.exe
App   :INFO :If you want to over-ride the selection, use ENV=EX_SSS_BOOT_SSS_PORT or␣
↪pass in command line arguments.
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :WARN :#####################################################
App   :INFO :Applet Major = 7
App   :INFO :Applet Minor = 2
App   :INFO :Applet patch = 0
App   :INFO :AppletConfig = 3FFF
App   :INFO :With    ECDSA_ECDH_ECDHE
App   :INFO :With    EDDSA
App   :INFO :With    DH_MONT
App   :INFO :With    HMAC
App   :INFO :With    RSA_PLAIN
App   :INFO :With    RSA_CRT
App   :INFO :With    AES
App   :INFO :With    DES
App   :INFO :With    PBKDF
App   :INFO :With    TLS
App   :INFO :With    MIFARE
App   :INFO :With    I2CM
App   :INFO :Internal = FFFF
App   :WARN :#####################################################
App   :INFO :Tag value - proprietary data 0xFE = 0xFE
App   :INFO :Length of following data 0x45 = 0x45
App   :INFO :Tag card identification data (Len=2)
      DF 28
App   :INFO :Length of card identification data = 0x42
App   :INFO :Tag configuration ID (Must be 0x01) = 0x01
App   :INFO :Configuration ID (Len=12)
      00 01 A8 78    80 10 29 0E    F3 33 19 C1
App   :INFO :OEF ID (Len=2)
      A8 78
App   :INFO :Tag patch ID (Must be 0x02) = 0x02
App   :INFO :Patch ID (Len=8)
      00 00 00 00    00 00 00 00
App   :INFO :Tag platform build ID1 (Must be 0x03) = 0x03
App   :INFO :Platform build ID (Len=24)
      4A 33 52 33    35 31 30 32    39 42 34 31    31 31 30 30
      30 30 30 30    30 30 30 30
App   :INFO :JCOP Platform ID = J3R351029B411100
App   :INFO :Tag FIPS mode (Must be 0x05) = 0x05
App   :INFO :FIPS mode var = 0x00
App   :INFO :Tag pre-perso state (Must be 0x07) = 0x07
App   :INFO :Bit mask of pre-perso state var = 0x01
App   :INFO :Tag ROM ID (Must be 0x08) = 0x08
App   :INFO :ROM ID (Len=8)
      52 4F 4D 5F    5F 5F 49 44
```

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```
App    :INFO :Status Word (SW) (Len=2)
       90 00
App    :INFO :se05x_GetInfoPlainApplet Example Success !!!...
App    :WARN :#####################################################
App    :INFO :cplc_data.IC_fabricator (Len=2)
       47 90
App    :INFO :cplc_data.IC_type1 (Len=2)
       D3 21
App    :INFO :cplc_data.Operating_system_identifier (Len=2)
       47 00
App    :INFO :cplc_data.Operating_system_release_date (Len=2)
       00 00
App    :INFO :cplc_data.Operating_system_release_level (Len=2)
       00 00
App    :INFO :cplc_data.IC_fabrication_date (Len=2)
       74 74
App    :INFO :cplc_data.IC_Serial_number (Len=4)
       6E 6E 6E 62
App    :INFO :cplc_data.IC_Batch_identifier (Len=2)
       62 62
App    :INFO :cplc_data.IC_module_fabricator (Len=2)
       00 00
App    :INFO :cplc_data.IC_module_packaging_date (Len=2)
       00 00
App    :INFO :cplc_data.ICC_manufacturer (Len=2)
       00 00
App    :INFO :cplc_data.IC_embedding_date (Len=2)
       00 00
App    :INFO :cplc_data.IC_OS_initializer (Len=2)
       57 58
App    :INFO :cplc_data.IC_OS_initialization_date (Len=2)
       59 4E
App    :INFO :cplc_data.IC_OS_initialization_equipment (Len=4)
       4E 4E 4E 4E
App    :INFO :cplc_data.IC_personalizer (Len=2)
       00 00
App    :INFO :cplc_data.IC_personalization_date (Len=2)
       00 00
App    :INFO :cplc_data.IC_personalization_equipment_ID (Len=4)
       00 00 00 00
App    :INFO :cplc_data.SW (Len=2)
       90 00
App    :INFO :ex_sss Finished
```

5.7.3 APDU Player Demo

This demo is to transceive raw APDUs to the SE. It takes a command line argument as the input file containing APDUs to be sent, followed by the reponse. An example of command to be in the file is `/send 00A4040000 6F108408A000000151000000A5049F6501FF9000`

In this, the `00A4040000` is the command to be transmitted and `6F108408A000000151000000A5049F6501FF9000` is the expected response.

Note: Ensure that authentication with the SE is either plain or platform SCP This demo only supports only SE05x devices

---

How to use

Run the demo as `apdu_player_demo [Input-file] <Port>`

5.7.4 Using policies for secure objects

This demo is to demonstrate the use of policies for secure objects. Object policies such as `can_Sign` or `can_Encrypt` can be used to restrict operations other than the given policies. Objects inside the secure element are linked to a particular authentication object, based on communication authentication type selected. Objects inside the secure element linked with one authentication object cannot be used when session is open with another authentication type.

Authentication Object ID to be linked with secure object can be selected as

```
#if (SSS_HAVE_SE05X_AUTH_USERID) || (SSS_HAVE_SE05X_AUTH_USERID_PLATFSCP03) //UserID␣
↪Session
#define EX_LOCAL_OBJ_AUTH_ID EX_SSS_AUTH_SE05X_UserID_AUTH_ID
#elif (SSS_HAVE_SE05X_AUTH_NONE) || (SSS_HAVE_SE05X_AUTH_PLATFSCP03) //No auth
#define EX_LOCAL_OBJ_AUTH_ID EX_SSS_AUTH_SE05X_NONE_AUTH_ID
#elif (SSS_HAVE_SE05X_AUTH_AESKEY) || (SSS_HAVE_SE05X_AUTH_AESKEY_PLATFSCP03) //AESKey
#define EX_LOCAL_OBJ_AUTH_ID EX_SSS_AUTH_SE05X_APPLETSCP_AUTH_ID
#elif (SSS_HAVE_SE05X_AUTH_ECKEY) || (SSS_HAVE_SE05X_AUTH_ECKEY_PLATFSCP03) //ECKey␣
↪session
#define EX_LOCAL_OBJ_AUTH_ID EX_SSS_AUTH_SE05X_ECKEY_ECDSA_AUTH_ID
#endif
```

Note: Ensure that the authentication object ID in policy set matches the authentication type.

Sign Policy

Create a policy set using the authentication object ID

```

/*Logic to pass sign & verifypolicy*/
const int allow_sign = 1;
const int allow_verify = 0;

/* doc:start:allow-policy-sign-part1 */
/* Policies for key */
const sss_policy_u key_withPol = {
    .type = KPolicy_Asym_Key,
    /*Authentication object based on SE05X_AUTH*/
    .auth_obj_id = EX_LOCAL_OBJ_AUTH_ID,
    .policy = {
        /*Asymmetric key policy*/
        .asymmkey = {
            /*Policy for sign*/
            .can_Sign = allow_sign,
            /*Policy for verify*/
```

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```
            .can_Verify = allow_verify,
            /*Policy for encrypt*/
            .can_Encrypt = 1,
            /*Policy for decrypt*/
            .can_Decrypt = 1,
            /*Policy for Key Derivation*/
            .can_KD = 1,
            /*Policy for wrapped object*/
            .can_Wrap = 1,
            /*Policy to re-write object*/
            .can_Write = 1,
            /*Policy for reading object*/
            .can_Read = 1,
            /*Policy to use object for attestation*/
            .can_Attest = 1,
        }
    }
};

/* Common rules */
const sss_policy_u common = {
    .type = KPolicy_Common,
    /*Authentication object based on SE05X_AUTH*/
    .auth_obj_id = EX_LOCAL_OBJ_AUTH_ID,
    .policy = {
    .common = {
    /*Secure Messaging*/
    .req_Sm = 0,
    /*Policy to Delete object*/
    .can_Delete = 1,
    /*Forbid all operations on object*/
    .forbid_All = 0,
}
}
};

/* create policy set */
sss_policy_t policy_for_ec_key = {
    .nPolicies = 2,
    .policies = { &key_withPol, &common }
};
/* doc:end:allow-policy-sign-part1 */

status    = sss_key_object_init(&object, &pCtx->ks);
if (status != kStatus_SSS_Success) {
    LOG_E("sss_key_object_init Failed!!!");
    goto exit;
}

status = sss_key_object_allocate_handle(
    &object, keyId, kSSS_KeyPart_Pair, kSSS_CipherType_EC_NIST_P, keylen, kKeyObject_
↪Mode_Persistent);
if (status != kStatus_SSS_Success) {
    LOG_E("key_object_allocate_handle Failed!!!");
    goto exit;
}
```

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```
/* doc:start:allow-policy-sign-part2 */
status = sss_key_store_generate_key(
    &pCtx->ks,
    &object,
    ECC_KEY_BIT_LEN,
    &policy_for_ec_key);
/* doc:end:allow-policy-sign-part2 */
```

Using PCR Object

PCR is a special secure object which stores 32-byte data. A PCR object can be used to ensure that secure objects inside the SE cannot be used if the PCR object value is altered.

We can assign a PCR policy to a secure object as given in the following sample code

```
#if SSS_HAVE_SE05X_VER_GTE_06_00
    uint8_t pcr_expected_value[] = { 0x87, 0xD3, 0xE3, 0x93, 0x19, 0x8F, 0x5C, 0x80,␣
↪0xE0, 0xBC, 0x9B, 0xC9, 0x82, 0x00, 0x1F, 0xB0, 0xEE, 0x20, 0x1C, 0x27, 0x0B, 0x6D,␣
↪0xC8, 0x84, 0x52, 0xE4, 0x13, 0xA3, 0x25, 0x56, 0x81, 0x75 };
#else
    uint8_t pcr_expected_value[] = { 0x89, 0x51, 0x56, 0x9f, 0x41, 0x5f, 0xeb, 0x4f,␣
↪0xb6, 0x37, 0x02, 0x86, 0xe7, 0xdd, 0xa0, 0x99, 0x33, 0x6c, 0x46, 0x36, 0xbc, 0xbb,␣
↪0x4c, 0x11, 0x04, 0x10, 0x0a, 0x86, 0x0d, 0x0c, 0xa4, 0x14 };
#endif

    size_t pcr_expected_value_size = sizeof(pcr_expected_value);
    LOG_I("Setting PCR Expected value as:");
    LOG_AU8_I(pcr_expected_value, pcr_expected_value_size);

    const sss_policy_u common = {
        .type = KPolicy_Common,
        .auth_obj_id = TST_LOCAL_OBJ_AUTH_ID,
        .policy = {
            .common = {
                .req_Sm = 0,
                .can_Delete = 1
            }
        }
    };

    const sss_policy_u file = {
        .type = KPolicy_File,
        .auth_obj_id = TST_LOCAL_OBJ_AUTH_ID,
        .policy = {
            .file = {
                .can_Read = 1,
                .can_Write = 1
            }
        }
    };

    sss_policy_u pcr1 = {
        .type = KPolicy_Common_PCR_Value,
        .auth_obj_id = TST_LOCAL_OBJ_AUTH_ID,
```

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```
        .policy = {
            .common_pcr_value = {
                .pcrObjId = 0x7fffffff,
            }
        }
    };
    memset(pcr1.policy.common_pcr_value.pcrExpectedValue,
        0x00,
        sizeof(pcr1.policy.common_pcr_value.pcrExpectedValue));
    memcpy(pcr1.policy.common_pcr_value.pcrExpectedValue, pcr_expected_value, pcr_
↪expected_value_size);

    sss_policy_t policy_for_binary_object = {
        .nPolicies = 3,
        .policies = { &common, &pcr1, &file }
    };
    /* clang-format on */
    NVM_RESET();

    status = sss_key_store_set_key(&gtCtx.ks,
        &gtCtx.key,
        binary_object,
        sizeof(binary_object),
        sizeof(binary_object),
        &policy_for_binary_object,
        sizeof(policy_for_binary_object));
```

Note: Ensure that the `pcrObjID` in PCR policy is the same object ID at which the PCR is stored.

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :This example is to demonstrate the use of policies for secure objects
App   :INFO :Signing was succesful
App   :INFO :Example Success
App   :INFO :ex_sss Finished
```

5.7.5 Get Certificate from the SE

This tool is to retrieve Trust provisioned certificates from the SE. It will read the certificate and store it on the file system. It takes as argument, the keyID at which certificate is stored and the file path where to save the certificate on the file system.

Note: It can only be compiled when Host Crypto is mbedTLS.

Building the example

Use the following CMake configurations to compile the example

- CMake configurations: `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
- Project: `se05x_GetCertificate`

How to use

Run the tool as:

```
se05x_GetCertificate <32-bit keyID> </path/to/file> <port>
```

- The keys ID has to be in HEX format.
- For systems connecting with T=1 over I2C, the port parameter can be skipped.
- The certificate will be stored in *PEM* format at the specified path on the file system.

5.7.6 SE05X Rotate PlatformSCP Keys Demo

This project is to demonstrate rotation of Platform SCP03 keys for IOT SSD. The Platform SCP03 keys used during inital authentication can be replaced using this example. In this example, we will rotate existing SCP03 keys to new keys and then revert back to the old keys.

Once the key rotation is successful on the IC a file is created `plain_scp.txt`. This file contains updated key values written to IC. For the next authentication if the above file is available, the keys are taken from the file. If the file is not present, the keys which are pre-compiled are picked up for authentication.

Note: SCP03 uses 3 sets of AES keys ENC MAC and DEK. After first rotation user can delete DEK key from file/code for security purpose.

Following are the file paths for different platforms:

For Android

```
#define EX_SSS_SCP03_FILE_DIR "/data/vendor/SE05x/"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

For Linux

```
#define EX_SSS_SCP03_FILE_DIR "/tmp/SE05X/"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

For Windows

```
#define EX_SSS_SCP03_FILE_DIR "C:\\nxp\\SE05X\\"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

Note: For Android based platforms, it is important that the keymaster service has access to the PlatfSCP03 keys file while system boot. Be sure to update sepolicy accordingly.

Prerequisites

Since this example is portable across various platforms, the needs are different.

See Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Configuring the Demo

New Platform SCP03 keys are defined as following. Update your keys here.

```
#define EX_SSS_AUTH_NEW_ENC_KEY                                                                   ␣
↪                 \
    {                                                                                             ␣
↪                 \
        0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C,␣
↪0x4D, 0x4E, 0x4F \
    }

#define EX_SSS_AUTH_NEW_MAC_KEY                                                                   ␣
↪                 \
    {                                                                                             ␣
↪                 \
        0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C,␣
↪0x4D, 0x4E, 0x4F \
    }

#define EX_SSS_AUTH_NEW_DEK_KEY                                                                   ␣
↪                 \
    {                                                                                             ␣
↪                 \
        0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C,␣
↪0x4D, 0x4E, 0x4F \
    }
```

Note: We have hard-coded new PlatformSCP03 keys for demonstration purpose. The user can either modify these to their own keys or use a random number generator for randomized keys.

Old Platform SCP03 keys are defined as following. Make sure these match the ones in SE05X.

```
    uint8_t OLD_KEY_ENC[16] = {0};
    uint8_t OLD_KEY_MAC[16] = {0};
    uint8_t OLD_KEY_DEK[]   = EX_SSS_AUTH_SE05X_KEY_DEK;
```

The following code reverts to old Platform SCP03 keys. If you do not wish to revert to old keys and want to use the new keys, comment out the following line from the example. For development testing, we rollback to original keys. It is left to customer to comment out this line.

```
    status = tp_PlatformKeys(OLD_KEY_ENC, OLD_KEY_MAC, OLD_KEY_DEK, pCtx);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
```

Building the Demo

Use the following configurations in CMake:

- `SE05X_Auth_PlatfSCP03`: ON

Build project: `se05x_RotatePlatformSCP03Keys`

Running the Example

If you have built a binary, flash the `se05x_RotatePlatformSCP03Keys` binary on to the board and reset the board.

If you have built an *exe* to be run from PC using VCOM, run as:

```
se05x_RotatePlatformSCP03Keys.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_RotatePlatformSCP03Keys
```

Console output

If everything is setup correctly the output would be as follows

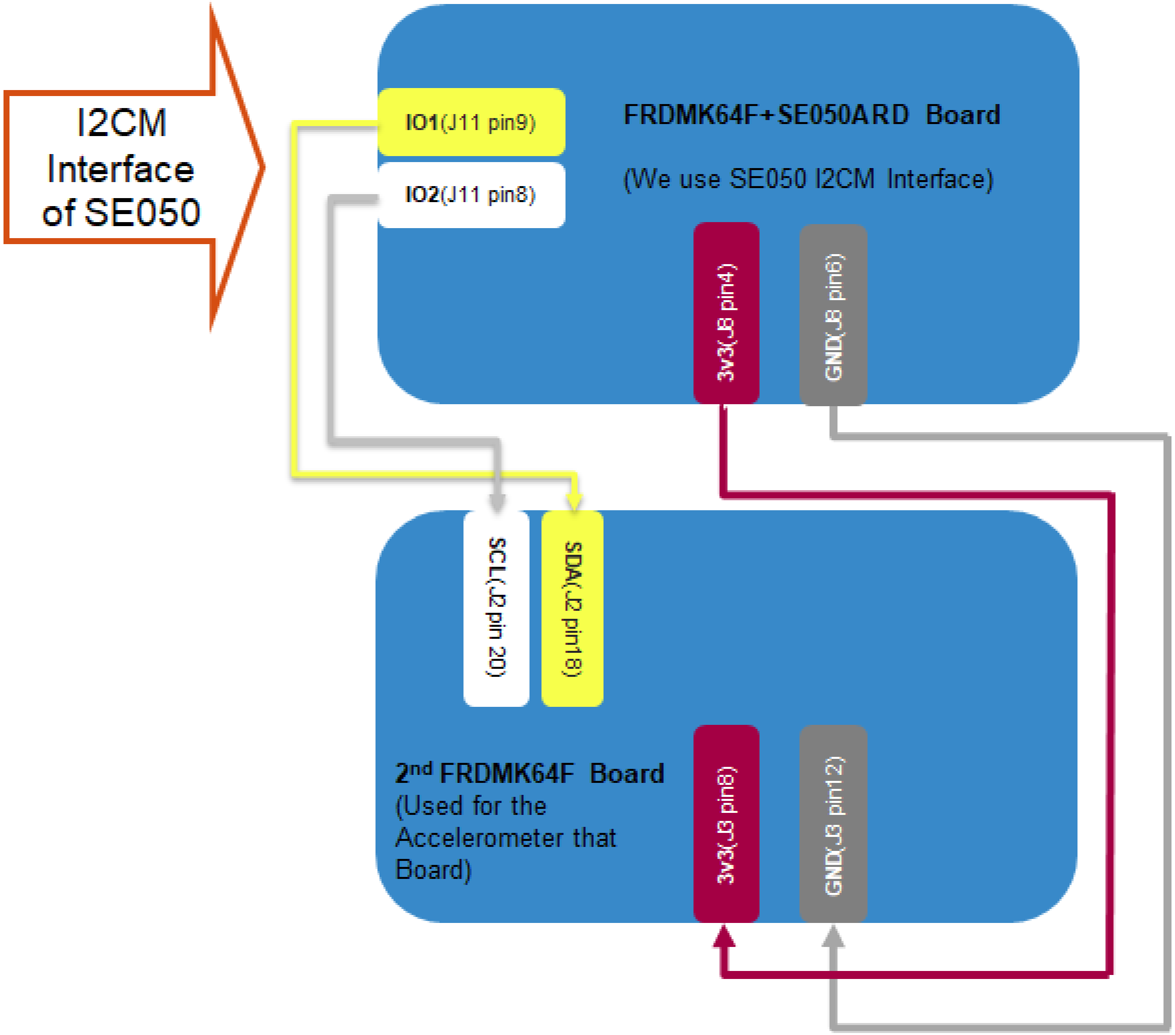
```
App:INFO :Congratulations !!! Key Rotation Successful!!!!
App:INFO :Congratulations !!! Key Rotation Successful!!!!
App:INFO :ex_sss Finished
```

5.7.7 I2C Master Example

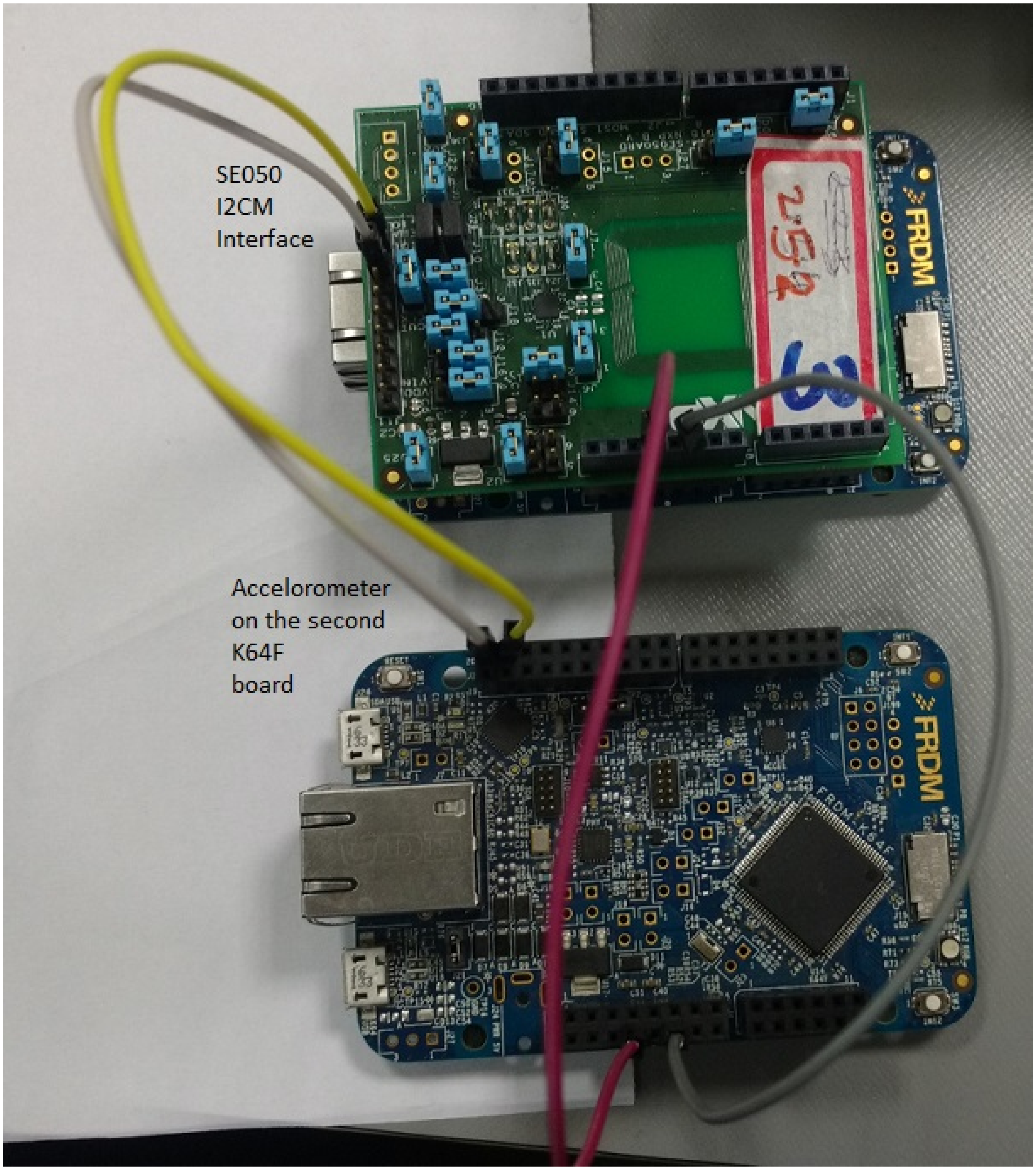
This page is regarding the documentation on I2CM, for more information on I2CM Transaction, See Section 3.6 *I2CM / Secure Sensor*

Prerequisites

- Bring Up Hardware. (Refer *Development Platforms*)
- Connection to be done for I2C Master example.



Here is a photograph of above wiring diagram.



Note:

- We are using 2nd freedom K64F board only for connecting Accelerometer device to I2CM.
- Short Jumper J9 & J10 of se050ARD board.

Disable K64F on board 2

Warning: If the K64F of the 2nd board doing some operations on I2C Pins, this demo would not work.

Follow below steps to make this demo work.

- Flash `frdmk64f_nop_wfi.bin` binary located at `demos/se05x/se05x_I2cMaster` directory to K64F board.
- This binary will put K64F in unoperation state and we will have easy access to Accelerometer through I2C pins.

Below is the c code

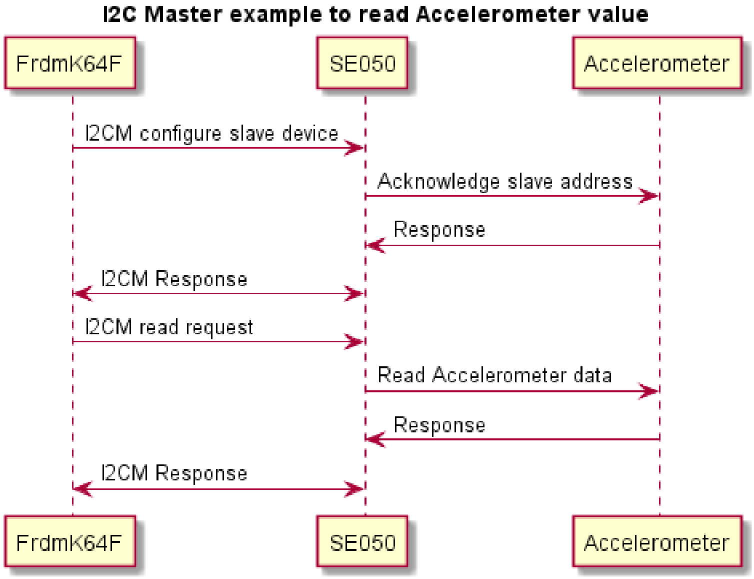
```
int main(void)
{
    /* Init board hardware. */
    BOARD_InitPins();
    BOARD_BootClockRUN();
    BOARD_InitDebugConsole();

    __disable_irq();
    while (1)
    {
        __disable_irq();
        __WFI();
    }
}
```

About the Example

This example reads Accelerometer data via the I2C master interface.

The Accelerometer on other K64F is used as an I2C Slave.



It uses the following APIs and data types:

- *`Se05x_i2c_master_txn()`*
- *`Se05x_i2c_master_attst_txn()`*
- `kSE05x_I2CM_Configure` from `SE05x_I2CM_TLV_type_t`
- `kSE05x_I2CM_Write` from `SE05x_I2CM_TLV_type_t`
- `kSE05x_I2CM_Read` from `SE05x_I2CM_TLV_type_t`
- `kSE05x_I2CM_Baud_Rate_400Khz` from `SE05x_I2CM_Baud_Rate_t`

Running the Demo

1) Import project `cmake_project_frdmk64f` from `simw-top/projects` directory.
2) Mention `BUILD_TARGET` as `se05x_I2cMaster` or `se05x_I2cMasterWithAttestation` in `Debug/Makefile`.
3) Build the project and flash binary inside `FRDMK64F_SE050ARD` board.
4) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo.
5) Rotate second K64F in any direction.

If everything is setup correctly the output would be as follows:

```
App:INFO :I2CM example to read Accelerometer value
   App:INFO :x =   113 , y =   -73 , z =  2118
   App:INFO :x =   109 , y =   -67 , z =  2103
   App:INFO :x =   108 , y =   -68 , z =  2120
   App:INFO :x =   117 , y =   -69 , z =  2109
   App:INFO :x =   117 , y =   -71 , z =  2105
   App:INFO :x =   111 , y =   -71 , z =  2108
   App:INFO :x =   115 , y =   -72 , z =  2104
   App:INFO :x =   117 , y =   -69 , z =  2122
   App:INFO :x =   115 , y =   -73 , z =  2120
   App:INFO :x =   115 , y =   -74 , z =  2114
   App:INFO :I2CM test completed !!!...
```

5.7.8 SE05X WiFi KDF Example

This project is to demonstrate Password based KDF (PBKDF) operation using SE05X. This operation is used in deriving Pre-Shared key (PSK) for WiFi ssid using stored passwords.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `ex_se05x_WiFiKDF_inject`
- Project: `ex_se05x_WiFiKDF_derive`

Running the Example

If you have built a binary, first flash the `ex_se05x_WiFiKDF_inject` binary on to the board and reset the board. Then flash `ex_se05x_WiFiKDF_derive` binary and reset the board.

If you have built an *exe* to be run from PC using VCOM, run as:

```
ex_se05x_WiFiKDF_inject.exe <PORT NAME>
ex_se05x_WiFiKDF_derive.exe -s <ssid_name> <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port and **<ssid_name>** is the name of SSID for which you want to derive the PSK.

Console output

During injection, if everything is successful, the output will be similar to:

```
App   :INFO :Injecting wifi_password='some-wifi-password'
App   :INFO :ex_sss Finished
```

While deriving the key, if everything is successful, the output will be similar to:

```
App   :INFO :Deriving PBKDF2 for wifi_ssid='some-wifi-ssid', WIFI_COUNT='4096'
App   :INFO :wifi_derivedKey (Len=32)
      C9 A6 69 F9    6D A2 74 A1    41 43 A9 ED    D1 8F 68 1B
      B1 3E 6B 8B    F0 16 02 7A    7D 72 BF 0E    0C 53 CD 7C

# Data for /etc/wpa_supplicant/wpa_supplicant.conf
network={
    ssid="some-wifi-ssid"
    psk=c9a669f96da274a14143a9edd18f681bb13e6b8bf01627a7d72bfec53cd7c
}
App   :INFO :Done
App   :INFO :ex_sss Finished
```

5.7.9 SE05X Export Transient objects

This example does following steps:

- Generate a Transient ECC Key
- Export that to a blob
- Sign some dummy data with that key
- Store the signature in local file for future use.

After running this example, you can run Section 5.7.10 *SE05X Import Transient objects*

Note: This example needs File system access and hence it is not applicable for embedded platforms.

The exported files are current working directory.

Visual Studio - Debug settings

Kindly set debug `Working Directory` to `$(TargetDir)` in project's debug stettings. This ensures that the examples *SE05X Export Transient objects* and *SE05X Import Transient objects* work seamlessly.

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running Example ex_sss_export.c
App   :INFO :Export ec key to 'export_serializedECKey.bin'!!!
App   :INFO :Signing Successful !!!
App   :INFO :Export signature key to 'export_serializedSingedData.bin'.
App   :INFO :ex_sss_export Example Success !!!...
App   :INFO :ex_sss Finished
```

5.7.10 SE05X Import Transient objects

Before running this example, please run Section 5.7.9 *SE05X Export Transient objects*

This example does following steps:

- Re-Generates a Transient ECC Key at the same location as created by *SE05X Export Transient objects*
- Tries to verify previously signed data. (This must fail, because key is over-written)
- Imports previously exported key inside the SE.
- Tries to verify previously signed data. (This must be seccessful, because it is the same key)

Note: This example needs File system access and hence it is not applicable for embedded platforms.

The exported files are current working directory.

Visual Studio - Debug settings

Kindly set debug `Working Directory` to `$(TargetDir)` in project's debug stettings. This ensures that the examples *SE05X Export Transient objects* and *SE05X Import Transient objects* work seamlessly.

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :Running Example ex_sss_import.c
App   :INFO :Object exists!!!
App   :INFO :This verify must fail, because keys are different
App   :INFO :Reading contents form 'export_serializedSingedData.bin'
App   :WARN :Verification Failed!
App   :WARN :nxEnsure:'status == kStatus_SSS_Success' failed. At Line:196␣
↪Function:ExampleDoVerify
App   :INFO :Reading contents form 'export_serializedECKey.bin'
App   :INFO :This verify must pass, because keys are same
App   :INFO :Reading contents form 'export_serializedSingedData.bin'
```

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```
App   :INFO :Verification Successful.
App   :INFO :ex_sss_import Example Success !!!...
App   :INFO :ex_sss Finished
```

5.7.11 Import External Object Prepare

Import External Object command allows the user to import an external object wrapped with a secure `ECKey_Auth` context. A session is not required to execute this command, the `ECKey_Auth` parameters are provided with the wrapped WriteSecureObject command. The applet will use `ECKey_Auth` parameters and derive session keys to unwrap the command and execute it. `ImportExternalObject` command works in its own session. It will open an `ECKey` session, write the secure object and close the session.

In this example, we prepare a complete raw APDU to be sent to SE05x. A `WriteSecureObject` command needs to be prepared which will be wrapped and sent as a part of `ImportExternalObject` command. For an example we are preparing `WriteSymmKey` command as :

```
/* Symmetric Key */
/* clang-format off */
uint8_t keyValue[] = {0x48, 0x45, 0x4C, 0x4C, 0x4F, 0x48, 0x45, 0x4C, 0x4C, 0x4F,␣
↪0x48, 0x45, 0x4C, 0x4C, 0x4F, 0x31};
/* clang-format on */
/* API to create buffer */
pse05xWriteBufferSessionCtx->fp_TXn = &se05x_ImportExtObjCreateAPDU;
int index                            = 0;

sm_status = Se05x_API_WriteSymmKey(pse05xWriteBufferSessionCtx,
    NULL,
    SE05x_MaxAttemps_NA,
    __LINE__,
    SE05x_KeyID_KEK_NONE,
    keyValue,
    sizeof(keyValue),
    kSE05x_INS_NA,
    kSE05x_SymmKeyType_AES);
if (sm_status != SM_OK) {
    LOG_E("Failed to create buffer");
    status = kStatus_SSS_Fail;
    goto exit;
}

/* WriteSecureObject API will prepare complete APDU.
 * We need to skip initial CLA INS P1 P2 and use just the TLVs
 *
 * The length is determined by the first length byte. If it
 * is 0x00, the next two bytes are the length, otherwise that
 * byte is the length.
 *
 * Determine the length here and accordingly determine the TLV.
 */
if (gTxBuffer[4] == 0x00) {
    WriteSymmKeyAPDU_len = ((gTxBuffer[5] << 8) && 0xFF00) | ((gTxBuffer[6]) && 0xFF);
    index                = 7;
}
else {
    WriteSymmKeyAPDU_len = gTxBuffer[4];
```

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```
    index                   = 5;
}
if (WriteSymmKeyAPDU_len > sizeof(WriteSymmKeyAPDU)) {
    LOG_E("Insufficient buffer");
    status = kStatus_SSS_Fail;
    goto exit;
}
memcpy(WriteSymmKeyAPDU, &gTxBuffer[index], WriteSymmKeyAPDU_len);
```

```
/* This API creates an APDU buffer of the object stores it to the global buffer */
smStatus_t se05x_ImportExtObjCreateAPDU(Se05xSession_t *pwrite_apdubufferctx,
    const tlvHeader_t *hdr,
    uint8_t *cmdBuf,
    size_t cmdBufLen,
    uint8_t *rsp,
    size_t *rspLen,
    uint8_t hasle)
{
    AX_UNUSED_ARG(pwrite_apdubufferctx);
    AX_UNUSED_ARG(rsp);
    AX_UNUSED_ARG(rspLen);
    memset(gTxBuffer, 0, sizeof(gTxBuffer));
    size_t i = 0;
    memcpy(&gTxBuffer[i], hdr, sizeof(*hdr));
    smStatus_t ret = SM_OK;
    i += sizeof(*hdr);
    if (cmdBufLen > 0) {
        // The Lc field must be extended in case the length does not fit
        // into a single byte (Note, while the standard would allow to
        // encode 0x100 as 0x00 in the Lc field, nobody who is sane in his mind
        // would actually do that).
        if ((cmdBufLen < 0xFF) && !hasle) {
            gTxBuffer[i++] = (uint8_t)cmdBufLen;
        }
        else {
            gTxBuffer[i++] = 0x00;
            gTxBuffer[i++] = 0xFFu & (cmdBufLen >> 8);
            gTxBuffer[i++] = 0xFFu & (cmdBufLen);
        }
        memcpy(&gTxBuffer[i], cmdBuf, cmdBufLen);
        i += cmdBufLen;
    }
    if (hasle) {
        gTxBuffer[i++] = 0x00;
        gTxBuffer[i++] = 0x00;
    }
    ret          = SM_OK;
    gTxBufferLen = i;

    LOG_AU8_I(gTxBuffer, gTxBufferLen);

    return ret;
}
```

```
/* This API transforms buffer to APDU and internally calls transmit and Decrypt */
smStatus_t se05x_ImportExtObjTransformBuffer(Se05xSession_t *pSe05xSession,
```

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```
    const tlvHeader_t *hdr,
    uint8_t *cmdBuf,
    size_t cmdBufLen,
    uint8_t *rsp,
    size_t *rspLen,
    uint8_t hasle)
{
    memset(gTxBuffer, 0, sizeof(gTxBuffer));
    size_t i = 0;
    memcpy(&gTxBuffer[i], hdr, sizeof(*hdr));
    smStatus_t ret = SM_NOT_OK;
    i += sizeof(*hdr);
    if (cmdBufLen > 0) {
        // The Lc field must be extended in case the length does not fit
        // into a single byte (Note, while the standard would allow to
        // encode 0x100 as 0x00 in the Lc field, nobody who is sane in his mind
        // would actually do that).
        if ((cmdBufLen < 0xFF) && !hasle) {
            gTxBuffer[i++] = (uint8_t)cmdBufLen;
        }
        else {
            gTxBuffer[i++] = 0x00;
            gTxBuffer[i++] = 0xFFu & (cmdBufLen >> 8);
            gTxBuffer[i++] = 0xFFu & (cmdBufLen);
        }
        ENSURE_OR_GO_EXIT(cmdBufLen <= sizeof(gTxBuffer) - i);
        memcpy(&gTxBuffer[i], cmdBuf, cmdBufLen);
        i += cmdBufLen;
    }
    if (hasle) {
        gTxBuffer[i++] = 0x00;
        gTxBuffer[i++] = 0x00;
    }
    gTxBufferLen = i;

    LOG_D("Here is the buffer of Object needs to be Import");
    LOG_AU8_D(gTxBuffer, gTxBufferLen);

    if (pSe05xSession->fp_RawTXn) {
        ret = pSe05xSession->fp_RawTXn(
            pgSe05xSessionCtx->conn_ctx, NULL, kSSS_AuthType_None, hdr, cmdBuf,␣
↪cmdBufLen, rsp, rspLen, hasle);
        ENSURE_OR_GO_EXIT(ret == SM_OK);
    }
    if (pSe05xSession->fp_DeCrypt) {
        ret = pSe05xSession->fp_DeCrypt(pSe05xSession, cmdBufLen, rsp, rspLen, hasle);
    }
exit:
    return ret;
}
```

```
/* This API transmit the buffer in default session */
static smStatus_t se05x_ImportExtObjTransmitBuffer(void *conn_ctx,
    struct _sss_se05x_tunnel_context *pChannelCtx,
    SE_AuthType_t currAuth,
    const tlvHeader_t *hdr,
```

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```
    uint8_t *cmdBuf,
    size_t cmdBufLen,
    uint8_t *rsp,
    size_t *rspLen,
    uint8_t hasle)
{
    AX_UNUSED_ARG(pChannelCtx);
    AX_UNUSED_ARG(currAuth);
    uint8_t txBuf[SE05X_MAX_BUF_SIZE_CMD] = {0};
    size_t i                              = 0;
    memcpy(&txBuf[i], hdr, sizeof(*hdr));
    smStatus_t ret = SM_NOT_OK;
    i += sizeof(*hdr);
    if (cmdBufLen > 0) {
        // The Lc field must be extended in case the length does not fit
        // into a single byte (Note, while the standard would allow to
        // encode 0x100 as 0x00 in the Lc field, nobody who is sane in his mind
        // would actually do that).
        if ((cmdBufLen < 0xFF) && !hasle) {
            txBuf[i++] = (uint8_t)cmdBufLen;
        }
        else {
            txBuf[i++] = 0x00;
            txBuf[i++] = 0xFFu & (cmdBufLen >> 8);
            txBuf[i++] = 0xFFu & (cmdBufLen);
        }
        memcpy(&txBuf[i], cmdBuf, cmdBufLen);
        i += cmdBufLen;
    }
    else {
        if (cmdBufLen == 0) {
            txBuf[i++] = 0x00;
        }
    }

    if (hasle) {
        txBuf[i++] = 0x00;
        txBuf[i++] = 0x00;
    }

    uint32_t U32rspLen = (uint32_t)*rspLen;
    ret                = (smStatus_t)smCom_TransceiveRaw(conn_ctx, txBuf, (U16)i, rsp,
↪ &U32rspLen);
    *rspLen            = U32rspLen;
    return ret;
}
```

```
/* This API decrypts the response buffer  */
smStatus_t se05x_ImportExtObjDecryptResponse(
    struct Se05xSession *pSessionCtx, size_t cmd_cmacLen, uint8_t *rsp, size_t␣
↪*rspLength, uint8_t hasle)
{
    U16 rv = SM_NOT_OK;

    if (*rspLength >= 2) {
        rv = rsp[(*rspLength) - 2] << 8 | rsp[(*rspLength) - 1];
```

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```
        if ((rv == SM_OK) && (pSessionCtx->pdynScp03Ctx != NULL)) {
#if SSS_HAVE_SCP_SCP03_SSS
            rv = nxpSCP03_Decrypt_ResponseAPDU(pSessionCtx->pdynScp03Ctx, cmd_cmacLen,
↪ rsp, rspLength, hasle);
#else
            LOG_W("Decrypting without SSS_HAVE_SCP_SCP03_SSS");
            rv = SM_NOT_OK;
#endif
        }
#if SSS_HAVE_SCP_SCP03_SSS
        else { /*Counter to be increament only in case of authentication is all kind␣
↪of SCP
               and response is not 9000 */
            if ((rv != SM_OK) && (pSessionCtx->pdynScp03Ctx != NULL)) {
                if (((pSessionCtx->pdynScp03Ctx->authType == kSSS_AuthType_AESKey) ||
                        (pSessionCtx->pdynScp03Ctx->authType == kSSS_AuthType_ECKey))␣
↪||
                    ((pSessionCtx->pdynScp03Ctx->authType == kSSS_AuthType_SCP03) &&␣
↪(cmd_cmacLen - 8) > 0)) {
                    nxpSCP03_Inc_CommandCounter(pSessionCtx->pdynScp03Ctx);
                }
            }
        }
#endif
    }
    else {
        rv = SM_NOT_OK;
    }

    return rv;
}
```

You can call any of the `WriteSecureObject` API with your data and create the buffer.

Building

Build the project with the following configurations.

se05x_ImportExternalObjectPrepare

- `Project = se05x_ImportExternalObjectPrepare`
- `SCP=SCP03_SSS`
- `SE05x_Auth=ECKey`

How to use

Generate the raw APDU file by running the executable. Run **se05x_ImportExternalObjectPrepare** as

```
se05x_ImportExternalObjectPrepare.exe -keyid 0x7DA00003 -file eckey_ecdsa.der
↪<portName>
```

where,

- *keyid* is the authentication keyId at which ECDSA public key is stored.

- *file* is the input ECDSA keypair file (in binary format)
- *portName* is the name of the port over which to connect (COMPORT in case running over VCOM)

5.7.12 SE05X Mandate SCP example

This project demonstrates how to configure SE05X to mandate platform SCP. This can be used if you always want the communication with SE05X to be encrypted.

Note: After this example runs successfully, further communication would require Platform SCP03 encryption.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_MandatePlatformSCP`
    - CMake configuration

      `SE05X_Auth:None`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_MandatePlatformSCP.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_MandatePlatformSCP
```

5.7.13 Read object with Attestation

This example demonstrates how to read an object with attestation and parse the attested data to check various object attributes.

In this example, we use pre-provisioned EC/RSA keypair as the attestation key and a binary object which will be attested. The pre-provisioned attestation key for Se05x *A & C EC keypair is at 0xF0000012* and for Se05x *B RSA keypair is at 0xF0000010*

Note: The maximum size of a binary object that can be attested at a time is 500 bytes. The API available will only work on binary objects with size up to 500 bytes. To perform attestation on an object of greater size, we need to call corresponding `Se05x` API in a loop, verifying the obtained signature every time.

A reference implementation is available at *Reading large binary objects with attestation*

Building

Build the project with the following configurations.

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_ReadWithAttestation`

Running

On running the example, you would be able to see object attributes logged on the screen like:

```
App   :INFO :Key att data (Len=28)
      00 F5 EF FA    0B 01 00 00    00 00 00 00    00 00 08 00
      00 00 00 00    34 00 00 01    00 00 00 00
App   :INFO :Object Id 0xF5EFFA
App   :INFO :Object Type  0xB
App   :INFO :Type:
App   :INFO :   BINARY_FILE
App   :INFO :Object Auth Attribute  0x1
App   :INFO :Auth:
App   :INFO :   Not Set
App   :INFO :Auth Object:
App   :INFO :   No authentication required
App   :INFO :Policies:
App   :INFO :   POLICY_OBJ_ALLOW_READ
App   :INFO :   POLICY_OBJ_ALLOW_WRITE
App   :INFO :   POLICY_OBJ_ALLOW_DELETE
App   :INFO :tagLen for AEAD:0x00
App   :INFO :RFU bytes:0x00
App   :INFO :Owner:0x0000
App   :INFO :Object origin : 0x1
App   :INFO :Origin:
App   :INFO :   EXTERNAL
App   :INFO :Object Version : 0x0000
App   :INFO :se05x_ReadWithAttestation Example Success !!!
App   :INFO :ex_sss Finished
```

You can see the various attributes associated with the object such as object type, authentication mechanism, origin and policies.

An example of how to perform read with attestation is given below

```
/* Prepare/init attestation data structure */

sss_se05x_attst_comp_data_t comp_data[2] = {0};
sss_se05x_attst_data_t att_data          = {.valid_number = 2};
/* Random data from the host to check if SE
 * answers to current attestation request and
 * not an older response is used */

/* clang-format off */
uint8_t freshness[16] = { 0x00,0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08,0x09,0x0a,0x0b,
↪0x0c,0x0d,0x0e,0x0f };
```

The data received in `att_data` variable can be parsed to read the object attributes.

Reading large binary objects with attestation

Following is an example code on how to read a large binary file with attestation.

Note: This is required only when reading binary objects of size larger than 500 bytes. For any other case, you should use SSS API as above

---

```
sss_status_t read_large_object_with_attestation(sss_se05x_key_store_t *keyStore,
    sss_se05x_object_t *keyObject,
    uint8_t *key,
    size_t *keylen,
    size_t *pKeyBitLen,
    sss_algorithm_t algorithm_attst,
    uint8_t *random_attst,
    size_t randomLen_attst,
    sss_se05x_attst_data_t *attst_data,
    sss_object_t *verification_object)
{
    AX_UNUSED_ARG(pKeyBitLen);
    AX_UNUSED_ARG(algorithm_attst);
    smStatus_t status                  = SM_NOT_OK;
    sss_status_t sss_status            = kStatus_SSS_Fail;
    uint16_t rem_data                  = 0;
    uint16_t offset                    = 0;
    uint16_t size                      = 0;
    size_t max_buffer                  = 0;
    size_t signatureLen                = 0;
    uint32_t attestID                  = ATTESTATION_KEY_ID;
    SE05x_AttestationAlgo_t attestAlgo = kSE05x_AttestationAlgo_EC_SHA_256;

    /* Variables for verification */
    uint8_t plainData[2500] = {0};
    size_t plainDataLen     = sizeof(plainData);
    uint8_t digest[64]      = {0};
    size_t digestLen        = sizeof(digest);
    sss_digest_t digest_ctx;
    sss_algorithm_t algorithm        = kAlgorithm_SSS_ECDSA_SHA256;
    sss_algorithm_t digest_algorithm = kAlgorithm_SSS_SHA256;
    sss_asymmetric_t verify_ctx;
#if SSS_HAVE_SE05X_VER_GTE_07_02
    uint8_t *pData         = &plainData[0];
    uint8_t cmdHashed[32] = {0};
    size_t cmdHashedLen    = sizeof(cmdHashed);
    int tlvRet             = 0;
    uint8_t timestamp[32] = {0};
#endif

    status = Se05x_API_ReadSize(&keyStore->session->s_ctx, keyObject->keyId, &size);
    ENSURE_OR_GO_CLEANUP(status == SM_OK);

    if (*keylen < size) {
        LOG_E("Insufficient buffer ");
        goto cleanup;
    }

    rem_data = size;
```

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```
    *keylen  = size;
    while (rem_data > 0) {
        uint16_t chunk = (rem_data > BINARY_WRITE_MAX_LEN) ? BINARY_WRITE_MAX_LEN :␣
↪rem_data;
        rem_data       = rem_data - chunk;
        max_buffer     = chunk;

        signatureLen                     = attst_data->data[0].signatureLen;
        attst_data->data[0].timeStampLen = sizeof(SE05x_TimeStamp_t);
#if !SSS_HAVE_SE05X_VER_GTE_07_02
        status = Se05x_API_ReadObject_W_Attst(&keyStore->session->s_ctx,
            keyObject->keyId,
            offset,
            chunk,
            attestID,
            attestAlgo,
            random_attst,
            randomLen_attst,
            (key + offset),
            &max_buffer,
            attst_data->data[0].attribute,
            &(attst_data->data[0].attributeLen),
            &(attst_data->data[0].timeStamp),
            attst_data->data[0].outrandom,
            &(attst_data->data[0].outrandomLen),
            attst_data->data[0].chipId,
            &(attst_data->data[0].chipIdLen),
            attst_data->data[0].signature,
            &signatureLen);
#else

        attst_data->data[0].cmdLen       = sizeof(attst_data->data[0].cmd);
        attst_data->data[0].objSizeLen   = sizeof(attst_data->data[0].objSize);
        attst_data->data[0].attributeLen = sizeof(attst_data->data[0].attribute);
        attst_data->data[0].chipIdLen    = sizeof(attst_data->data[0].chipId);
        pData                            = &plainData[0];
        status                           = Se05x_API_ReadObject_W_Attst_V2(&keyStore->
↪session->s_ctx,
            keyObject->keyId,
            offset,
            chunk,
            attestID,
            attestAlgo,
            random_attst,
            randomLen_attst,
            (key + offset),
            &max_buffer,
            attst_data->data[0].attribute,
            &(attst_data->data[0].attributeLen),
            &(attst_data->data[0].timeStamp),
            attst_data->data[0].chipId,
            &(attst_data->data[0].chipIdLen),
            attst_data->data[0].cmd,
            &(attst_data->data[0].cmdLen),
            attst_data->data[0].objSize,
            &(attst_data->data[0].objSizeLen),
            attst_data->data[0].signature,
```

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```
            &signatureLen);
#endif

        attst_data->data[0].signatureLen -= signatureLen;
        attst_data->valid_number = 1;

        ENSURE_OR_GO_CLEANUP(status == SM_OK);
        //#if !SSS_HAVE_SE05X_VER_GTE_07_02
        /* Perform verification operation here on the following data
         *      (key + offset) +
         *      attst_data->data[0].attribute +
         *      attst_data->data[0].timestamp +
         *      attst_data->data[0].outrandom +
         *      attst_data->data[0].chipId
         * with signature
         *      attst_data->data[0].signature
         *
         * We perform signature verification on host.
         * First we digest the data then pass it to verify API
         */

        memcpy(plainData, (key + offset), max_buffer);
        memcpy(plainData + max_buffer, attst_data->data[0].attribute, attst_data->
↪data[0].attributeLen);
        memcpy(plainData + max_buffer + attst_data->data[0].attributeLen,
            &(attst_data->data[0].timeStamp),
            attst_data->data[0].timeStampLen);
#if !SSS_HAVE_SE05X_VER_GTE_07_02
        memcpy(plainData + max_buffer + attst_data->data[0].attributeLen + attst_data-
↪>data[0].timeStampLen,
            attst_data->data[0].outrandom,
            attst_data->data[0].outrandomLen);
        memcpy(plainData + max_buffer + attst_data->data[0].attributeLen + attst_data-
↪>data[0].timeStampLen +
                   attst_data->data[0].outrandomLen,
            attst_data->data[0].chipId,
            attst_data->data[0].chipIdLen);
        plainDataLen = max_buffer + attst_data->data[0].attributeLen + attst_data->
↪data[0].timeStampLen +
                       attst_data->data[0].outrandomLen + attst_data->data[0].
↪chipIdLen;
#else
        /* Perform verification operation here on the following data
        *      Perform hash on capdu +
        *      Tag(0x41) + Length + data +
        *      Tag(0x42) + Length +att_data.data[0].chipId +
        *      Tag(0x43) + Length +att_data.data[0].attribute +
        *      Tag(0x44) + Length +dataLen +
        *      Tag(0x4F) + Length +att_data.data[0].timestamp
        * We perform signature verification on host.
        * First we digest the data then pass it to verify API with recv signature
        */

        sss_status = sss_digest_context_init(
            &digest_ctx, verification_object->keyStore->session, digest_algorithm,␣
↪kMode_SSS_Digest);
        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);
```

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```
        LOG_MAU8_I("Cmd ", attst_data->data[0].cmd, attst_data->data[0].cmdLen);

        sss_status = sss_digest_one_go(
            &digest_ctx, attst_data->data[0].cmd, (attst_data->data[0].cmdLen),␣
↪cmdHashed, &cmdHashedLen);
        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);

        LOG_MAU8_I("Cmd Hashed ", cmdHashed, cmdHashedLen);
        sss_digest_context_free(&digest_ctx);
        plainDataLen = 0;

        memcpy(pData, cmdHashed, cmdHashedLen);
        plainDataLen = plainDataLen + cmdHashedLen;
        pData        = pData + plainDataLen;

        tlvRet = add_taglength_to_data(&pData, &plainDataLen, kSE05x_TAG_1, (key +␣
↪offset), max_buffer, true);
        ENSURE_OR_GO_CLEANUP(tlvRet == 0);
        tlvRet = add_taglength_to_data(
            &pData, &plainDataLen, kSE05x_TAG_2, attst_data->data[0].chipId, attst_
↪data->data[0].chipIdLen, true);
        ENSURE_OR_GO_CLEANUP(tlvRet == 0);
        tlvRet = add_taglength_to_data(
            &pData, &plainDataLen, kSE05x_TAG_3, attst_data->data[0].attribute, attst_
↪data->data[0].attributeLen, true);
        ENSURE_OR_GO_CLEANUP(tlvRet == 0);
        tlvRet = add_taglength_to_data(
            &pData, &plainDataLen, kSE05x_TAG_4, attst_data->data[0].objSize, attst_
↪data->data[0].objSizeLen, true);
        ENSURE_OR_GO_CLEANUP(tlvRet == 0);

        memcpy(timestamp, &(attst_data->data[0].timeStamp), attst_data->data[0].
↪timeStampLen);

        tlvRet = add_taglength_to_data(
            &pData, &plainDataLen, kSE05x_TAG_TIMESTAMP, timestamp, attst_data->
↪data[0].timeStampLen, true);
        ENSURE_OR_GO_CLEANUP(tlvRet == 0);

        LOG_MAU8_I("plainData ", plainData, plainDataLen);

#endif
        sss_status = sss_digest_context_init(
            &digest_ctx, verification_object->keyStore->session, digest_algorithm,␣
↪kMode_SSS_Digest);
        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);

        sss_status = sss_digest_one_go(&digest_ctx, plainData, plainDataLen, digest, &
↪digestLen);
        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);

        sss_digest_context_free(&digest_ctx);

        /* Verify signature */
        sss_status = sss_asymmetric_context_init(
            &verify_ctx, verification_object->keyStore->session, verification_object,␣
↪algorithm, kMode_SSS_Verify);
```

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```
        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);

        sss_status =
            sss_asymmetric_verify_digest(&verify_ctx, digest, digestLen, attst_data->
↪data[0].signature, signatureLen);

        sss_asymmetric_context_free(&verify_ctx);

        ENSURE_OR_GO_CLEANUP(sss_status == kStatus_SSS_Success);

        offset = offset + chunk;
    }

cleanup:
    return sss_status;
}
```

5.7.14 SE05X Transport Lock example

This demo Locks SE05x applet.

During transportation of the secure element, this lock can be enforced to avoid malicious access to the SE during transport.

Warning: This demo is just for reference for the usage of APIs, it should not be used for production.

See the corresponding demo Section 5.7.15 *SE05X Transport UnLock example*

Both the lock and unlock demo use same key and common logic from `se05x_TransportAuth.c`

5.7.15 SE05X Transport UnLock example

This demo UnLocks SE05x applet, after it is locked by Section 5.7.14 *SE05X Transport Lock example*

Warning: This demo is just for reference for the usage of APIs, it should not be used for production.

See the corresponding demo Section 5.7.14 *SE05X Transport Lock example*

Both the lock and unlock demo use same key and common logic from `se05x_TransportAuth.c`

5.7.16 SE05X Timestamp

The timestamp is a 12-byte value. The most significant 4 bytes are persistent and the least significant 8 bytes are transient. The persistent value is incremented at every session open and the transient 8 bytes are incremented every 100ms and reset at every session open.

So every time the timestamp is read, the newer value will always be greater than the previous value.

This example demonstrates that the timestamp value is incremented internally. Timestamp is used by the applet during attestation. We initially read the timestamp value and then perform attestation operation. We compare the initial timestamp with the timestamp received during attestation. The newer value must be greater than the older value.

Building

Build the project with the following configuration.

- `Applet=SE05X_C`
- `Project = se05x_TimeStamp`

Running

On successful execution, you would be able to see the timestamp printed out:

```
App   :INFO :timestamp.ts (Len=12)
      00 00 00 08    00 00 00 00    00 1F BD 00
App   :INFO :new_timestamp.ts (Len=12)
      00 00 00 08    00 00 00 00    00 20 B7 00
App   :INFO :ex_sss Finished
```

As you can see in the above logs, the timestamp value received during attestation operation is larger than the previous value.

5.7.17 SE05X PCR example

This project can be used to demonstrate PCR as Policy.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_PCR`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_PCR.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_PCR
```

Console output

If everything is successful, the output will be similar to:

```
APDU  :DEBUG:CheckObjectExists []
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0xEF000040
smCom :DEBUG:Tx> (Len=11)
      80 04 00 27    06 41 04 EF    00 00 40
```

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```
smCom :DEBUG:<Rx (Len=5)
      41 01 02 90    00
sss   :DEBUG:sss_key_store_generate_key(@EF000040, cipherType=kSSS_CipherType_EC_NIST_
↪P, keyBitLen=256)

APDU  :DEBUG:ReadECCurveList []
smCom :DEBUG:Tx> (Len=5)
      80 02 0B 25    00
smCom :DEBUG:<Rx (Len=23)
      41 82 00 11    01 01 02 01    01 01 01 01    01 01 01 01
      01 01 01 01    01 90 00

APDU  :DEBUG:CheckObjectExists []
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0xEF000040
smCom :DEBUG:Tx> (Len=11)
      80 04 00 27    06 41 04 EF    00 00 40
smCom :DEBUG:<Rx (Len=5)
      41 01 02 90    00

APDU  :DEBUG:WriteECKey []
APDU  :DEBUG:kSE05x_TAG_POLICY
APDU  :DEBUG:policy (Len=45)
      2C 00 00 00    00 1F FD 90    00 7F FF FF    FF 87 D3 E3
      93 19 8F 5C    80 E0 BC 9B    C9 82 00 1F    B0 EE 20 1C
      27 0B 6D C8    84 52 E4 13    A3 25 56 81    75
APDU  :DEBUG:kSE05x_TAG_MAX_ATTEMPTS [maxAttempt] = 0x0
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0xEF000040
APDU  :DEBUG:kSE05x_TAG_2 [curveID] = 0x3
APDU  :DEBUG:kSE05x_TAG_3 [privKey] (Len=0)
APDU  :DEBUG:kSE05x_TAG_4 [pubKey] (Len=0)
smCom :DEBUG:Tx> (Len=61)
      80 01 61 00    38 11 2D 2C    00 00 00 00    1F FD 90 00
      7F FF FF FF    87 D3 E3 93    19 8F 5C 80    E0 BC 9B C9
      82 00 1F B0    EE 20 1C 27    0B 6D C8 84    52 E4 13 A3
      25 56 81 75    41 04 EF 00    00 40 42 01    03
smCom :DEBUG:<Rx (Len=2)
      90 00

APDU  :DEBUG:ECDSASign []
APDU  :DEBUG:kSE05x_TAG_1 [objectID] = 0xEF000040
APDU  :DEBUG:kSE05x_TAG_2 [ecSignAlgo] = 0x21
APDU  :DEBUG:kSE05x_TAG_3 [inputData] (Len=32)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
smCom :DEBUG:Tx> (Len=48)
      80 03 0C 09    2B 41 04 EF    00 00 40 42    01 21 43 20
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
smCom :DEBUG:<Rx (Len=2)
      69 85
sss   :WARN :nxEnsure:'ret == SM_OK' failed. At Line:5601 Function:sss_se05x_TXn
App   :INFO :Sign failed due to PCR expected value mismatch!!!

APDU  :DEBUG:CheckObjectExists []
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0x7FFFFFFF
smCom :DEBUG:Tx> (Len=11)
      80 04 00 27    06 41 04 7F    FF FF FF
```

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```
smCom :DEBUG:<Rx (Len=5)
      41 01 02 90    00

APDU  :DEBUG:WritePCR []
APDU  :INFO :Policy is NULL
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0x7FFFFFFF
APDU  :DEBUG:kSE05x_TAG_2 [initialValue] (Len=32)
      12 A1 49 82    32 00 00 00    00 00 00 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
APDU  :DEBUG:kSE05x_TAG_3 [inputData] (Len=0)
smCom :DEBUG:Tx> (Len=45)
      80 01 09 00    28 41 04 7F    FF FF FF 42    20 12 A1 49
      82 32 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00
smCom :DEBUG:<Rx (Len=2)
      90 00

APDU  :DEBUG:WritePCR []
APDU  :INFO :Policy is NULL
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0x7FFFFFFF
APDU  :DEBUG:kSE05x_TAG_2 [initialValue] (Len=0)
APDU  :DEBUG:kSE05x_TAG_3 [inputData] (Len=5)
      12 A1 49 82    32
smCom :DEBUG:Tx> (Len=18)
      80 01 09 00    0D 41 04 7F    FF FF FF 43    05 12 A1 49
      82 32
smCom :DEBUG:<Rx (Len=2)
      90 00

APDU  :DEBUG:ECDSASign []
APDU  :DEBUG:kSE05x_TAG_1 [objectID] = 0xEF000040
APDU  :DEBUG:kSE05x_TAG_2 [ecSignAlgo] = 0x21
APDU  :DEBUG:kSE05x_TAG_3 [inputData] (Len=32)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
smCom :DEBUG:Tx> (Len=48)
      80 03 0C 09    2B 41 04 EF    00 00 40 42    01 21 43 20
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
smCom :DEBUG:<Rx (Len=76)
      41 82 00 46    30 44 02 20    50 06 84 FF    D1 CE 87 E7
      F6 89 BE 6C    5B 93 EE EB    26 FB 9D 86    01 25 4F C5
      CE EF 4E 0D    68 9A 64 D9    02 20 6A 4F    27 D0 95 CC
      BD D4 20 66    60 B2 9E 52    26 96 A1 31    3C 1F 7D 77
      E3 16 02 AA    B2 E3 36 61    05 70 90 00

APDU  :DEBUG:ECDSAVerify []
APDU  :DEBUG:kSE05x_TAG_1 [objectID] = 0xEF000040
APDU  :DEBUG:kSE05x_TAG_2 [ecSignAlgo] = 0x21
APDU  :DEBUG:kSE05x_TAG_3 [inputData] (Len=32)
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
APDU  :DEBUG:kSE05x_TAG_5 [signature] (Len=70)
      30 44 02 20    50 06 84 FF    D1 CE 87 E7    F6 89 BE 6C
      5B 93 EE EB    26 FB 9D 86    01 25 4F C5    CE EF 4E 0D
      68 9A 64 D9    02 20 6A 4F    27 D0 95 CC    BD D4 20 66
      60 B2 9E 52    26 96 A1 31    3C 1F 7D 77    E3 16 02 AA
```

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```
      B2 E3 36 61    05 70
smCom :DEBUG:Tx> (Len=120)
      80 03 0C 0A    73 41 04 EF    00 00 40 42    01 21 43 20
      48 65 6C 6C    6F 20 57 6F    72 6C 64 00    00 00 00 00
      00 00 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      45 46 30 44    02 20 50 06    84 FF D1 CE    87 E7 F6 89
      BE 6C 5B 93    EE EB 26 FB    9D 86 01 25    4F C5 CE EF
      4E 0D 68 9A    64 D9 02 20    6A 4F 27 D0    95 CC BD D4
      20 66 60 B2    9E 52 26 96    A1 31 3C 1F    7D 77 E3 16
      02 AA B2 E3    36 61 05 70
smCom :DEBUG:<Rx (Len=5)
      41 01 01 90    00
App   :INFO :Sign & Verify is Success with Expected PCR value!!!

APDU  :DEBUG:DeleteSecureObject []
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0xEF000040
smCom :DEBUG:Tx> (Len=11)
      80 04 00 28    06 41 04 EF    00 00 40
smCom :DEBUG:<Rx (Len=2)
      90 00

APDU  :DEBUG:DeleteSecureObject []
APDU  :DEBUG:kSE05x_TAG_1 [object id] = 0x7FFFFFFF
smCom :DEBUG:Tx> (Len=11)
      80 04 00 28    06 41 04 7F    FF FF FF
smCom :DEBUG:<Rx (Len=2)
      90 00
App   :INFO :ex_sss Finished
Press any key to continue . . .
```

5.7.18 Configuring Applet Features

This tool is used to configure the applet for different variants, i.e. Variant A, Variant B and Variant C. Note that this tool only enables or disables the features according to the configured variant, it **does not alter the variant itself**. The tool should be compiled with ECKey encryption, and optionally PlatfSCP03 encryption also. You would need to provide a command line parameter for ECKey key to be used, and an environment variable for your own Platform SCP03 keys, if required.

Configuring ECKey key for command line

This example takes as a command-line input, the filename in which ECDSA key is stored. The key should be stored in *.der* (binary) format only. If the available key is in *.pem* format, it can be converted into binary format using OpenSSL command-line utility. Refer to OpenSSL Commands for more information on how to convert *.pem* formatted file to *.der* formatted file.

Configuring Environment for PlatfSCP03 Keys

If you do not wish to use Platform SCP03 encryption, skip to the next step.

To use your own platform SCP03 keys, refer to Section 11.10 *Using own Platform SCP03 Keys* on details on setting up your environment.

Using with PC as host

1) Flash the VCOM binary present in `binaries` directory on to the target board.
2) Note the VCOM *COMPORT* from device manager.
3) Build the project `se05x_setAppletFearures`. Configure the tool with `SE050_A`, `SE050_B` or `SE050_C`, to enable the applet specific features.
4) Run the executable for desired variant as:

```
cd tools
set EX_SSS_BOOT_SCP03_PATH_ENV=\path\to\platfscp03\keys
se05x_setAppletFearures.exe -file <filename> <COMPORT>
```

Where `EX_SSS_BOOT_SCP03_PATH_ENV` is set to the path of file containing Platform SCP03 keys as described in *Configuring Environment for PlatfSCP03 Keys*.

COMPORT is the port obtained from step 2.

filename is the path to file containing ECDSA keypair provisioned at **RESERVED_ID_FEATURE** in binary format as described in *Configuring ECKey key for command line*

Using with iMX-6 as host

1) Build the project `se05x_setAppletFearures`. Configure the tool with `SE050_A`, `SE050_B` or `SE050_C`, to enable the applet specific features.
2) Run the executable for desired variant as:

```
cd tools
export EX_SSS_BOOT_SCP03_PATH_ENV=\path\to\platfscp03\keys
./se05x_setAppletFearures -file <filename>
```

Where `EX_SSS_BOOT_SCP03_PATH_ENV` is set to the path of file containing Platform SCP03 keys as described in *Configuring Environment for PlatfSCP03 Keys*.

filename is the path to file containing ECDSA keypair provisioned at **RESERVED_ID_FEATURE** in binary format as described in *Configuring ECKey key for command line*

5.7.19 Write APDU to buffer

Normally, when we create an APDU, we also perform transceive operation and return the result to the application. Optionally, the user may want to just create the APDU and not perform the transceive operation.

This can be done by creating your own transaction function. All `SE05x` APIs call a common transaction function in which the complete APDU is created and then transmitted.

The following function can be used as reference.

```
smStatus_t fLogTransmitBuffer(Se05xSession_t *pwrite_apdubufferctx,
    const tlvHeader_t *hdr,
    uint8_t *cmdBuf,
    size_t cmdBufLen,
    uint8_t *rsp,
    size_t *rspLen,
    uint8_t hasle)
{
```

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```
    memset(gTxBuffer, 0, sizeof(gTxBuffer));
    size_t i = 0;
    memcpy(&gTxBuffer[i], hdr, sizeof(*hdr));
    smStatus_t ret = SM_OK;
    i += sizeof(*hdr);
    if (cmdBufLen > 0) {
        // The Lc field must be extended in case the length does not fit
        // into a single byte (Note, while the standard would allow to
        // encode 0x100 as 0x00 in the Lc field, nobody who is sane in his mind
        // would actually do that).
        if ((cmdBufLen < 0xFF) && !hasle) {
            gTxBuffer[i++] = (uint8_t)cmdBufLen;
        }
        else {
            gTxBuffer[i++] = 0x00;
            gTxBuffer[i++] = 0xFFu & (cmdBufLen >> 8);
            gTxBuffer[i++] = 0xFFu & (cmdBufLen);
        }
        memcpy(&gTxBuffer[i], cmdBuf, cmdBufLen);
        i += cmdBufLen;
    }
    if (hasle) {
        gTxBuffer[i++] = 0x00;
        gTxBuffer[i++] = 0x00;
    }
    ret          = SM_OK;
    gTxBufferLen = i;

    return ret;
}
```

Assign this function to session context and use as following

```
Se05xSession_t write_apdubufferctx = {0};
write_apdubufferctx.fp_TXn         = &fLogTransmitBuffer;

Se05x_API_WriteBinary(&write_apdubufferctx, &policy, objectID, offset, length,␣
↪inputData, inputDataLen);
```

After this, whichever `SE05x` API you call with `write_apdubufferctx`, it will just create the APDU and write it to the buffer. No transceive operation will be performed.

Building

Build the project with the following configurations.

se05x_GetAPDUBuffer

- `SCP = None`
- `Project = se05x_GetAPDUBuffer`

Running

On successful execution you can see the APDU buffer printed out:

```
App   :INFO :Policy for ReadOnly File:
App   :INFO :Locked = READ
App   :INFO :Excluded = DELETE, WRITE.
App   :INFO :pPolicyBuffer (Len=9)
      08 00 00 00    00 00 20 00    00
App   :INFO :gTxBuffer (Len=38)
      80 01 06 00    21 11 09 08    00 00 00 00    00 20 00 00
      41 04 11 22    33 44 43 02    00 0A 44 0A    01 02 03 04
      05 06 07 08    09 0A
```

5.7.20 Inject Certificate into SE

This tool is to demonstrate how to inject certificates into the SE. The keyIDs where certificates are injected are defined in `se05x_InjectCertificate.h`:

```
#define ECC_CERTIFICATE_KEYID 0x00000014
#define RSA_CERTIFICATE_KEYID 0x00000011
```

Note: Certificates to be injected are also defined in `se05x_InjectCertificate.h` file. These can be changed as required.

Building the example

Use the following CMake configurations to compile the example

- Project: `se05x_InjectCertificate`

How to use

Run the tool as:

```
se05x_InjectCertificate <port>
```

- For systems connecting with T=1 over I2C, the port parameter can be skipped.

5.7.21 SE05X Read State example

This project can be used to get SE05X state information. The state information is w.r.t

1) LockState
2) Restriction on Object Creation
3) Platform SCP mandate state

Refer to `SE05x_LockState_t` Refer to `SE05x_RestrictMode_t` Refer to `SE05x_PlatformSCPRequest_t`

```
SE05x_LockState_t lockState;
SE05x_RestrictMode_t restrictMode;
SE05x_PlatformSCPRequest_t platformSCPRequest;
```

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_ReadState`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_ReadState.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_ReadState
```

Console output

If everything is successful, the output will be similar to:

```
APDU  :DEBUG:ReadState []
smCom :DEBUG:Tx> (Len=5)
      80 02 00 5B    00
smCom :DEBUG:<Rx (Len=9)
      41 82 00 03    02 00 02 90    00
App   :INFO :SE05x Read State Successfully!!!
App   :INFO :Following is the SE05x Read State status
App   :INFO :SE05x Lock State = 0x2  i.e. SE05x is Unlocked!!!
App   :INFO :SE05x Restrict Mode = 0x0  i.e. No Restriction is applied for object␣
↪creation!!!
App   :INFO :SE05x Platform SCP Request = 0x2  i.e. Platform SCP is not required for␣
↪Communication!!!
App   :INFO :ex_sss Finished
Press any key to continue . . .
```

5.7.22 SE05X Personalization Remove RSA Key Generation Module

This project permanently deletes rsa key generation module from secure element. Running this example will restrict the generation of rsa keys inside the secure element.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_Perso_Delete_Mod_RSAKeyGen`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_Perso_Delete_Mod_RSAKeyGen.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_Perso_Delete_Mod_RSAKeyGen
```

Console output

If everything is successful, the output will be similar to:

```
App   :INFO :# Running Remove Module RSAKEYGEN : On chip generation of RSA keys.
App   :INFO :# Remove Module RSAKEYGEN is complete.
App   :INFO :ex_sss Finished
```

5.7.23 DEMO for Personalization of SE051

This demo can be used to personalize some of the parameters for SE051.

The demo is self explanatory:

```
se05x_Personalization.exe <operation> [operation] <port_name>

Where, 'operation': one or sequence of the following:

                           HELP : Prints list of APIs
     I2C_DisableClockStretching : I2C: Disables clock stretching
      I2C_EnableCLockStretching : I2C: Enables clock stretching
                I2C_ProtocolGP : I2C: Use GP Mode for I2C
                I2C_ProtocolUM : I2C: Use UM Mode like SE050 for I2C
        I2C_ProtocolAutoDetect : I2C: Automatically detect I2C Protocol
            I2C_ProtocolManual : I2C: Manually use fixed Protocol
           I2C_EnablePowerSave : I2C: Go to power save after last APDU
          I2C_DisablePowerSave : I2C: DO not go to power save after last APDU
               I2C_SemiBlocking : I2C: SEMI Blocking I2C
                I2C_NonBlocking : I2C: Non Blocking I2C
           RM_MOD_IOT_EXTENDED : Delete: Extension to Elliptic Curve Cryptography.
               RM_MOD_IOT_BASE : Delete: Collection of crypto algorithms often used␣
↪in IoT devices.
      RM_MODX_EGOVACCELERATORS : Delete: Secure Messaging Accelerators for␣
↪eGovernment applications and modular arithmetic math API.
               RM_MOD_RSAKEYGEN : On chip generation of RSA keys.
```

For further details, please see product user manual.

Note: You can add more operations in a single command.

Warning: These values are effective only after IC Reset.

Compatible settings from host and SE

Some parameters need compatible settings at both sides, from host and SE. Else it leaves system in a non-operable state.

e.g. If the SE is configured to be in `ProtocolGP`, and host is using `ProtocolUM`, there can't be any further communication with the SE without re-compiling the middleware/demo at the host. And since the communication between Host and SE is not function, there is no direct/easy way to re-configure the SE Back.

5.7.24 SE05X MultiThread demo

This project demonstrates two threads, opening two sessions with the se05x using tunneling api's. Each thread performing ecc sign and verify operations.

If we use user sessions then at least two authentication objects need to be provisioned in se05x using the `delete and test provision` utility before running the demo:

- For an overview of authentication objects refer to *Auth Objects*
- For a provisioning example refer to *Delete and Test Provision*

In Multistep operations the concurrent execution with same cipher mode is not allowd. (Refer *Known limitations*)

Note: This demo can be build for FreeRTOS on embedded platforms or for pthread on POSIX systems (e.g. Linux).

Prerequisites

- Micro USB cable
- FRDM-K64F/imx-RT1060/Raspberry-Pi/iMX board
- Personal Computer
- SE05x Arduino shield

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_MultiThread`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_Multithread.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_Multithread
```

Console output

If everything is successful, the output will be similar to:

```
sss   :WARN :Communication channel is with Plain.
sss   :WARN :!!!Not recommended for production use.!!!
sss   :WARN :Communication channel is with Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Key Store Generate Key success user 2!!!
App   :INFO :Key Store Generate Key success user 1!!!
App   :INFO :sss_asymmetric_sign_digest success user 2
App   :INFO :sss_asymmetric_sign_digest success user 1
App   :INFO :Set public key success user 2
App   :INFO :Set public key success user 1
App   :INFO :sss_asymmetric_verify_digest success user 2
App   :INFO :Done User 2
App   :INFO :sss_asymmetric_verify_digest success user 1
App   :INFO :Done User 1
App   :INFO :SE05x Multithreaded example finished
```

5.7.25 SE05X Invoke Garbage Collection Example

The example will trigger the garbage collection in SE05X. Invoking `CM_InvokeGarbageCollection` api will close the existing session to SE05X. To use SE05X, open session again.

Warning: Excessive calls to `CM_InvokeGarbageCollection` API will impact the device durability

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_InvokeGarbageCollection`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_InvokeGarbageCollection.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_InvokeGarbageCollection
```

Console output

If everything is successful, the output will be similar to:

```
hostLib:WARN :Invoking this api will close the existing session to SE05X.
hostLib:WARN :To use SE05X, open session again.
hostLib:INFO :Sending Select command
hostLib:INFO :Command Successful!!!
hostLib:INFO :Command Response (Len=18)
      6F 10 84 08    A0 00 00 01    51 00 00 00    A5 04 9F 65
      01 FF
hostLib:INFO :Sending 'Invoke Garbage Collection' Command
hostLib:INFO :Command Successful!!!
hostLib:INFO :Command Response (Len=5)
      FE 03 DF 25    00
App   :INFO :se05x_InvokeGarbageCollection Success !!!...
App   :INFO :ex_sss Finished
```

5.7.26 ECC Concurrent Example

This project demonstrates Elliptic Curve Cryptography sign and verify operations using SSS APIs. On a multiprocess OS it can be run as multiple instances. Before running an instance ensure the secure element is properly provisioned. The utility *Delete and Test Provision* can be used to provision the authentication objects used by this example. Invoke `se05x_Delete_and_test_provision` once during the preparation of the demo. The authentication objects are required for user sessions of type UserID/AESKey/ECKey.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- When used in combination with Access Manager compile for SMCOM = JRCPv1

Restrictions

- Each user session needs to have a different authentication object

Running the Example in combination with the Access Manager

For additional information on the AccessManager refer to *Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*.

Usage

The client process opens an authenticated user session (None/UserID/AESkey/ECkey) configured at build time. The user session must be without platform SCP03. Platform SCP03 is handled by the Access Manager.

The client process connects to the AccessManager over JRCPv1.

Two concurrent client processes (establishing a user session) can connect to the AccessManager.

This program takes 4 command line arguments:

- authid: Authentication object id with which the session can be opened. It can be of type UserID/AESkey/ECkey (or authentication type 'None'). In case the user session authentication is of type 'None' pass '0' as argument

- keyid: The id at which the functional Ec key pair will be stored, use a unique value per process.
- count (optional argument): Number of times the Ec Sign Verify operation will be repeated
- port: Connection port to AccessManager. e.g. 127.0.0.1:8040

An example invocation of the program (passing the Authentication Id of a UserID object) is:

```
./se05x_ConcurrentEcc -authid 0x7DA00001 -keyid 0xEF001234 -cnt 100 -port 127.0.0.
↪1:8040
```

Concurrent Usage

The following command invocations illustrate how two processes connect to the AccessManger using different Authentication Id's and (functional) key Id's.

The following Authentication Id's are provisioned in SE using the "delete & provision" utility

AuthId	1	2
UserID	0x7DA00001	0x7DA00011
AESkey	0x7DA00002	0x7DA00012
ECKey	0x7DA00003	0x7DA00013

KeyId can be anything above 0xEF000000, choose a different value for each client process.

- Ec Sign / Verify Auth=ID_1 Auth=ID_2
  - ./se05x_ConcurrentEcc -authid 0x7DA00001 -keyid 0xEF001234 -cnt 100 -port 127.0.0.1:8040
  - ./se05x_ConcurrentEcc -authid 0x7DA00011 -keyid 0xEF001244 -cnt 100 -port 127.0.0.1:8040
- Ec Sign / Verify Auth=None Auth=EC
  - ./se05x_ConcurrentEcc -authid 0 -keyid 0xEF001236 -cnt 100 -port 127.0.0.1:8040
  - ./se05x_ConcurrentEcc -authid 0x7DA00003 -keyid 0xEF001246 -cnt 100 -port 127.0.0.1:8040
- Ec Sign / Verify Auth=AES_1 Auth=AES_2
  - ./se05x_ConcurrentEcc -authid 0x7DA00002 -keyid 0xEF001238 -cnt 100 -port 127.0.0.1:8040
  - ./se05x_ConcurrentEcc -authid 0x7DA00012 -keyid 0xEF001248 -cnt 100 -port 127.0.0.1:8040

5.7.27 Symmetric Multi Step Concurrent Example

This project demonstrates Symmetric Multi step operations. using SSS APIs. On a multiprocess OS it can be run as multiple instances. Before running an instance ensure the secure element.is properly provisioned. The block cipher mode to apply (ECB or CBC) can be chosen by the user. The utility *Delete and Test Provision* can be used to provision the authentication objects used by this example. Invoke `se05x_Delete_and_test_provision` once during the preparation of the demo. The authentication objects are required for user sessions of type UserID/AESKey/ECKey.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- When used in combination with Access Manager compile for SMCOM = JRCPv1

Restrictions

- Each user session needs to have a different authentication object
- The same block cipher mode cannot be used for two concurrent client processes. If one process uses ECB the other must use CBC. This is a restriction from the SSS layer.

Running the Example in combination with the Access Manager

For additional information on the AccessManager refer to *Access Manager: Manage access from multiple (Linux) processes to an SE05x IoT Applet*.

Usage

The client process opens an authenticated user session (None/UserID/AESkey/ECkey) configured at build time. The user session must be without platform SCP03. Platform SCP03 is handled by the Access Manager.

The client process connects to the AccessManager over JRCPv1.

Two concurrent client processes (establishing a user session) can connect to the AccessManager.

This program takes 5 command line arguments:

- authid: Authentication object id with which the session can be opened. It can be of type UserID/AESkey/ECkey (or authentication type 'None'). In case the user session authentication is of type 'None' pass '0' as argument
- keyid: The id at which the symmetric key has to be stored, use a unique value per process.
- algo: Block cipher mode, use 1 for ECB and 2. for CBC
- count (optional argument): Number of times the crypto operation will be repeated.
- port: Connection port to AccessManager. e.g. 127.0.0.1:8040

An example invocation of the program is:

```
./se05x_ConcurrentSymm -authid 0x7DA00001 -keyid 0xEF002234 -algo 1 -cnt 100 -port␣
↪127.0.0.1:8040
```

Concurrent Usage

The following command invocations illustrate how two processes connect to the AccessManger using different Authentication Id's and (functional) key Id's.

The following Authentication Id's are provisioned in SE using the "delete & provision" utility

AuthId	1	2
UserID	0x7DA00001	0x7DA00011
AESkey	0x7DA00002	0x7DA00012
ECKey	0x7DA00003	0x7DA00013

KeyId can be anything above 0xEF000000, choose a different value for each client process.

- ECB Enc/Dec CBC Enc/Dec Auth=ID Auth=AES
  - ./se05x_ConcurrentSymm -authid 0x7DA00001 -keyid 0xEF002234 -algo 1 -cnt 100 -port 127.0.0.1:8040
  - ./se05x_ConcurrentSymm -authid 0x7DA00002 -keyid 0xEF002235 -algo 2 -cnt 100 -port 127.0.0.1:8040

- ECB Enc/Dec CBC Enc/Dec Auth=ID_1 Auth=ID_2
    - ./se05x_ConcurrentSymm -authid 0x7DA00001 -keyid 0xEF002236 -algo 1 -cnt 100 -port 127.0.0.1:8040
    - ./se05x_ConcurrentSymm -authid 0x7DA00011 -keyid 0xEF002237 -algo 2 -cnt 100 -port 127.0.0.1:8040
- ECB Enc/Dec; CBC Enc/Dec Auth=EC Auth=AES
    - ./se05x_ConcurrentSymm -authid 0x7DA00003 -keyid 0xEF002238 -algo 1 -cnt 100 -port 127.0.0.1:8040
    - ./se05x_ConcurrentSymm -authid 0x7DA00002 -keyid 0xEF002239 -algo 2 -cnt 100 -port 127.0.0.1:8040

5.7.28 Delete and Test Provision

'Delete and Test Provision' is a utility that deletes a subset of the crypto objects stored on the secure element. Next it provisions different types of key objects (as documented in the table below). These key objects enable various use cases with the secure element. As an example: the authentication objects for session based authentication (UserID/AESkey/ECKey) are provisioned through this utility.

To enable concurrent (up to the maximum of two) authenticated user sessions, two authentication objects of each type (UserID/AESkey/ECKey) are provisioned.

Note: Authentication objects - of the same object type - are provisioned on Ids with an offset of +0x10.

Warning: This utility provisions the same value for both authentication object type instances. In a product deployment different values must be used, do not re-use any of the values provisioned by this test utility in a product deployment.

Object IDs provisioned

Object ID	Object Type	Usage
0x7DA00001	User ID	Allows the user to Open User ID Auth Session to SE.
0x7DA00002	Symm Key	Allows the user to Open AES Key Auth Session to SE.
0x7DA00003	EC Key	Allows the user to Open EC Key Auth Session to SE.
0x7DA00011	User ID	Allows the user to Open additional User ID Auth Session to SE.
0x7DA00012	Symm Key	Allows the user to Open additional AES Key Auth Session to SE.
0x7DA00013	EC Key	Allows the user to Open additional EC Key Auth Session to SE.
0x7FFF0200	Symm Key	Allows the user to switch transport LockState of the SE.
0x7FFF0201	EC Key	Provisions ECKA pair at SE for EC key Session Authentication.
0x7FFF0202	EC Key	Provisions ECKA pair at SE for EC key Session Authentication.
0x7FFF0203	EC Key	Provisions ECKA pair at SE for EC key Session Authentication.
0x7FFF0204	EC Key	Used for applet personalization.
0x7FFF0205	User ID	Allows the user to delete all objects. Except those provisioned by NXP.
0x7FFF0206	Binary	Holds the device unique ID.
0x7FFF0207	User ID	Allows the user to make platform SCP mandatory or not.

Warning: Some of the object Ids here are provisioned with same values. This is for test, example and demo purpose only.

Authentication Keys

Warning: These values are just for demonstration. The user **MUST** modify these values in the secure element and the application for real world use cases.

User ID

```
#define EX_SSS_AUTH_SE05X_UserID_AUTH_ID kEX_SSS_ObjID_UserID_Auth

#define EX_SSS_AUTH_SE05X_UserID_VALUE  \
    {                                    \
        0xC0, 0x01, 0x02, 0x03, 0x04     \
    } /* COOL 234*/

#define EX_SSS_AUTH_SE05X_UserID_VALUE2      \
    {                                        \
        0xC0, 0x01, 0x02, 0x03, 0x04, 0x05   \
    } /* COOL 2345*/
```

Applet SCP

```
#define EX_SSS_AUTH_SE05X_APPLETSCP_AUTH_ID kEX_SSS_ObjID_APPLETSCP03_Auth

#define EX_SSS_AUTH_SE05X_APPLETSCP_VALUE                                 \
    {                                                                     \
        0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, \
        0x4B, 0x4C, 0x4D, 0x4E, 0x4F                                      \
    }

#define EX_SSS_AUTH_SE05X_APPLETSCP_VALUE2                                \
    {   0xea, 0x62, 0x04, 0x48, 0x0b, 0xf5, 0x19, 0xf6, 0xc2, 0xb7, 0x7f, \
        0xba, 0x8b, 0x2d, 0x57, 0x30                                      \
    }
```

EC Key

```
#define EX_SSS_AUTH_SE05X_ECKEY_ECDSA_AUTH_ID kEX_SSS_objID_ECKEY_Auth

#define EX_SSS_AUTH_SE05X_KEY_HOST_ECDSA_KEY                              \
    {                                                                     \
        0x30, 0x81, 0x87, 0x02, 0x01, 0x00, 0x30, 0x13,                   \
        0x06, 0x07, 0x2A, 0x86, 0x48, 0xCE, 0x3D, 0x02,                   \
        0x01, 0x06, 0x08, 0x2A, 0x86, 0x48, 0xCE, 0x3D,                   \
        0x03, 0x01, 0x07, 0x04, 0x6D, 0x30, 0x6B, 0x02,                   \
        0x01, 0x01, 0x04, 0x20,                                           \
        0x6D, 0x2F, 0x43, 0x2F, 0x8A, 0x2F, 0x45, 0xEC,                   \
        0xD5, 0x82, 0x84, 0x7E, 0xC0, 0x83, 0xBB, 0xEB,                   \
        0xC2, 0x3F, 0x1D, 0xF4, 0xF0, 0xDD, 0x2A, 0x6F,                   \
        0xB8, 0x1A, 0x24, 0xE7, 0xB6, 0xD5, 0x4C, 0x7F,                   \
        0xA1, 0x44, 0x03, 0x42, 0x00,                                     \
        0x04, 0x3C, 0x9E, 0x47, 0xED, 0xF0, 0x51, 0xA3,                   \
        0x58, 0x9F, 0x67, 0x30, 0x2D, 0x22, 0x56, 0x7C,                   \
        0x2E, 0x17, 0x22, 0x9E, 0x88, 0x83, 0x33, 0x8E,                   \
        0xC3, 0xB7, 0xD5, 0x27, 0xF9, 0xEE, 0x71, 0xD0,                   \
        0xA8, 0x1A, 0xAE, 0x7F, 0xE2, 0x1C, 0xAA, 0x66,                   \
```

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```
        0x77, 0x78, 0x3A, 0xA8, 0x8D, 0xA6, 0xD6, 0xA8,                   \
        0xAD, 0x5E, 0xC5, 0x3B, 0x10, 0xBC, 0x0B, 0x11,                   \
        0x09, 0x44, 0x82, 0xF0, 0x4D, 0x24, 0xB5, 0xBE,                   \
        0xC4                                                              \
    }

#define EX_SSS_AUTH_SE05X_KEY_HOST_ECDSA_KEY2                             \
    {                                                                     \
        0x30, 0x81, 0x87, 0x02, 0x01, 0x00, 0x30, 0x13,                   \
        0x06, 0x07, 0x2A, 0x86, 0x48, 0xCE, 0x3D, 0x02,                   \
        0x01, 0x06, 0x08, 0x2A, 0x86, 0x48, 0xCE, 0x3D,                   \
        0x03, 0x01, 0x07, 0x04, 0x6D, 0x30, 0x6B, 0x02,                   \
        0x01, 0x01, 0x04, 0x20,                                           \
        0x12, 0xe2, 0xd3, 0xc7, 0x31, 0xa6, 0x7c, 0x32,                   \
        0xfb, 0xd7, 0x2f, 0xa9, 0xc4, 0xbb, 0xc2, 0xd0,                   \
        0x64, 0xad, 0x50, 0x99, 0xd3, 0x3d, 0x01, 0x4b,                   \
        0x4f, 0x36, 0x90, 0x9c, 0xba, 0xab, 0xbb, 0xda,                   \
        0xA1, 0x44, 0x03, 0x42, 0x00,                                     \
        0x04, 0x0d, 0x0e, 0x03, 0xdd, 0x40, 0x1e, 0x77,                   \
        0xff, 0xab, 0xa8, 0xb5, 0x79, 0xdb, 0x8a, 0xf4,                   \
        0x09, 0x7b, 0x59, 0x4e, 0xe8, 0xa0, 0xb8, 0x1c,                   \
        0xeb, 0xa8, 0x53, 0x96, 0xc6, 0x13, 0x96, 0x56,                   \
        0x13, 0x5e, 0x68, 0x75, 0xb9, 0xe9, 0x79, 0x29,                   \
        0x28, 0x8c, 0x7d, 0xa1, 0xf2, 0x78, 0x7b, 0x66,                   \
        0x86, 0xcc, 0x9e, 0x6b, 0xf6, 0x03, 0xc2, 0xfe,                   \
        0x59, 0x1b, 0xab, 0x4a, 0x40, 0x24, 0x70, 0xe4,                   \
        0x8b                                                              \
    }
```

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- `SE05X_Auth=None`
- Project: `se05x_Delete_and_test_provision`

5.7.29 se05x Multiple Digest Crypto Objects example

This project demonstrates managing multiple crypto objects from application layer. The example will create 2 digest crypto objects which will be used for SHA256 multistep operations. The example can be extended for AES, AEAD, MAC crypto objects also.

Note: Disable *SSSFTR_SE05X_CREATE_DELETE_CRYPTOOBJ* in cmake options to run this example. This will ensure crypto objects are not created at SSS layer.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_MultipleDigestCryptoObj`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_MultipleDigestCryptoObj.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_MultipleDigestCryptoObj
```

Console output

If everything is successful, the output will be similar to:

```
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Running Multiple Digest Crypto Example se05x_MultipleDigestCryptoObj.c
App   :INFO :Create digest crypto object with id - 58 !!!
App   :INFO :Create digest crypto object with id - 59 !!!
App   :INFO :Calling Update function for crypto objectId1 !!!
App   :INFO :Calling Update function for crypto objectId2 !!!
App   :INFO :Calling Update function for crypto objectId1 !!!
App   :INFO :Calling Update function for crypto objectId2 !!!
App   :INFO :Calling Update function for crypto objectId1 !!!
App   :INFO :Calling Update function for crypto objectId2 !!!
App   :INFO :Message Digest (input1) successful !!!
App   :INFO :digest (Len=32)
      90 B4 6D D6    FA D0 A8 DB    49 69 45 A6    BE 27 D9 5F
      BB 78 60 48    22 35 69 70    56 B8 9B 1D    07 83 68 5E
App   :INFO :Message Digest (input2) successful !!!
App   :INFO :digest (Len=32)
      D8 ED 22 5A    FC 4B B0 9B    47 EF DB 9E    D4 51 7F 2F
      87 4E 3F 61    00 A3 6D 4F    DD 4D 90 B8    7B 70 72 45
App   :INFO :ex_sss Finished
Press any key to continue . . .
```

5.7.30 SE05X Allow Without SCP example

This project demonstrates how to configure SE05X to allow without platform SCP.

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_AllowWithoutPlatformSCP`
  - CMake configuration

    `SE05X_Auth:PlatfSCP03`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
se05x_AllowWithoutPlatformSCP.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On Raspberry-Pi or iMX board, run as:

```
./se05x_AllowWithoutPlatformSCP
```

5.7.31 SE05X SCP03 BOOT Example

This project demonstrates that the HostOS does NOT need to know the SCP03 Base Keys to establish an SCP03 session. Provided the boot loader has established the SCP03 session and saved the SCP03 session state.

Refer - `simw-top/demos/se05x/se05x_scp03_boot/se05x_scp03_boot.c`

Prerequisites

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `se05x_scp03_boot`
- Required build settings

```
cmake -DPTMW_SCP:STRING=SCP03_SSS -DPTMW_SE05X_Auth:STRING=PlatfSCP03 -DPTMW_
↪SMCOM:STRING=T1oI2C
make se05x_scp03_boot
```

Running the Example

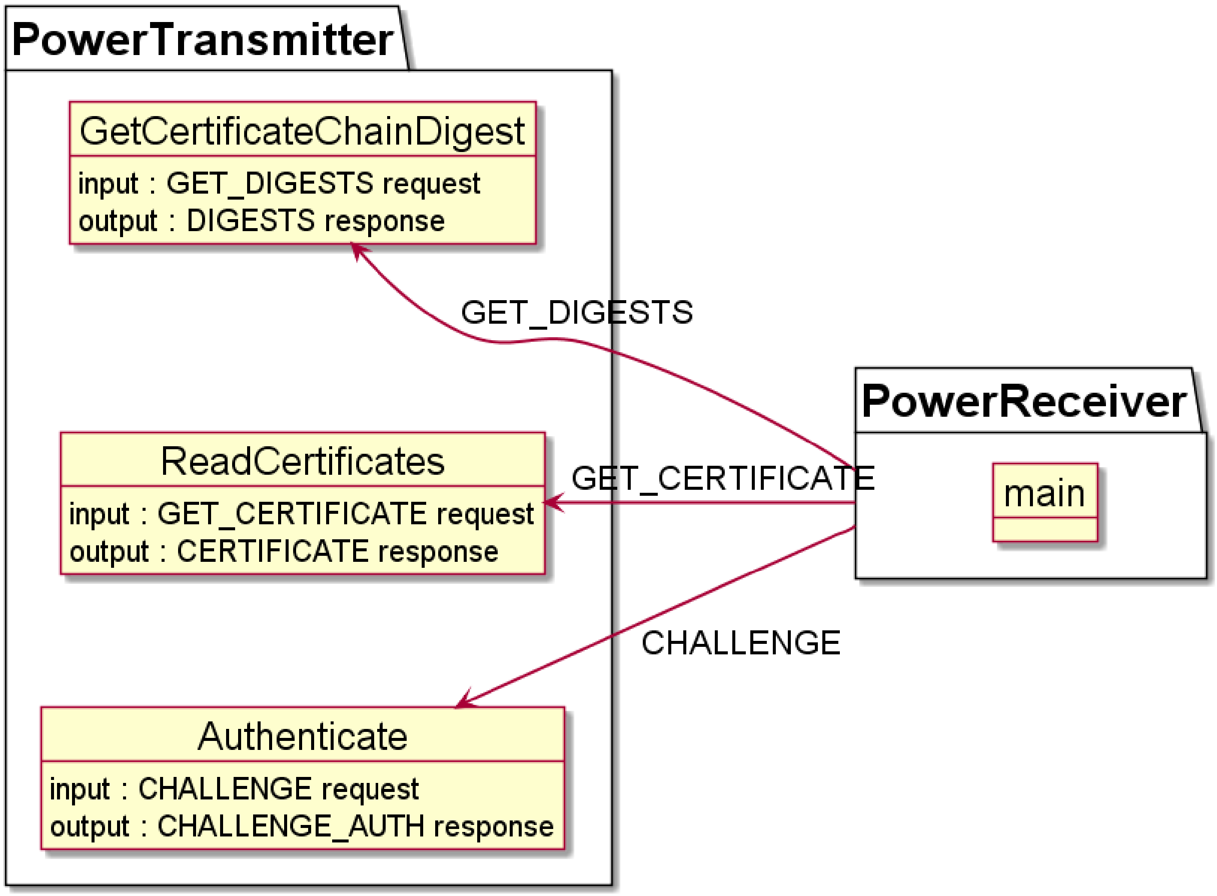
Create `/tmp/SE05X` directory (if not exists) to store the session keys.

If you have built on Raspberry-Pi or iMX board, run as:

```
./se05x_scp03_boot BOOTLOADER_ROLE
./se05x_scp03_boot HOST_OS_RESUME
```

5.7.32 Secure Authenticator (Qi) Authentication demo

This project is used to demonstrate the Qi authentication flow between a Power Transmitter and a Power Receiver. The Power Transmitter implements 3 functions for the 3 authentication requests a Receiver can issue to the Transmitter : `GetCertificateChainDigest`, `ReadCertificates`, `Authenticate`.


PowerTransmitter
GetCertificateChainDigest
input : GET_DIGESTS request
output : DIGESTS response
ReadCertificates
input : GET_CERTIFICATE request
output : CERTIFICATE response
Authenticate
input : CHALLENGE request
output : CHALLENGE_AUTH response
GET_DIGESTS
GET_CERTIFICATE
CHALLENGE
PowerReceiver
main

Pre-requisites

- The secure element should be trust provisioned with correct keys and certificates for Qi Authentication. Keys and certificates can be provisioned for test purpose by updating keys in `demos/se05x/sa_qi_provisioning/sa_qi_credentials.c` and running example ex-se05x-qi-provisioning.
- By default WPC Root certificate is used in the certificate chain. If example ex-se05x-qi-provisioning is run, you would need to disable macro `USE_ROOT_WPCCA` in `sa_qi_rootcert.c` to use test RootCA:

```
#ifndef USE_ROOT_WPCCA
#define USE_ROOT_WPCCA 1
#endif
```

GetCertificateChainDigest (GET_DIGESTS)

This function reads the digests of certificate chains stored inside the secure element and returns all the digests as requested by the Power Receiver.

```
void GetCertificateChainDigest(const uint8_t *pGetDigestRequest,
    const size_t getDigestRequestLen,
    uint8_t *pDigestResponse,
    size_t *pDigestResponseLen)
{
    smStatus_t retStatus        = SM_NOT_OK;
    uint32_t certChainId        = 0;
    uint16_t objectSize         = 0;
    size_t readSize             = 0;
    uint8_t *pData              = NULL;
    pSe05xSession_t session_ctx = pgSe05xSessionctx;
    uint8_t *pDigestPtr         = NULL;

    qi_error_code_t errorCode  = kQiErrorUnspecified;
    uint8_t authMsgHeader      = 0;
    uint8_t requestedSlotMask  = 0;
    uint8_t slotsPopulated     = 0x00;
    uint8_t slotsReturned      = 0x00;
    uint8_t slotsReturnedCount = 0;

    if (NULL == pGetDigestRequest || NULL == pDigestResponse) {
        LOG_E("Null buffer");
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    authMsgHeader = pGetDigestRequest[0];

    if (getDigestRequestLen != GET_DIGESTS_CMD_LEN) {
        LOG_E("Invalid request length");
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    requestedSlotMask = pGetDigestRequest[1] & 0x0F;

    /* Invalid slot requested */
    if (requestedSlotMask == 0) {
        errorCode = kQiErrorInvalidRequest;
        LOG_E("No slot requested");
        goto error;
    }

    /* Get all populated slots */
    retStatus = getPopulatedSlots(session_ctx, &slotsPopulated);
    if (SM_OK != retStatus) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Failed to retrieve populated slots");
        goto error;
    }

    /* Is Slot 0 empty? - Return error as slot 0 must always be populated */
    if (!(slotsPopulated & 0x01)) {
```

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```
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    /* We will return slots which were requested AND are provisioned */
    slotsReturned = requestedSlotMask & slotsPopulated;
    pDigestPtr    = &pDigestResponse[2];

    /* Validate response buffer size */
    for (size_t i = 0; i < MAX_SLOTS; i++) {
        if ((slotsReturned) & (0x01 << i)) {
            slotsReturnedCount++;
        }
    }
    if (*pDigestResponseLen < (size_t)((slotsReturnedCount * DIGEST_SIZE_BYTES) + 2))
↪{
        /* Response buffer size too less */
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    pData = (uint8_t *)SSS_MALLOC(slotsReturnedCount * DIGEST_SIZE_BYTES);
    if (!pData) {
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    for (size_t i = 0; i < MAX_SLOTS; i++) {
        if ((slotsReturned) & (0x01 << i)) {
            certChainId = QI_SLOT_ID_TO_CERT_ID(i);
            /* Read size of object to allocate necessary memory
             * so that we can read the complete object */
            retStatus = Se05x_API_ReadSize(session_ctx, certChainId, &objectSize);
            if (retStatus != SM_OK) {
                errorCode = kQiErrorUnspecified;
                LOG_E("Failed Se05x_API_ReadSize");
                goto error;
            }
            /* Size of binary object cannot be less than Digest size */
            if (objectSize < DIGEST_SIZE_BYTES) {
                errorCode = kQiErrorUnspecified;
                goto error;
            }
            readSize  = DIGEST_SIZE_BYTES;
            retStatus = Se05x_API_ReadObject(session_ctx, certChainId, 0, DIGEST_SIZE_
↪BYTES, pData, &readSize);
            if (retStatus != SM_OK) {
                errorCode = kQiErrorUnspecified;
                LOG_E("Failed Se05x_API_ReadObject");
                goto error;
            }
            memcpy(pDigestPtr, pData, DIGEST_SIZE_BYTES);
            pDigestPtr += DIGEST_SIZE_BYTES;
        }
    }

    /* Successfully filled all digests - fill response buffer header now */
```

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```
    pDigestResponse[0]   = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseDigest);
    pDigestResponse[1]   = (uint8_t)(slotsPopulated << 4) + (uint8_t)(slotsReturned);
    *pDigestResponseLen = (slotsReturnedCount * DIGEST_SIZE_BYTES) + 2;

    if (pData) {
        SSS_FREE(pData);
    }

    return;

error:
    if (pData) {
        SSS_FREE(pData);
    }
    if (pDigestResponse) {
        pDigestResponse[0]   = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseError);
        pDigestResponse[1]   = (uint8_t)(errorCode);
        pDigestResponse[2]   = 0x00;
        *pDigestResponseLen = 3;
    }
}
```

ReadCertificates (GET_CERTIFICATE)

This function reads the certificate chain on the provided slot ID starting from the provided offset and reading provided length bytes.

If the provided offset exceeds `0x600` then that indicates the power transmitter to offset from the Product Unit Certificate. Otherwise the offset starts from the beginning of the certificate chain.

```
void ReadCertificates(const uint8_t *pGetCertificateRequest,
    const size_t getCertificateRequestLen,
    uint8_t *pCertificateResponse,
    size_t *pCertificateResponseLen)
{
    smStatus_t retStatus         = SM_NOT_OK;
    uint16_t objectSize          = 0;
    pSe05xSession_t session_ctx = pgSe05xSessionctx;
    uint32_t certChainId         = 0;
    size_t readSize              = 0;
    uint8_t *pData               = NULL;

    qi_error_code_t errorCode    = kQiErrorUnspecified;
    uint8_t authMsgHeader        = 0;
    uint8_t requestedslots       = 0;
    uint8_t certificateOffsetA8 = 0;
    uint8_t certificateOffset70 = 0;
    uint8_t certificateLengthA8 = 0;
    uint8_t certificateLength70 = 0;
    uint16_t certificateOffset  = 0;
    uint16_t certificatelength  = 0;
    /* Offset first DIGEST bytes to skip certificate chain hash */
    uint16_t offset      = DIGEST_SIZE_BYTES;
```

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```
    uint16_t N_MC        = 0;
    uint16_t bytesToRead = 0;

    if (NULL == pGetCertificateRequest || NULL == pCertificateResponse) {
        LOG_E("Null buffer");
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    authMsgHeader = pGetCertificateRequest[0];

    if (getCertificateRequestLen != GET_CERTIFICATE_CMD_LEN) {
        LOG_E("Invalid request length");
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    requestedslots      = pGetCertificateRequest[1] & 0x03;
    certificateOffsetA8 = (pGetCertificateRequest[1] & 0xE0) >> 5;
    certificateOffset70 = pGetCertificateRequest[2];
    certificateLengthA8 = (pGetCertificateRequest[1] & 0x1C) >> 2;
    certificateLength70 = pGetCertificateRequest[3];
    certificateOffset   = certificateOffsetA8 * 256 + certificateOffset70;
    certificatelength   = certificateLengthA8 * 256 + certificateLength70;

    certChainId = QI_SLOT_ID_TO_CERT_ID(requestedslots);

    retStatus = Se05x_API_ReadSize(session_ctx, certChainId, &objectSize);
    if (retStatus != SM_OK) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Se05x_API_ReadSize failed");
        goto error;
    }

    /* Read length of manufacturer certificate to determine the offset for PUC */
    retStatus = getManufacturerCertificateLength(session_ctx, certChainId, &N_MC);
    if (retStatus != SM_OK) {
        LOG_E("Failed to read manufacturer certificate length");
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    if (certificateOffset >= MAXIMUM_CERT_OFFSET) {
        LOG_D("Read PUC");
        /* N_RH is length of root Hash Certificate and
         * N_MC is length of Manufacturer Certificate
         */
        offset += 2 /* Length of length field */
                  /* Length of RootHash */
                  + DIGEST_SIZE_BYTES
                  /* Length of Manufacturer certificate */
                  + N_MC
                  /* Offset from Product Unit Certificate */
                  + certificateOffset - MAXIMUM_CERT_OFFSET;
    }
    else {
        offset += certificateOffset;
```

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```
    }

    /* Calculate actual bytes to read */
    if (certificatelength == 0) {
        bytesToRead = objectSize - offset;
    }
    else {
        bytesToRead = certificatelength;
    }

    if (bytesToRead == 0) {
        /* Cannot read 0 bytes */
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    /* Bytes to read cannot exceed the total object size */
    if ((offset + bytesToRead) > objectSize) {
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    readSize = bytesToRead;
    pData    = (uint8_t *)SSS_MALLOC(bytesToRead * sizeof(uint8_t));
    if (!pData) {
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    if (*pCertificateResponseLen < (size_t)(bytesToRead + 1)) {
        LOG_E("Insufficient buffer");
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    /* Read certificate chain */
    retStatus = readCertificateChain(session_ctx, certChainId, offset, bytesToRead,␣
↪pData, &readSize);
    if (retStatus != SM_OK) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Se05x_API_ReadObject failed");
        goto error;
    }
    LOG_MAU8_D("ReadCertificate object", pData, readSize);

    /* Copy the data read out to response buffer */
    memcpy(&pCertificateResponse[1], pData, readSize);
    if (pData) {
        SSS_FREE(pData);
    }

    pCertificateResponse[0]  = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseCertificate);
    *pCertificateResponseLen = (bytesToRead) + 1;

    return;
```

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```
error:
    if (pData) {
        SSS_FREE(pData);
    }
    if (pCertificateResponse) {
        pCertificateResponse[0]  = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseError);
        pCertificateResponse[1]  = (uint8_t)(errorCode);
        pCertificateResponse[2]  = 0x00;
        *pCertificateResponseLen = 3;
    }
}
```

Authenticate (CHALLENGE)

This function performs the CHALLENGE operation and returns the signature `R` and signature `S` values to the power receiver.

```
void Authenticate(const uint8_t *pChallengeRequest,
    const size_t challengeRequestLen,
    uint8_t *pChallengeAuthResponse,
    size_t *pChallengeAuthResponseLen)
{
    smStatus_t retStatus                     = SM_NOT_OK;
    uint16_t objectSize                      = 0;
    pSe05xSession_t session_ctx              = pgSe05xSessionctx;
    uint8_t *pTbsAuthPtr                     = NULL;
    size_t readSize                          = 0;
    uint8_t certChainHash[DIGEST_SIZE_BYTES] = {0};
    uint8_t hash[DIGEST_SIZE_BYTES]          = {0};
    size_t hashLen                           = sizeof(hash);

    uint8_t authMsgHeader                = 0;
    uint8_t requestedSlot                = 0;
    uint8_t slotsPopulated               = 0x00;
    uint8_t tbsAuth[TBSAUTH_MAX_SIZE]    = {0};
    size_t tbsAuthlen                    = sizeof(tbsAuth);
    uint8_t signature[MAX_SIGNATURE_LEN] = {0};
    size_t sigLen                        = sizeof(signature);
    qi_error_code_t errorCode            = kQiErrorUnspecified;
    uint32_t certChainId                 = 0;
    uint32_t keyId                       = 0;

    if (NULL == pChallengeRequest || NULL == pChallengeAuthResponse) {
        LOG_E("Null buffer");
        errorCode = kQiErrorInvalidRequest;
        goto error;
    }

    authMsgHeader = pChallengeRequest[0];

    if (challengeRequestLen != CHALLENGE_CMD_LEN) {
        LOG_E("Invalid request length");
        errorCode = kQiErrorInvalidRequest;
        goto error;
```

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```
    }

    requestedSlot = pChallengeRequest[1] & 0x03;
    certChainId   = QI_SLOT_ID_TO_CERT_ID(requestedSlot);
    keyId         = QI_SLOT_ID_TO_KEY_ID(requestedSlot);

    if (*pChallengeAuthResponseLen < CHALLENGE_AUTH_RESPONSE_LEN) {
        LOG_E("Insufficient buffer");
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    retStatus = getPopulatedSlots(session_ctx, &slotsPopulated);
    if (SM_OK != retStatus) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Failed to retrieve populated slots");
        goto error;
    }

    if (!(slotsPopulated & 0x01)) {
        /* Slot 0 is empty */
        errorCode = kQiErrorUnspecified;
        goto error;
    }
    /* Check if the requested slot is populated */
    if (!((1 << requestedSlot) & slotsPopulated)) {
        errorCode = kQiErrorInvalidRequest;
        LOG_E("Requested slot not populated");
        goto error;
    }

    retStatus = Se05x_API_ReadSize(session_ctx, certChainId, &objectSize);
    if (retStatus != SM_OK) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Se05x_API_ReadSize failed");
        goto error;
    }

    /* Certificate chain size cannot be less than DIGEST_SIZE_BYTES */
    if (objectSize < DIGEST_SIZE_BYTES) {
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    /* Read Certificate chain hash value */
    pTbsAuthPtr = &tbsAuth[1];
    readSize    = DIGEST_SIZE_BYTES;
    retStatus   = Se05x_API_ReadObject(session_ctx, certChainId, 0, DIGEST_SIZE_BYTES,
↪ certChainHash, &readSize);
    if (retStatus != SM_OK) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Se05x_API_ReadObject failed");
        goto error;
    }
    memcpy(pTbsAuthPtr, certChainHash, DIGEST_SIZE_BYTES);

    /* Copy Challenge request to TBS Auth */
```

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```
    pTbsAuthPtr = &tbsAuth[TBSAUTH_CHALLENGE_REQ_OFFSET];
    memcpy(pTbsAuthPtr, pChallengeRequest, challengeRequestLen);

    pChallengeAuthResponse[0] = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseChallengeAuth);
    pChallengeAuthResponse[1] = (uint8_t)(AUTH_PROTOCOL_VERSION << 4) + (uint8_
↪t)(slotsPopulated);
    pChallengeAuthResponse[2] = (uint8_t)(certChainHash[DIGEST_SIZE_BYTES - 1]);

    tbsAuth[0] = CHALLENGE_AUTH_RESPONSE_PREFIX; // ASCII representation of A
    memcpy(&tbsAuth[TBSAUTH_CHALLENGE_AUTH_RESP_OFFSET], pChallengeAuthResponse, 3);

    /* Calculate SHA256 of TBSAuth for signature */
    retStatus = getSha256Hash(session_ctx, tbsAuth, tbsAuthlen, hash, &hashLen);
    if (retStatus != SM_OK) {
        errorCode = kQiErrorUnspecified;
        LOG_E("Failed getSha256Hash");
        goto error;
    }

    /* Calculate signature */
    retStatus =
        Se05x_API_ECDSASign(session_ctx, keyId, kSE05x_ECSignatureAlgo_SHA_256, hash,␣
↪hashLen, &signature[0], &sigLen);
    if (retStatus != SM_OK) {
        LOG_E(" sss_asymmetric_sign_digest Failed...");
        errorCode = kQiErrorUnspecified;
        goto error;
    }

    /* Extract R and S values from signature */
    retStatus = EcSignatureToRandS(signature, &sigLen);
    if (retStatus != SM_OK) {
        LOG_E(" EcSignatureToRandS Failed...");
        errorCode = kQiErrorUnspecified;
        goto error;
    }
    *pChallengeAuthResponseLen = (sigLen) + 3;
    memcpy(&pChallengeAuthResponse[3], signature, sigLen);

    return;

error:
    if (pChallengeAuthResponse) {
        pChallengeAuthResponse[0]  = (uint8_t)(authMsgHeader & 0xF0) + (uint8_
↪t)(kQiResponseError);
        pChallengeAuthResponse[1]  = (uint8_t)(errorCode);
        pChallengeAuthResponse[2]  = 0x00;
        *pChallengeAuthResponseLen = 3;
    }
}
```

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

Select CMake options:

- `PTMW_SE05X_Ver=07_02`

Note: If you have run ex-se05x-qi-provisioning, do not select `PTMW_SE05X_Auth=AESKey`

Build project:

- Project: `sa_qi_auth`

Running the Example

If you have built a binary, flash the binary on to the board and reset the board.

If you have built an *exe* to be run from Windows using VCOM, run as:

```
sa_qi_auth.exe <PORT NAME>
```

Where **<PORT NAME>** is the VCOM COM port.

On successful execution you should be able to see logs as:

```
App   :INFO :PlugAndTrust_v04.01.01_20220112
sss   :INFO :atr (Len=35)
      01 A0 00 00 03 96 04 03 E8 00 FE 02 0B 03 E8 00
      01 00 00 00 00 64 13 88 0A 00 65 53 45 30 35 31
      00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Send command GET_DIGESTS
App   :INFO :Retrieved digest (Len=32)
      46 29 65 3A    D1 CE B3 7C    6A 36 F0 CC    11 B4 29 16
      86 39 27 85    F0 F8 26 DF    DE D3 5E AC    5F CC 50 FC
App   :INFO :Send command GET_CERTIFICATE
App   :INFO :Certificate chain digest successfully verified
App   :INFO :Retrieved PUC (Len=442)
      30 82 01 B6    30 82 01 5B    A0 03 02 01    02 02 0A 00
      B0 9B 9F 24    00 A7 9E A0    AE 30 0A 06    08 2A 86 48
      CE 3D 04 03    02 30 12 31    10 30 0E 06    03 55 04 03
      0C 07 43 41    43 41 2D 58    31 30 22 18    0F 32 30 32
      31 30 38 32    33 31 35 35    31 35 33 5A    18 0F 32 30
      32 31 30 38    32 34 31 35    35 31 35 33    5A 30 81 8B
      31 2C 30 2A    06 03 55 04    03 0C 23 30    30 30 31 32
      33 2D 52 61    70 69 64 20    63 68 61 72    67 69 6E 67
      20 62 61 67    65 6C 20 74    6F 61 73 74    65 72 31 29
      30 27 06 03    55 04 5C 04    20 53 58 4D    67 64 47 68
      70 63 79 42    68 62 69 42    46 59 58 4E    30 5A 58 49
      67 52 57 64    6E 50 77 3D    3D 31 30 30    2E 06 0A 09
      92 26 89 93    F2 2C 64 01    01 0C 20 44    6F 20 6E 6F
      74 20 75 73    65 20 61 73    20 61 20 66    6C 6F 74 61
      74 69 6F 6E    20 64 65 76    69 63 65 30    59 30 13 06
      07 2A 86 48    CE 3D 02 01    06 08 2A 86    48 CE 3D 03
      01 07 03 42    00 04 07 7B    1F 30 E5 D7    9A 63 FB CC
      35 DE 84 36    E4 5D 89 C1    5F 99 98 E8    B8 F2 C6 00
      1C AE DA E5    F8 59 3A 50    76 D2 C7 A4    AF 0B C5 6B
      47 9D E1 6A    DA 11 0C 0A    EF D7 39 E1    F0 4D 0D D7
      65 7E B9 32    13 53 A3 1B    30 19 30 17    06 05 67 81
```

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```
      14 01 02 01    01 FF 04 0B    04 09 F1 02    D3 C4 15 06
      E7 68 79 30    0A 06 08 2A    86 48 CE 3D    04 03 02 03
      49 00 30 46    02 21 00 A8    29 0E C3 C9    AF DC 08 52
      58 CB B4 7A    B7 02 3A BC    D5 CD 36 78    F4 1D CE 2F
      7C 4C CC 95    46 FC 56 02    21 00 FA EB    67 F9 14 79
      DE 6D 31 DE    E7 0B 0C 51    3E 0A 36 1D    C4 49 F7 FA
      F4 E9 33 FE    90 49 57 AD    EC 10
App   :INFO :PUC successfully verified
App   :INFO :Manufacturer certificate successfully verified
App   :INFO :Certificate chain successfully verified
App   :INFO :Retrieved PUC public key (Len=65)
      04 07 7B 1F    30 E5 D7 9A    63 FB CC 35    DE 84 36 E4
      5D 89 C1 5F    99 98 E8 B8    F2 C6 00 1C    AE DA E5 F8
      59 3A 50 76    D2 C7 A4 AF    0B C5 6B 47    9D E1 6A DA
      11 0C 0A EF    D7 39 E1 F0    4D 0D D7 65    7E B9 32 13
      53
App   :INFO :Send command CHALLENGE
App   :INFO :Challenge Signature (Len=64)
      7E B0 82 D3    3D 91 02 37    AA FE 81 15    DF 02 A2 57
      D1 8C D6 A1    BB C0 20 DE    CF E2 69 B0    57 35 93 5E
      62 E1 E6 37    E0 64 92 5A    D8 BB 7E 92    FB 52 1E 84
      F9 DD A1 43    F9 7B 11 48    0B 1C F9 CD    31 40 77 AD
App   :INFO :TBSAuth (Len=54)
      41 46 29 65    3A D1 CE B3    7C 6A 36 F0    CC 11 B4 29
      16 86 39 27    85 F0 F8 26    DF DE D3 5E    AC 5F CC 50
      FC 1B 00 00    00 00 00 00    00 00 00 00    00 00 00 00
      00 00 00 13    11 FC
App   :INFO :Challenge successfully verified
App   :INFO :ex_sss Finished
```

Porting

The example allows porting of host verification and host RNG functions in case mbedTLS is not available. If you want to add your own implementation of these operations, update the following APIs in `sa_qi_auth/port/sa_qi_helper_port.c`:

```
/* Port to implement RNG to get 16 byte nonce value
 * for authentication operation.
 * This API does not guarantee the randomness of the RNG.
 * User should make sure that the RNG seed is from a trusted source
 * and that the randomness of the source is NIST compliant
 */
int port_getRandomNonce(uint8_t *nonce, size_t *pNonceLen)
{
    int ret              = 0;
    size_t random_length = (*pNonceLen > NONCE_LEN) ? NONCE_LEN : (*pNonceLen);
    *pNonceLen           = random_length;
    ret                  = getRandom(nonce, random_length);
    if (0 != ret) {
        *pNonceLen = 0;
    }
    return ret;
}

/* Port to implement function which will
```

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```
 * parse an X.509 certificate and extract the public key
 * from it.
 */
void port_parseCertGetPublicKey(uint8_t *pCert, size_t certLen, uint8_t *pPublicKey,␣
↪size_t *publicKeylen)
{
    parseCertGetPublicKey(pCert, certLen, pPublicKey, publicKeylen);
}

/* Port to implement function which will
 * verify the complete certificate chain as passed in certificate_chain
 */
int port_hostVerifyCertificateChain(uint8_t *certificate_chain,
    size_t certificate_chain_size,
    uint16_t pucCertOffset,
    uint16_t manufacturerCertLenOffset)
{
    return hostVerifyCertificateChain(
        certificate_chain, certificate_chain_size, pucCertOffset,␣
↪manufacturerCertLenOffset);
}

/* Port to implement function which will
 * verify CHALLENGE on host
 */
int port_hostVerifyChallenge(uint8_t *pPublicKey,
    size_t publicKeyLen,
    uint8_t *pCertificateChainHash,
    uint8_t *pChallengeRequest,
    uint8_t *pChallengeResponse)
{
    return hostVerifyChallenge(pPublicKey, publicKeyLen, pCertificateChainHash,␣
↪pChallengeRequest, pChallengeResponse);
}
```

5.8 OpenSSL Examples

5.8.1 Tool to create Reference key file

This tool is to demonstrate how to implement a command-line utility for native systems. This utiltity can be used to generate/inject keypair and create reference key files.

This is beneficial for environments which do not have python installed.

Note: This example is implemented only for NIST-P256 curve. It can only be compiled when Host Crypto is OpenSSL.

Building the example

Use the following CMake configurations to compile the example

- CMake configurations: `SSS_HAVE_HOSTCRYPTO_OPENSSL`: ON

- Project: `seTool`

How to use

This example provides four command-line parameters to select the operation to perform.

1) To **generate** a keypair, run the tool as:

   ```
   seTool genECC <keyId>
   ```

   Where:

   - *keyId* is the keypair index at which we want to generate the keypair.

2) To **inject** a keypair, run the tool as:

   ```
   seTool setECC <keyId> <filename>
   ```

   Where:

   - *keyId* is the keypair index at which we want to inject the keypair
   - *filename* is the path of the file in which keypair is stored in PEM format.

3) To **retrieve the public key**, run the tool as:

   ```
   seTool getPublic <keyId> <filename>
   ```

   Where:

   - *keyId* is the keypair index from which we want to retrieve the public key
   - *filename* is the path of the file in which we want to store the key in PEM format.

4) To **create a reference key** for an injected keypair, run the tool as:

   ```
   seTool getRef <keyId> <filename>
   ```

   Where:

   - *keyId* is the keypair index at which we keypair is stored and
   - *filename* is the path of the file in which we want to store the reference key in PEM format.

The generated reference key can be used by OpenSSL Engine.

5.8.2 Building a self-signed certificate

This demo is to demonstrate how we can use provisioned keys to create a self-signed certificate to communicate with cloud platforms. In this example, we use two binaries, one to generate a keypair inside the secure element and another to use the generated keypair to create a self-signed certificate.

Note: We use OpenSSL in this example to create the certificate.

How to use

1. Run the binary `generate_certificate_key` to generate an ECC-256 keypair inside the secure element.
2. Run the binary `generate_certificate` to create a self-signed certificate. This demo provisions the the generated certificate into the secure element.
3. You can read-out the certificate using SSS-APIs from keyId `CERTIFICATE_KEY_ID + 1` as defined in `certificate.h` file.

5.9 Tests for User Crypto

5.9.1 Tests for User Crypto

- Tests are implementated based on pre-computed data.
- Validates cryptographic results against test vectors.
- The User Crypto can be validate with this test suite.
- The tests to be used during User Crypto development.

List of Crypto Algorithms

Following Crypto Algorithms for which tests are available

- Get Random Number
- AES_CBC_Encrypt
- AES_CBC_Decrypt
- MAC_One_Go
- MAC_Multistep

Building the Demo

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `test_Crypto`

5.10 NXPNFCRDLIB examples

5.10.1 MIFARE DESFire EV2 : Prepare Secure Element

Prerequisites

- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

About the Example

This is an example project for provisioning the SE05x for running other SE05x MIFARE DESFire EV2 examples. This example Creates the required Se05x secure objects for further use by other examples.

The two AES key storage for NFC application in SE05x

This example calls the API `InitialSetupSe050()` which inits, allocates and sets the AES keys.

The keyIDs are as below

```
#define MFDFEV2_KEYID (EX_SSS_OBJID_DEMO_MFDF_START)

#define MFDFEV2_CK_AUTH (EX_SSS_OBJID_DEMO_MFDF_START + 1)
#define MFDFEV2_CK_CHANGED_KEYID (EX_SSS_OBJID_DEMO_MFDF_START + 2)
#define MFDFEV2_CK_REVERT_KEYID (EX_SSS_OBJID_DEMO_MFDF_START + 3)
#define MFDFEV2_DK_AUTH (EX_SSS_OBJID_DEMO_MFDF_START + 4)
#define MFDFEV2_DK_MASTERKEY (EX_SSS_OBJID_DEMO_MFDF_START + 5)
#define MFDFEV2_DK_CHANGED_KEYID (EX_SSS_OBJID_DEMO_MFDF_START + 6)
#define MFDFEV2_DK_DIVERSIFY_AGAIN_KEYID (EX_SSS_OBJID_DEMO_MFDF_START + 7)
```

```
#define EX_SSS_OBJID_DEMO_MFDF_START                0x7D5DF000u
```

Key values

The key that is provisioned into SE05x is called the oldKey and newKey and it takes the values as below.

```
const uint8_t oldKeyValue[KEY_BIT_LEN / 8] = {  0x00, 0x00, 0x00, 0x00,
                                                0x00, 0x00, 0x00, 0x00,
                                                0x00, 0x00, 0x00, 0x00,
                                                0x00, 0x00, 0x00, 0x00 };

const uint8_t newKeyValue[KEY_BIT_LEN / 8] = {  0x01, 0x02, 0x03, 0x04,
                                                0x05, 0x06, 0x07, 0x08,
                                                0x09, 0x0a, 0x0b, 0x0c,
                                                0x0d, 0x0e, 0x0f, 0x10 };
```

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
sss:INFO :atr (Len=35)
    00 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 08
    01 00 00 00     00 64 00 00     0A 4A 43 4F     50 34 20 41
    54 50 4F
sss:WARN :Communication channel is Plain.
sss:WARN :!!!Not recommended for production use.!!!
App:INFO :SE050 prepared successfully for MIFARE DESFire EV2 examples
App:INFO :ex_sss Finished
```

5.10.2 MIFARE DESFire EV2 : Prepare MFDFEV2

Warning: To run this example, you would need the nxpnfcrdlib component for which a Non-Disclosure Agreement(NDA) needs to be signed. Please contact your FAE for additional details.

Prerequisites

- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

About the Example

This is an example project for preparing the MIFARE DESFire EV2 card for running other SE05x MIFARE DESFire EV2 examples.This example formats the card creates app, keys and file for running the other examples.

This does not make use of any SE05X APIs. It make use of nxpNfcrdLib apis for:

- formatting the card
- Creating an AFC application
- Selecting the application
- Creating a value file

Creation of application

creation of application with application ID happens in API `phEx_Personalize_AFCApp()`:

The application ID is

```
uint8_t bAfcApp[3] = {0x11, 0x22, 0x33};
```

AES Keys provisioned in card

We create One key in the card, This key is set when we are creating the transaction mac file. The key value is

```
uint8_t bTMKey[16] = {  0x00, 0x00, 0x00, 0x00,
                        0x00, 0x00, 0x00, 0x00,
                        0x00, 0x00, 0x00, 0x00,
                        0x00, 0x00, 0x00, 0x00 };
```

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
App   :INFO :PlugAndTrust_v03.03.01_20210923
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Sleeping for 10 seconds for debugger stabilization
App   :INFO :UID after L3 Activation (Len=10)
                08 63 DC 14     00 00 00 00     00 00
App   :INFO :ATS after L4 Activation (Len=6)
                06 75 77 81     02 80
App   :INFO :Performing Pre Personalization ......

App   :INFO :Formating the card Successful

App   :INFO :bCardUid[0] = 0x4

App   :INFO :bCardUid[1] = 0x41

App   :INFO :bCardUid[2] = 0x65

App   :INFO :bCardUid[3] = 0x7a

App   :INFO :bCardUid[4] = 0x6e

App   :INFO :bCardUid[5] = 0x4d

App   :INFO :bCardUid[6] = 0x80

App   :INFO :bCardUid[7] = 0x0

App   :INFO :bCardUid[8] = 0x0

App   :INFO :bCardUid[9] = 0x0

App   :INFO :Create AFC Application Successful

App   :INFO :Select the AFC Application Successful

App   :INFO :phEx_Create_ValueFile...

App   :INFO : create Transaction MAC File  Successful

App   :INFO : create Value File  Successful

App   :INFO :***** Creating standard data file SUCCESS!!*******

App   :INFO :ex_sss Finished
```

5.10.3 MIFARE DESFire EV2 : se05x_Ev2GetCardUID

Warning: To run this example, you would need the nxpnfcrdlib component for which a Non-Disclosure Agreement(NDA) needs to be signed. Please contact your FAE for additional details.

Prerequisites

- *MIFARE DESFire EV2 : Prepare MFDFEV2* must have been executed, so that the MIFARE DESFire EV2 card has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare MFDFEV2*.
- *MIFARE DESFire EV2 : Prepare Secure Element* must have been executed, so that the Secure element has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare Secure Element*.

Examples se05x_Ev2ChangeKey and se05x_Ev2DivChngKey should not have been executed

Note : Order of execution se05x_Ev2PrepareCard, se05x_Ev2PrepareSE, se05x_Ev2GetCardUID.

- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

About the Example

This project is an example demonstrating the Mifare Desfire EV2 authentication using Se05x. After authentication it gets the UID from the desfire EV2 card.

It uses the following APIs and data types:

- *`Se05x_API_DFAuthenticateFirstPart1()`*
- *`Se05x_API_DFAuthenticateFirstPart2()`*
- *`Se05x_API_DFKillAuthentication()`*

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
App   :INFO :PlugAndTrust_v03.03.01_20210923
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Sleeping for 10 seconds for debugger stabilization
App   :INFO :UID after L3 Activation (Len=10)
                08 51 80 4D     00 00 00 00     00 00
App   :INFO :ATS after L4 Activation (Len=6)
                06 75 77 81     02 80
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308288
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                1A 20 7F FF     64 5E F7 49     D7 40 A5 72     72 82 CB 24
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
```

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```
                41 BF 63 61     3D 1B 8C DC     24 EC 9B 69     B2 E5 97 A0
                6D D8 8B 62     8D 21 38 B5     64 D6 AD C3     50 CF BF E0
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                58 E6 33 4C     97 E0 ED 4E     4E 5F 18 4D     CE BA D8 E5
                33 5A A4 22     98 32 C8 D9     7D C7 8B 42     0B 47 48 73
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO :Dumped Session Key is (Len=16)
                83 82 BC 32     A5 63 AB 35     2E E0 16 65     B5 48 9D 38
App   :INFO :Dumped Session Mac is (Len=16)
                7E 34 5E 3D     AA 83 F0 FD     AD C6 38 FB     05 04 ED 13
App   :INFO :Dumped TI is (Len=4)
                AB 97 3B 6C
App   :INFO :pDataParams->wCmdCtr=0
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :CARD UID is as below  (Len=7)
                04 41 65 7A     6E 4D 80
App   :INFO : Auth session is reset in software
App   :INFO : Auth session is killed in SE
App   :INFO :ex_sss Finished
```

5.10.4 MIFARE DESFire EV2 : Authentication

Warning: To run this example, you would need the nxpnfcrdlib component for which a Non-Disclosure Agreement(NDA) needs to be signed. Please contact your FAE for additional details.

Prerequisites

- Section 5.10.2 *MIFARE DESFire EV2 : Prepare MFDFEV2* must have been executed, so that the MIFARE DESFire EV2 card has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare MFDFEV2*.
- Section 5.10.1 *MIFARE DESFire EV2 : Prepare Secure Element* must have been executed, so that the Secure element has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare Secure Element*.
- Section 5.10.5 *MIFARE DESFire EV2 : Change Key* must have been executed.
- Section 5.10.6 *MIFARE DESFire EV2 : Diversified Change Key* must have been executed.

Note : Order of execution se05x_Ev2PrepareCard, se05x_Ev2PrepareSE, se05x_Ev2ChangeKey, se05x_Ev2DivChngKey, se05x_Ev2AuthTransaction.

- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

About the Example

This project is an example demonstrating the Mifare Desfire EV2 authentication using Se05x. After authentication, it performs encrypted communication with the desfire EV2 card.

It uses the following APIs and data types:

- *`Se05x_API_DFAuthenticateFirstPart1()`*
- *`Se05x_API_DFAuthenticateNonFirstPart1()`*
- *`Se05x_API_DFAuthenticateFirstPart2()`*
- *`Se05x_API_DFAuthenticateNonFirstPart2()`*
- *`Se05x_API_DFKillAuthentication()`*

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
App   :INFO :PlugAndTrust_v03.03.01_20210923
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Sleeping for 10 seconds for debugger stabilization
App   :INFO :UID after L3 Activation (Len=10)
                08 81 68 F5     00 00 00 00     00 00
App   :INFO :ATS after L4 Activation (Len=6)
                06 75 77 81     02 80
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 2 and Se0Obj ID = 2103308290
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                58 DE D1 A3     07 65 1B 5B     6E 97 8F D5     F0 24 79 F1
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                34 91 01 A3     4D 19 98 A2     D5 5C CB FE     5F 61 E4 2B
                CF 04 DF 37     69 62 95 9C     AC F0 56 84     B3 B7 1B 1C
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                B2 63 BF C7     D3 B0 A0 74     CB F7 86 C8     35 FB 1F 06
                84 9D 10 AC     5C 02 4F EC     B2 47 D6 1B     6D 65 B4 D8
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO :Dumped Session Key is (Len=16)
                FB 0E 3C 2D     2A 10 EB 6E     65 44 D3 67     A9 ED 63 F1
App   :INFO :Dumped Session Mac is (Len=16)
```

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```
                FC 75 23 E2     2D 38 4C 90     8A 45 1C 06     E0 5D 1F F9
App   :INFO :Dumped TI is (Len=4)
                2B 30 C6 B4
App   :INFO :pDataParams->wCmdCtr=0
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :CARD UID will be used for diversification
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308294
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                85 C2 89 57     CD A4 8A 69     EC 30 03 51     4F EB 84 46
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                FB F0 16 B2     8A 1F B4 DA     E8 FA 2B F0     AA 41 62 D1
                6D CE 52 51     5B CD 37 D1     F8 C4 A1 8F     72 DE FF B9
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                6A 0D BA E6     94 4A 92 4C     25 32 6D CF     C2 06 35 34
                91 19 B7 E0     6C 46 0C 80     5A 57 B1 5C     CF 1F 7C D7
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                65 61 B4 35     9E 9F 3C BC     F1 79 CB 08     6F 4A 9B E8
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                26 F5 4C 8B     86 22 95 93     13 71 A5 B9     06 9C FB 12
                C7 B6 97 5F     0F 66 39 0F     03 01 D2 20     79 60 2B 29
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=16)
                BD 33 43 58     DB 50 80 3A     6E 1B 82 85     5E 47 65 6A
App   :INFO : EV2 Following Authenticate  Successful

App   :INFO :Authenticated with cardkey = 0 and Se0Obj ID = 2103308294
App   :INFO :attempting to change cardkey = 0 from  Old Se050ObjID= 0 to new␣
↪Se050ObjID= 2103308295
App   :INFO : Change Key for card key 0 is Successful to Se050ObjID= 2103308295

App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308295
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                5D 18 97 25     86 13 08 CD     93 50 FC CF     F6 FB F4 07
```

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```
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                00 07 CD D3     B4 C1 02 5C     B6 E7 5A F0     F7 1E D8 3C
                A4 1D 5D 83     E1 95 BC AF     8F 20 23 A9     E1 13 33 6B
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                0B D8 81 8B     3F 53 E2 5A     23 7C 66 8F     46 08 F6 9F
                4C BF 06 2A     63 4C 45 28     A1 8F AA FB     FB F4 40 78
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO :Dumped Session Key is (Len=16)
                AF 86 09 B0     88 A9 52 78     6C 7E D0 F7     14 F5 1A 75
App   :INFO :Dumped Session Mac is (Len=16)
                0E 7B 03 B3     77 A5 B1 A8     6C 99 AD 71     C3 5B 5E 19
App   :INFO :Dumped TI is (Len=4)
                C8 33 3B F7
App   :INFO :pDataParams->wCmdCtr=0
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)   =
 (Len=16)
                C9 58 CB 6B     6B 3B BD C5     0B 8E FD 88     AD 55 65 2C
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                58 91 1B 41     46 AD 8E A9     A2 51 B3 DF     C9 3C FC 89
                C6 E3 C3 02     AC F2 58 E2     7A 71 F5 12     84 7E E8 BC
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=16)
                CF 90 99 00     DE 02 96 22     C0 B8 EF 29     0A 43 83 99
App   :INFO :Dumped Session Key is (Len=16)
                19 01 7F 30     3C 08 21 FB     C3 5A F1 DC     25 9F 68 EC
App   :INFO :Dumped Session Mac is (Len=16)
                46 FC 59 4B     0B 7E 15 C5     47 65 82 20     19 B6 42 3E
App   :INFO :Dumped TI is (Len=4)
                C8 33 3B F7
App   :INFO :pDataParams->wCmdCtr=0
App   :INFO : EV2 Following Authenticate  Successful

App   :INFO :Authenticated with cardkey = 0 and Se0Obj ID = 2103308295
App   :INFO :phEx_Use_ValueFile...

App   :INFO :Performing Accreditation in AFC App....

App   :INFO :(Plain Communicatioon)Trying to Get the Current Value. Plain␣
↪Communicatioon

App   :INFO :Getting current value Successful

App   :INFO :(Enc Communication using session Key)Trying to Add money to the account
```

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```
App   :INFO :Add money to the account successful

App   :INFO : The amount in your account  After credit is 0 0 0 17

App   :INFO :   Accreditation DONE!

App   :INFO : Auth session is reset in software
App   :INFO : Auth session is killed in SE
App   :INFO :ex_sss Finished
```

5.10.5 MIFARE DESFire EV2 : Change Key

Warning: To run this example, you would need the nxpnfcrdlib component for which a Non-Disclosure Agreement(NDA) needs to be signed. Please contact your FAE for additional details.

Prerequisites

- *MIFARE DESFire EV2 : Prepare MFDFEV2* must have been executed, so that the MIFARE DESFire EV2 card has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare MFDFEV2*.
- *MIFARE DESFire EV2 : Prepare Secure Element* must have been executed, so that the Secure element has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare Secure Element*.
- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

Note : Order of execution se05x_Ev2PrepareCard, se05x_Ev2PrepareSE, se05x_Ev2ChangeKey.

About the Example

This project demonstrates the Mifare Desfire EV2 ChangeKeyEv2 using Se05x.

It uses the following APIs and data types:

- *`Se05x_API_DFChangeKeyPart1()`*
- *`Se05x_API_DFChangeKeyPart2()`*
- *`Se05x_API_DFAuthenticateFirstPart1()`*
- *`Se05x_API_DFAuthenticateNonFirstPart1()`*
- *`Se05x_API_DFAuthenticateFirstPart2()`*
- *`Se05x_API_DFAuthenticateNonFirstPart2()`*
- *`Se05x_API_DFKillAuthentication()`*

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
App   :INFO :PlugAndTrust_v03.03.01_20210923
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Sleeping for 10 seconds for debugger stabilization
App   :INFO :UID after L3 Activation (Len=10)
                08 58 5E F7     00 00 00 00     00 00
App   :INFO :ATS after L4 Activation (Len=6)
                06 75 77 81     02 80
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308289
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                5D 3F 1D 55     C1 73 D5 DD     E3 9B 87 4F     5E C2 11 4F
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                84 0A E2 DA     38 B2 2B AA     2F 46 AC 92     88 41 F6 70
                2E 08 26 8B     1E 1B C2 72     46 8A 26 92     F8 12 5E 2B
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                58 D3 B6 7C     49 C9 07 13     CF 32 21 F0     40 6D 73 1E
                21 AC 41 66     80 1C E6 2F     3F C8 50 F4     AB 29 77 B2
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                CE F2 E7 6F     15 D7 A3 D9     44 C1 5F E0     22 36 38 11
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                AF 77 8E A1     C7 99 1B BB     E7 44 B7 5E     EA EF DE 0F
                94 DC 8E 1C     C2 1E 32 E0     3F D4 D1 35     2D BD 35 13
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=16)
                AE A2 59 A7     53 98 52 CE     62 38 0A 33     F8 ED 32 72
App   :INFO : EV2 Following Authenticate  Successful

App   :INFO :Authenticated with cardkey = 0 and Se0Obj ID = 2103308289
App   :INFO :attempting to change cardkey = 2 from  Old Se050ObjID= 2103308289 to new␣
↪Se050ObjID= 2103308290
App   :INFO : Change Key for card key 2 is Successful to Se050ObjID= 2103308290

App   :INFO : Auth session is reset in software
```

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```
App   :INFO : Auth session is killed in SE
App   :INFO :ex_sss Finished
```

5.10.6 MIFARE DESFire EV2 : Diversified Change Key

> **Warning:** To run this example, you would need the nxpnfcrdlib component for which a Non-Disclosure Agreement(NDA) needs to be signed. Please contact your FAE for additional details.

Prerequisites

- *MIFARE DESFire EV2 : Prepare MFDFEV2* must have been executed, so that the MIFARE DESFire EV2 card has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare MFDFEV2*.
- *MIFARE DESFire EV2 : Prepare Secure Element* must have been executed, so that the Secure element has the required credentials. For relevant platforms, a KSDK package is available. Please import and execute the example *MIFARE DESFire EV2 : Prepare Secure Element*.
- Bring Up Hardware. (Refer *Development Platforms*)
- Connect RC663 to your microcontroller. (Refer mifarekdf-rc663)

Note : Order of execution se05x_Ev2PrepareCard, se05x_Ev2PrepareSE, se05x_Ev2ChangeKey, se05x_Ev2DivChngKey.

About the Example

This project demonstrates the Mifare Desfire EV2 Diversified ChangeKeyEv2 using Se05x. The Key is diversified using the card UID After changing Keys.

It uses the following APIs and data types:

- *`Se05x_API_DFDiversifyKey()`*
- *`Se05x_API_DFChangeKeyPart1()`*
- *`Se05x_API_DFChangeKeyPart2()`*
- *`Se05x_API_DFAuthenticateFirstPart1()`*
- *`Se05x_API_DFAuthenticateNonFirstPart1()`*
- *`Se05x_API_DFAuthenticateFirstPart2()`*
- *`Se05x_API_DFAuthenticateNonFirstPart2()`*
- *`Se05x_API_DFKillAuthentication()`*

Running the Demo

1) Either press the reset button on your board or launch the debugger in your IDE to begin running the demo

If everything is setup correctly the output would be as follows:

```
App   :INFO :PlugAndTrust_v03.03.01_20210923
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :WARN :Communication channel is Plain.
sss   :WARN :!!!Not recommended for production use.!!!
App   :INFO :Sleeping for 10 seconds for debugger stabilization
App   :INFO :UID after L3 Activation (Len=10)
                08 B0 2D 07     00 00 00 00     00 00
App   :INFO :ATS after L4 Activation (Len=6)
                06 75 77 81     02 80
App   :INFO :Auth with the  cardkey 0 and getting the card UID for diversification
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308292
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                77 49 69 E2     D6 18 45 30     1E 0F 4F 72     D1 E9 B9 84
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                B9 B3 51 0D     74 20 0B 35     7B 3B 39 2E     01 CB 4B 67
                06 6B BF 1F     EF A8 EC 96     43 F3 6A 3C     F6 1F 11 41
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                56 2C 7D A1     EF C4 69 F6     A6 03 01 51     C8 6B 87 4C
                43 45 05 CD     09 F6 D2 5A     19 EC B1 BC     5C 08 12 6E
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO :Dumped Session Key is (Len=16)
                67 3B 5B D7     F6 86 98 30     A3 A0 58 4F     5E 90 5C 8A
App   :INFO :Dumped Session Mac is (Len=16)
                69 32 00 28     7C 49 BE 6B     33 46 A6 7A     B8 22 9F AA
App   :INFO :Dumped TI is (Len=4)
                17 74 87 8B
App   :INFO :pDataParams->wCmdCtr=0
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :CARD UID will be used for diversification
App   :INFO :Select the AFC Application Successful

App   :INFO :attempting to authenticate with cardkey = 0 and Se0Obj ID = 2103308292
App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                B7 E3 A7 BD     90 7B FD 23     93 22 9D 65     58 BD 73 69
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                9D 5F 6B 65     A5 33 80 CF     71 35 4E FE     A7 8D 08 88
                34 6A 41 F5     C8 17 C8 F2     D0 6A 7B D5     2F FF E4 5F
App   :INFO :
```

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```
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=32)
                1B 88 5F 4F     56 CE F3 1F     B5 14 74 27     A9 7D 7F 34
                8B 0C 96 80     B6 23 06 9A     23 F8 98 CF     FB 3D 62 0B
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=12)
                00 00 00 00     00 00 00 00     00 00 00 00
App   :INFO : EV2 First Authenticate  Successful

App   :INFO :
 CARD =====> SE050   16-byte Ek(RndB)  =
 (Len=16)
                D2 BF 2C 15     7E 2F 24 86     2E D1 96 49     50 E1 61 C2
App   :INFO :
  CARD <====== SE050  E(Kx, RandA || RandB') =
 (Len=32)
                2B 44 7C ED     65 44 29 D9     74 75 63 4E     49 5B 79 D5
                D5 95 F6 0D     AD 43 FE 73     5E 90 EF C3     AB BC 00 CF
App   :INFO :
  CARD ======> SE050  32-byte E(Kx, TI||RndA'||PDCap2||PCDcap2) =
 (Len=16)
                D5 EA 02 26     02 BB 0B DC     1E 57 95 02     E9 E3 51 25
App   :INFO : EV2 Following Authenticate  Successful

App   :INFO :Authenticated with cardkey = 0 and Se0Obj ID = 2103308292
App   :INFO :attempting to change cardkey = 0 from  Old Se050ObjID= 0 to new␣
↪Se050ObjID= 2103308294
App   :INFO : Change Key for card key 0 is Successful to Se050ObjID= 2103308294

App   :INFO : Auth session is reset in software
App   :INFO : Auth session is killed in SE
App   :INFO :ex_sss Finished
```

5.11 Ease-of-Use examples

5.11.1 Ease of Use configuration - IBM Watson

Configuring Device type and Device name

Follow steps given in *How to get SE Platform Information and UID* to get the device unique ID.

The device name to be registered on the cloud is the 18-byte UID output in uppercase. In this case, `04005001F5EA9CC8CA7B33042C0559550000`.

Device type would change based on which type of keys are being used (EC/RSA2K/RSA4K). Device type is set as `NXP-SE050-<type>-D`, where type is `EC`, `RSA2K` or `RSA4K` based on the type of key. Refer to section *Trust provisioned KeyIDs* for keyIDs of trust provisioned keys and certificates. On your IoT platform, create a new device type and create a new device under it with names as obtained in the previous step.

Note: If you wish to create a gateway on IoT platform, change Device type as `NXP-SE050-<type>-G`, where type is `EC`, `RSA2K` or `RSA4K` based on the type of key.

Uploading certificate chain

Certificate chain for cloud connection can be found under `demos/Certificate_Chains/0004_A1F4` directory.

Also see *Certificate Chains : DEV Kit* for details about certificate chain.

Note: A1F4 is the OEF number. The directory name may change based on your OEF configuration.

The certificate chain for *ECC* from RootCA to Device certificate is as:

`IOT_NXP-01-CERT_IOT_CA_KEY-IoTRootCAvE305-01-20190320162439-EC_SEC_P384R1-4B7E5A.crt` –> `IOT_NXP-01-CERT_IOT_4LAYER_CA_KEY-IoTInt4LAYERCAvE205-01-20190320164314-EC_SEC_P256R1` `crt` –> `CloudConn-Intermediate-ECC_OEF_A1F4.crt` –> `ECC Device/Gateway Certificate`

The certificate chain for *RSA* from RootCA to Device certificate is as:

`IOT_NXP-01-CERT_IOT_CA_KEY-IoTRootCAvR406-01-20190425163255-RSA4096-BAB872.crt` –> `IOT_NXP-01-CERT_IOT_4LAYER_CA_KEY-IoTInt4LayerCAvR406-01-20190425163534-RSA4096-540F19.crt` –> `CloudConn-Intermediate-RSA_OEF_A1F4.crt` –> `RSA Device/Gateway Certificate`

In your IoT platform, go to settings –> CA Certificates section and upload the certificate chain (RootCA and Intermediate CA certificates) for the device certificate.

Running the Demo

This step is only for Linux platforms. If you wish to use an embedded microcontroller, continue to the next step

- Create a reference key file to be used with OpenSSL engine:

  ```
  ssscli connect se05x t1oi2c none
  ssscli refpem ecc/rsa pair <trust_provisioned_keyid> keyref.pem
  ssscli disconnect
  ```

- Build the OpenSSL engine:

  ```
  cd simw-top
  python scripts/create_cmake_projects.py
  cd ../simw-top_build/<board>_native_se050_t1oi2c
  cmake --build .
  make install
  ldconfig /usr/local/lib
  ```

- Based on OpenSSL version, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

  ```
  openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
  openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
  ```

- Set the openssl config path as:

  ```
  $ export OPENSSL_CONF=/simw-top/demos/linux/common/<appropriate-cnf-file>
  ```

- To run the demo, see *Running the Demo on iMX/Raspberry Pi*

Update cloud example

In file `demos/ksdk/ibm_watson/ibm_watson_iot_config.h`, update the **broker endpoint** and **client ID** according to your account, and **keyIDs** of Trust provisioned keys and certificates used (as obtained from *Trust provisioned KeyIDs*):

```
#define WATSONIOT_MQTT_BROKER_ENDPOINT "leohx6.messaging.internetofthings.ibmcloud.com
↪"
```

```
#define WatsonechoCLIENT_ID \
    "d:leohx6:NXP-SE050-EC-D:377813914287991534125055" ///< MQTT client ID should be␣
↪unique for every device
```

```
#define SSS_KEYPAIR_INDEX_CLIENT_PRIVATE 0x20181003 //keyID of device keypair
#define SSS_CERTIFICATE_INDEX 0x20181004           //keyID of device certificate
```

Build and run the demo.

Build and run `cloud_ibm_watson`.

CMake configurations:

- `RTOS_FreeRTOS`: ON
- `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
- `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

5.11.2 Ease of Use configuration - Google Cloud Platform

Pre-requisites

- Google Cloud Platform Account
- ssscli Tool. Refer to *CLI Tool*

Creating Registry and Devices

- If you are using an embedded microcontroller, flash VCOM binary present in `binaries` folder onto the board.
- Read out the device certificate from the SE using ssscli Tool
    - Refer to section *Trust provisioned KeyIDs* for keyIDs of trust provisioned certificates.
    - Read out the trust provisioned certificate as:

    ```
    ssscli connect se05x <conn-type> COMxx
    ssscli get cert <trust_provisioned_keyid> <filename>
    ssscli disconnect
    ```

    Note: Give connection parameters according to your board. Refer to *List of ssscli commands* for details on supported parameters.

    - Device certificate will be stored at the file location provided.

Note: Give extension of the filename as .cer to store in *PEM* format

---

- Create a registry on Google Cloud Platform and upload the intermediate certificate:
  - Intermediate certificates are located in `demos/Certificate_Chains/0004_A1F4` directory. Based on device certificate, ECC or RSA, the intermediate certificates are `CloudConn-Intermediate-ECC_OEF_A1F4.crt` or `CloudConn-Intermediate-RSA_OEF_A1F4.crt` respectively.
- Create a device in that registry and upload the device certificate obtained in the second step.

Also see *Certificate Chains : DEV Kit* for details about certificate chain.

Running the Demo

This step is only for Linux platforms. If you wish to use an embedded microcontroller, continue to the next step

- Create a reference key file to be used with OpenSSL engine:

```
ssscli connect se05x t1oi2c none
ssscli refpem ecc/rsa pair <trust_provisioned_keyid> keyref.pem
ssscli disconnect
```

- Build the OpenSSL engine:

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/<board>_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

- Based on OpenSSL version, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

```
openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
```

- Set the openssl config path as:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/<appropriate-cnf-file>
```

- To run the demo, see *Building the application*

Update cloud example

In file `demos/ksdk/gcp/gcp_iot_config.h`, update the **project name**, **location name**, **registry name** and **device name** according to your account, and **keyIDs** of Trust provisioned keys and certificates used (as obtained from *Trust provisioned KeyIDs*):

```
#define GCP_PROJECT_NAME "pgh-cloud-iot"
#define GCP_LOCATION_NAME "us-central1"
#define GCP_REGISTRY_NAME "nxp-se-demo-reg"

#if (SSS_HAVE_APPLET_SE05X_C || SSS_HAVE_APPLET_SE05X_A)
```

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```
#define GCP_DEVICE_NAME "nxp-ecc-dev-01"
#elif SSS_HAVE_APPLET_SE05X_B
#define GCP_DEVICE_NAME "nxp-rsa-dev-01"
#else
#define GCP_DEVICE_NAME "a71ch-dev-04"
#endif
```

```
#define SSS_KEYPAIR_INDEX_CLIENT_PRIVATE 0x20181001
#define SSS_CERTIFICATE_INDEX 0x20181002
```

Build and run the demo.

Build and run `cloud_gcp`.

CMake configurations:

- `RTOS_FreeRTOS`: ON
- `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
- `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

5.11.3 Ease of Use configuration - Azure IoT Hub

Creating Device on Azure DPS

Follow *Raspberry Pi Build* or *i.MX Linux Build* to prepare your board.

You will need to read-out the device certificates using ssscli tool.

If you wish to use an embedded microcontroller, follow the steps given below.

- Flash vcom binary present in `binaries` folder onto the board.
- Read out the device certificate from the SE using `ssscli.exe` present in `binaries/PCWindows/ssscli` directory.

Refer to section *Trust provisioned KeyIDs* for keyIDs of trust provisioned certificates.

- Read out the trust provisioned certificate as:

```
ssscli connect se05x vcom COMxx
ssscli get cert <trust_provisioned_keyid> <filename>
ssscli disconnect
```

Note: Give connection parameters according to your board. Refer to *List of ssscli commands* for details on supported parameters.

- Device certificate will be stored at the file location provided.

Note: Give extension of the filename as .cer to store in *PEM* format

- Parse the extracted certificate using a cryptography tool such as OpenSSL to see the subject common name. This common name should be the name of the device registered on the Azure DPS.

- On your Azure portal, go to Azure DPS and create an *Individual Enrollment*. Enter the **DeviceID** as the subject name extracted in the previous step and in **Primary Certificate**, upload the extracted device certificate. You do not need to upload secondary certificate.

  Note: Ensure that your DPS is linked to IoT Hub.

  Select the device as an **Edge device** and save the configuration.

Registering Device to IoT Hub

- To register the saved device to IoT Hub, you would need a Linux platform. Run the following command to create a reference key file to be used with OpenSSL engine:

```
ssscli connect se05x t1oi2c none
ssscli refpem ecc/rsa pair <trust_provisioned_keyid> keyref.pem
ssscli disconnect
```

- Build the OpenSSL engine:

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/<board>_native_se050_t1oi2c
cmake --build .
make install
ldconfig /usr/local/lib
```

- Based on OpenSSL version, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

```
openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
```

- Set the openssl config path as:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/<appropriate-cnf-file>
```

Follow the steps listed in *Create device enrollment in azure IoT Hub portal* to register your device to the linked IoT Hub.

If you do not have a linux platform, follow the steps listed in https://docs.microsoft.com/en-us/azure/iot-dps/tutorial-provision-device-to-hub to register your device to IoT Hub.

Running Azure Demo

This step is only for Linux platforms. If you wish to use an embedded microcontroller, continue to the next step

Running Azure registration application successfully would have generated a JSON file to connect to your device. Use this JSON file to connect to Azure as:

```
./azure_imx_connect --json <JSON-file>
```

Where **JSON-file** is the generated file.

Update cloud example

In file `demos/ksdk/azure/azure_iot_config.h`, update `AZURE_IOT_HUB_NAME`, `AZURE_LOCATION_NAME` and `AZURE_DEVICE_NAME` according to your credentials and update **keyIDs** of Trust Provisioned keys and certificates used (as obtained from *Trust provisioned KeyIDs*):

```
#define AZURE_IOT_HUB_NAME "NXPIoTHub"
#define AZURE_LOCATION_NAME "bengaluru"
#define AZURE_DEVICE_NAME "528951164068620272177235"
```

```
#define AZURE_IOT_KEY_INDEX_SM 0x223344         ///< Index where client key is kept ␣
↪        //Decimal - 2241348
#define AZURE_IOT_CLIENT_CERT_INDEX_SM 0x223345 ///< Index where client certificate␣
↪is kept    //Decimal - 2241349
```

Build and run the demo.

Build and run `cloud_azure`.

CMake configurations:

- `RTOS_FreeRTOS`: ON
- `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
- `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

5.11.4 Ease of Use configuration - AWS IoT Console

Pre-requisites

- AWS IoT Console Account
- AWS CLI installed and configured (linked to you AWS account)
- ssscli Tool

Extracting Device Certificate

Using ssscli Tool, read out the device certificate. Refer to *Trust provisioned KeyIDs* for keyIDs of trust provisioned keys and certificates.

Note: If you wish to use an embedded microcontroller, flash the VCOM binary on your board first. VCOM binaries are available in `binaries` directory.

Extract the device certificate as:

```
ssscli connect se05x <conn-type> <port>
ssscli get cert <certificate-keyId> <certificate-filename>
ssscli disconnect
```

Note: Give connection parameters according to your board. Refer to *List of ssscli commands* for details on supported parameters.

Registering Device Certificate

Use AWS CLI Tool to register the extracted device certificate on to your AWS IoT Console:

```
aws iot register-certificate-without-ca --certificate-pem file://<certificate-
↪filename> --status ACTIVE
aws iot attach-policy --target <certificate ARN> --policy-name <policy name>
```

Note: Certificate ARN will be printed out after execution of the first command

---

Run the following command to print out the SNI string. This will be used later:

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

Note: Additionally, you can create and attach policies using **aws create-policy** and **aws attach-policy** commands. Although this is not required for this demo as we test only publish and subscribe functionalities, you would need to use policies to allow/restrict access to any resource. For more information on policies, refer to AWS CLI CreatePolicy and AWS CLI AttachPolicy

---

Running on Linux

This step is only for Linux platforms. If you wish to use an embedded microcontroller, continue to the next step

- Run the following commands to build OpenSSL engine for SE050:

  ```
  cd simw-top
  python scripts/create_cmake_projects.py
  cd ../simw-top_build/<board>_native_se050_t1oi2c
  cmake --build .
  make install
  ldconfig /usr/local/lib
  ```

- Navigate to `demos/linux/aws_eou` directory and execute the `buildScript.sh` as:

  ```
  chmod +x buildScript.sh
  ./buildScript.sh
  ```

  This will build the project `iot_demo_mqtt`.

- Based on OpenSSL version, select the appropriate configuration file in `<MW_SRC_DIR>/simw-top/demos/linux/common` directory:

  ```
  openssl11_sss_se050.cnf   ----- OpenSSL 1.1.1 and SE050
  openssl_sss_se050.cnf     ----- OpenSSL 1.0.0 and SE050
  ```

- Set the openssl config path as:

```
$ export OPENSSL_CONF=<absolute-path-to-MW>/demos/linux/common/<appropriate-cnf-
↪file>
```

- Create a reference file of device keypair for OpenSSL engine:

```
ssscli connect se05x <conn-type> <port>
ssscli refpem ecc/rsa pair <keypair-keyId> <ref-filename>
ssscli disconnect
```

Note: Make sure that the device keypair used corresponds to the device certificate

- Run the demo:

```
cd output/bin
./iot_demo_mqtt -i "ThingName" -h <endpoint> -r AmazonRootCA1.pem -c <certificate-
↪filename> -k <ref-filename>
```

where `endpoint` is the SNI string obtained in step *Registering Device Certificate*, `certificate-filename` is the device certificate extracted in step *Extracting Device Certificate* and `ref-filename` is the reference key created in the previous step.

Running on MCU

- Update the `clientcredentialMQTT_BROKER_ENDPOINT` variable in `demos/ksdk/common/aws_clientcredential.h` file with the SNI string obtained in previous step.
- Update `SSS_KEYPAIR_INDEX_CLIENT_PRIVATE` and `SSS_CERTIFICATE_INDEX_CLIENT` in file `demos/ksdk/common/aws_iot_config.h` with KeyIDs of device keypair and device certificate respectively. Refer to trust provisioned keyIDs listed in Section 3.17 *Trust provisioned KeyIDs*.

```
#define SSS_KEYPAIR_INDEX_CLIENT_PRIVATE 0x20181005
#define SSS_CERTIFICATE_INDEX_CLIENT 0x20181007
```

- Build and run project `cloud_aws`.

  CMake configurations:

  - `RTOS_FreeRTOS`: ON
  - `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
  - `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

5.12 Semslite examples

5.12.1 SEMS Lite Agent Demo (sems_lite_ex_update)

This application will update Applet through SEMS Lite agent.

In this demo, an update package, is pre-compiled into the example binary. See `SEMS_Lite_UpgradeTo_iotDev-7_3_0_A8FA.h`. This file contans a byte array that is encoded in protobuf format. This demo will call API *`sems_lite_agent_load_package()`* which will decode the stream and send update commands command to SE.

Note: This demo is used for OEF A8FA. If you use it for another OEF, you should update the header file with correct one.

Prerequisites

- Micro USB cable
- Kinetis FRDM-K64F/imx-RT1050 board
- Personal Computer
- SE051 Board
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Build Project: `sems_lite_ex_update`

Running the Example

- In case the a new update package is available or the IC is a new OEF, replace `SEMS_Lite_UpgradeTo_iotDev-7_3_0_A8FA.h`
- Recompile the example for your platform
- If you have built a binary for an embedded target, flash the `sems_lite_ex_update` binary on to the board and reset the board.
- If you have built an *exe* to be run from PC using VCOM, run as:

  ```
  sems_lite_ex_update.exe <PORT NAME>
  ```

  Where **<PORT NAME>** is the VCOM COM port.

5.12.2 SEMS Lite CLI APP

This example, is more advanced than Section 5.12.1 *SEMS Lite Agent Demo (sems_lite_ex_update)*.

This example takes command line parameters and talks to the SEMS Lite Applet.

Warning: This application is alpha status and would keep evolving/changing.

Building the CLI APP

- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)
- Project: `sems_lite_cli_app`

CLI Parameters

- `--loadpkg` <path-to-SEMS-Lite-applet-package-binary-file>

Load a binary file.

- `--getuid`

Get UID

- `--getappcontents` [optional-app-aid]

Store contents of card to `File-Name-to-store-card-contents`

e.g. `--getappcontents out_contents_file.bin 01030011`

- `--getpkgcontents` [optional-pkg-aid]
- `--semslitegetversion`

Print version of the SEMS Lite Applet

- `--getsignature` <File-Name-to-store-signature>

Get signature of last script

- `--checkTear`

Check if tearing has happened

- `--checkUpgradeProgress`

Check upgrade progress

- `--getENCIdentifier`

Get SK.SEMS.ENC Identifier

- `--getCAIdentifier`

Get CA-SEMS Identifier

- `--getCAKeyIdentifier`

Get CA-SEMS signature verification key identifier

- `--getpkgversion`

Get Package Version

- `--getFreePHeap`

Get PHeap Information

- `--getECParameter`

Get configured EC domain parameter type

- `--getFIPSInfo`

Get configured FIPS Information

- `--testapplet` <applet-aid> <apdu-command>

Used to select test applet and send dummy APDU Command

Usage - K64F

- Ensure VCOM interface is setup for K64.
- SET EX_SSS_BOOT_SSS_PORT=<COM Port>
- Run application with applicable commandline parameters

Usage - Raspberry Linux

- Run application with applicable commandline parameters

Version Compatibility

SEMS Lite cli application from SEMS Lite 2.0.0 can support binary file generated by tools of SEMS Lite 2.0.0 and those of SEMS Lite 1.0.0. But SEMS Lite cli application from SEMS Lite 1.0.0 can not support binary file generated by tools of SEMS Lite 2.0.0.

	`Bin file from SEMS Lite 1.0.0`	`Bin file from SEMS Lite 2.0.0`
Cli app from SEMS Lite 1.0.0	Supported	Not supported
Cli app from SEMS Lite 2.0.0	Supported	Supported

5.13 PUF examples

5.13.1 Key Injection to PUF

This example demonstrates how to enroll PUF on LPC55S, inject PlatformSCP keys into PUF and retrieve key codes. This example can be used as a starting point to inject default SCP03 keys into PUF.

Note: After running this example, update `ex_scp03_puf.h` file with the new Activation code and keyCodes.

Pre-requisites

- Section 11.5.5 *LPC55S69*
- Section 4.2.4 *Logging on console*
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

How to build

- Replace the following keys with the keys to be provisioned into PUF:

```
    /** New key material
      * These will be the static platform SCP03 keys
      * which will be provisioned on the SE and in PUF.
      */
    uint8_t PROV_KEY_ENC[PUF_INTRINSIC_KEY_SIZE] = SSS_AUTH_KEY_ENC;
    uint8_t PROV_KEY_MAC[PUF_INTRINSIC_KEY_SIZE] = SSS_AUTH_KEY_MAC;
    uint8_t PROV_KEY_DEK[PUF_INTRINSIC_KEY_SIZE] = SSS_AUTH_KEY_DEK;
```

For information on PUF, refer *SCP03 with PUF*.

- Compile and run the example with the following CMake options:
  - `Host=lpcxpresso55s`
  - Project:`puf_inject_scp03`

How to use

- Flash the binary on the device.
- On successful execution, you will be able to see the ActivationCode and KeyCodes printed out on the console.

Injecting keys into PUF

Refer to the below implementation on how to implement a simple function to inject SCP03 keys into PUF.

```
static status_t puf_insert_scp03_keys(uint8_t *PROV_KEY_ENC, uint8_t *PROV_KEY_MAC,␣
↪uint8_t *PROV_KEY_DEK)
{
    status_t result = kStatus_Fail;
    uint8_t activationCode[PUF_ACTIVATION_CODE_SIZE];

    srand(0xbabadeda);

    puf_config_t conf;
    PUF_GetDefaultConfig(&conf);
    PUF_Deinit(PUF, &conf);

    result = PUF_Init(PUF, &conf);
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);

    result = PUF_Enroll(PUF, activationCode, sizeof(activationCode));
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);
    LOG_MAU8_I("ActivationCode", activationCode, sizeof(activationCode));
    PUF_Deinit(PUF, &conf);

    result = PUF_Init(PUF, &conf);
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);

    result = PUF_Start(PUF, activationCode, PUF_ACTIVATION_CODE_SIZE);
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);

    result = PUF_SetUserKey(PUF,
        kPUF_KeyIndex_00,
        PROV_KEY_ENC,
        PUF_INTRINSIC_KEY_SIZE,
```

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```
        keyCodeENC_01,
        PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_INTRINSIC_KEY_SIZE));
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);
    LOG_MAU8_I("KeyCode_ENC", keyCodeENC_01, PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_
↪INTRINSIC_KEY_SIZE));
    result = PUF_SetUserKey(PUF,
        kPUF_KeyIndex_00,
        PROV_KEY_MAC,
        PUF_INTRINSIC_KEY_SIZE,
        keyCodeMAC_01,
        PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_INTRINSIC_KEY_SIZE));
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);
    LOG_MAU8_I("KeyCode_MAC", keyCodeMAC_01, PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_
↪INTRINSIC_KEY_SIZE));
    result = PUF_SetUserKey(PUF,
        kPUF_KeyIndex_00,
        PROV_KEY_DEK,
        PUF_INTRINSIC_KEY_SIZE,
        keyCodeDEK_01,
        PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_INTRINSIC_KEY_SIZE));
    ENSURE_OR_GO_CLEANUP(result == kStatus_Success);
    LOG_MAU8_I("KeyCode_DEK", keyCodeDEK_01, PUF_GET_KEY_CODE_SIZE_FOR_KEY_SIZE(PUF_
↪INTRINSIC_KEY_SIZE));

cleanup:
    PUF_Deinit(PUF, &conf);
    return result;
}
```

5.13.2 Key Rotation using PUF

This example demonstrates how to use PUF to manage PlatformSCP keys and rotate the keys using PUF. For details on PUF and usage with LPC55S, refer to *SCP03 with PUF*.

Before running this example, be sure that correct PlatformSCP keys are already provisioned in PUF. For details on how to provision keys in PUF, refer Section 5.13.1 *Key Injection to PUF*.

In this example, we first open a session with default PlatformSCP keys and perform an RNG operation, then we rotate the keys in SE and PUF, reopen session with new keys and perform RNG operation again to demonstrate that the keys have been rotated. Finally, we revert to the old keys.

Warning: We are using randomized keys for key rotation. Make sure that the demo runs completely without any power interruptions. In case of failure, SE050 could be using the new keys and re-running the demo will fail.

Pre-requisites

- Section 11.5.5 *LPC55S69*
- Section 4.2.4 *Logging on console*
- Build Plug & Trust middleware stack. (Refer *Building / Compiling*)

- PUF must be enrolled first and original SCP03 keys must be provisioned and ActivationCode and KeyCodes must be updated in `ex_scp03_puf.h`. SBL and secure app should be compiled with the correct AC and KCs. See Section 5.13.1 *Key Injection to PUF* on how to provision PUF with PlatformSCP03 keys.

How to build

Make sure that you compile the secure example first. The non-secure example links to the secure example.

Compile the secure example with the following CMake options:

- `Host=lpcxpresso55s_s`
- `SCP=SCP03_SSS`
- `SE05X_Auth=PlatfSCP03`
- Project:`puf_rotate_scp03_s`

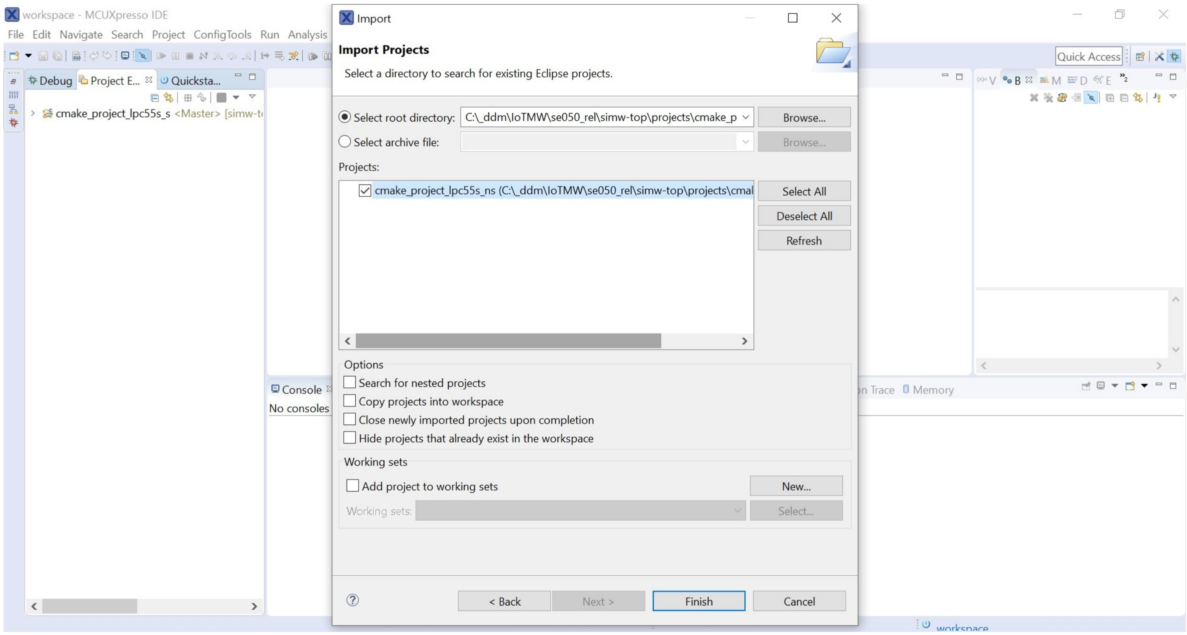
Compile the non-secure example with the following CMake options:

- `Host=lpcxpresso55s_ns`
- `SCP=SCP03_SSS`
- `SE05X_Auth=PlatfSCP03`
- Project:`puf_rotate_scp03_ns`

How to run

Follow the steps given below to flash secure and non-secure binaries on LPC55S board.

1) Import secure and non-secure projects into MCUXpresso IDE



Import Projects

Select a directory to search for existing Eclipse projects.

● Select root directory: C:_ddm\IoTMW\se050_rel\simw-top\projects\cmake_p

○ Select archive file:

Projects:

☑ cmake_project_lpc55s_ns (C:_ddm\IoTMW\se050_rel\simw-top\projects\cmal

Options

☐ Search for nested projects

☐ Copy projects into workspace

☐ Close newly imported projects upon completion

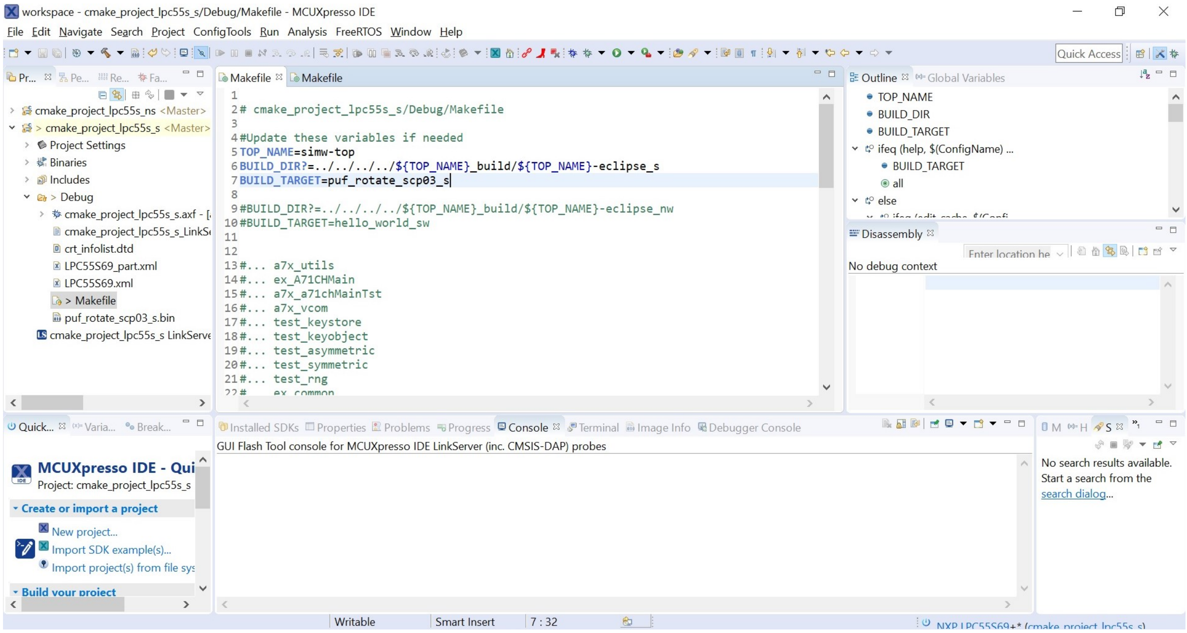
☐ Hide projects that already exist in the workspace

Working sets

☐ Add project to working sets

Working sets:

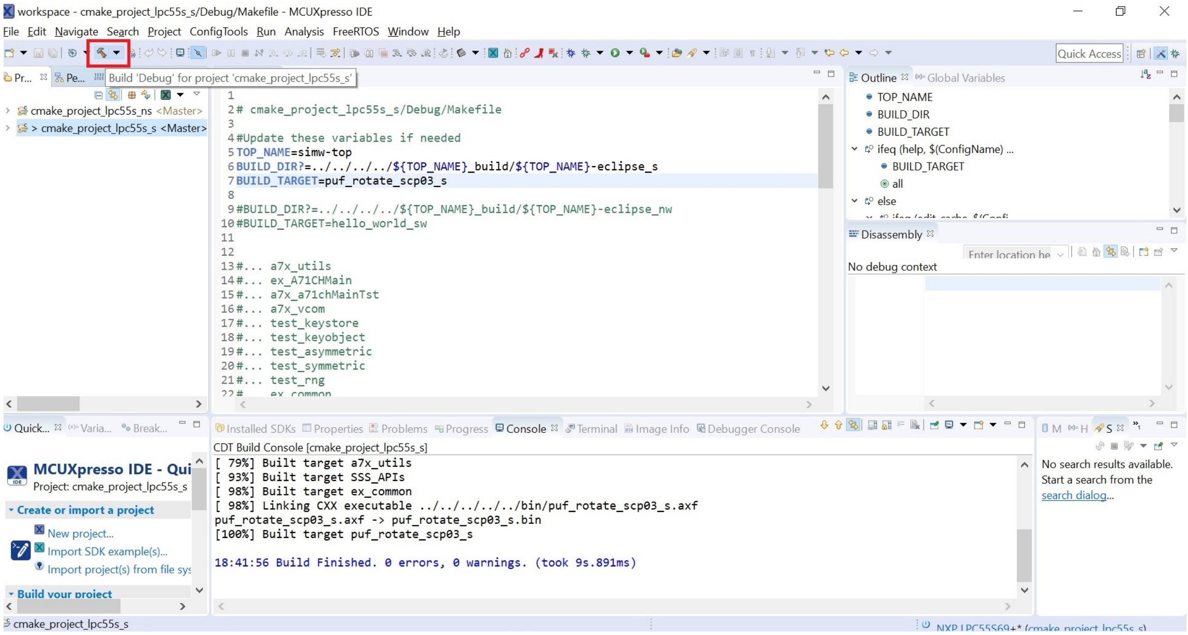
2) Update `Makefile` target for both projects


workspace - cmake_project_lpc55s_s/Debug/Makefile - MCUXpresso IDE

```
# cmake_project_lpc55s_s/Debug/Makefile

#Update these variables if needed
TOP_NAME=simw-top
BUILD_DIR?=../../../../${TOP_NAME}_build/${TOP_NAME}-eclipse_s
BUILD_TARGET=puf_rotate_scp03_s

#BUILD_DIR?=../../../../${TOP_NAME}_build/${TOP_NAME}-eclipse_nw
#BUILD_TARGET=hello_world_sw


#... a7x_utils
#... ex_A71CHMain
#... a7x_a71chMainTst
#... a7x_vcom
#... test_keystore
#... test_keyobject
#... test_asymmetric
#... test_symmetric
#... test_rng
```

GUI Flash Tool console for MCUXpresso IDE LinkServer (inc. CMSIS-DAP) probes

3) Build the projects.



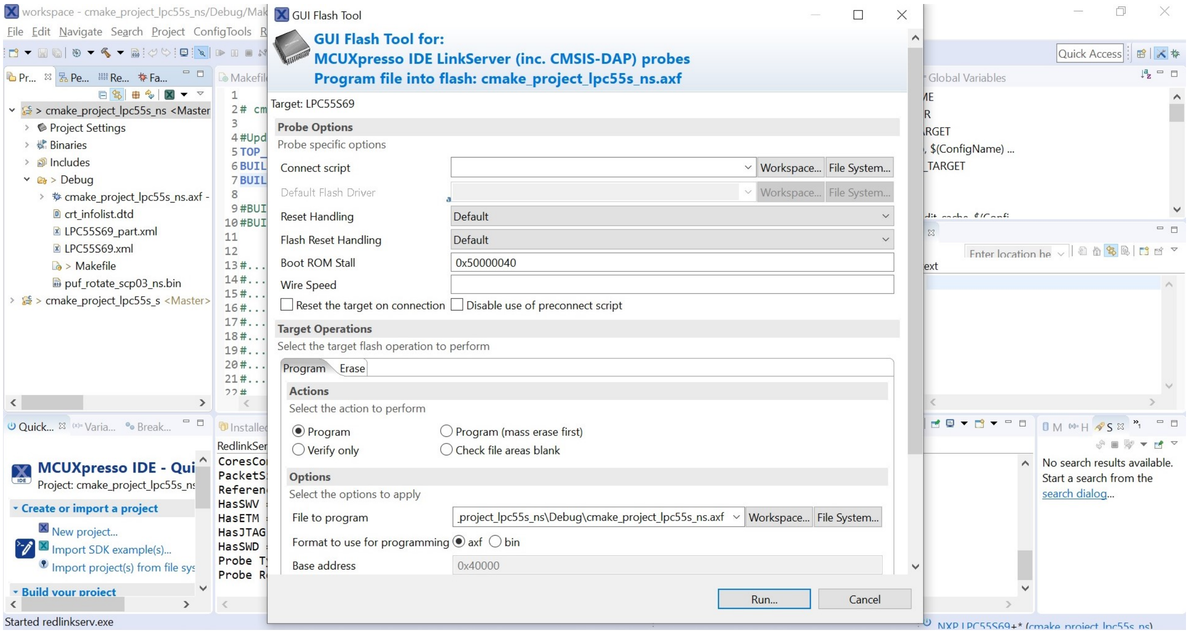
CDT Build Console [cmake_project_lpc55s_s]

```
[ 79%] Built target a7x_utils
[ 93%] Built target SSS_APIs
[ 98%] Built target ex_common
[ 98%] Linking CXX executable ../../../../../bin/puf_rotate_scp03_s.axf
puf_rotate_scp03_s.axf -> puf_rotate_scp03_s.bin
[100%] Built target puf_rotate_scp03_s

18:41:56 Build Finished. 0 errors, 0 warnings. (took 9s.891ms)
```

Note: Be sure that you build the secure project first and then the non-secure project.

4) Start `GUI Flash Tool`

Note: You can program the binary by debugging the project also. If you want to debug, go to step 6.



GUI Flash Tool for:
MCUXpresso IDE LinkServer (inc. CMSIS-DAP) probes
Program file into flash: cmake_project_lpc55s_ns.axf

Target: LPC55S69

Probe Options
Probe specific options

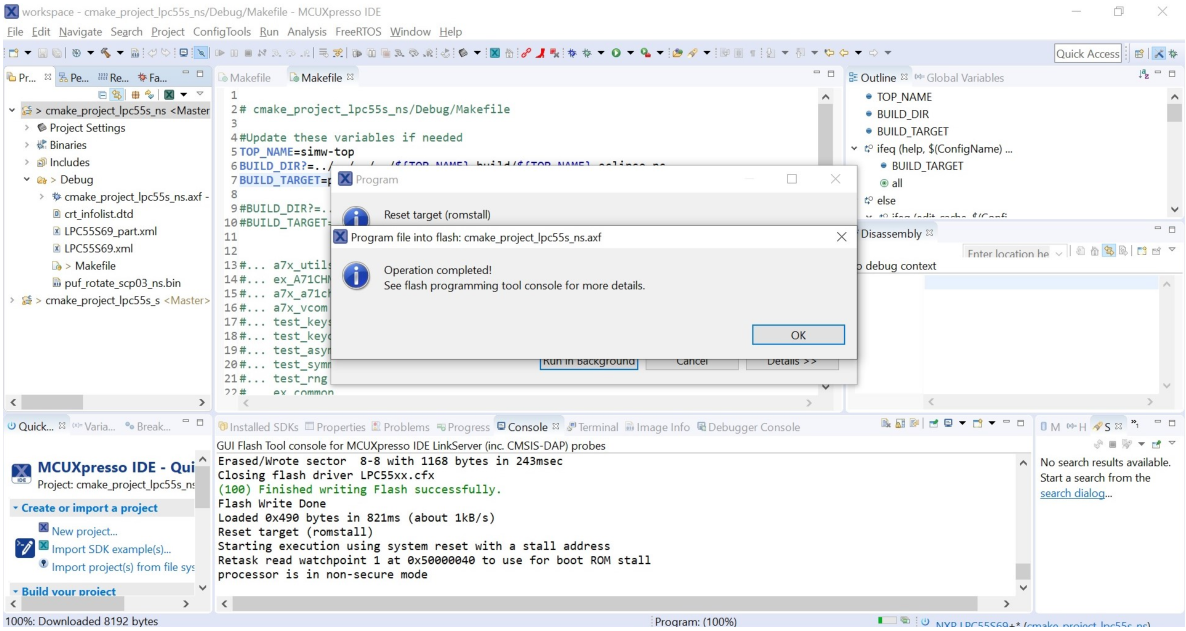
Connect script:
Reset Handling: Default
Flash Reset Handling: Default
Boot ROM Stall: 0x50000040
Wire Speed:
☐ Reset the target on connection ☐ Disable use of preconnect script

Target Operations
Select the target flash operation to perform

Actions
Select the action to perform
● Program ○ Program (mass erase first)
○ Verify only ○ Check file areas blank

Options
Select the options to apply
File to program: project_lpc55s_ns\Debug\cmake_project_lpc55s_ns.axf
Format to use for programming: ● axf ○ bin
Base address: 0x40000

5) On successful operation you should see the following message



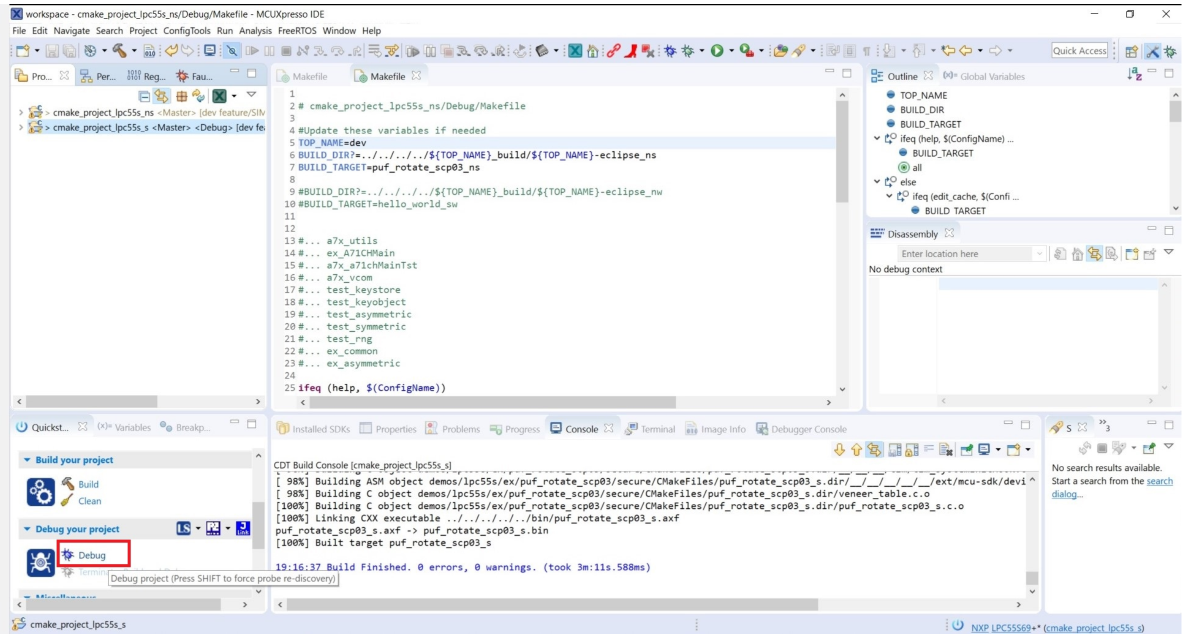
Program file into flash: cmake_project_lpc55s_ns.axf

Operation completed!
See flash programming tool console for more details.

GUI Flash Tool console for MCUXpresso IDE LinkServer (inc. CMSIS-DAP) probes

```
Erased/Wrote sector  8-8 with 1168 bytes in 243msec
Closing flash driver LPC55xx.cfx
(100) Finished writing Flash successfully.
Flash Write Done
Loaded 0x490 bytes in 821ms (about 1kB/s)
Reset target (romstall)
Starting execution using system reset with a stall address
Retask read watchpoint 1 at 0x50000040 to use for boot ROM stall
processor is in non-secure mode
```

6) To start debugging into the project, simply select the project that you want to debug and press the `Debug` button in QuickStart Menu.



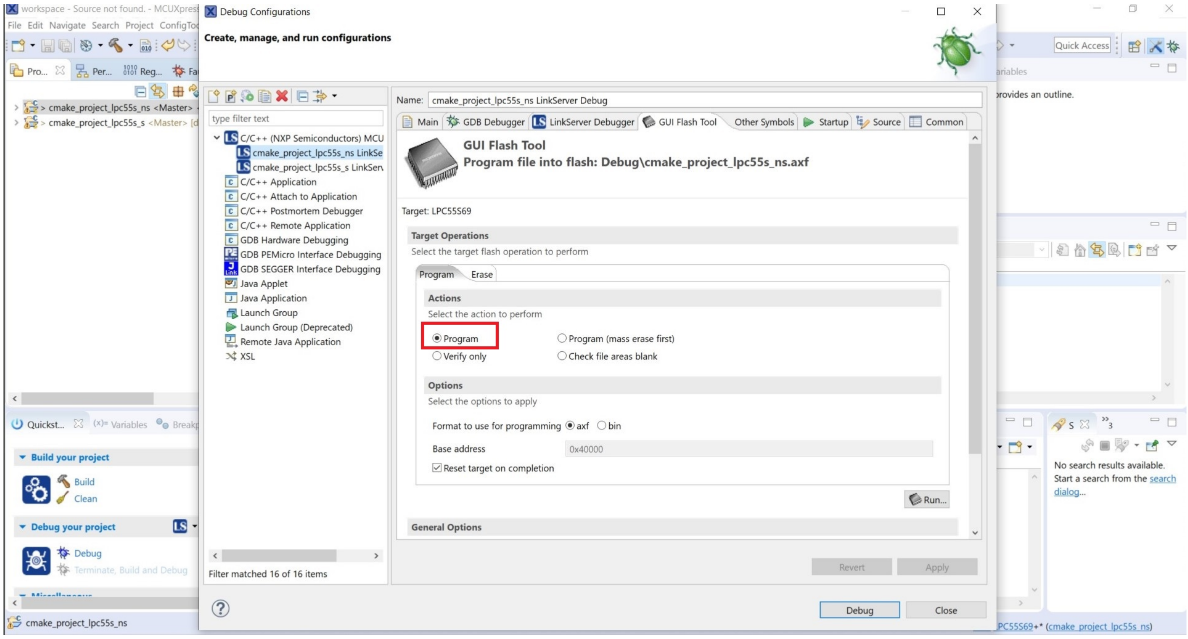
workspace - cmake_project_lpc55s_ns/Debug/Makefile - MCUXpresso IDE

```
# cmake_project_lpc55s_ns/Debug/Makefile

#Update these variables if needed
TOP_NAME=dev
BUILD_DIR?=../../../../${TOP_NAME}_build/${TOP_NAME}-eclipse_ns
BUILD_TARGET=puf_rotate_scp03_ns

#BUILD_DIR?=../../../../${TOP_NAME}_build/${TOP_NAME}-eclipse_nw
#BUILD_TARGET=hello_world_sw


#... a7x_utils
#... ex_A71CHMain
#... a7x_a71chMainTst
#... a7x_vcom
#... test_keystore
#... test_keyobject
#... test_asymmetric
#... test_symmetric
#... test_rng
#... ex_common
#... ex_asymmetric

ifeq (help, $(ConfigName))
```

CDT Build Console [cmake_project_lpc55s_s]

```
[ 98%] Building ASM object demos/lpc55s/ex/puf_rotate_scp03/secure/CMakeFiles/puf_rotate_scp03_s.dir/__/__/__/__/__/ext/mcu-sdk/devi
[ 98%] Building C object demos/lpc55s/ex/puf_rotate_scp03/secure/CMakeFiles/puf_rotate_scp03_s.dir/veneer_table.c.o
[100%] Building C object demos/lpc55s/ex/puf_rotate_scp03/secure/CMakeFiles/puf_rotate_scp03_s.dir/puf_rotate_scp03_s.c.o
[100%] Linking CXX executable ../../../../../bin/puf_rotate_scp03_s.axf
puf_rotate_scp03_s.axf -> puf_rotate_scp03_s.bin
[100%] Built target puf_rotate_scp03_s

19:16:37 Build Finished. 0 errors, 0 warnings. (took 3m:11s.588ms)
```

7) Make sure that in the `Debug Configuration` under `GUI Flash Tool` tab, you have selected **Program**.



Debug Configurations

Create, manage, and run configurations

Name: cmake_project_lpc55s_ns LinkServer Debug

GUI Flash Tool
Program file into flash: Debug\cmake_project_lpc55s_ns.axf

Target: LPC55S69

Target Operations
Select the target flash operation to perform

Actions
Select the action to perform

● Program ○ Program (mass erase first)
○ Verify only ○ Check file areas blank

Options
Select the options to apply

Format to use for programming ● axf ○ bin

Base address 0x40000

☑ Reset target on completion

Perform the last two steps for both the projects (order does not matter). While debugging, flash the program that you want to debug second.

When you have flashed both the projects, reset the board. On successful execution you would be able to see the following log in terminal

```
App   :INFO :PlugAndTrust_v02.15.00_20200522
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
sss   :INFO :atr (Len=35)
```

(continues on next page)

(continued from previous page)

```
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Random test 1 was successful, with default SCP03 keys!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet deselection successful!
App   :INFO :Key Rotation was successful!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Applet is now using PUF keys!
App   :INFO :Random test 2 was successful, with new PUF keys!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet deselection successful!
App   :INFO :Key Rotation was successful!
App   :INFO :Rotation back to default keys was successful!
App   :INFO :Entering normal world.

Welcome in normal world (SIMW)!
```

5.13.3 Secure Boot Demo

This example is to demonstrate how secure binding is achieved between LPC55S and SE05X using PUF for secure storage of PlatformSCP keys on the MCU. For details on secure boot process, refer to Section 3.20 *Secure Boot*

Secondary Bootloader (SBL)

Refer to Section 3.20.2 *Secondary Bootloader* for details on operations performed by the Secondary Bootloader (SBL).

Secure Application

The secure application is verified by SBL using RSA2k public key stored at KeyID `K_PUB_OEM_ID`. Secure application will have the reference to keyCodes prepared by SBL, using which PlatformSCP session can be established.

In this example, secure application is opening a PlatformSCP03 session using keyCodes prepared by SBL and transfers the control to non-secure application which will open an Applet session and test communication.

Non-Secure Application

The non-secure application used in this example is used to establish an Applet session and use non-secure callable APIs provided in secure application to wrap data with PlatformSCP context before sending to the SE.

Prerequisites

- Section 11.5.5 *LPC55S69*
- Section 4.2.4 *Logging on console*
- Building Plug & Trust middleware stack. (Refer *Building / Compiling*)
- PUF must be enrolled first and original SCP03 keys must be provisioned and ActivationCode and KeyCodes must be updated in `ex_scp03_puf.h`. SBL and secure app should be compiled with the correct AC and KCs. See Section 5.13.1 *Key Injection to PUF* on how to provision PUF with PlatformSCP03 keys.
- Secure application verification public key must be provisioned at keyID `K_PUB_OEM_ID` and updated in `puf_se05x_sbl_s.c` at:

  ```
  #define K_PUB_OEM_ID 0xA55A
  ```

  Refer to *CLI Tool* for details on how to provision keys into SE05x.
- New PlatformSCP03 keys updated in `puf_se05x_sbl_s.c` at:

  ```
  uint8_t newScpKeyENC[PUF_INTRINSIC_KEY_SIZE] = {0};
  uint8_t newScpKeyMAC[PUF_INTRINSIC_KEY_SIZE] = {0};
  uint8_t newScpKeyDEK[PUF_INTRINSIC_KEY_SIZE] = {0};

  status = getHostAesKeys(pCtx, newScpKeyENC, PUF_INTRINSIC_KEY_SIZE);
  ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
  // LOG_MAU8_W("Random ENC Key", newScpKeyENC, PUF_INTRINSIC_KEY_SIZE);

  status = getHostAesKeys(pCtx, newScpKeyMAC, PUF_INTRINSIC_KEY_SIZE);
  ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
  // LOG_MAU8_W("Random MAC Key", newScpKeyMAC, PUF_INTRINSIC_KEY_SIZE);

  status = getHostAesKeys(pCtx, newScpKeyDEK, PUF_INTRINSIC_KEY_SIZE);
  ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
  // LOG_MAU8_W("Random DEK Key", newScpKeyDEK, PUF_INTRINSIC_KEY_SIZE);
  ```

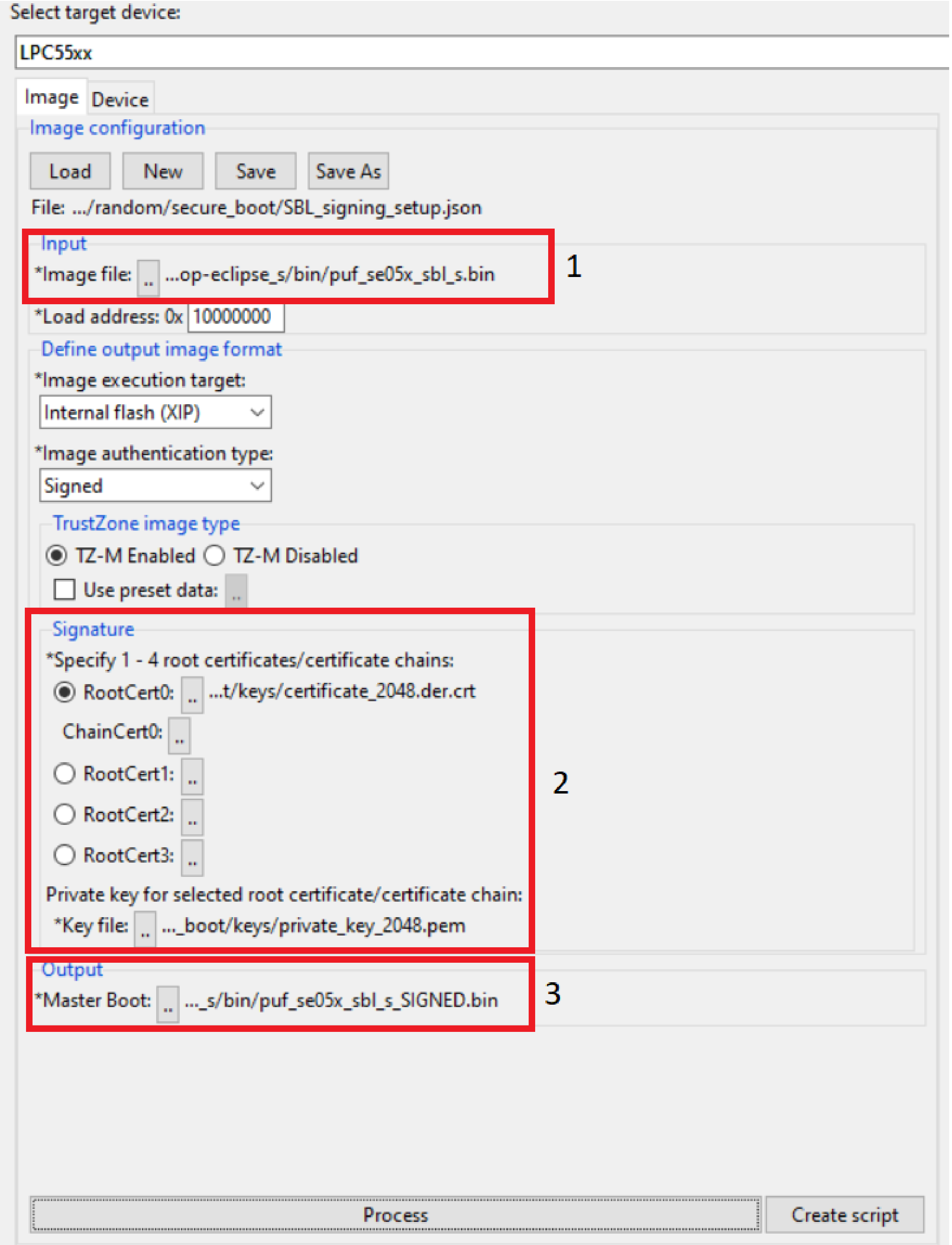
  Note: The SBL performs key rotation when run first time with randomized keys. If required for development, the user should change this to known keys so that in case of failure recovering SE050 is easy.
- `elftosb` tool from ELF to Secure Binary GUI to prepare signed images.
- Also see Section 3.20 *Secure Boot*
- Refer AppNote AN12283.

How to build

1) Compile the SBL with the following CMake options:
   - `PTMW_Host=lpcxpresso55s_s`
   - `PTMW_SCP=SCP03_SSS`
   - `PTMW_SE05X_Auth=PlatfSCP03`
   - `PTMW_SBL:STRING=None`
   - Project:`puf_se05x_sbl_s`

2) To complete the build process, you also need to sign the image for Bootloader verification. For this, you need to use ELF to Secure Binary GUI.

   Configure elftosb GUI tool as:



Select target device: LPC55xx

Image configuration

File: .../random/secure_boot/SBL_signing_setup.json

Input

*Image file: ...op-eclipse_s/bin/puf_se05x_sbl_s.bin

*Load address: 0x 10000000

Define output image format

*Image execution target: Internal flash (XIP)

*Image authentication type: Signed

TrustZone image type

● TZ-M Enabled ○ TZ-M Disabled

☐ Use preset data:

Signature

*Specify 1 - 4 root certificates/certificate chains:

● RootCert0: ...t/keys/certificate_2048.der.crt

ChainCert0:

○ RootCert1:

○ RootCert2:

○ RootCert3:

Private key for selected root certificate/certificate chain:

*Key file: ..._boot/keys/private_key_2048.pem

Output

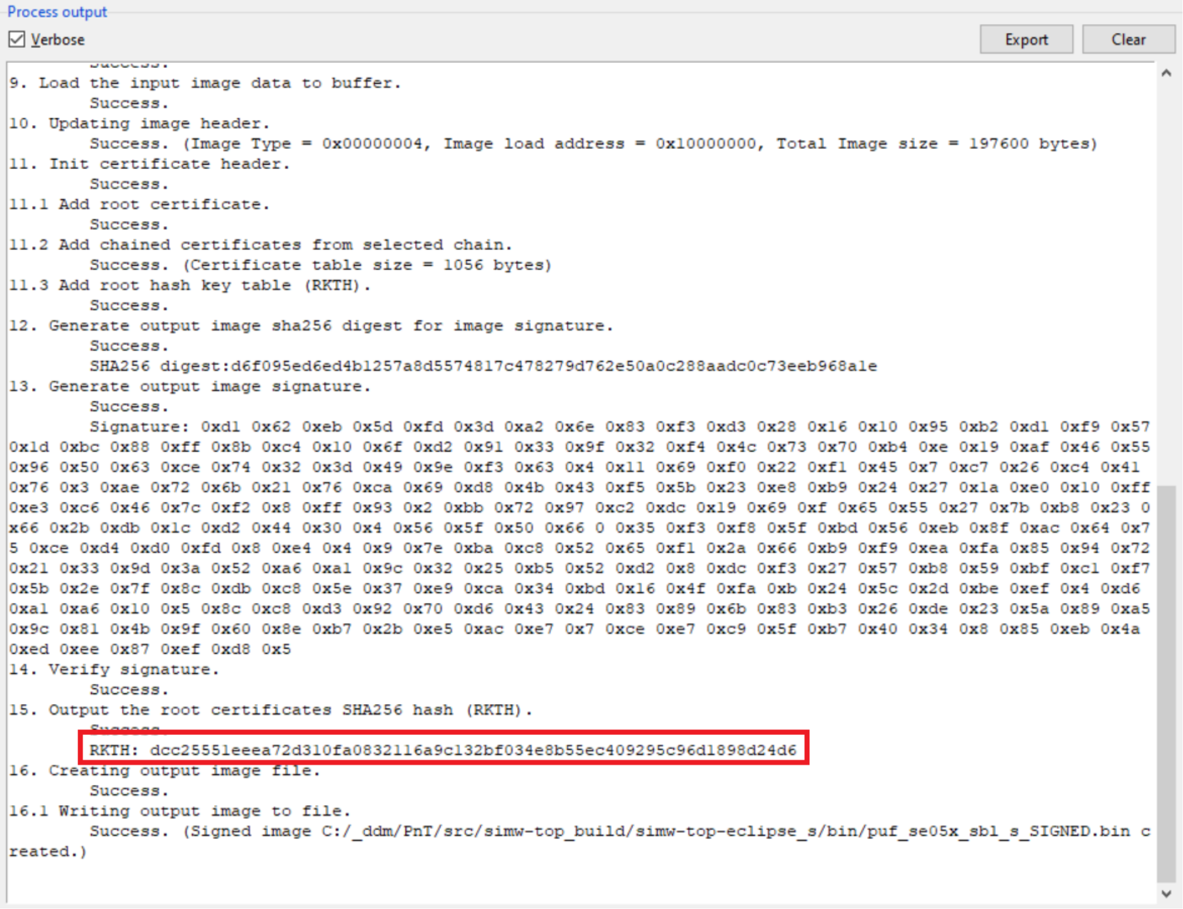
*Master Boot: ..._s/bin/puf_se05x_sbl_s_SIGNED.bin

1) Select your SBL input binary

2) Add certificate chain and signing key (Refer **Chapter 3. Keys and certificates** in AN12283)
3) Select your output signed SBL binary

Press `Process` button to create signed image.

You should be able to see the log generated on right window containing RKTH as highlighted:

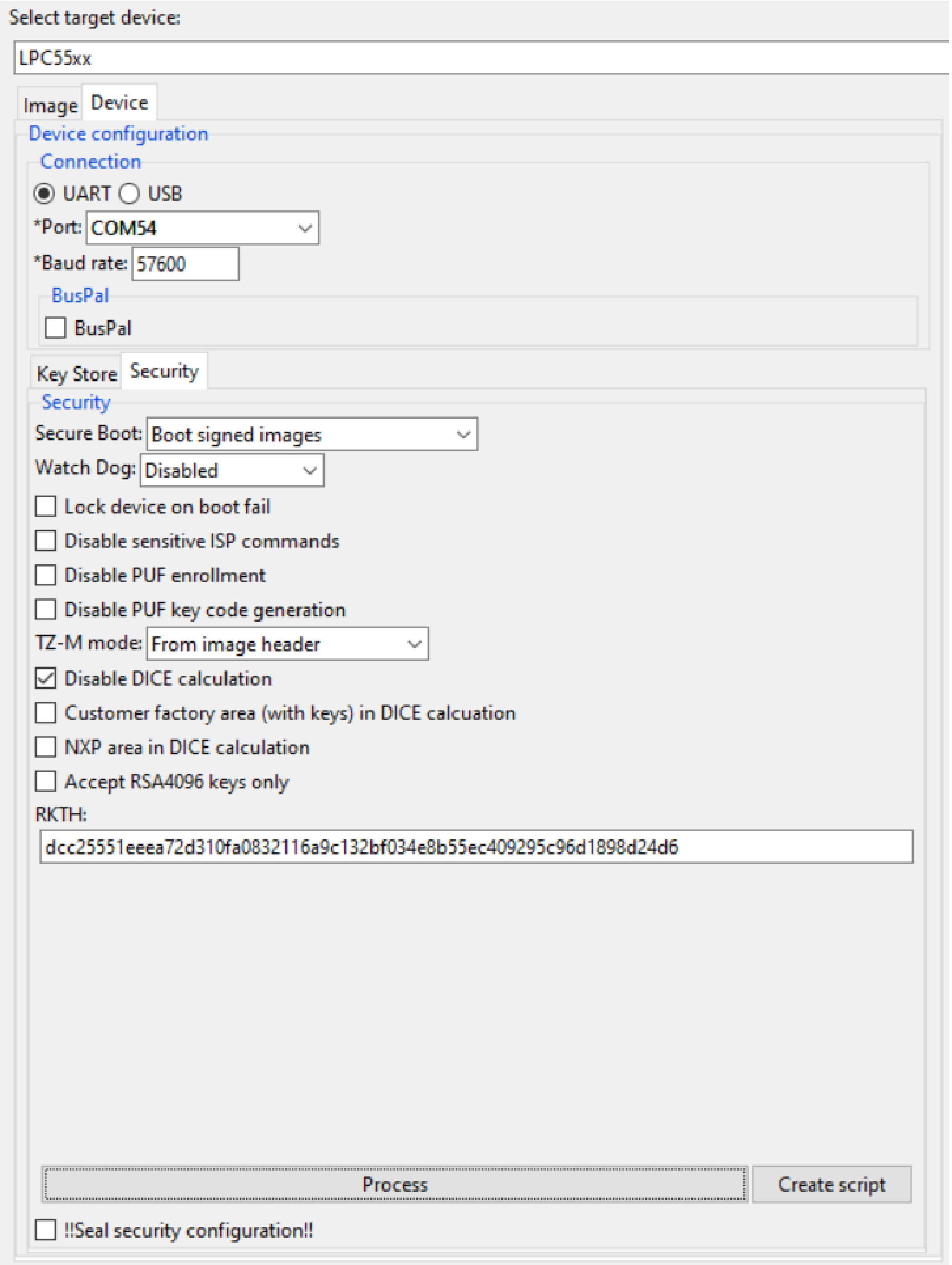


```
9. Load the input image data to buffer.
        Success.
10. Updating image header.
        Success. (Image Type = 0x00000004, Image load address = 0x10000000, Total Image size = 197600 bytes)
11. Init certificate header.
        Success.
11.1 Add root certificate.
        Success.
11.2 Add chained certificates from selected chain.
        Success. (Certificate table size = 1056 bytes)
11.3 Add root hash key table (RKTH).
        Success.
12. Generate output image sha256 digest for image signature.
        Success.
        SHA256 digest:d6f095ed6ed4b1257a8d5574817c478279d762e50a0c288aadc0c73eeb968a1e
13. Generate output image signature.
        Success.
        Signature: 0xd1 0x62 0xeb 0x5d 0xfd 0x3d 0xa2 0x6e 0x83 0xf3 0xd3 0x28 0x16 0x10 0x95 0xb2 0xd1 0xf9 0x57
0x1d 0xbc 0x88 0xff 0x8b 0xc4 0x10 0x6f 0xd2 0x91 0x33 0x9f 0x32 0xf4 0x4c 0x73 0x70 0xb4 0xe 0x19 0xaf 0x46 0x55
0x96 0x50 0x63 0xce 0x74 0x32 0x3d 0x49 0x9e 0xf3 0x63 0x4 0x11 0x69 0xf0 0x22 0xf1 0x45 0x7 0xc7 0x26 0xc4 0x41
0x76 0x3 0xae 0x72 0x6b 0x21 0x76 0xca 0x69 0xd8 0x4b 0x43 0xf5 0x5b 0x23 0xe8 0xb9 0x24 0x27 0x1a 0xe0 0x10 0xff
0xe3 0xc6 0x46 0x7c 0xf2 0x8 0xff 0x93 0x2 0xbb 0x72 0x97 0xc2 0xdc 0x19 0x69 0xf 0x65 0x55 0x27 0x7b 0xb8 0x23 0
x66 0x2b 0xdb 0x1c 0xd2 0x44 0x30 0x4 0x56 0x5f 0x50 0x66 0 0x35 0xf3 0xf8 0x5f 0xbd 0x56 0xeb 0x8f 0xac 0x64 0x7
5 0xce 0xd4 0xd0 0xfd 0x8 0xe4 0x4 0x9 0x7e 0xba 0xc8 0x52 0x65 0xf1 0x2a 0x66 0xb9 0xf9 0xea 0xfa 0x85 0x94 0x72
0x21 0x33 0x9d 0x3a 0x52 0xa6 0xa1 0x9c 0x32 0x25 0xb5 0x52 0xd2 0x8 0xdc 0xf3 0x27 0x57 0xb8 0x59 0xbf 0xc1 0xf7
0x5b 0x2e 0x7f 0x8c 0xdb 0xc8 0x5e 0x37 0xe9 0xca 0x34 0xbd 0x16 0x4f 0xfa 0xb 0x24 0x5c 0x2d 0xbe 0xef 0x4 0xd6
0xa1 0xa6 0x10 0x5 0x8c 0xc8 0xd3 0x92 0x70 0xd6 0x43 0x24 0x83 0x89 0x6b 0x83 0xb3 0x26 0xde 0x23 0x5a 0x89 0xa5
0x9c 0x81 0x4b 0x9f 0x60 0x8e 0xb7 0x2b 0xe5 0xac 0xe7 0x7 0xce 0xe7 0xc9 0x5f 0xb7 0x40 0x34 0x8 0x85 0xeb 0x4a
0xed 0xee 0x87 0xef 0xd8 0x5
14. Verify signature.
        Success.
15. Output the root certificates SHA256 hash (RKTH).
        Success.
        RKTH: dcc25551eeea72d310fa0832116a9c132bf034e8b55ec409295c96d1898d24d6
16. Creating output image file.
        Success.
16.1 Writing output image to file.
        Success. (Signed image C:/_ddm/PnT/src/simw-top_build/simw-top-eclipse_s/bin/puf_se05x_sbl_s_SIGNED.bin c
reated.)
```

Note this value for next step.

3) We will configure CMPA and CFPA pages in next 2 steps. These pages are required to configure LPC55S registers before boot. We can configure boot config, boot speed, debugging registers, RKTH, etc (See AN12283 and AN13037 for more details). In this example, we configure CMPA page with RKTH value and CFPA with RoT Keys enabled. RKTH value is checked from CMPA while verifying the image to ensure that a different certificate chain was not used to create the signed binary. CFPA page is used to check if any key used in signed image preparation is enabled or revoked.

   In `Device` tab, configure the following settings:



Select target device: LPC55xx

● UART ○ USB

*Port: COM54

*Baud rate: 57600

☐ BusPal

Secure Boot: Boot signed images

Watch Dog: Disabled

☐ Lock device on boot fail

☐ Disable sensitive ISP commands

☐ Disable PUF enrollment

☐ Disable PUF key code generation

TZ-M mode: From image header

☑ Disable DICE calculation

☐ Customer factory area (with keys) in DICE calcuation

☐ NXP area in DICE calculation

☐ Accept RSA4096 keys only

RKTH: dcc25551eeea72d310fa0832116a9c132bf034e8b55ec409295c96d1898d24d6

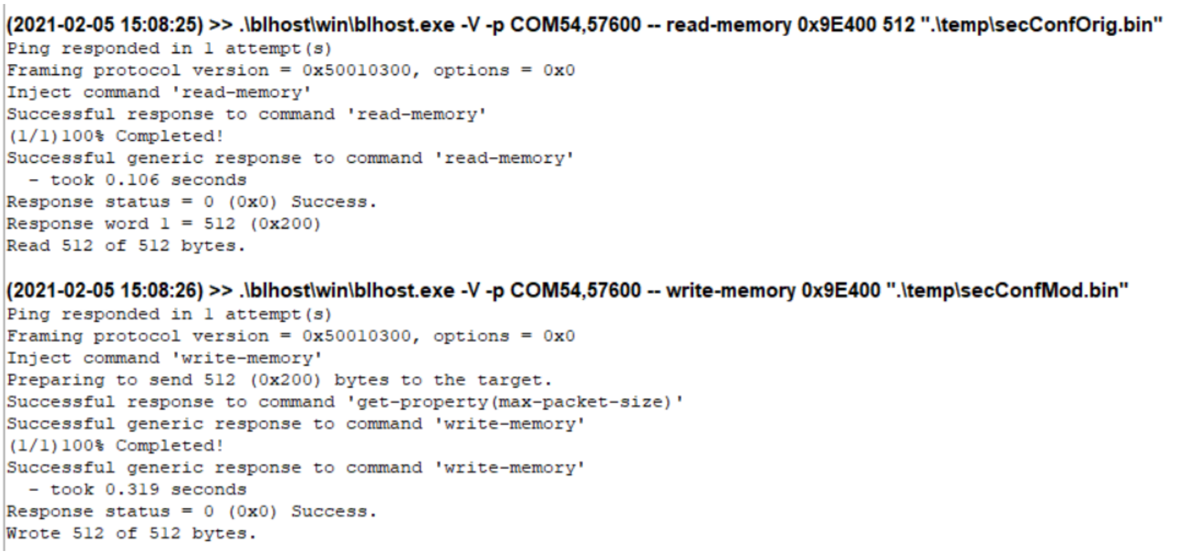
☐ !!Seal security configuration!!

In place of RKTH, enter your RKTH that you noted in the previous step.

Note: Do **NOT** Seal Security configuration

Enter ISP mode by holding ISP button on the device and pressing Reset button.

Update the COMPort and press `Process`. This will update CMPA page with this RKTH value which will allow ROM Bootloader to successfully verify SBL image. On successful programming of CMPA page, you should be able to see logs like this:



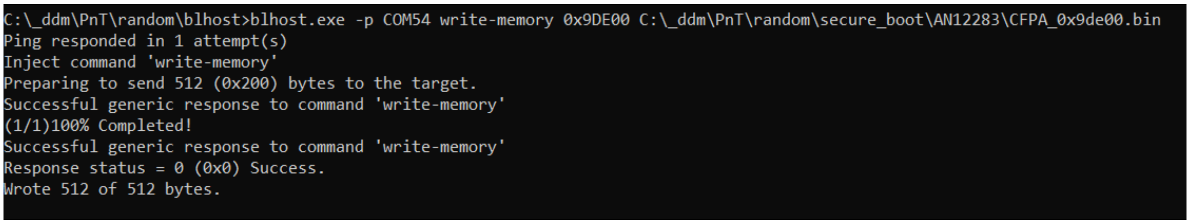
```
(2021-02-05 15:08:25) >> .\blhost\win\blhost.exe -V -p COM54,57600 -- read-memory 0x9E400 512 ".\temp\secConfOrig.bin"
Ping responded in 1 attempt(s)
Framing protocol version = 0x50010300, options = 0x0
Inject command 'read-memory'
Successful response to command 'read-memory'
(1/1)100% Completed!
Successful generic response to command 'read-memory'
  - took 0.106 seconds
Response status = 0 (0x0) Success.
Response word 1 = 512 (0x200)
Read 512 of 512 bytes.

(2021-02-05 15:08:26) >> .\blhost\win\blhost.exe -V -p COM54,57600 -- write-memory 0x9E400 ".\temp\secConfMod.bin"
Ping responded in 1 attempt(s)
Framing protocol version = 0x50010300, options = 0x0
Inject command 'write-memory'
Preparing to send 512 (0x200) bytes to the target.
Successful response to command 'get-property(max-packet-size)'
Successful generic response to command 'write-memory'
(1/1)100% Completed!
Successful generic response to command 'write-memory'
  - took 0.319 seconds
Response status = 0 (0x0) Success.
Wrote 512 of 512 bytes.
```

Note: This will allow to boot only signed images. You won't be able to boot plain images. To revert this setting to boot plain images, change Secure Boot setting to **Boot plain images** and update the CMPA page again.

---

4) Update CFPA page using `blhost` utility available in `elftosb` package:

```
blhost.exe -p COM54 write-memory 0x9DE00 C:\_ddm\PnT\random\secure_boot\AN12283\CFPA_0x9de00.bin
```



```
C:\_ddm\PnT\random\blhost>blhost.exe -p COM54 write-memory 0x9DE00 C:\_ddm\PnT\random\secure_boot\AN12283\CFPA_0x9de00.bin
Ping responded in 1 attempt(s)
Inject command 'write-memory'
Preparing to send 512 (0x200) bytes to the target.
Successful generic response to command 'write-memory'
(1/1)100% Completed!
Successful generic response to command 'write-memory'
Response status = 0 (0x0) Success.
Wrote 512 of 512 bytes.
```

Sample CFPA page is available with this demo which can be directly flashed. If you want to update the CFPA page again, you need to increment the CFPA version. See AN12283 for more details.

5) Compile SBL bootable secure application with the following CMake options:

   - `PTMW_Host=lpcxpresso55s_s`
   - `PTMW_SCP=SCP03_SSS`
   - `PTMW_SE05X_Auth=PlatfSCP03`
   - `PTMW_SBL=SBL_LPC55S`
   - Project:`sbl_app_s`

6) To prepare Secure application signed image, configure elftosb as:

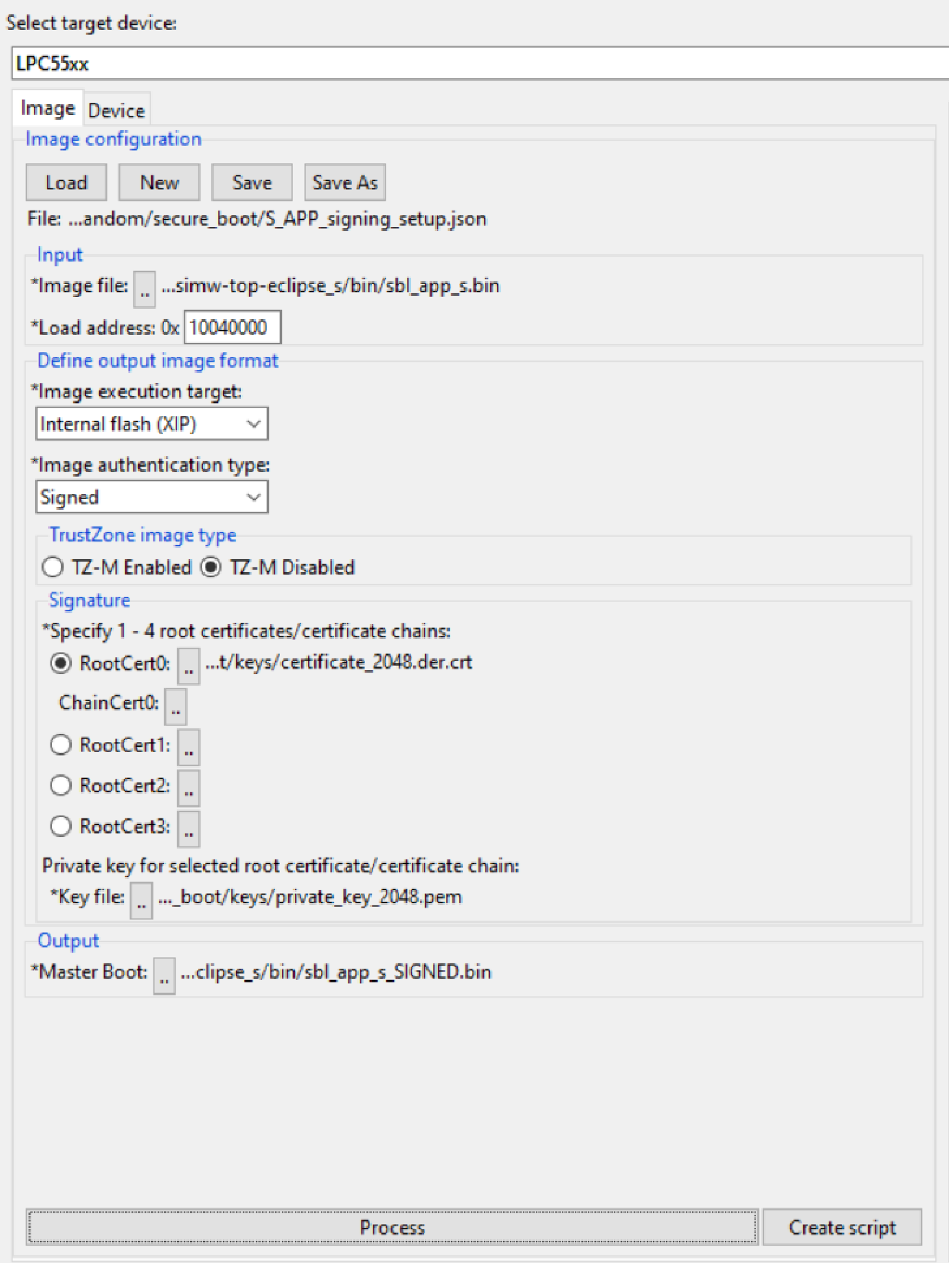

Select target device: LPC55xx

Image configuration

File: ...andom/secure_boot/S_APP_signing_setup.json

Input

*Image file: ...simw-top-eclipse_s/bin/sbl_app_s.bin

*Load address: 0x 10040000

Define output image format

*Image execution target: Internal flash (XIP)

*Image authentication type: Signed

TrustZone image type

○ TZ-M Enabled ● TZ-M Disabled

Signature

*Specify 1 - 4 root certificates/certificate chains:

● RootCert0: ...t/keys/certificate_2048.der.crt

ChainCert0:

○ RootCert1:

○ RootCert2:

○ RootCert3:

Private key for selected root certificate/certificate chain:

*Key file: ..._boot/keys/private_key_2048.pem

Output

*Master Boot: ...clipse_s/bin/sbl_app_s_SIGNED.bin

Run process to create signed secure application image.

7) Compile non-secure application with the following CMake options:

   - `PTMW_Host=lpcxpresso55s_ns`

- `PTMW_SCP=SCP03_SSS`
- `PTMW_SE05X_Auth=PlatfSCP03`
- `PTMW_Log=Silent`
- Project:`sbl_app_ns`

Note: This process creates a signed image for SBL. However, there is an option to create signed + encrypted image. In that, the encrypted image is first decrypted by symmetric key provisioned in PUF, then the decrypted image is loaded in flash for signature verification. Refer to section 5.6 in AN12283 for details on creating Secure Binary (Signed + Encrypted).

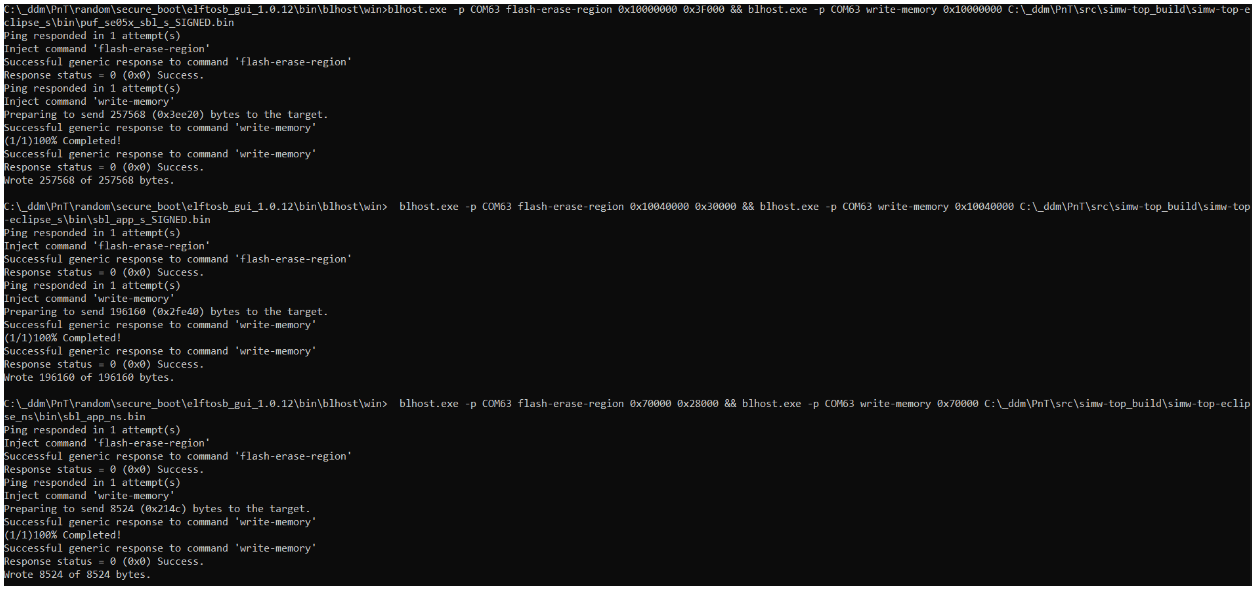
A "Secure" Binary in this case means it is signed and encrypted, it is not related to Secure Boot or LPC55S TrustZone.

Using a Secure Binary would also disable debugging. Refer to AN13037 for details on how to update **CC_SOCU** registers in CMPA and CFPA pages to enable debugging.

How to run

Enter ISP mode by holding ISP button on the device and pressing Reset button. Flash the built images with these commands:

```
blhost.exe -p COMxx flash-erase-region 0x10000000 0x3F000 && blhost.exe -p COMxx␣
↪write-memory 0x10000000 puf_se05x_sbl_s_SIGNED.bin

blhost.exe -p COMxx flash-erase-region 0x10040000 0x30000 && blhost.exe -p COMxx␣
↪write-memory 0x10040000 sbl_app_s_SIGNED.bin

blhost.exe -p COMxx flash-erase-region 0x70000 0x28000 && blhost.exe -p COMxx write-
↪memory 0x70000 sbl_app_ns.bin
```



```
C:\_ddm\PnT\random\secure_boot\elftosb_gui_1.0.12\bin\blhost\win>blhost.exe -p COM63 flash-erase-region 0x10000000 0x3F000 && blhost.exe -p COM63 write-memory 0x10000000 C:\_ddm\PnT\src\simw-top_build\simw-top-e
clipse_s\bin\puf_se05x_sbl_s_SIGNED.bin
Ping responded in 1 attempt(s)
Inject command 'flash-erase-region'
Successful generic response to command 'flash-erase-region'
Response status = 0 (0x0) Success.
Ping responded in 1 attempt(s)
Inject command 'write-memory'
Preparing to send 257568 (0x3ee20) bytes to the target.
Successful generic response to command 'write-memory'
(1/1)100% Completed!
Successful generic response to command 'write-memory'
Response status = 0 (0x0) Success.
Wrote 257568 of 257568 bytes.

C:\_ddm\PnT\random\secure_boot\elftosb_gui_1.0.12\bin\blhost\win>  blhost.exe -p COM63 flash-erase-region 0x10040000 0x30000 && blhost.exe -p COM63 write-memory 0x10040000 C:\_ddm\PnT\src\simw-top_build\simw-top
-eclipse_s\bin\sbl_app_s_SIGNED.bin
Ping responded in 1 attempt(s)
Inject command 'flash-erase-region'
Successful generic response to command 'flash-erase-region'
Response status = 0 (0x0) Success.
Ping responded in 1 attempt(s)
Inject command 'write-memory'
Preparing to send 196160 (0x2fe40) bytes to the target.
Successful generic response to command 'write-memory'
(1/1)100% Completed!
Successful generic response to command 'write-memory'
Response status = 0 (0x0) Success.
Wrote 196160 of 196160 bytes.

C:\_ddm\PnT\random\secure_boot\elftosb_gui_1.0.12\bin\blhost\win>  blhost.exe -p COM63 flash-erase-region 0x70000 0x28000 && blhost.exe -p COM63 write-memory 0x70000 C:\_ddm\PnT\src\simw-top_build\simw-top-eclip
se_ns\bin\sbl_app_ns.bin
Ping responded in 1 attempt(s)
Inject command 'flash-erase-region'
Successful generic response to command 'flash-erase-region'
Response status = 0 (0x0) Success.
Ping responded in 1 attempt(s)
Inject command 'write-memory'
Preparing to send 8524 (0x214c) bytes to the target.
Successful generic response to command 'write-memory'
(1/1)100% Completed!
Successful generic response to command 'write-memory'
Response status = 0 (0x0) Success.
Wrote 8524 of 8524 bytes.
```

Press the Reset button after completion. On successful execution you should be able to see these logs:

First boot log:

```
App   :INFO :PlugAndTrust_v03.01.00_20210102
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Random test was successful with default SCP03 keys
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet deselection successful!
App   :INFO :Key Rotation was successful!
App   :INFO :NewKeyCode_ENC (Len=52)
                00 00 00 02     E2 26 23 39     CB 6F D3 57     46 75 7D 7E
                47 9C F4 68     D6 65 D4 8C     3D CF 28 4F     1F 3F 9D 4A
                66 1F E3 D1     BB B0 0A D7     57 C3 35 3B     48 17 1B AF
                33 AE 2C A6
App   :INFO :NewKeyCode_MAC (Len=52)
                00 00 00 02     10 F9 83 8B     91 BD 14 5E     6D 57 4A C2
                46 13 7A 71     38 8D 14 05     99 B3 08 13     EE 1B 68 9E
                36 E6 99 4B     EC 1B BB 48     2D 50 58 D1     16 6E F3 3D
                8D 2F 18 41
App   :INFO :NewKeyCode_DEK (Len=52)
                00 00 00 02     4D F1 02 83     E7 B9 C5 30     66 DB 92 43
                86 7E 3C E2     A3 61 FF 48     72 C9 AE 68     03 31 6C 7B
                6F C9 5C E4     28 BC D1 3F     B6 DD 6C C9     AF 65 D8 B0
                0B 38 E2 E6
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Session Open successful
App   :INFO :Random test was successful with new SCP03 keys
App   :INFO :Image verification successful, booting the application now!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet deselection successful!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Random test was successful from secure application
App   :INFO :Entering normal world see you there.

Non-secure entry
NS Channel initialize successful
sss:WARN :Communication channel is Plain.
sss:WARN :!!!Not recommended for production use.!!!
NS Session open is Successful
sss_rng_get_random successful
```

Next boot log:

```
App   :INFO :PlugAndTrust_v03.01.00_20210102
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Random test was successful, with KCs loaded from Flash!
App   :INFO :Image verification successful, booting the application now!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet deselection successful!
sss   :INFO :atr (Len=35)
                01 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 00
                01 00 00 00     00 64 13 88     0A 00 65 53     45 30 35 31
                00 00 00
App   :INFO :Applet selection successful!
App   :INFO :Random test was successful from secure application
App   :INFO :Entering normal world see you there.

Non-secure entry
NS Channel initialize successful
sss:WARN :Communication channel is Plain.
sss:WARN :!!!Not recommended for production use.!!!
NS Session open is Successful
sss_rng_get_random successful
```

CHAPTER

SIX

NXP EDGELOCK 2GO AGENT

6.1 Introduction

EdgeLock 2GO is a cloud service by NXP for provisioning keys and credentials into devices equipped with SE050 and for easily onboarding the device into the cloud services of the user. Please visit https://www.nxp.com/edgelock2go for more information.

The EdgeLock 2GO agent is the on-device counterpart of the EdgeLock 2GO cloud service. Its purpose is to establish a secure connection to the EdgeLock 2GO service, report status of the device and update the device with up-to-date credentials and configuration data. It handles credentials for authentication at customer cloud services in cooperation with a secure keystore and manages configuration data/connection information for these the cloud services.

6.2 Building and running the EdgeLock 2GO agent

6.2.1 Building / Compiling the EdgeLock 2GO agent

The build instructions for the EdgeLock 2GO agent do not deviate from the build instructions already introduced in section *Building / Compiling*. For convenience, the script `<SE05X_root_folder>/simw-top/scripts/create_cmake_projects.py` will generate bespoke CMake configurations with all CMake options set correctly for building the EdgeLock2 GO agent for KSDK (FRDMK64F, LPC55S69), and i.MX:

- KSDK: `<SE05X_root_folder>/simw-top_build/simw-top-eclipse_arm_el2go`
- i.MX (native compilation): `<SE05X_root_folder>/simw-top_build/imx_native_se050_t1oi2c_openssl_el2go`

6.2.2 Registering the device to the EdgeLock 2GO service

In order to connect your device to EdgeLock 2GO and provision the keys and credentials that you have configured, you first need to register your device to your EdgeLock 2GO account. This can be done in different ways including:

- Registering your device UID into your EdgeLock 2GO account. You must first read-out the UID of your device. This can be achieved for example by executing the se05x_Get_Info executable that is part of this release. How to do this is described in more detail in *SE05X Get Info example*.
- Injecting a claim code on the device, see *Claim Codes*.

For more details, please refer to the EdgeLock 2GO documentation (AN12691).

6.2.3 Connecting the device to the EdgeLock 2GO service

For the connection to the EdgeLock 2GO cloud service, each account uses an individual hostname. You can obtain this hostname in the company settings on the GUI of the EdgeLock 2GO cloud service. The hostname can be picked up by the EdgeLock 2GO agent from different locations, please see also *Parameters for the connection to EdgeLock 2GO cloud service*.

Once you have registered your device or installed a claim code, you can simply connect your device to the EdgeLock 2GO cloud service by calling the EdgeLock 2GO agent API. See *EdgeLock 2GO Agent Examples* for an example. During the connection to the EdgeLock 2GO cloud service, the device will get provisioned with the credentials that you have configured. For more details, please refer to the EdgeLock 2GO documentation (AN12691).

6.3 Datastore / Keystore

For storage of credentials and configuration data two types of storage entities are available. A keystore is used for storing sensitive information, typically private keys for a client authentication, whereas a datastore is used for storing configuration data required for connecting to a cloud service. Both are managed remotely from the EdgeLock 2GO cloud service. From the point of view of the EdgeLock 2GO cloud service datastores and keystores are considered endpoints. The EdgeLock 2GO cloud service sends messages to endpoints to set them up according to the desired configuration.

After the device is configured/provisioned for a cloud service by the EdgeLock 2GO cloud service, the relevant information can be extracted for usage in client software from the storages. The access to the credentials is abstracted by using the *SSS APIs*, configuration data is accessed using a service descriptor struct object.

One keystore implementation is included for supporting the SE050. The EdgeLock 2GO cloud service uses a direct APDU channel to read out from and insert objects into the secure element.

For the sake of demonstration, also two datastore implementations are part of this package. A filesystem based datastore which uses files for storing the data delivered by the EdgeLock 2GO cloud service is present in `<SE05X_root_folder>/simw-top/nxp_iot_agent/*/nxp_iot_agent_datastore_fs.*` (* stands for `inc` or `src` folder in the path and for `h` or `c` in the file name extension), one that uses raw memory can be found in `<SE05X_root_folder>/simw-top/nxp_iot_agent/*/nxp_iot_agent_datastore_plain.*`.

When writing contents to a datastore, EdgeLock 2GO cloud service protects the data with a checksum. This allows the EdgeLock 2GO agent to check whether the data that is found inside a datastore is valid/uncorrupted.

6.4 Connection to the EdgeLock 2GO cloud service

This section gives a short overview of the communication channel between the EdgeLock 2GO agent and the EdgeLock 2GO cloud service. The connection to the EdgeLock 2GO cloud service is always initiated from the EdgeLock 2GO agent.

6.4.1 Transport layer security

Communication between client and server is protected in a mutually authenticated TLS channel. The TLS protocol versions TLS 1.2 and TLS 1.3 are supported. The supported ciphersuites are:

For TLS 1.2:

- TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256
- TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384

- TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256
- TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384
- TLS_DHE_RSA_WITH_AES_128_GCM_SHA256
- TLS_DHE_RSA_WITH_AES_256_GCM_SHA384

For TLS 1.3:

- TLS_AES_128_GCM_SHA256
- TLS_AES_256_GCM_SHA384

6.4.2 Client authentication

When using SE050 for authenticating at the EdgeLock 2GO cloud service, the client's private key as well as the client certificate are stored on the secure element. SE050 comes with those credentials already pre-installed from the NXP production site with predefined object identifiers.

There are two crypto libraries available to do the TLS handshake in combination with the SE050. It is possible to use OpenSSL with an custom crypto engine (see *Introduction on OpenSSL engine*). Alternatively mbedTLS with an alternative implementation for the SE050 can be used (see *Introduction on mbedTLS ALT Implementation*).

6.4.3 Server authentication

The server is authenticated by using a certificate chain ultimately signed by an NXP root CA. There are two different certificate chains available, one using ECC with the NIST P-384 curve, the other chain uses RSA with 4096 bit keys. The trusted root CA certificates are included with the distributed package of the NXP Plug & Trust Middleware (see also *Parameters for the connection to EdgeLock 2GO cloud service*).

The EdgeLock 2GO cloud service provides certificate revocation lists (CRLs) for the CA signing the server certificates. The CRLs are transferred via TLS channel in order to avoid having to implement another protocol (typically http) for retrieving the CRL. When using openssl as crypto library, the CRL processing is skipped for openssl versions < 1.1.1.

6.4.4 Application layer protocol

On the application layer, the EdgeLock 2GO cloud service sends protobuf messages (requests) to individual endpoints which are handled by those. Depending on the endpoint type, different requests are used. Requests to the EdgeLock 2GO agent itself are used for querying the presence of endpoints and their supported features and managing the communication channel. Other requests directly address reading data or writing contents of keystores and datastores.

For configuring an SE050 keystore, the EdgeLock 2GO cloud service uses APDU commands that are directly forwarded to the secure element. If sensitive information is included or integrity protection is required, APDUs can be encrypted. This way a secure end-to-end channel between the EdgeLock 2GO cloud service and the secure element can be established.

For datastores the EdgeLock 2GO cloud service is able to perform read operations to retrieve the current contents. Should it be necessary, an update of the datastore contents can be performed. The EdgeLock 2GO cloud service always replaces the complete contents of the datastore. The first request is an allocate operation, allowing the datastore to make sure memory for the contents is available. It is followed by one or more write operations. If the datastore supports transactions, after the last write, an additional commit operation is done to trigger an atomic update of the datastore contents.

The definition of the protobuf application layer protocol can be found in `<SE05X_root_folder>/simw-top/nxp_iot_agent/doc/protobuf`.

6.4.5 Parameters for the connection to EdgeLock 2GO cloud service

The EdgeLock 2GO agent attempts to take hostname, port, a reference to the client key and client certificate as well as a collection of trusted root ca certificates from a datastore that is registered with a particular id. If a datastore with this id is registered and contains valid data (checksum verification), then the EdgeLock 2GO agent uses its contents. If this is not the case, it falls back to compile-time constants defined in `<SE05X_root_folder>/simw-top/nxp_iot_agent/inc/nxp_iot_agent_config.h`.

For demonstration purposes, in the demo application in `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/iot_agent_demo.c`, a datastore for the EdgeLock 2GO cloud service connection parameters is registered. It is filled at the first boot with the compile-time constants from the configuration file.

In order to be able to mitigate a potential corruption of the keys of the trusted root certificates, in case the connection parameters are taken from the datastore, the EdgeLock 2GO cloud service has the opportunity to update the connection parameters remotely.

6.5 Claim Codes

A claim code allows registering the device into the user account automatically. Claim codes are created and managed from the EdgeLock 2GO service. Please refer to the EdgeLock 2GO documentation (AN12691, section 5.3: 'Add a device to the allowlist using claim codes') for more details.

To facilitate injection of claim code into device, a simple application capable of injecting and deleting claim codes (claimcode_inject) is delivered in combination with the EdgeLock 2GO agent. This application reads a claim code from a text file.

After the claim code was generated on EdgeLock 2GO service, the user has to create a .txt file (`claim.txt` for example) and copy the generated claim code value inside the file. Then, to inject the claim code copied in the file `claim.txt`, the following command can be used:

```
./claimcode_inject claim.txt
```

Application also supports deleting existing claim code from with the following command:

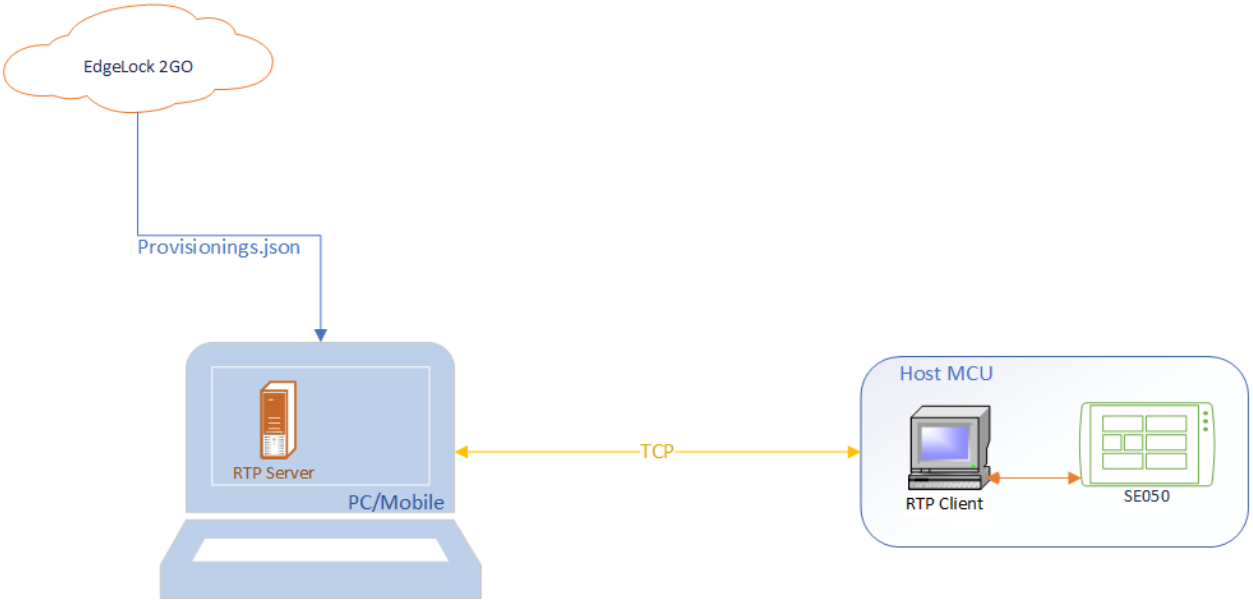
```
./claimcode_inject --delete
```

6.6 Offline Provisioning of Secure Objects

The EdgeLock 2GO agent supports managed provisioning of secure objects via secure TLS channel (see *Connection to the EdgeLock 2GO cloud service*) between device and EdgeLock 2GO. EdgeLock 2GO also supports provisioning of secure objects without a connection from device to EdgeLock 2GO (referred to as offline remote trust provisioning). Please refer to provisioning of secure objects in the EdgeLock 2GO documentation (AN12691, section 8.3: 'Offline secure object provisioning') for more details.

To demonstrate offline remote trust provisioning, a simple client-server example capable of importing secure objects into device is delivered in combination with the EdgeLock 2GO agent. Communication between server-client is implemented by a simple TCP protocol. Below picture depicts a block diagram for offline remote trust provisioning.

- **Block diagram:**



6.6.1 Offline Remote Trust Provisioning Server (RTP Server)

After configuring device and secure objects in your EdgeLock 2GO account, you have the possibility to download provisionings for the device in the form of JSON file. For more details with regard to this step, please refer to EdgeLock 2GO documentation (AN12691, section 8.3: 'Offline secure object provisioning'). The RTP Server application is meant to run on machine capable of connecting to EL2GO and retrieving JSON files containing provisionings. For the sake of simplicity, the RTP Server is implemented in Java language with minimal dependencies and source code is located under:

```
<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/tools/edge-lock-device-link-rtp-server
```

Once the JSON file containing provisionings is downloaded from EL2GO, following commands can be used to build and run application. Please note, it is expected to have maven installed on the machine.

Compile and create jar file:

```
mvn package
```

Print usage details of RTP Server:

```
java -jar target/RtpServer.jar -h
```

Print version details of RTP Server:

```
java -jar target/RtpServer.jar -V
```

Run RTP Server on specified port reading JSON files from specified directory:

```
java -jar target/RtpServer.jar -d c:\el2go -p 7080
```

6.6.2 Offline Remote Trust Provisioning Client (RTP Client)

The RTP Client application is meant to run on the MCU to which the secure element is connected. The build instructions for the RTP Client are similar to that of EdgeLock 2GO agent. The RTP Client application is implemented in C language and source code is located under:

```
<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/apps/remote_provisioning_client.
c
```

To start the RTP Client application, the following command can be used:

`./remote_provisioning_client.exe hostname port` where:

- hostname = Hostname/IP address of machine on which RTP server is running
- port = Port on which RTP Server is listening

Once the RTP Client is connected, the RTP Server reads the UID of the secure element. The RTP Server parses all JSON files located at the given directory and finds all provisionings for this particular UID. These provisioning are then sent to RTP Client and imported to secure element.

6.7 API

6.7.1 EdgeLock 2GO Main

group **`edgelock2go_agent_main`**

Main API for registering keystores, datastores and connecting to the cloud to update provisionings.

Defines

`EDGELOCK2GO_ATTESTATION_KEY_ECC`

The attestation keyid on the SSS API to use for the attestation.

`EDGELOCK2GO_ATTESTATION_KEY_RSA`

`EDGELOCK2GO_CERTID_ECC`

The certid on the SSS API to use for the keystore to use for connecting to EdgeLock 2GO cloud service.

`EDGELOCK2GO_CERTID_RSA`

`EDGELOCK2GO_KEYID_ECC`

The keyid on the SSS API to use for the keystore and keypair to use for connecting to EdgeLock 2GO cloud service.

`EDGELOCK2GO_KEYID_RSA`

`EDGELOCK2GO_KEYSTORE_ID`

The keystore that stores the credentials for the EdgeLock 2GO cloud service.

When connecting to the EdgeLock 2GO cloud service, for the client authentication a private key is required. This key is expected to be in a keystore which is registered to the EdgeLock 2GO agent.

In case there is a datastore which holds the information how to connect to the EdgeLock 2GO cloud service this datastore also holds the information where to get the private key.

In case the EdgeLock 2GO agent needs to fall back to compile-time constant connection information, it does assume that the private key for the client authentication is stored in a keystore that is registered with this ID.

`EDGELOCK2GO_MANAGED_SERVICE_KEY_MAX`

@ brief End of the range of keys to use for keys of cloud services provisioned by EdgeLock 2GO.

`EDGELOCK2GO_MANAGED_SERVICE_KEY_MIN`

@ brief Start of the range of keys to use for keys of cloud services provisioned by EdgeLock 2GO.

Typedefs

typedef struct _nxp_iot_UpdateStatusReport **nxp_iot_UpdateStatusReport**

typedef struct pb_field_s **pb_field_t**

typedef struct pb_istream_s **pb_istream_t**

typedef struct pb_ostream_s **pb_ostream_t**

Functions

void **iot_agent_free_service_descriptor**(nxp_iot_ServiceDescriptor **service_descriptor*)

Free all FT_POINTER fields of a service descriptor.

When selecting a service, a service descriptor is read from a datastore. A service descriptor can contain fields of variable length (binary data (certificates, etc.) or text (hostname, etc.)). Those fields use dynamically allocated memory. The memory is freed by calling this function.

Parameters

- `[in] service_descriptor`: Reference to service descriptor

void **iot_agent_free_update_status_report**(*nxp_iot_UpdateStatusReport* **status_report*)

Free all FT_POINTER fields of a update status report.

When a status report is filled during updating a device configuration, it contains pointer fields which use dynamically allocated memory. The memory is freed by calling this function.

Parameters

- `[in] status_report`: Reference to status_report

iot_agent_status_t **iot_agent_get_datastore_by_id**(**const** *iot_agent_context_t* **ctx*, **const** uint32_t *id*, *iot_agent_datastore_t* ***datastore*)

Get a reference to a datastore based on its identifier.

Return Value

- `IOT_STATUS_SUCCESS`: A datastore with the `id` was found in the agent's context and a pointer to it is returned in `datastore`.

iot_agent_status_t **iot_agent_get_datastore_index_by_id**(**const** *iot_agent_context_t* **ctx*, **const** uint32_t *id*, size_t **index*)

Get the index of a datastore based on its identifier.

Return Value

- `IOT_STATUS_SUCCESS`: A datastore with the `id` was found in the agent's context and its index is returned in `index`.

bool **iot_agent_get_endpoint_info**(void **context*, void **endpoint_information*)

Get an endpoint information of the endpoint.

Parameters

- `[in] context`: Reference to end point context

- `[in] endpoint_information`: Reference to end point information

iot_agent_status_t **iot_agent_get_keystore_by_id** (**const** *iot_agent_context_t *ctx*, **const** uint32_t *id*, *iot_agent_keystore_t **keystore*)

Get a reference to a keystore based on its identifier.

Return Value

- `IOT_STATUS_SUCCESS`: A keystore with the `id` was found in the agent's context and a pointer to it is returned in `keystore`.

iot_agent_status_t **iot_agent_get_keystore_index_by_id** (**const** *iot_agent_context_t *ctx*, **const** uint32_t *id*, size_t **index*)

Get the index of a keystore based in its identifier.

Return Value

- `IOT_STATUS_SUCCESS`: A keystore with the `id` was found in the agent's context and its index is returned in `index`.

size_t **iot_agent_get_number_of_services** (**const** *iot_agent_context_t *ctx*)

Returns total number of services of all registered datastores.

Parameters

- `[in] ctx`: Context for the iot_agent.

Return Value

- `Total`: number of services of all registered datastores

iot_agent_status_t **iot_agent_get_service_descriptor** (**const** *iot_agent_context_t *ctx*, nxp_iot_ServiceDescriptor **service_descriptor*)

Get the service descriptor of the currently selected service.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

Parameters

- `[in] ctx`: The context of the agent.
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

bool **iot_agent_handle_request** (*pb_istream_t *istream*, *pb_ostream_t *ostream*, **const** *pb_field_t *message_type*, void **context*)

handle request by end point

Parameters

- `[in] istream`: Input stream
- `[in] ostream`: Output stream
- `[in] message_type`: a pointer to the message type fields array
- `[in] context`: End point context

iot_agent_status_t **`iot_agent_init`** (*iot_agent_context_t *ctx*)

Initialize EdgeLock 2GO agent context memory with zeros.

Parameters

- `[inout] ctx`: EdgeLock 2GO agent context

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_init_dispatcher`** (iot_agent_dispatcher_context_t **dispatcher_context*, *iot_agent_context_t *agent_context*, nxp_iot_ServiceDescriptor **service_descriptor*, *nxp_iot_UpdateStatusReport *status_report*)

Initialize Dispatcher.

Parameters

- `[in] dispatcher_context`: Context for the dispatcher
- `[in] agent_context`: Context for the agent
- `[in] service_descriptor`: The service descriptor containing the connection parameters to connect to the EdgeLock 2GO cloud service.
- `[out] status_report`: A pointer to a structure that gets filled with a status report after the update is complete. If NULL is given, no status report is created.

bool **`iot_agent_is_service_configuration_data_valid`** (**`const`** *iot_agent_context_t *ctx*)

Checks whether service configuration data of all registered datastores is valid.

Parameters

- `[in] ctx`: Context for the iot_agent.

Return Value

- `true`: Service configuration data of all registered datastores is valid
- `false`: Service configuration data of a registered datastores is invalid

iot_agent_status_t **`iot_agent_register_datastore`** (*iot_agent_context_t *ctx*, *iot_agent_datastore_t *datastore*)

Register datastore endpoint.

Note that the ownership for the datastore is not transferred. The caller is responsible that the datastore is freed at the appropriate time.

It is not possible to register two endpoints with the same identifier.

Parameters

- `[in] ctx`: Context for the iot_agent.
- `[in] datastore`: Datastore that is registered.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_register_keystore`**(*iot_agent_context_t* **ctx*, *iot_agent_keystore_t* **keystore*)

Register a keystore endpoint.

Note that the ownership for the keystore is not transferred. The caller is responsible that the keystore is freed at the appropriate time.

It is not possible to register two endpoints with the same identifier.

Parameters

- `ctx`: Context for the iot_agent.
- `[in] keystore`: Keystore that is registered.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_select_service_by_id`**(*iot_agent_context_t* **ctx*, uint64_t *service_id*, nxp_iot_ServiceDescriptor **service_descriptor*)

Select service by given ID.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

See *iot_agent_is_service_configuration_data_valid*

Parameters

- `[in] ctx`: Context for the iot_agent.
- `[in] service_id`: ID of the service
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_select_service_by_index`**(*iot_agent_context_t* **ctx*, size_t *index*, nxp_iot_ServiceDescriptor **service_descriptor*)

Select service by given index.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

See *iot_agent_is_service_configuration_data_valid*

Parameters

- `[in] ctx`: Context for the iot_agent.
- `[in] index`: Index of the service
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_set_edgelock2go_datastore`** (*iot_agent_context_t* **ctx*, *iot_agent_datastore_t* **datastore*)

Set the datastore that is used to hold the information to connect to the EdgeLock 2GO cloud service.

Note that the ownership for the datastore is not transferred. The caller is responsible that the datastore is freed at the appropriate time.

iot_agent_status_t **`iot_agent_update_device_configuration`** (*iot_agent_context_t* **ctx*, *nxp_iot_UpdateStatusReport* **status_report*)

Update device configuration Reach out to EdgeLock 2GO cloud service for checking and (if applicable) fetching configuration updates for the device.

Post In case of success, the status_report structure is filled using dynamically allocated fields and needs to be freed after usage by calling #iot_agent_free_status_report.

Parameters

- `[in] ctx`: Context for the iot_agent.
- `[out] status_report`: Provides a more detailed view on the operations performed during the update and its outcomes. If the argument is NULL, no detailed status is reported.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success
- `IOT_AGENT_FAILURE`: Upon failure

iot_agent_status_t **`iot_agent_update_device_configuration_from_constants`** (*iot_agent_context_t* **agent_context*, uint32_t *client_key_object_id*, uint32_t *client_cert_object_id*, *nxp_iot_UpdateStatusReport* **status_report*)

Update device configuration.

Reach out to EdgeLock 2GO cloud service for checking and (if applicable) fetching configuration updates for the device.

The connection details (hostname/port/server root certificates, etc.) are taken from the configuration constants in nxp_iot_agent_config.h.

It is necessary that an sss keystore that contains credentials (client key and client certificate) for connecting to the EdgeLock 2GO cloud service. The object ids to those credentials are settable via function arguments.

Post In case of success, the status_report structure is filled using dynamically allocated fields and needs to be freed after usage by calling #iot_agent_free_status_report.

Parameters

- `[in] ctx`: Context for the iot_agent.
- `[out] status_report`: Provides a more detailed view on the operations performed during the update and its outcomes. If the argument is NULL, no detailed status is reported.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success
- `IOT_AGENT_FAILURE`: Upon failure

iot_agent_status_t **iot_agent_update_device_configuration_from_datastore**(iot_agent_context_t *agent_context, iot_agent_datastore_t *datastore, nxp_iot_UpdateStatusReport *status_report)

iot_agent_status_t **iot_agent_update_device_configuration_from_service_descriptor**(iot_agent_contex *agent_context, nxp_iot_ServiceD *service_descriptor, nxp_iot_UpdateS *status_report)

6.7.2 EdgeLock 2GO Datastore

group **edgelock2go_agent_datastore**

Functions that define how to interact with a datastore. There exist multiple concrete implementations for different microcontrollers.

Typedefs

typedef iot_agent_status_t (***iot_agent_datastore_allocator_t**)(void *context, size_t len)

typedef iot_agent_status_t (***iot_agent_datastore_committer_t**)(void *context)

typedef iot_agent_status_t (***iot_agent_datastore_destroyer_t**)(void *context)

typedef iot_agent_status_t (***iot_agent_datastore_reader_t**) (void *context, void *dst, size_t offset, size_t *len)

typedef iot_agent_status_t (***iot_agent_datastore_writer_t**) (void *context, size_t offset, **const** void *src, size_t len)

typedef struct _nxp_iot_ResponsePayload **nxp_iot_ResponsePayload**

Functions

bool **datastore_read_callback** (*pb_istream_t* **stream*, uint8_t **buf*, size_t *count*)

iot_agent_status_t **iot_agent_datastore_allocate** (*iot_agent_datastore_t* **datastore*, size_t *len*)

Allocate memory in a datastore.

Reserve memory in a datastore that can be written to by subsequent writes.

If the memory allocation fails, this function does not return IOT_AGENT_SUCCESS.

iot_agent_status_t **iot_agent_datastore_commit** (*iot_agent_datastore_t* **datastore*)

Commit a transaction to a datastore.

A call to this function indicates that all necessary writes of a transaction are done and the datastore contens can be considered valid.

This is the indication to the datastore to invalidate old contents and from point in time onwards use the data that was updated with the transaction tht is committed.

bool **iot_agent_datastore_encode_datastore_ok_response** (*pb_ostream_t* **ostream*)

iot_agent_status_t **iot_agent_datastore_free** (*iot_agent_datastore_t* **datastore*)

Destroy the datastore.

Depending on the type of the datastore this is triggering actions on the datastore's context itself by calling the _destroy() function of the datastore interface.

This does not free the context of the datastore.

The `datastore` is not usable after a call to iot_agent_datastore_free.

iot_agent_status_t **iot_agent_datastore_read** (*iot_agent_datastore_t* **datastore*, void **dst*, size_t *offset*, size_t **len*)

Read from a datastore to a buffer in memory.

Starting at position `offset`, `len` bytes are read from the datastore and copied to the memory pointed to by `dst`.

If the datastore does not hold `len` bytes or the read would be out of bounds, only as many bytes as available are read.

`len` is updated to hold the number of bytes that actually were read from the datastore.

No length checks on `dst` are performed, the caller is responsible that the memory location is writeable and can hold `len` bytes.

iot_agent_status_t **iot_agent_datastore_write** (*iot_agent_datastore_t* **datastore*, size_t *offset*, **const** void **src*, size_t *len*)

Write from a buffer in memory to a datastore.

From `src`, `len` bytes are copied to the datastore. The first byte is written to the position `offset` in the datastore.

Length check on the destaination - the datastore - is performed, memory in the datastore needs to be pre-allocated. If the data does not fit, this function does not return IOT_AGENT_SUCCESS.

struct datastore_stream_context_t

#include <nxp_iot_agent_datastore.h> A stream for reading contents from within a datastore, starting at an offset.

struct iot_agent_datastore_interface_t

#include <nxp_iot_agent_datastore.h> The interface any datastore needs to implement.

struct iot_agent_datastore_t

#include <nxp_iot_agent_datastore.h> A context holding the state of a datastore; this is passed to datastore interface functions.

6.7.3 EdgeLock 2GO Keystore

group **edgelock2go_agent_keystore**

Functions to interact with a keystore. There are concrete implementations of this API for different SEs.

Typedefs

typedef iot_agent_status_t (***iot_agent_keystore_destroyer_t**) (void *context)

typedef void (***iot_agent_keystore_session_closer_t**) (void *context)

typedef iot_agent_status_t (***iot_agent_keystore_session_opener_t**) (void *context)

typedef struct pb_field_s **pb_field_t**

typedef struct pb_istream_s **pb_istream_t**

typedef struct pb_ostream_s **pb_ostream_t**

Functions

void **iot_agent_keystore_close_session** (*iot_agent_keystore_t *keystore*)

Close a session/connection to a keystore.

iot_agent_status_t **iot_agent_keystore_free** (*iot_agent_keystore_t *keystore*)

Destroy the keystore.

Depending on the type of the keystore this is triggering actions on the keystore's context itself by calling the _destroy() function of the keystore interface.

This does not free the context of the keystore.

The `keystore` is not usable after a call to iot_agent_keystore_free.

iot_agent_status_t **iot_agent_keystore_open_session** (*iot_agent_keystore_t *keystore*)

Open a session/connection to a keystore.

struct iot_agent_keystore_interface_t

#include <nxp_iot_agent_keystore.h> The interface any keystore needs to implement.

struct iot_agent_keystore_t

#include <nxp_iot_agent_keystore.h> A structure binding a keystore interface and a keystore context to a keystore instance.

6.7.4 EdgeLock 2GO Session

group **`edgelock2go_agent_session`**

Session handling functions for the EdgeLock 2GO agent. When interacting with the OpenSSL engine, the agent session needs to be closed before and opened after OpenSSL is active.

Functions

iot_agent_status_t **`iot_agent_session_connect`** (ex_sss_boot_ctx_t **pSeBootCtx*)

Re-create an open a session with secure element

Parameters

- `[in] pCtx`: pointer to session context

Return Value

- `IOT_AGENT_SUCCESS`: upon success
- `IOT_AGENT_FAILURE`: upon failure

void **`iot_agent_session_disconnect`** (ex_sss_boot_ctx_t **pSeBootCtx*)

Disconnect and close session with secure element

Parameters

- `[in] pCtx`: pointer to session context

iot_agent_status_t **`iot_agent_session_init`** (int *argc*, **`const`** char **argv*[], ex_sss_boot_ctx_t **pCtx*)

Create an open a session with secure element

Parameters

- `[in] argc`: arguments from command-line if any
- `[in] argv`: arguments from command-line if any
- `[in] pCtx`: pointer to session context

Return Value

- `IOT_AGENT_SUCCESS`: upon success
- `IOT_AGENT_FAILURE`: upon failure

6.7.5 EdgeLock 2GO Service

group **`edgelock2go_agent_service`**

Functionality to work with service descriptors. A service descriptor represents all information from a single cloud provisioning.

Defines

`IOT_AGENT_CONFIGURATION_DATA_VERSION`

Typedefs

typedef configuration_data_header_t
The header of configuration data stored in a datastore.

typedef uint8_t **public_key_identifier_t**[16]

typedef uint8_t **service_identifier_t**[32]

Functions

void **iot_agent_service_free_service_descriptor**(nxp_iot_ServiceDescriptor **service_descriptor*)

Free all FT_POINTER fields of a service descriptor.

When selecting a service, a service descriptor is read from a datastore. A service descriptor can contain fields of variable length (binary data (certificates, etc.) or text (hostname, etc.)). Those fields use dynamically allocated memory. The memory is freed by calling this function.

Parameters

- `[in] service_descriptor`: Reference to service descriptor

size_t **iot_agent_service_get_number_of_services**(**const** *iot_agent_datastore_t* **ctx*)

Get the number of services that are available.

Return The number of services that are avilable.

Parameters

- `[in] ctx`: Context for the iot_agent.

iot_agent_status_t **iot_agent_service_get_protocol_of_service_as_string**(**const** nxp_iot_ServiceDescriptor **service_descriptor*, **const** char ***buffer*)

Get a textual description of the protocol.

Protocol strings are internal constant c-strings. This function returns a pointer to such a string, ownership remains with the iot_agent.

Parameters

- `[in] service_descriptor`: The service descriptor to get the protocol for.
- `[out] buffer`: A pointer to a c-string that is changed to point to the textual representation of the protocol.

Return Value

- `IOT_AGENT_SUCCESS`: The service type could be resolved.
- `IOT_AGENT_FAILURE`: The service type is invalid.

iot_agent_status_t **iot_agent_service_get_service_descriptor_of_service**(**const** *iot_agent_datastore_t* **data-store*, size_t *offset*, nxp_iot_ServiceDescriptor **service_descriptor*)

Get the service descriptor of a service specified by offset.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

See *iot_agent_is_service_configuration_data_valid*

Parameters

- `[in] ctx`: The datastore to query for the service.
- `[in] offset`: The offset of the service - the memory location in the given datastore.
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **iot_agent_service_get_service_offset_by_id**(**const** *iot_agent_datastore_t* **ctx*, uint64_t *service_id*, size_t **offset*, nxp_iot_ServiceDescriptor **service_descriptor*)

Get the offset and the service descriptor of a service specified by service_id.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

See *iot_agent_is_service_configuration_data_valid*

Parameters

- `[in] ctx`: The datastore to query for the service.
- `[in] service_id`: ID of the service
- `[out] offset`: The offset of the service descriptor within the datastore.
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_service_get_service_offset_by_index`**(**const** *iot_agent_datastore_t* **datastore*, size_t *index*, size_t **offset*, nxp_iot_ServiceDescriptor **service_descriptor*)

Get the offset and the service descriptor of a service specified by index.

Pre The configuration data associated to the context is valid.

Post In case of success, the service_descriptor structure is filled and needs to be freed after usage by calling *iot_agent_free_service_descriptor*. In case of failure no freeing is required. Also in case of failures, the contents of service_descriptor are not guaranteed to remain intact.

See *iot_agent_is_service_configuration_data_valid*

Parameters

- `[in] ctx`: The datastore to query for the service.
- `[in] index`: The index of the service (within the given datastore).
- `[out] service_descriptor`: Structure for holding a service descriptor. Must point to a valid service descriptor object upon invocation. Any FT_POINTER fields in the service descriptor are freed before changing the contents to the service_descriptor of the selected service.

Return Value

- `IOT_AGENT_SUCCESS`: Upon success

iot_agent_status_t **`iot_agent_service_get_service_type_as_string`**(**const** nxp_iot_ServiceDescriptor **service_descriptor*, **const** char ***buffer*)

Get a textual description of the service type.

Service type strings are internal constant c-strings. This function returns a pointer to such a string, ownership remains with the iot_agent.

Parameters

- `[in] service_descriptor`: The service descriptor to get the type for.
- `[out] buffer`: A pointer to a c-string that is changed to point to the textual representation of the service type.

Return Value

- `IOT_AGENT_SUCCESS`: The service type could be resolved.
- `IOT_AGENT_FAILURE`: The service type is invalid.

bool **`iot_agent_service_is_configuration_data_valid`**(**const** *iot_agent_datastore_t* **ctx*)

Checks service configuration data of all registered datastores are valid.

Parameters

- `[in] ctx`: Context for the iot_agent.

Return Value

- `true`: Service configuration data of all registered datastores are valid
- `false`: Service configuration data of a registered datastores is invalid

iot_agent_status_t **`iot_agent_service_read_buffer`**(**`const`** *iot_agent_datastore_t* **ctx*, size_t *offset*, void **buffer*, size_t *expected_len*)

void **`iot_agent_service_read_header`**(**`const`** *iot_agent_datastore_t* **ctx*, size_t *offset*, *configuration_data_header_t* **header*)

Variables

uint32_t **`length`**

Total length of the stored data (incl. all fields of configuration_data_header_t).

uint32_t **`number_of_services`**

Number of stored service configurations.

uint32_t **`version`**

Version number of the structure of the configuration data.

6.7.6 EdgeLock 2GO Dispatcher

group **`edgelock2go_agent_dispatcher`**

The dispatcher handles and decodes requests of endpoints.

Typedefs

`typedef` bool (***`get_endpoint_info_callback_t`**)(void *context, void *endpoint_information)

`typedef struct` *iot_agent_context_t* **`iot_agent_context_t`**

`typedef` bool (***`request_handler_callback_t`**)(*pb_istream_t* *istream, *pb_ostream_t* *ostream, **`const`** *pb_field_t* *message_type, void *endpoint_context)

Enums

`enum _iot_agent_stream_type_t`

Values:

`STREAM_TYPE_NETWORK` = 0U

Network stream

`STREAM_TYPE_BUFFER_REQUESTS` = 1U

Buffer stream in Requests format

Functions

bool **encode_responses_callback** (*pb_ostream_t *ostream*, **const** *pb_field_t *field*, void ***const** **arg*)

bool **encode_responses_from_payload** (*pb_ostream_t *ostream*, *nxp_iot_ResponsePayload *response_payload*)

bool **handle_request_payload** (*pb_istream_t *stream*, **const** *pb_field_t *field*, void ***arg*)

bool **handle_requests** (*pb_istream_t *stream*, **const** *pb_field_t *field*, void ***arg*)

iot_agent_status_t **iot_agent_dispatcher** (iot_agent_dispatcher_context_t **dispatcher_context*, *pb_istream_t *input*, *pb_ostream_t *output*)

Dispatcher.

Parameters

- `[in] dispatcher_context`: Context for the dispatcher
- `[in] input`: Input stream
- `[in] out`: Output stream

struct handle_request_payload_args_t

#include <nxp_iot_agent_dispatcher.h> Context structure for passing dispatcher information to callbacks for message decoding.

6.7.7 EdgeLock 2GO Utils

group **edgelock2go_agent_utils**

Utility functions for the EdgeLock 2GO agent for writing and generating key references and certificates.

Defines

NXP_IOT_AGENT_EDGELOCK2GO_CLIENT_CERTIFICATE_BUFFER_SIZE

The size of the buffer to reserve for the EdgeLock 2GO cloud service client certificate.

Typedefs

typedef struct *iot_agent_context_t* **iot_agent_context_t**

Functions

iot_agent_status_t **iot_agent_get_first_found_object** (*sss_key_store_t *keystore*, uint32_t **object_ids*, size_t *num_objects*, uint32_t **object_id*)

Maps a given service id to the range of keys that are managed by the EdgeLock 2GO cloud service.

Parameters

- `[in] service_id`: Service ID
- `[out] key_id`: Key ID

Return Value

- `IOT_AGENT_SUCCESS`: upon success
- `IOT_AGENT_FAILURE`: upon failure

iot_agent_status_t **`iot_agent_keystore_file_existence`**(**`const`** char **filename*, bool *forceCreation*)

Checks existence of a file. If required it forces creation of file.

Parameters

- `[in] filename`: Name of the file
- `[in] forceCreation`: Switch to force creation of the file

Return Value

- `IOT_AGENT_SUCCESS`: upon success
- `IOT_AGENT_FAILURE`: upon failure

iot_agent_status_t **`iot_agent_utils_get_certificate_common_name`**(*iot_agent_context_t* **ctx*, **`const`** nxp_iot_ServiceDescriptor **service_descriptor*, char **common_name*, size_t *max_size*)

Gets the common name from the client certificte.

Parameters

- `[in] ctx`: Context for the iot_agent
- `[in] service_descriptor`: Descriptor with service data
- `[inout] common_name`: Common name string
- `[in] max_size`: Maximum size

Return Value

- `IOT_AGENT_SUCCESS`: upon success
- `IOT_AGENT_FAILURE`: upon failure

iot_agent_status_t **`iot_agent_utils_get_edgelock2go_certificate_id`**(*sss_key_store_t* **keystore*, uint32_t **object_id*)

Checks whether a keystore contains the object with the defined certificate to use for authenticating at the EdgeLock 2GO cloud service.

The keystore might contain keys using ECC and/or RSA. If available, it will return the object id of the ECC certificate, otherwise the object id of the RSA certificate.

When neither is found or in case of other issues with the keystore, the function does not return IOT_AGENT_SUCCESS.

iot_agent_status_t **`iot_agent_utils_get_edgelock2go_key_id`**(*sss_key_store_t* **keystore*, uint32_t **object_id*)

Checks whether a keystore contains the object with the defined key to use for authenticating at the EdgeLock 2GO cloud service.

The keystore might contain keys using ECC and/or RSA. If available, it will return the object id of the ECC key, otherwise the object id of the RSA key.

When neither is found or in case of other issues with the keystore, the function does not return IOT_AGENT_SUCCESS.

iot_agent_status_t **`iot_agent_utils_write_edgelock2go_datastore`**(*iot_agent_keystore_t *keystore*, *iot_agent_datastore_t *datastore*, **const** char **hostname*, uint32_t *port*, **const** pb_bytes_array_t **trusted_root_ca_certificates*)

Assemble a service descriptor for the connection to EdgeLock 2GO cloud service and write it to a datastore.

It is assumed that credentials (either ECC or RSA) for client certificate authentication are stored in `keystore`.

iot_agent_status_t **`iot_agent_utils_write_edgelock2go_datastore_from_env`**(*iot_agent_keystore_t *keystore*, *iot_agent_datastore_t *datastore*)

Assemble a service descriptor for the connection to EdgeLock 2GO cloud service and write it to a datastore.

Per default this function takes the hostname and port from the defines

- EDGELOCK2GO_HOSTNAME and
- EDGELOCK2GO_PORT

For testing purposes, it is possible to set-up the connection parameters to the EdgeLock 2GO cloud service from externally by passing in information via environment variables.

The following env variables are considered:

- IOT_AGENT_TEST_EDGELOCK2GO_HOSTNAME
- IOT_AGENT_TEST_EDGELOCK2GO_PORT

It is assumed that credentials (either ECC or RSA) for client certificate authentication are stored in `keystore`.

6.8 EdgeLock 2GO Agent Examples

The usage of EdgeLock 2GO agent is demonstrated with the following example demo source code. The source code example is taken from the following file `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/iot_agent_demo.c`.

6.8.1 Initializaton of context and updating device configuration

Initialization of contexts of EdgeLock 2GO agent its keystores and datastores

```
    agent_status = iot_agent_init(&iot_agent_context);
    AGENT_SUCCESS_OR_EXIT();

        // print the uid of the device
        agent_status = iot_agent_print_uid((sss_se05x_session_t*)&pCtx->session);
        AGENT_SUCCESS_OR_EXIT();

    /************* Register keystore*************/

        agent_status = iot_agent_keystore_sss_se05x_init(&keystore, EDGELOCK2GO_
↪KEYSTORE_ID, pCtx, true);
        AGENT_SUCCESS_OR_EXIT();

        agent_status = iot_agent_register_keystore(&iot_agent_context, &keystore);
    AGENT_SUCCESS_OR_EXIT();

    /************* Register datastore*************/

        // This is the datastore that holds connection information on how to connect␣
↪to
        // the EdgeLock 2GO cloud service itself. Typically this would be a persistent
        // datastore which supports transactions to allow for atomic updates of
        // the URL/port/etc. If a filesystem is available, here, we use a file-based
        // datastore.
        // Note, that the ID of the datastore is a given.
#if DS_FS
        agent_status = iot_agent_datastore_fs_init(&edgelock2go_datastore,
                nxp_iot_DatastoreIdentifiers_DATASTORE_EDGELOCK2GO_ID,␣
↪gszEdgeLock2GoDatastoreFilename,
                &iot_agent_service_is_configuration_data_valid);
#elif DS_PLAIN
        agent_status = iot_agent_datastore_plain_init(&edgelock2go_datastore,
                nxp_iot_DatastoreIdentifiers_DATASTORE_EDGELOCK2GO_ID);
#endif
        AGENT_SUCCESS_OR_EXIT();

        // If the contents of the datastore for the connectin to the EdgeLock 2O␣
↪datastore
        // are not valid (e.g. on the first boot), fill the datastore with contents
        // from the settings contained in nxp_iot_agent_config.h
        if (!iot_agent_service_is_configuration_data_valid(&edgelock2go_datastore)) {
                iot_agent_utils_write_edgelock2go_datastore(&keystore, &edgelock2go_
↪datastore,
                        EDGELOCK2GO_HOSTNAME, EDGELOCK2GO_PORT, iot_agent_trusted_
↪root_ca_certificates);
        }

        // For connecting to the EdgeLock 2GO cloud service, we also need to register␣
↪the
        // datastore that contains the information on how to connect there.
        agent_status = iot_agent_set_edgelock2go_datastore(&iot_agent_context, &
↪edgelock2go_datastore);
        AGENT_SUCCESS_OR_EXIT();

#if DS_FS
        agent_status = iot_agent_datastore_fs_init(&datastore, 0U,␣
↪gszDatastoreFilename,
```

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```
                &iot_agent_service_is_configuration_data_valid);
        AGENT_SUCCESS_OR_EXIT();
#endif
#if DS_PLAIN
        agent_status = iot_agent_datastore_plain_init(&datastore, 0U);
        AGENT_SUCCESS_OR_EXIT();
#endif
        agent_status = iot_agent_register_datastore(&iot_agent_context, &datastore);
    AGENT_SUCCESS_OR_EXIT();
```

Update device configuration:

```
        agent_status = iot_agent_update_device_configuration(&iot_agent_context, &
↪status_report);

        // We have a status report which can have some details on the operations that␣
↪happened.
        // This gives the opportunity to programmatically react on errors/failures.␣
↪For demonstration
        // purpose, print that information to the console here.
        if ((agent_status == IOT_AGENT_SUCCESS || agent_status == IOT_AGENT_UPDATE_
↪FAILED) && status_report.has_status) {
                print_status_report(&status_report);
        }

        AGENT_SUCCESS_OR_EXIT();
```

Iterate over configured services and access credentials and service configuration data:

```
    if (!iot_agent_is_service_configuration_data_valid(&iot_agent_context))
    {
        EXIT_STATUS_MSG(IOT_AGENT_FAILURE, "Not all configuration data is valid");
    }

    // get total number of services
    number_of_services = iot_agent_get_number_of_services(&iot_agent_context);
    IOT_AGENT_INFO("Found configuration data for %d services.", (int) number_of_
↪services);
```

6.8.2 MQTT connection tests with Cloud Onboarding Provisioning

The example shows how to trigger the MQTT connection tests to the services when they are provisioned through the Cloud Onboaring Provisioning; the connection is triggered from following file: `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/iot_agent_demo.c`

```
#if (AX_EMBEDDED && defined(USE_RTOS) && USE_RTOS == 1) || (SSS_HAVE_HOSTCRYPTO_
↪OPENSSL)
    agent_status = iot_agent_verify_mqtt_connection(&iot_agent_context);
    AGENT_SUCCESS_OR_EXIT();
#endif
```

In case of FreeRTOS platform as LPC55S or FRDM_K64F the MQTT FreeRTOS client will be used for connection; implementation details can be found under `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/utils/iot_agent_mqtt_freertos.c`:

```
iot_agent_status_t iot_agent_verify_mqtt_connection_for_service(iot_agent_context_t*␣
↪iot_agent_context,
        const nxp_iot_ServiceDescriptor* service_descriptor)
{
    iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;
    agent_status = pubSub(iot_agent_context, service_descriptor);
    AGENT_SUCCESS_OR_EXIT_MSG("MQTT connection test failed");
exit:
    return agent_status;
}

iot_agent_status_t iot_agent_verify_mqtt_connection(iot_agent_context_t* iot_agent_
↪context)
{
    iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;
    size_t number_of_services = 0U;
        nxp_iot_ServiceDescriptor service_descriptor = nxp_iot_ServiceDescriptor_init_
↪default;

    number_of_services = iot_agent_get_number_of_services(iot_agent_context);
    for (size_t i = 0U; i < number_of_services; i++)
    {
                agent_status = iot_agent_select_service_by_index(iot_agent_context, i,
↪ &service_descriptor);
                AGENT_SUCCESS_OR_EXIT();

                agent_status = iot_agent_verify_mqtt_connection_for_service(iot_agent_
↪context, &service_descriptor);
                AGENT_SUCCESS_OR_EXIT();
        }
exit:
        iot_agent_free_service_descriptor(&service_descriptor);
    return agent_status;
}
```

In case of Open SSL platform as iMX6 or iMX8 the MQTT Paho client will be used for connection; implementation details can be found under `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/utils/iot_agent_mqtt_paho.c`:

```
iot_agent_status_t iot_agent_verify_mqtt_connection_for_service(iot_agent_context_t*␣
↪iot_agent_context, const nxp_iot_ServiceDescriptor* service_descriptor)
{
        iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;
        int mkdir_check = 0;

#if IOT_AGENT_MQTT_CONNECTION_TEST_ENABLE
        mqtt_connection_params_t connection_params = { 0 };
        iot_agent_status_t mqtt_status = IOT_AGENT_SUCCESS;
#endif
        //write to files

        char config_filename[256];
        char certificate_filename[256];
        char keyref_filename[256];
        char server_cert_filename[256];
        char metadata_filename[256];

```

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```
        const char* service_type_str;
        char service_dir[64];

        uint32_t keystore_id = service_descriptor->client_key_sss_ref.endpoint_id;
        iot_agent_keystore_t* keystore = NULL;
        agent_status = iot_agent_get_keystore_by_id(iot_agent_context, keystore_id, &
↪keystore);
        AGENT_SUCCESS_OR_EXIT();

    agent_status = iot_agent_keystore_open_session(keystore);
    AGENT_SUCCESS_OR_EXIT();

        agent_status = iot_agent_service_get_service_type_as_string(service_
↪descriptor, &service_type_str);
        AGENT_SUCCESS_OR_EXIT();

        if (ACCESS(goutput_directory, R_OK) != 0)
        {
                mkdir_check = DO_MKDIR(goutput_directory);
                ASSERT_OR_EXIT(mkdir_check == 0);
        }

        snprintf(service_dir, sizeof(service_dir), "%s%c%s%c", goutput_directory,␣
↪path_separator, service_type_str, path_separator);
        if (ACCESS(service_dir, R_OK) != 0)
        {
                mkdir_check = DO_MKDIR(service_dir);
                ASSERT_OR_EXIT(mkdir_check == 0);
        }

        snprintf(config_filename, sizeof(config_filename), "%s" SERVICE_CONFIGURATION_
↪PATTERN, service_dir, service_descriptor->identifier);
        snprintf(metadata_filename, sizeof(metadata_filename), "%s" SERVICE_METADATA_
↪PATTERN, service_dir, service_descriptor->identifier);
        snprintf(keyref_filename, sizeof(keyref_filename), "%s" SERVICE_KEYREF_
↪PATTERN, service_dir, service_descriptor->identifier);
        snprintf(certificate_filename, sizeof(certificate_filename), "%s" SERVICE_
↪CERTIFICATE_PATTERN, service_dir, service_descriptor->identifier);
        snprintf(server_cert_filename, sizeof(server_cert_filename), "%s" SERVICE_
↪SERVER_CERT_PATTERN, service_dir, service_type_str, service_descriptor->identifier);

        //create service files
        char relative_certificate_filename[128];
        char relative_keyref_filename[128];
        char relative_server_cert_filename[128];
        snprintf(relative_certificate_filename, sizeof(relative_certificate_filename),
↪ SERVICE_CERTIFICATE_PATTERN, service_descriptor->identifier);
        snprintf(relative_keyref_filename, sizeof(relative_keyref_filename), SERVICE_
↪KEYREF_PATTERN, service_descriptor->identifier);
        snprintf(relative_server_cert_filename, sizeof(relative_server_cert_filename),
↪ SERVICE_SERVER_CERT_PATTERN, service_type_str, service_descriptor->identifier);

        if (IOT_AGENT_SUCCESS != write_service_configuration(service_descriptor,␣
↪config_filename,
                relative_certificate_filename, relative_keyref_filename, relative_
↪server_cert_filename))
        {
```

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```
                write_error_logs(config_filename);
        }
        else
        {
                LOG_D("Created service configuration file [%s]", config_filename);
        }

        if (IOT_AGENT_SUCCESS != write_service_metadata(service_descriptor, metadata_
↪filename))
        {
                write_error_logs(metadata_filename);
        }
        else
        {
                LOG_D("Created metadata file [%s]", metadata_filename);
        }

        if (service_descriptor->server_certificate != NULL) {
                if (IOT_AGENT_SUCCESS != iot_agent_utils_write_certificate_
↪pem(service_descriptor->server_certificate->bytes,
                        (size_t)service_descriptor->server_certificate->size, server_
↪cert_filename))
                {
                        write_error_logs(server_cert_filename);
                }
                else
                {
                        LOG_D("Created server root certificate file [%s]", server_
↪cert_filename);
                }
        }

        if (service_descriptor->client_certificate != NULL) {
                if (IOT_AGENT_SUCCESS != iot_agent_utils_write_certificate_
↪pem(service_descriptor->client_certificate->bytes,
                        (size_t)service_descriptor->client_certificate->size,␣
↪certificate_filename))
                {
                        write_error_logs(certificate_filename);
                }
                else
                {
                        LOG_D("Created service client certificate file [%s]",␣
↪certificate_filename);
                }
        }

        if (IOT_AGENT_SUCCESS != iot_agent_utils_write_key_ref_service_pem(iot_agent_
↪context, keyref_filename))
        {
                write_error_logs(keyref_filename);
        }
        else
        {
                LOG_D("Created service keyref file [%s]", keyref_filename);
        }
        //write to files - end
```

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```
#if IOT_AGENT_MQTT_CONNECTION_TEST_ENABLE
        iot_agent_keystore_close_session(keystore);

        connection_params.keypath = keyref_filename;
        connection_params.devcert = certificate_filename;
        connection_params.rootpath = server_cert_filename;
        mqtt_status = iot_agent_mqtt_test(service_descriptor, &connection_params);

        agent_status = iot_agent_keystore_open_session(keystore);
        AGENT_SUCCESS_OR_EXIT();
#endif
exit:
        if (mqtt_status != IOT_AGENT_SUCCESS) {
                return mqtt_status;
        }
        return agent_status;
}

iot_agent_status_t iot_agent_verify_mqtt_connection(iot_agent_context_t* iot_agent_
↪context)
{
    iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;
    size_t number_of_services = 0U;
        nxp_iot_ServiceDescriptor service_descriptor = nxp_iot_ServiceDescriptor_init_
↪default;

    number_of_services = iot_agent_get_number_of_services(iot_agent_context);
        delete_old_service_files_folders(goutput_directory);
    AGENT_SUCCESS_OR_EXIT();

    for (size_t i = 0U; i < number_of_services; i++)
    {
                agent_status = iot_agent_select_service_by_index(iot_agent_context, i,
↪ &service_descriptor);
                AGENT_SUCCESS_OR_EXIT();

                agent_status = iot_agent_verify_mqtt_connection_for_service(iot_agent_
↪context, &service_descriptor);
                AGENT_SUCCESS_OR_EXIT();
        }
exit:
        iot_agent_free_service_descriptor(&service_descriptor);
    return agent_status;
}
```

6.8.3 MQTT connection tests with Remote Trust Provisioning

The example shows how to trigger the MQTT connection tests to the services when they are provisioned through the Remote Trust Provisioning; the connection is triggered from following file: `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/iot_agent_demo.c`

```
#if         ((AX_EMBEDDED && defined(USE_RTOS) && USE_RTOS == 1) || (SSS_HAVE_
↪HOSTCRYPTO_OPENSSL)) && (IOT_AGENT_COS_OVER_RTP_ENABLE == 1)
        // example code for MQTT conneciton when provisioning services as RTP objects
```

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```
        iot_agent_cleanup_mqtt_config_files_cos_over_rtp();
        AGENT_SUCCESS_OR_EXIT();
        // use this code for AWS services
        // modify the connection parameters to allow connection to your AWS account
        agent_status = iot_agent_get_mqtt_service_descriptor_for_aws(&iot_agent_
↪context, &aws_service_descriptor);
        AGENT_SUCCESS_OR_EXIT();
        // in case of AWS device auto-registration the MQTT connection will fail on␣
↪the first connection; in this
        // use case add additional call to the funcion iot_agent_verify_mqtt_
↪connection_cos_over_rtp
        agent_status = iot_agent_verify_mqtt_connection_cos_over_rtp(&iot_agent_
↪context, &aws_service_descriptor);
        AGENT_SUCCESS_OR_EXIT();

        // use this code for Azure services
        agent_status = iot_agent_get_service_descriptor_for_azure(&iot_agent_context,␣
↪&azure_service_descriptor);
        AGENT_SUCCESS_OR_EXIT();
        agent_status = iot_agent_verify_mqtt_connection_cos_over_rtp(&iot_agent_
↪context, &azure_service_descriptor);
        AGENT_SUCCESS_OR_EXIT();
#endif
```

To enable the MQTT connection for the RTP use case some manual adjustments needs to be done in the Agent code; the use case can be enabled by setting the variable IOT_AGENT_COS_OVER_RTP_ENABLE to 1 in the file `<SE05X_root_folder>/simw-top/nxp_iot_agent/inc/nxp_iot_agent_config.h`

The user has to setup some configuration parameters for the service to which he want to connect; this can be done by changing some definitions in the file: `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/inc/iot_agent_config.h`

```
// CHANGE THIS : fill with key pair and device certificate object IDs as defined on␣
↪EL2GO when generating them
#define AWS_SERVICE_KEY_PAIR_ID                0x83000101
#define AWS_SERVICE_DEVICE_CERT_ID        0x83000102

// CHANGE THIS: the AWS hostname to which the device will connect
#define AWS_HOSTNAME        "aw9969rp3sm22-ats.iot.eu-central-1.amazonaws.com"

// optional: the client ID will be by default set dynamically to the Common Name of␣
↪the
// device leaf certficate; is possible to hardcode it, by uncommenting the below␣
↪line and assign
// the desired value
//#define AWS_CLIENT_ID                "awsrtptest-0000000000001e6e-0000"

// CHANGE THIS: set the desired service ID; is used internally by the MQTT client,␣
↪should be unique
// for every service
#define AWS_SERVICE_ID        101

// CHANGE THIS : fill with key pair and device certificate object IDs as defined on␣
↪EL2GO when generating them
#define AZURE_SERVICE_KEY_PAIR_ID        0x83000211
#define AZURE_SERVICE_DEVICE_CERT_ID        0x83000212
```

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```
// CHANGE THIS : set the ID scope and the global endpoint as defined in the Azure DPS␣
↪account
#define AZURE_ID_SCOPE          "0ne004510C6"
#define AZURE_GLOBAL_DEVICE_ENDPOINT        "global.azure-devices-provisioning.net"

// optional: the registration ID will be by default set dynamically to the Common␣
↪Name of the
// device leaf certficate; is possible to hardocode it, by uncommenting the below␣
↪line and assign
// the desired value
//#define AZURE_REGISTRATION_ID        "azurertptest-0000000000001e51-0000"

// CHANGE THIS: set the desired service ID; is used internally by the MQTT client,␣
↪should be unique
// for every service
#define AZURE_SERVICE_ID        102
```

Depending on the service type the Service Descriptor should be set to include the correct connection data and object IDs of the Key Pair and X.509 device leaf certificate associated with the service. The following functions should be modified in the file `<SE05X_root_folder>/simw-top/nxp_iot_agent/ex/src/iot_agent_demo.c`

```
iot_agent_status_t iot_agent_get_mqtt_service_descriptor_for_aws(iot_agent_context_t*␣
↪iot_agent_context,
        nxp_iot_ServiceDescriptor* service_descriptor)
{
        iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;

        ASSERT_OR_EXIT_MSG(service_descriptor != NULL, "Service descriptor is null");

        // AWS Service type
        service_descriptor->identifier = AWS_SERVICE_ID;
        service_descriptor->has_service_type = true;
        service_descriptor->service_type = nxp_iot_ServiceType_AWSSERVICE;

        // service key pair
        service_descriptor->has_client_key_sss_ref = true;
        service_descriptor->client_key_sss_ref.object_id = AWS_SERVICE_KEY_PAIR_ID;
        service_descriptor->client_key_sss_ref.has_type = false;
        service_descriptor->client_key_sss_ref.type = nxp_iot_EndpointType_INVALID;
        service_descriptor->client_key_sss_ref.has_endpoint_id = true;
        service_descriptor->client_key_sss_ref.endpoint_id = EDGELOCK2GO_KEYSTORE_ID;
        service_descriptor->client_key_sss_ref.has_object_id = true;

        // client certificate
        service_descriptor->has_client_certificate_sss_ref = true;
        service_descriptor->client_certificate_sss_ref.object_id = AWS_SERVICE_DEVICE_
↪CERT_ID;
        service_descriptor->client_certificate_sss_ref.has_type = false;
        service_descriptor->client_certificate_sss_ref.type = nxp_iot_EndpointType_
↪INVALID;
        service_descriptor->client_certificate_sss_ref.has_endpoint_id = true;
        service_descriptor->client_certificate_sss_ref.endpoint_id = EDGELOCK2GO_
↪KEYSTORE_ID;
        service_descriptor->client_certificate_sss_ref.has_object_id = true;
```

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```
        // AWS server certificate
        service_descriptor->server_certificate = (pb_bytes_array_t*)&aws_root_server_
↪cert;
        service_descriptor->has_server_certificate_sss_ref = false;

        // AWS MQTT connection parameters
        char hostname[] = AWS_HOSTNAME;
        iot_agent_fill_service_char_array(&service_descriptor->hostname, hostname,␣
↪sizeof(hostname));

        service_descriptor->has_port = true;
        service_descriptor->port = 8883;
        service_descriptor->has_timeout_ms = true;
        service_descriptor->timeout_ms = 0x4E20;
        service_descriptor->has_protocol = true;
        service_descriptor->protocol = nxp_iot_ServiceProtocolType_MQTTS;

#ifdef AWS_CLIENT_ID
        char client_id[] = AWS_CLIENT_ID;
        iot_agent_fill_service_char_array(&service_descriptor->client_id, client_id,␣
↪sizeof(client_id));
#else
        service_descriptor->client_id = malloc(COMMON_NAME_MAX_SIZE);
        memset(service_descriptor->client_id, 0, COMMON_NAME_MAX_SIZE);
        agent_status = iot_agent_utils_get_certificate_common_name(iot_agent_context,␣
↪service_descriptor, service_descriptor->client_id, COMMON_NAME_MAX_SIZE);
        AGENT_SUCCESS_OR_EXIT();
#endif

        service_descriptor->username = NULL;
        service_descriptor->password = NULL;

        // fill metadata if any
        service_descriptor->customer_metadata_json = NULL;

exit:
        return agent_status;
}

iot_agent_status_t iot_agent_get_service_descriptor_for_azure(iot_agent_context_t*␣
↪iot_agent_context,
        nxp_iot_ServiceDescriptor* service_descriptor)
{
        iot_agent_status_t agent_status = IOT_AGENT_SUCCESS;

        ASSERT_OR_EXIT_MSG(service_descriptor != NULL, "Service descriptor is null");

        // Azure Service type
        service_descriptor->identifier = AZURE_SERVICE_ID;
        service_descriptor->has_service_type = true;
        service_descriptor->service_type = nxp_iot_ServiceType_AZURESERVICE;

        // service key pair
        service_descriptor->has_client_key_sss_ref = true;
        service_descriptor->client_key_sss_ref.object_id = AZURE_SERVICE_KEY_PAIR_ID;
        service_descriptor->client_key_sss_ref.has_type = false;
        service_descriptor->client_key_sss_ref.type = nxp_iot_EndpointType_INVALID;
```

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```
        service_descriptor->client_key_sss_ref.has_endpoint_id = true;
        service_descriptor->client_key_sss_ref.endpoint_id = EDGELOCK2GO_KEYSTORE_ID;
        service_descriptor->client_key_sss_ref.has_object_id = true;

        // service client certificate
        service_descriptor->has_client_certificate_sss_ref = true;
        service_descriptor->client_certificate_sss_ref.object_id = AZURE_SERVICE_
↪DEVICE_CERT_ID;
        service_descriptor->client_certificate_sss_ref.has_type = false;
        service_descriptor->client_certificate_sss_ref.type = nxp_iot_EndpointType_
↪INVALID;
        service_descriptor->client_certificate_sss_ref.has_endpoint_id = true;
        service_descriptor->client_certificate_sss_ref.endpoint_id = EDGELOCK2GO_
↪KEYSTORE_ID;
        service_descriptor->client_certificate_sss_ref.has_object_id = true;

        // Azure server certificate
        service_descriptor->server_certificate = (pb_bytes_array_t*)&azure_root_
↪server_cert;
        service_descriptor->has_server_certificate_sss_ref = false;

        // Azure MQTT connection parameters
        char azure_id_scope[] = AZURE_ID_SCOPE;
        iot_agent_fill_service_char_array(&service_descriptor->azure_id_scope, azure_
↪id_scope, sizeof(azure_id_scope));

        // the registration ID will be by defualt set dynamically to the Common Name␣
↪of the device leaf certficate;
        // it is possible to hardocode it, by uncommenting the AZURE_REGISTRATION_ID␣
↪in the configuration file
#ifdef AZURE_REGISTRATION_ID
        char azure_registration_id[] = AZURE_REGISTRATION_ID;
        iot_agent_fill_service_char_array(&service_descriptor->azure_registration_id,␣
↪azure_registration_id, sizeof(azure_registration_id));
#else
        service_descriptor->azure_registration_id = malloc(COMMON_NAME_MAX_SIZE);
        memset(service_descriptor->azure_registration_id, 0, COMMON_NAME_MAX_SIZE);
        agent_status = iot_agent_utils_get_certificate_common_name(iot_agent_context,␣
↪service_descriptor, service_descriptor->azure_registration_id, COMMON_NAME_MAX_
↪SIZE);
        AGENT_SUCCESS_OR_EXIT();
#endif

        char azure_global_device_endpoint[] = AZURE_GLOBAL_DEVICE_ENDPOINT;
        iot_agent_fill_service_char_array(&service_descriptor->azure_global_device_
↪endpoint, azure_global_device_endpoint, sizeof(azure_global_device_endpoint));

        service_descriptor->has_port = false;
        service_descriptor->port = 0;
        service_descriptor->has_timeout_ms = true;
        service_descriptor->timeout_ms = 0x4E20;
        service_descriptor->has_protocol = false;
        service_descriptor->username = NULL;
        service_descriptor->password = NULL;

        // fill metadata if any
        service_descriptor->customer_metadata_json = NULL;
```

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```
exit:
        return agent_status;
}
```

In the case of AWS auto-registration the Intermediate certificate used to sign the device leaf certificate needs to be presented to the cloud when doing the registration; EdgeLock 2GO offers the possibility to provision the intermediate CA together with the leaf certificate in one combined object. The MQTT Client on Embedded Linux devices is able to automatically load the combined object and execute the auto-registration. On FreeRTOS devices the dynamic loading is not implemented and the intermediate certificate must be provided in the code; to achieve this, the value of the #define keyJITR_DEVICE_CERTIFICATE_AUTHORITY_PEM in file `<SE05X_root_folder>/simw-top/demos/ksdk/common/aws_clientcredential_keys.h` must be filled with the value of the intermediate certificate in PEM format.

CHAPTER

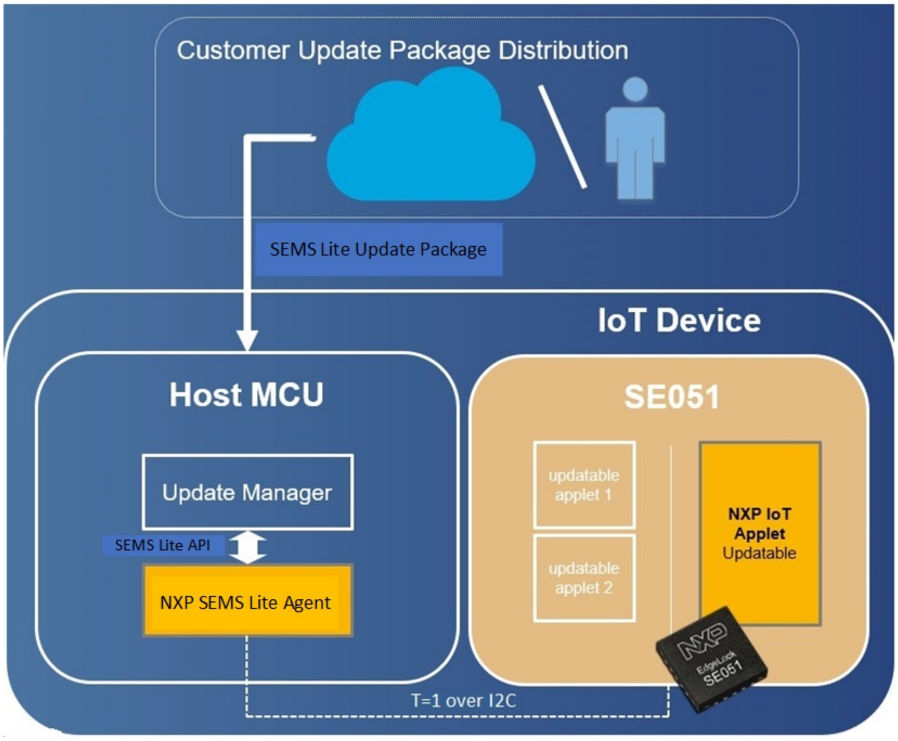
SEVEN

SEMS LITE AGENT

7.1 SEMS Lite Overview (Only for SE051)

SEMSLite enables the deployment and update of applets on SE in the field. When the applets are being upgraded, the data of previous/new applet remains inside the secure element only. Thus it securely preserves the device applet data.

Note: SEMS Lite is only supported for SE051.



7.1.1 Update Manager (from customer)

The role of update manager is as under:

- Securely downloading *update package* from its back-end
- Defining right time for update (depending on context: battery status, IoT device usage profile, etc.)
- Managing switching between current and new applet
- Optionally reporting update status to back-end

We provide some examples for update manager (Section 5.1.1 *SEMS Demos*)

7.1.2 SEMS Lite Agent (from NXP)

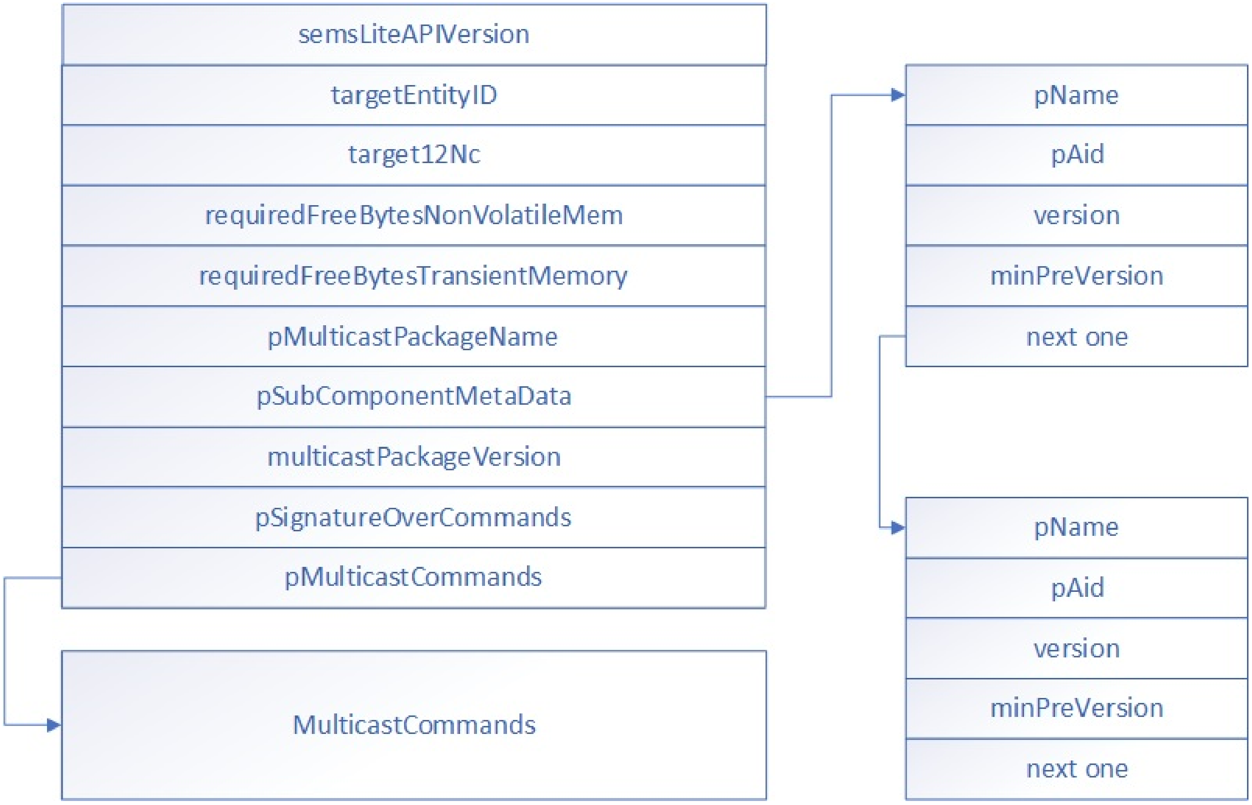
The role of SEMS Lite Agent is an under:

- Provide functional APIs to Update Manager
- It is a library/module that helps the *Update Manager* to query/know the state of the system
- Use the *update package* as received by the *Update Manager*, and update the Applet
- Track the update progress / interrupted updates
- Optionally retrieve loading receipt from the secure element.

7.2 Update Package

SEMS Lite agent gets an *update package* from the *update manager*. The upgrade package contains package meta data header and set of APDUs(MulticastCommands) to be sent to the SE for update. It may optionally also contain host control commands (e.g. Reset the secure element).

Format of the *update package*:



NXP provides customer package meta data and Multicast commands in JSON file. NXP also provides generator tool to turn the JSON file to binary file and .c/.h files. Customer can decide which one to be used by *update manager* according to their platform. *Update manager* should create *update package* from these files. This chapter has provided examples for the use of generator. It also provides links to the demos which will use the generated files to create *update package*.

7.2.1 Package Meta Data

Package meta data includes information such as version and memory requirement. These information will help SEMS Lite agent to preprocess package before loading APDU commands to SE.

- MulticastPackageFormatVersion: Version information of this json Format for MulticastPackages.
- TargetEntityID: Entity ID, 16bytes long Binary Coded Decimal, of the target device where this MulticastPackage is intended to be executed on. It is an identifier of the key-set of the Multicast Applet Loader.
- Target12nc: Target 12nc is a 12 digit numerical code identifying the target device where this MulticastPackage is intended to be executed on, as known to customers and used on EdgeLock2Go to identify device types.
- requiredFreeBytesNonVolatileMemory: Minimum required free Non Volatile memory in bytes that have to be available on the target device before execution of this MulticastPackage.
- requiredFreeBytesTransientMemory: Minimum required free transient (RAM) memory in bytes that have to be available on the target device before execution of this MulticastPackage.
- MulticastPackageName: Giving a descriptive name to the complete Multicast Package.
- MulticastPackageVersion: Version information of this MulticastPackage, describing the sum version over all contained content.
- SubComponentMetaData: A list of subcomponents of this MulticastPackage, designating all Executable Load Files (ELFs) Contained. It usually contains one entry, but can have multiple in the case multiple dependent ELFs get modified. This list can be empty, e.g. for a KeyRotation or deletion of content.
- SubComponentMetaData name: A human readable name for this subcomponent.
- SubComponentMetaData aid: The Application Identifier (AID) of the Executable Load File (ELF) which makes up the content of this subcomponent. This is stored as string to have it formatted in upper-case hexadecimal and therefore recognizable form.
- SubComponentMetaData version: Version information of this subcomponent.
- SubComponentMetaData minimumPreviousVersion: Minimum version number of this subcomponent as installed on the secure element before this script is executed. If this field is omitted there is no minimum version requirement, e.g. initial Installation of an applet.
- SignatureOverCommands: The signature over the multicast commands in an machine readable form. So it does not have to be parsed form the script commands. String encoding (upper-case hexadecimal) is chosen here, as many json parsers can not handle such large integer values.
- MulticastCommands: The complete Multicast Applet Loader Script (certificate, signature, encrypted and signed commands) in ls-cgt format, encoded in base64.

7.2.2 MulticastCommands In Protocol Buffer Format

Note: Advanced information

The information below is for advanced users and kept here for the sake of completeness of information. This section can be skipped.

Technically, the APDUS(MulticastCommands) in *update package* is encoded in Protocol Buffers format (https://developers.google.com/protocol-buffers/) as defined below

```
/* Full request from cloud/host to the agent */
message Requests {
  /* An array of RequestPayload */
  repeated RequestPayload payload = 1;
}

/* Consolidated response from the agent to the cloud/host */
message Responses {
  /* An array of ResponsePayload */
  repeated ResponsePayload responses = 1;
}
```

```
/* The request payload would be either of these */
message RequestPayload {
  oneof payload {
    /* Hello from EdgeLock 2GO cloud service to the EdgeLock 2GO agent.
     *
     * Used only by EdgeLock 2GO agent. */
    AgentHelloRequest hello = 1;
    /** Good Bye from EdgeLock 2GO cloud service to the EdgeLock 2GO agent.
     *
     * Used only by EdgeLock 2GO agent. */
    AgentGoodbyeRequest goodbye = 2;
    AgentCrlRequest crl = 3;
    /* An APDU to a SE.
     *
     * Used both by EdgeLock 2GO agent and SEMS Lite agent. */
    ApduRequest apdu = 20;
    /* Message to read and write configuration data.
     *
     * Used only by EdgeLock 2GO agent. */
    DatastoreRequest datastore = 30;
    /* Message to contol the host software on the device.
     *
     * Not implemented. */
    RpcRequest rpc = 40;
    /*
     *
     * Used only by SEMS Lite Agent */
    HostControlCmdRequest hostCmd = 50;
  }
}
```

```
message ApduRequest {

    /* Array of bytes to be sent to the SE */
    optional bytes message = 100;

    /* What response is expected from the SE for this APDU?
     *
     * If this field is skipped from protobuf, then,
     * only 0x9000 is expected from the SE
     *
     * There are potentially multiple distinct values
     * are expected the from the SE, then this
     * can be an array of those values.
     *
```

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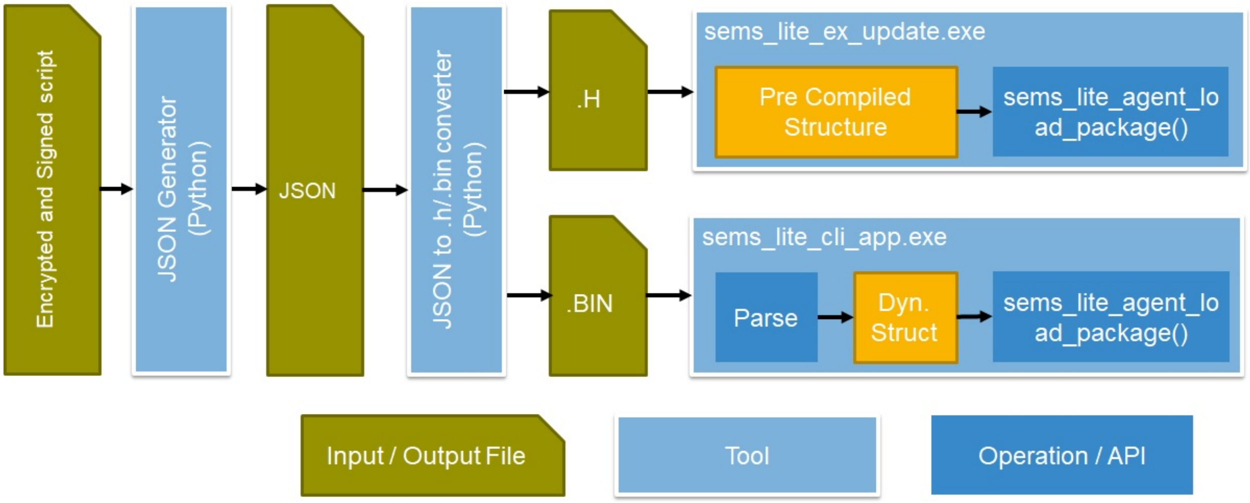
```
     *      e.g.    expectation: [ 0x9000, 0x6A82 ]
     *
     * For complex schems where a every big range/mask
     * is expected, e.g. 6AXX, 6DXX then the upper
     * 16 bits are treated as mask.
     *
     *      e.g.    expectation: [ 0x00FF6A00, 0x00FF6D00 ]
     *
     * This field is unused by EdgeLock 2GO cloud service.
     */
    repeated uint32 expectation = 101;
}


/* Response from the SE to host */
message ApduResponse {
    /* Byte array */
    optional bytes message = 100;
}
```

7.2.3 Generator Tools

NXP provides 2 generator tools in `semslit/tools/sems-lite-generator` directory:

- JSON Generator: A tool to convert the output of CGT tool to a JSON format output
- SEMS Lite generator: A tool to convert JSON output to binary file and .c/.h files which will be used by *update manager*



JSON Generator

Usage: MulticastPackageCli.py [-h] –config_file [CONFIG_FILE] –script_file [SCRIPT_FILE] –out [OUT]

Arguments:

- **–config_file [CONFIG_FILE]** Config File for MulticastPackage generation. It should follow the format defined in `semslit/tools/sems-lite-generator/schema/MulticastPackage.`

`jsonschema`. NXP provides an example in `semslit/tools/sems-lite-generator/config/ExampleConfig.json`

- **–script_file [SCRIPT_FILE]** Encrypted and Signed script as output by the ls-cgt tool.
- **–out [OUT]** Output MulticastPackage json file.

Example:

> python ./MulticastPackageCli.py –config_file .config.json –script_file .encrypted.txt –out .Upgrade_IoTApplet.json

SEMS Lite Generator

Usage: generate.py [-h] [-i INPUT_JSON] [-o OUTPUT_PATH] [-n NAME] [-p PROTOC_PATH]

Process sems-lite-generator arguments

Arguments:

-h, --help	show this help message and exit
-i, --input_json INPUT_JSON	input json file
-o, --output_path OUTPUT_PATH	output folder path
-n, --name NAME	stem name of output files. By default, it would use the same name as input json file.
-p, --protoc_path PROTOC_PATH	protoc file path. Use tools/mw_onverter/protoc.exe by default

Example:

> python ./generate.py -i ./Upgrade_NXP-IoTApplet-6.0.json -o ./

The generated files:

- Upgrade_NXP-IoTApplet-6.0.bin: Binary file. It can be used for platforms that have a file system (Windows, Linux, etc). It is encoded in TLV as following:

```
0x21  Len                               multicastPackage
  |-  0x22  Len  Major Minor            MulticastPackageFormatVersion
  |-  0x23  Len  Binary                 TargetEntityID
  |-  0x2f  Len  Binary                 Target12nc
  |-  0x24  Len  u32/u16                requiredFreeBytesNonVolatileMemory
  |-  0x25  Len  u32/u16                requiredFreeBytesTransientMemory
  |-  0x26  Len  String                 MulticastPackageName
  |-  0x27  Len  Major Minor            MulticastPackageVersion
  |-  0x28  Len  SubComponentMetaData
  |-     |-  0x2B  Len  String          SubComponentMetaData1.name
  |-     |-  0x2C  Len  Binary          SubComponentMetaData1.aid
  |-     |-  0x2D  Len  Major Minor     SubComponentMetaData1.version
  |-     |-  0x2E  Len  Major Minor     SubComponentMetaData1.minimumPreviousVersion
  |-     |-  0x2B  Len  String          SubComponentMetaData2.name
  |-     |-  0x2C  Len  Binary          SubComponentMetaData2.aid
  |-     |-  0x2D  Len  Major Minor     SubComponentMetaData2.version
  |-     |-  0x2E  Len  Major Minor     SubComponentMetaData2.minimumPreviousVersion
  ...
  |-     |-  0x2B  Len  String          SubComponentMetaDataN.name
  |-     |-  0x2C  Len  Binary          SubComponentMetaDataN.aid
  |-     |-  0x2D  Len  Major Minor     SubComponentMetaDataN.version
```

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```
  |-    |-  0x2E  Len  Major Minor    SubComponentMetaDataN.minimumPreviousVersion
  |-  0x29  Len  Binary               SignatureOverCommands
  |-  0x2A  Len  Binary               MulticastCommands
```

- Upgrade_NXP-IoTApplet-6.0.c and .h: These 2 files instantiate *update package*. They can be integrated into customer tools and can be used for all platforms.

We provide examples for how to use the generated files: Section 5.1.1 *SEMS Demos*

Generator Tool Version Compatibility

NXP provides both SEMS Lite generate tool and JSON format in semslite\tools folder. Generate tool should only work with the JSON schema in the same release. For example, in SEMS Lite 2.0.0 (Refer to semslite\version_info.txt) the JSON package format version is 1.2. Generate tool should only use this JSON schema.

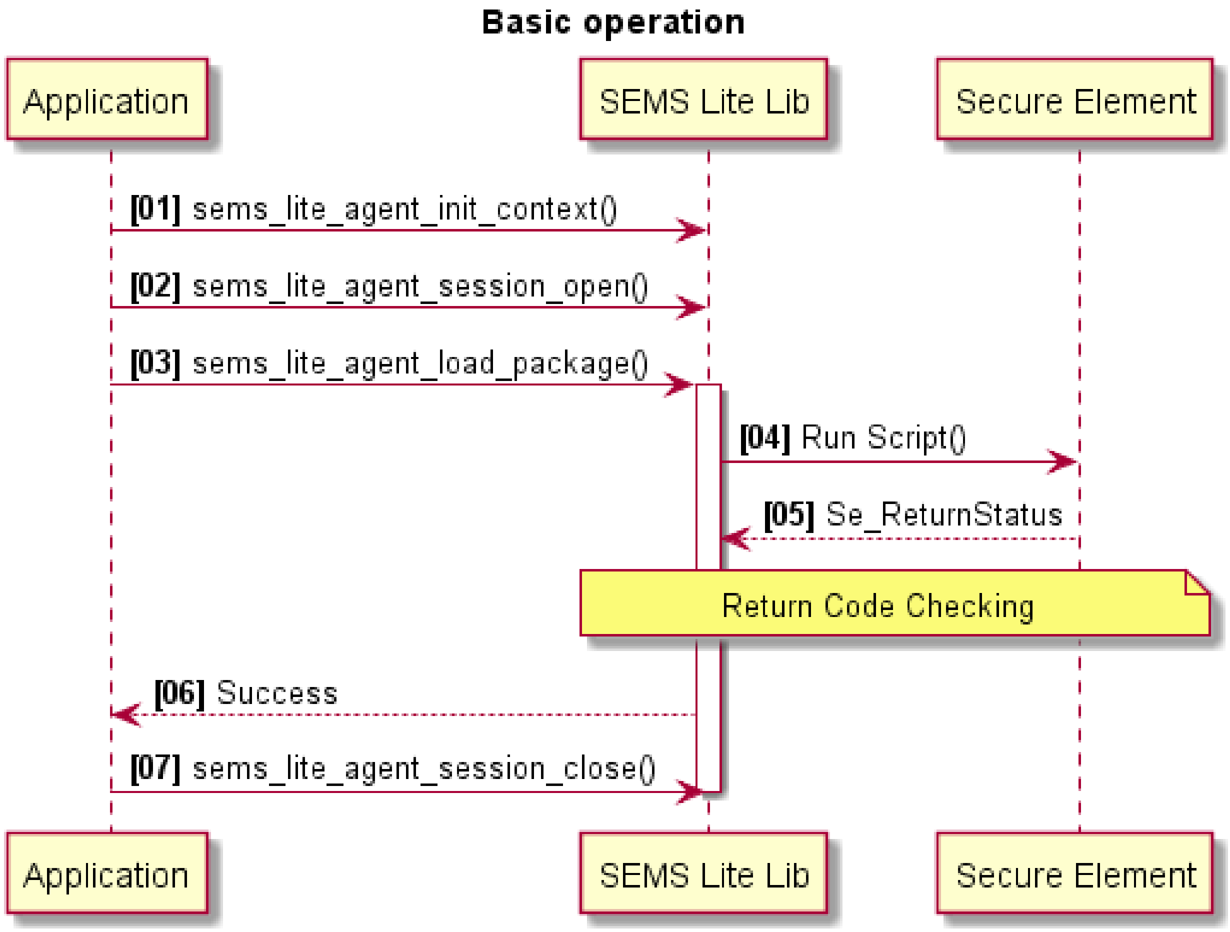
	`JSON package format 1.1`	`JSON package format 1.2`
SEMS Lite 1.0.0	Supported	Not supported
SEMS Lite 2.0.0	Not supported	Supported

7.3 SEMS Lite Agent Usage

7.3.1 Case 1: Basic Usage

Basic API usage documentation for using SEMS Lite agent is as under.

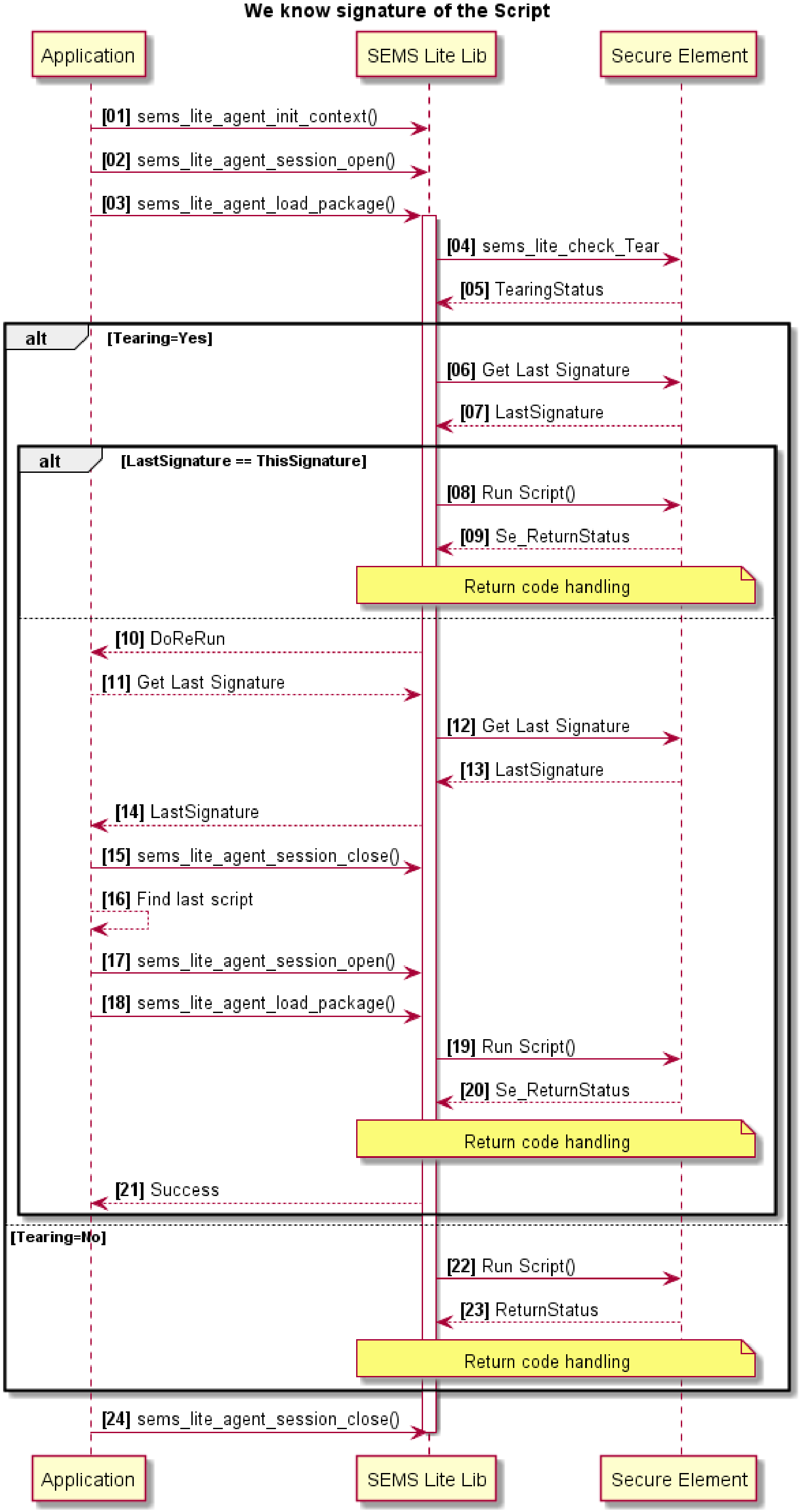
1. Call `sems_lite_agent_init_context()` to do context initialization.
2. Call `sems_lite_agent_session_open()` to open channel to SE and select SEMS Lite applet.
3. Call `sems_lite_agent_load_package()` to load upgrade script.
4. SEMS Lite agent would internally query the tear status from SE051, if there was a power interrupt during upgradation(tearing event).
5. SEMS Lite agent load the script from package to SE051 and get response from SE051.
6. SEMS Lite agent checking the response and return "Success" to user.
7. User call `sems_lite_agent_session_close()` to close channel.



7.3.2 Case 2: In case there was a tearing

In case of tear which is due to system power off during uploading, user would receive return code “DoRerun” when he try to load new package. Use must load the torn again.

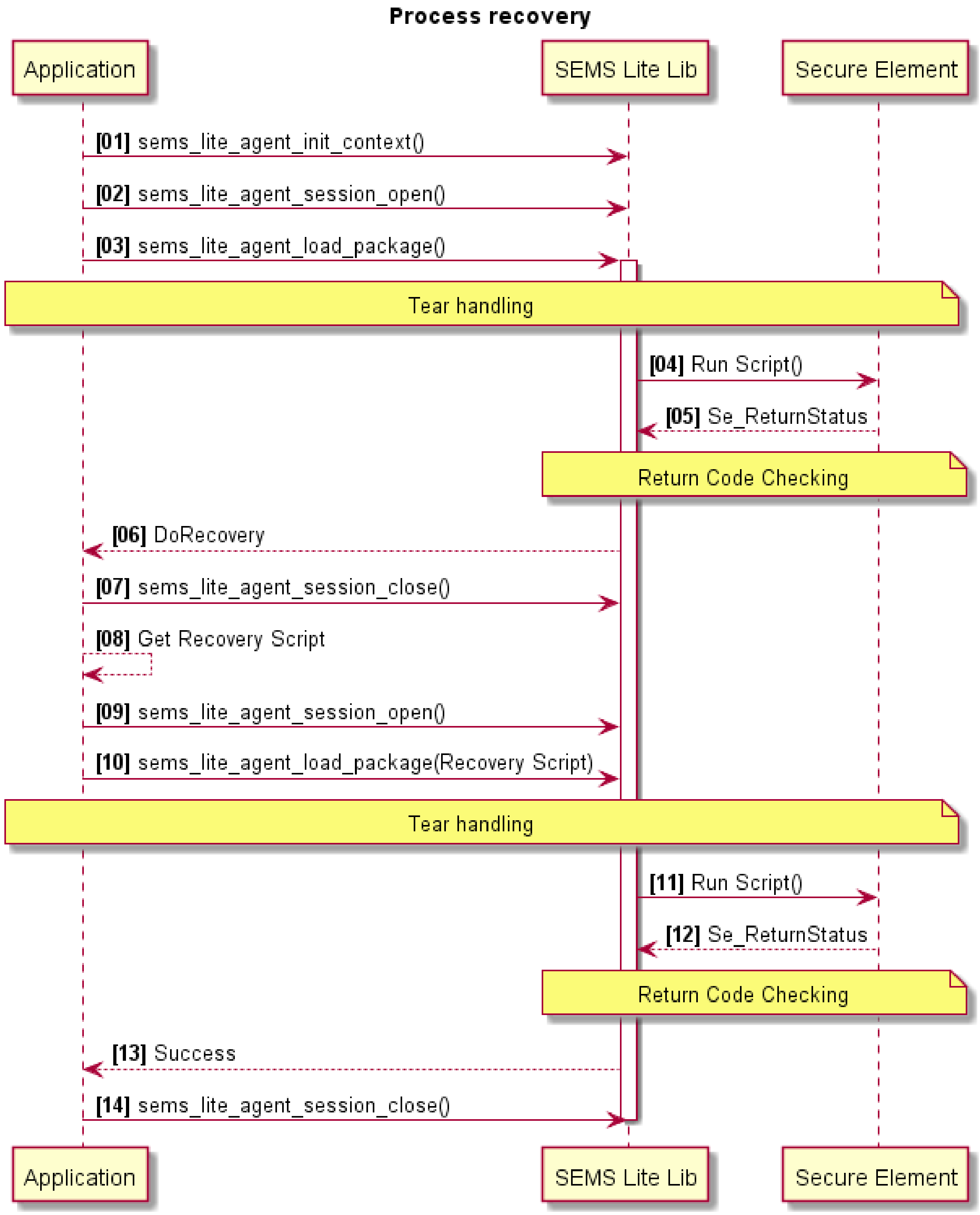
1. Call `sems_lite_agent_init_context()`, `sems_lite_agent_session_open()` and `sems_lite_agent_load_package()` as those in *Case 1: Basic Usage*.
2. SEMS Lite agent would query tear status from SE.
3. In case tear happens, SEMS Lite agent would get signature of tear script from SE and compare it to the signature of loaded script.
4. If these 2 signatures are same, it means the loaded script is the re-run script. SEMS Lite agent load it to SE.
5. If the signatures are different, SEMS Lite agent would inform user to load script again.
6. User must find the correct script by signature and load it again.


We know signature of the Script
Application
SEMS Lite Lib
Secure Element
[01] sems_lite_agent_init_context()
[02] sems_lite_agent_session_open()
[03] sems_lite_agent_load_package()
[04] sems_lite_check_Tear
[05] TearingStatus
alt
[Tearing=Yes]
[06] Get Last Signature
[07] LastSignature
alt
[LastSignature == ThisSignature]
[08] Run Script()
[09] Se_ReturnStatus
Return code handling
[10] DoReRun
[11] Get Last Signature
[12] Get Last Signature
[13] LastSignature
[14] LastSignature
[15] sems_lite_agent_session_close()
[16] Find last script
[17] sems_lite_agent_session_open()
[18] sems_lite_agent_load_package()
[19] Run Script()
[20] Se_ReturnStatus
Return code handling
[21] Success
[Tearing=No]
[22] Run Script()
[23] ReturnStatus
Return code handling
[24] sems_lite_agent_session_close()
Application
SEMS Lite Lib
Secure Element

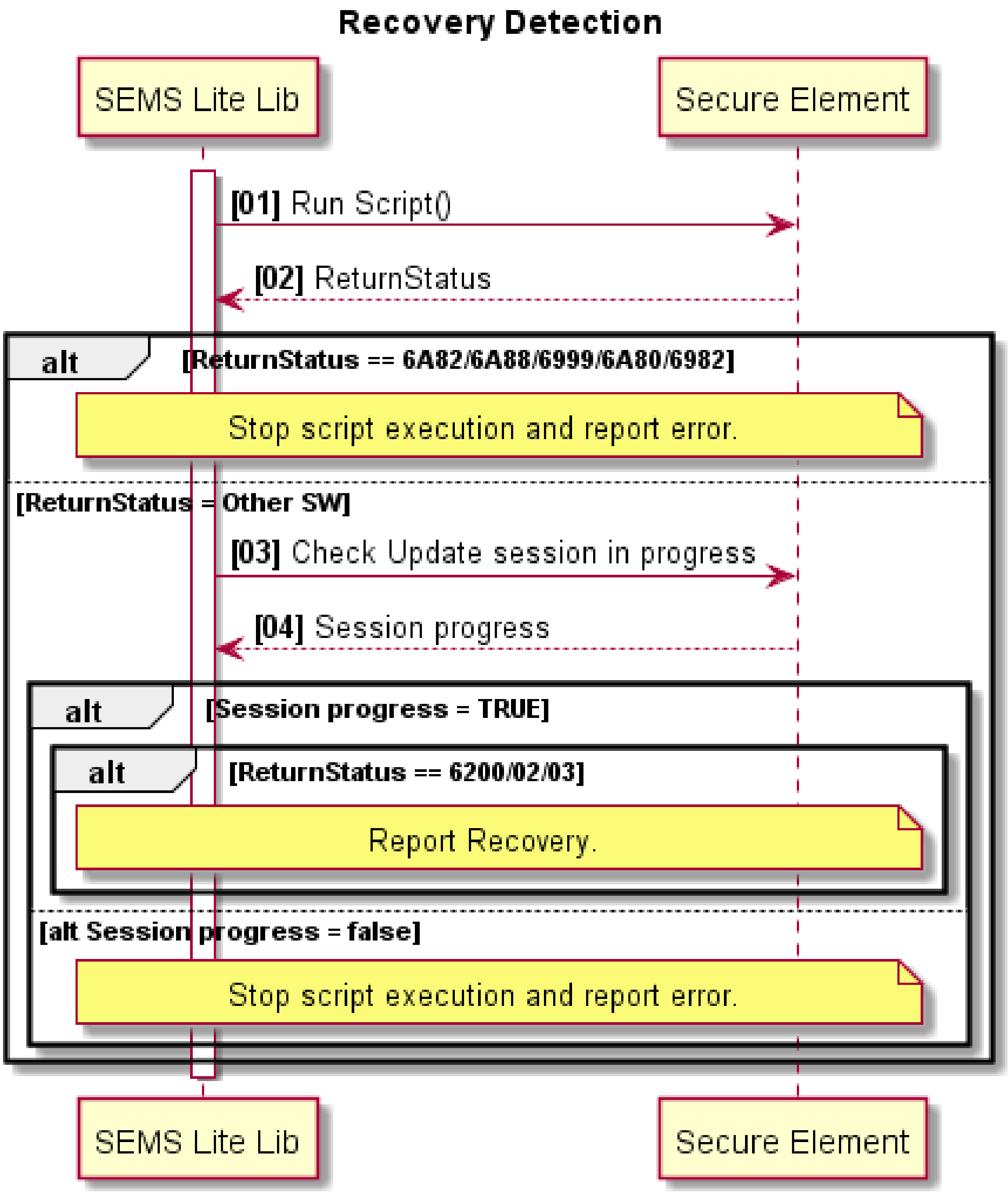
7.3.3 Case 3: Doing a recovery after a failed update

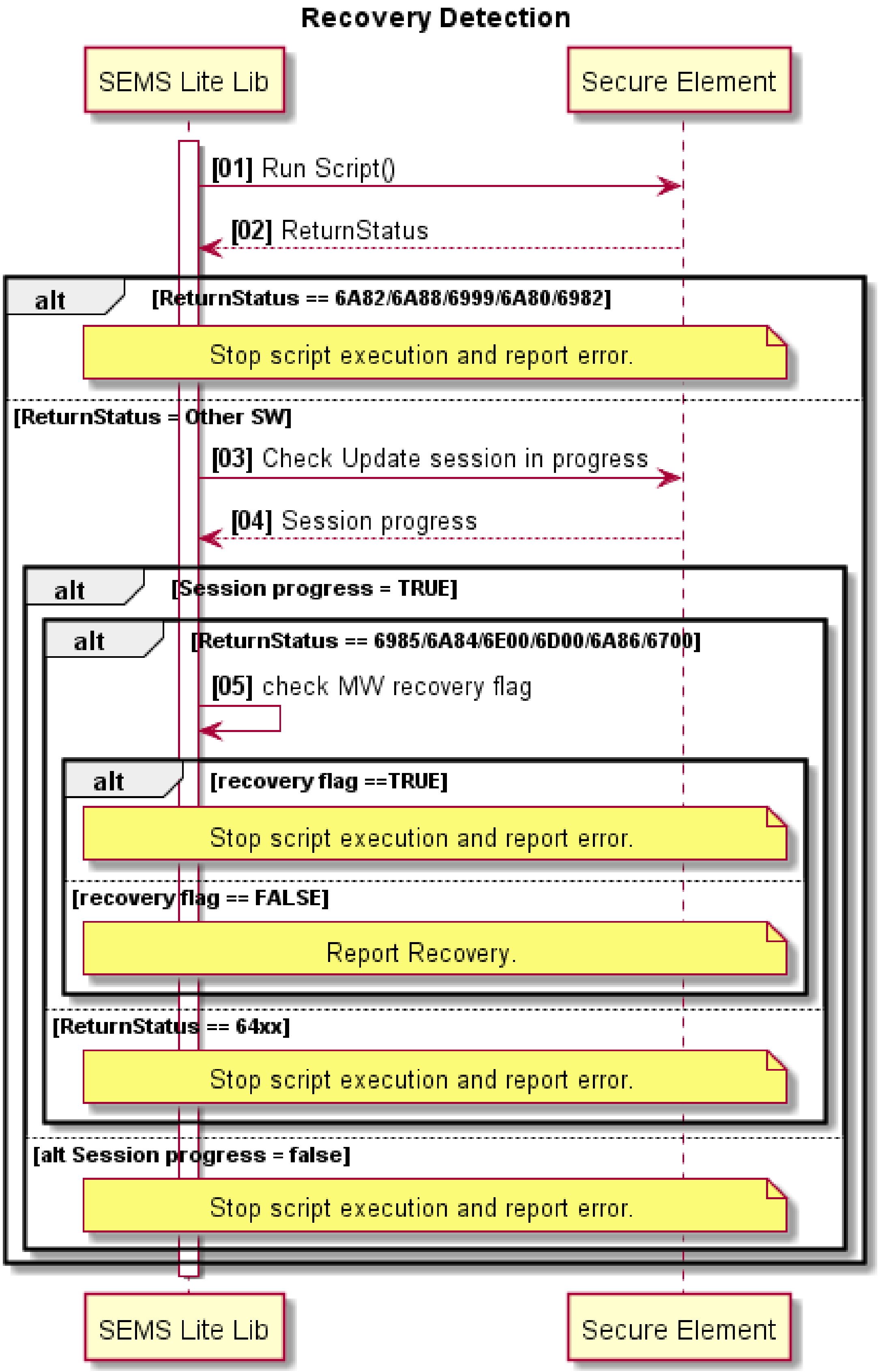
In case the upgrade can not complete, user would receive return code “Do Recovery”. User must load recovery script to resume SE to old Applet.

1. Call `sems_lite_agent_init_context()`, `sems_lite_agent_session_open()` and `sems_lite_agent_load_package()` as those in *Case 1: Basic Usage*.
2. SEMS Lite agent would query tear status from SE as in *Case 2: In case there was a tearing*.
3. SEMS Lite agent load the script from package to SE. SE can’t complete upgrade and inform SEMS Lite agent to do recovery by response.
4. SEMS Lite agent checking the response and return “DoRecovery” to user.
5. User must find the recovery script which is used to load the old Applet.
6. User load the recovery script and get response from SEMS Lite agent.



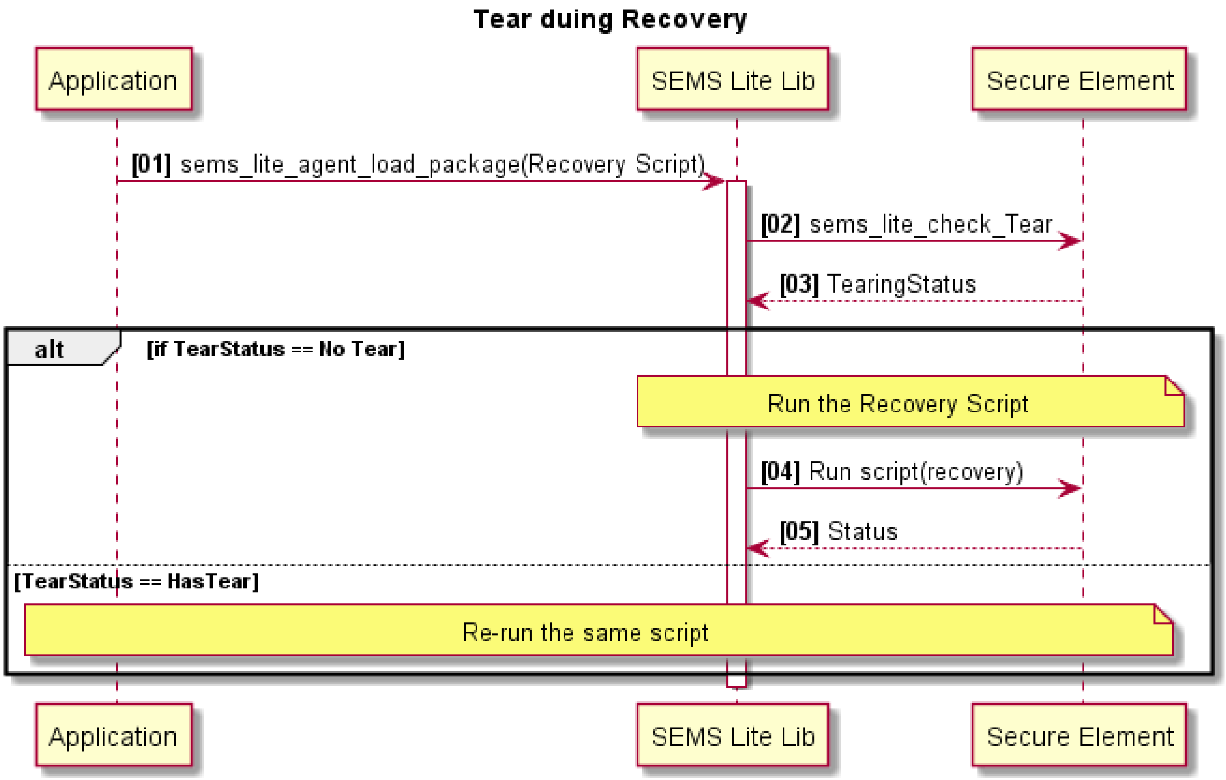
Details for SE to report “Do Recovery” can be found in following:


Recovery Detection
SEMS Lite Lib
Secure Element
[01] Run Script()
[02] ReturnStatus
alt
[ReturnStatus == 6A82/6A88/6999/6A80/6982]
Stop script execution and report error.
[ReturnStatus = Other SW]
[03] Check Update session in progress
[04] Session progress
alt
[Session progress = TRUE]
alt
[ReturnStatus == 6200/02/03]
Report Recovery.
[alt Session progress = false]
Stop script execution and report error.
SEMS Lite Lib
Secure Element


Recovery Detection
SEMS Lite Lib
Secure Element
[01] Run Script()
[02] ReturnStatus
alt
[ReturnStatus == 6A82/6A88/6999/6A80/6982]
Stop script execution and report error.
[ReturnStatus = Other SW]
[03] Check Update session in progress
[04] Session progress
alt
[Session progress = TRUE]
alt
[ReturnStatus == 6985/6A84/6E00/6D00/6A86/6700]
[05] check MW recovery flag
alt
[recovery flag ==TRUE]
Stop script execution and report error.
[recovery flag == FALSE]
Report Recovery.
[ReturnStatus == 64xx]
Stop script execution and report error.
[alt Session progress = false]
Stop script execution and report error.
SEMS Lite Lib
Secure Element

7.3.4 Case 4: Tearing during recovery

Case 4: In case tear happens when loading recovery package, User should re-run the script in the same way described in *Case 2: In case there was a tearing*.



7.3.5 Case 5: Load Key rotate script encounter SE unexpected power off

In case the SE is powered off unexpectedly during uploading key rotate script, user would receive return code "COM_FAILURE" which means communication failure. User has 2 choices:

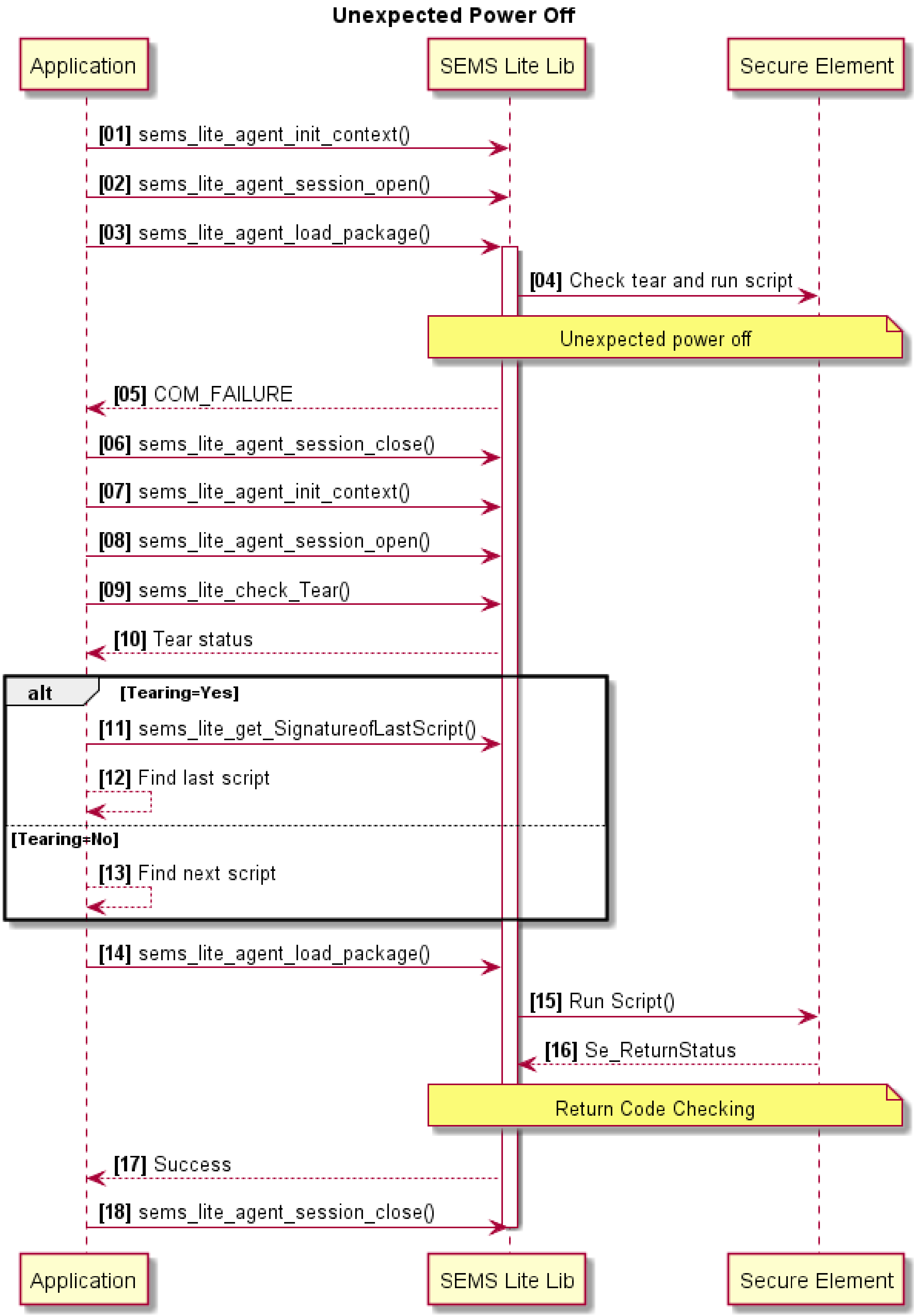
1. Load next script. SEMS Lite agent will check tear status and inform user if it's required to re-run last script. It's same to *Case 2: In case there was a tearing*.
2. User software checks tear status and then decides whether to re-load the broken script as following:

i) Call `sems_lite_agent_init_context()` and `sems_lite_agent_session_open()` as those in *Case 1: Basic Usage*.

ii) Call `sems_lite_check_Tear()` to decide if tear happens for last upgrade.

iii) In case tear happens, call `sems_lite_get_SignatureofLastScript()` to get last script signature

iv) Find the correct script by signature and load the tear script again with `sems_lite_agent_load_package()`.


Unexpected Power Off
Application
SEMS Lite Lib
Secure Element
[01] sems_lite_agent_init_context()
[02] sems_lite_agent_session_open()
[03] sems_lite_agent_load_package()
[04] Check tear and run script
Unexpected power off
[05] COM_FAILURE
[06] sems_lite_agent_session_close()
[07] sems_lite_agent_init_context()
[08] sems_lite_agent_session_open()
[09] sems_lite_check_Tear()
[10] Tear status
alt
[Tearing=Yes]
[11] sems_lite_get_SignatureofLastScript()
[12] Find last script
[Tearing=No]
[13] Find next script
[14] sems_lite_agent_load_package()
[15] Run Script()
[16] Se_ReturnStatus
Return Code Checking
[17] Success
[18] sems_lite_agent_session_close()
Application
SEMS Lite Lib
Secure Element

7.3.6 API Calls for Usage of SEMS Lite Agent

```
#include "sems_lite_api.h"
```

Declare a SEMS Lite input buffer: SEMS Lite input buffer is hex file converted from protobuf file

Declare SEMS Lite context: SEMS Lite context holds flags and variables used through the whole loading process

```
sems_lite_agent_ctx_t s_sems_lite_agent_ctx = {0};
```

Initilize the context:

```
rv = sems_lite_agent_init_context(&s_sems_lite_agent_ctx, &pCtx->session);
```

Open session:

```
rv = sems_lite_agent_session_open(&s_sems_lite_agent_ctx);
```

Load Package:

```
status = sems_lite_agent_load_package(
    &s_sems_lite_agent_ctx, &multicast_package);
```

Close the session:

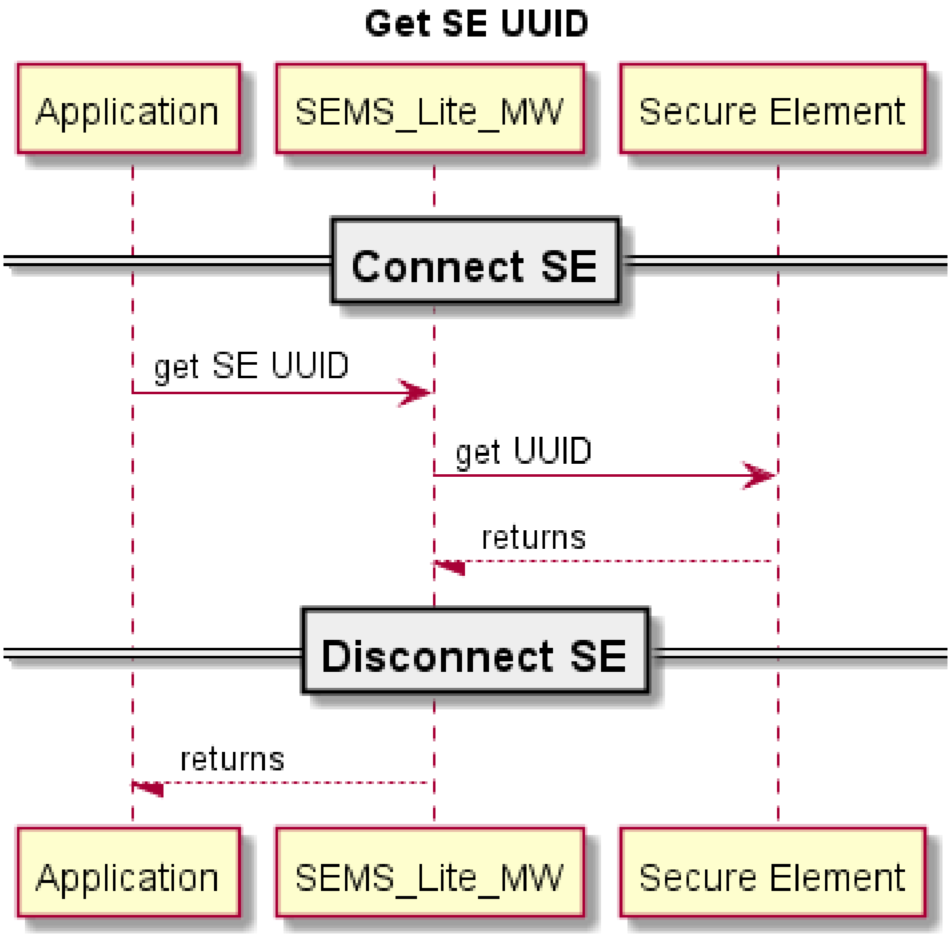
```
rv = sems_lite_agent_session_close(&s_sems_lite_agent_ctx);
```

7.4 SEMS Lite management APIs

SEMS Lite management API request data to SE. .. TODO To be received from SEMS Lite Applet interface documentation.

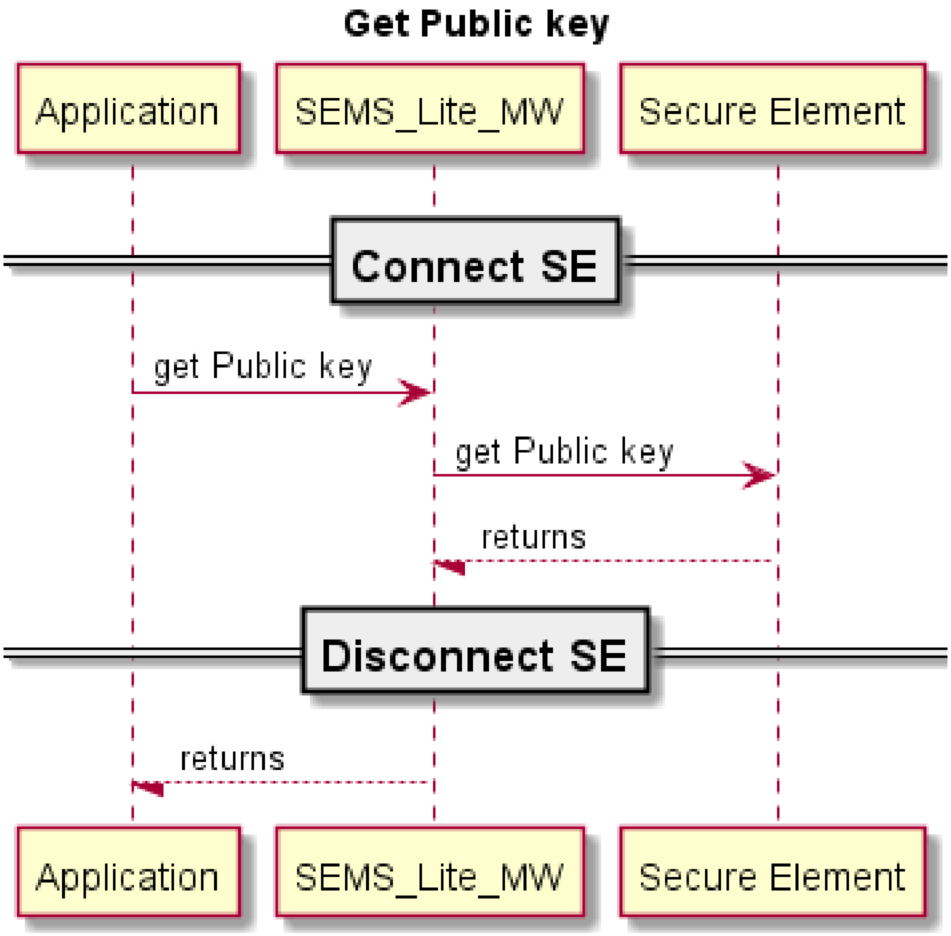
7.4.1 Get UUID

See *sems_lite_get_UUID*



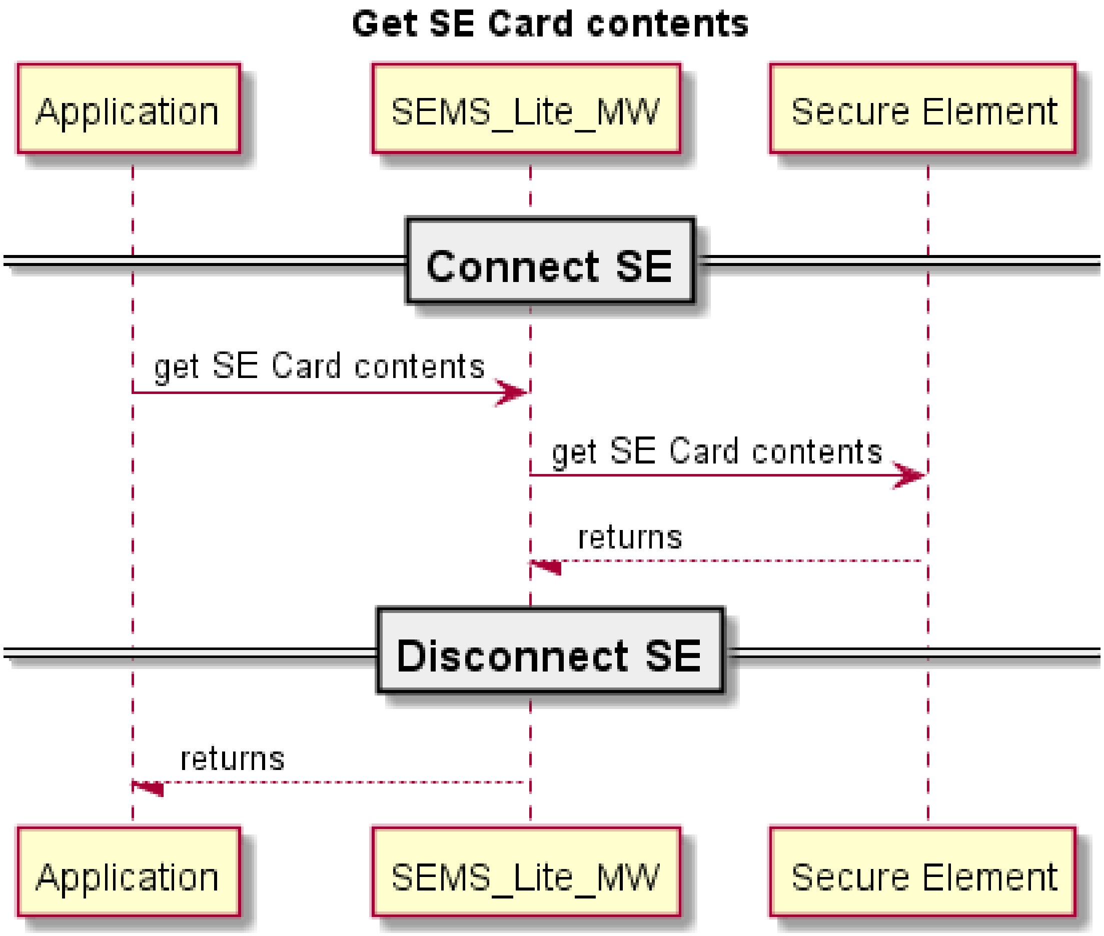
7.4.2 Get Public Key

See *sems_lite_get_Publickey*



7.4.3 Get Card contents

- See *sems_lite_get_SEAppInfoRAW*
- See *sems_lite_get_SEAppInfo*
- See *sems_lite_get_SEPkgInfoRAW*
- See *sems_lite_get_SEPkgInfo*



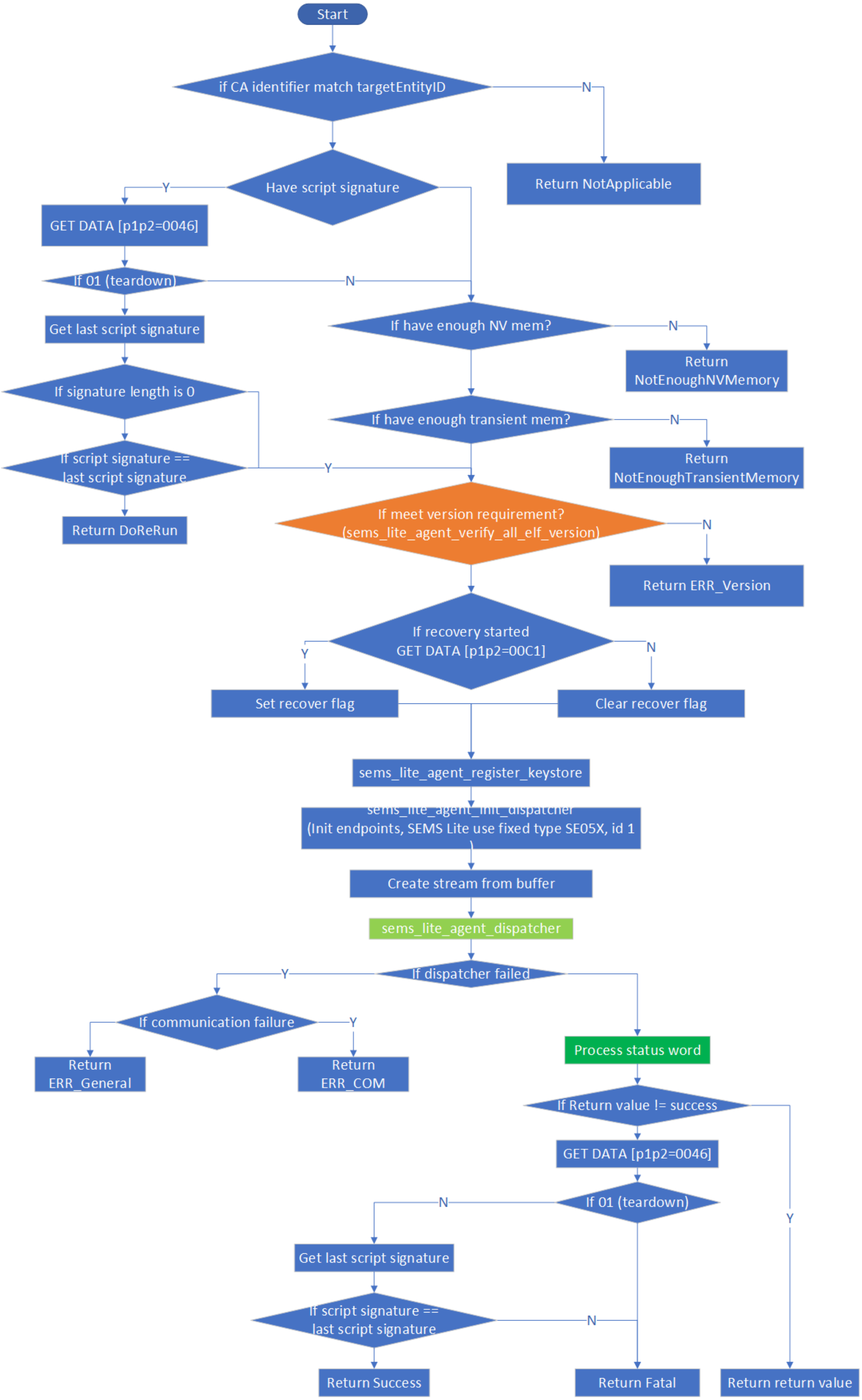
7.5 SEMS Lite Agent Package Load Process

When SE update package is loaded to SEMS Lite agent, SEMS Lite agent executes following steps to load package (offline) to the SE.

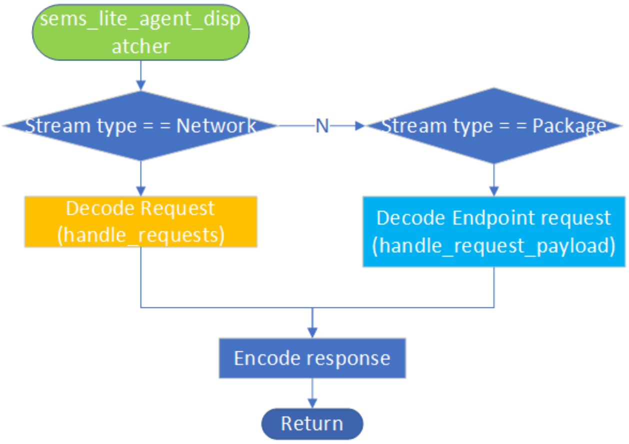
1. Check if target entity ID match.
2. Check tear status which indicate if last load operation succeed. If not, SEMS Lite agent will indicate user to re-run the tear script.
3. Check if recovery has started and record flag accordingly. This flag is used later in error code handling.
4. Check if meet minimum previous version and version request.
5. Decode the protobuf stream to find valid SEMS Lite agent package.
6. If the package includes host command, take relative actions (reset SE, etc).
7. If the package includes APDU command, send the APDU command to SE.
8. Get the status word from SE. Tranlate the status word to customer friendly return value.
9. Check tear status which indicate if this load operation succeed. If not, SEMS Lite agent will indicate user to re-run the tear script.

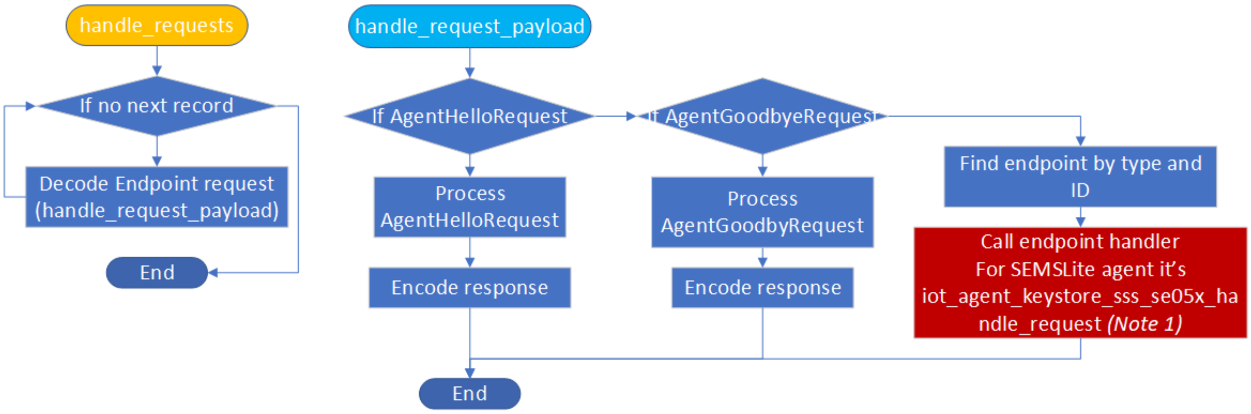
Refer to following flowchart for detail:

- **Flowchart Part 1:**

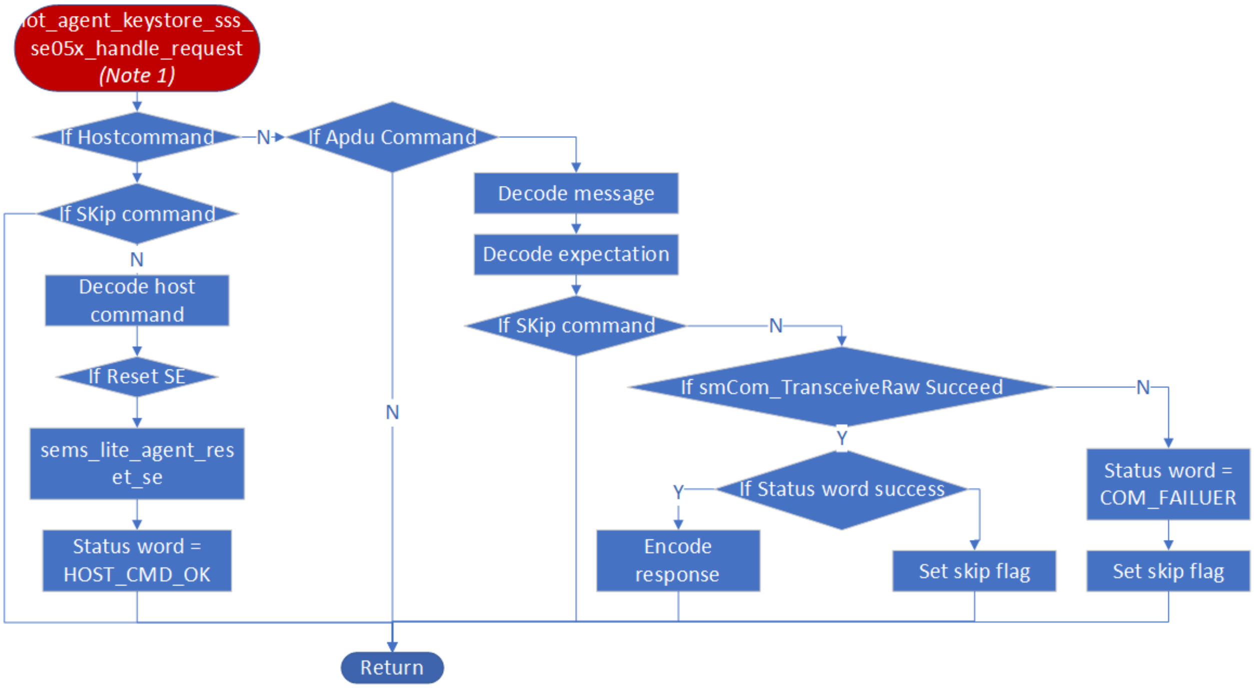

Start
if CA identifier match targetEntityID
N
Return NotApplicable
Have script signature
Y
GET DATA [p1p2=0046]
If 01 (teardown)
N
Get last script signature
If have enough NV mem?
N
Return NotEnoughNVMemory
If signature length is 0
If have enough transient mem?
N
Return NotEnoughTransientMemory
If script signature == last script signature
Y
Return DoReRun
If meet version requirement? (sems_lite_agent_verify_all_elf_version)
N
Return ERR_Version
If recovery started GET DATA [p1p2=00C1]
Y
N
Set recover flag
Clear recover flag
sems_lite_agent_register_keystore
sems_lite_agent_init_dispatcher (Init endpoints, SEMS Lite use fixed type SE05X, id 1)
Create stream from buffer
sems_lite_agent_dispatcher
If dispatcher failed
Y
If communication failure
Y
Return ERR_General
Return ERR_COM
Process status word
If Return value != success
GET DATA [p1p2=0046]
If 01 (teardown)
N
Y
Get last script signature
If script signature == last script signature
N
Return Success
Return Fatal
Return return value

- **Flowchart Part 2:**

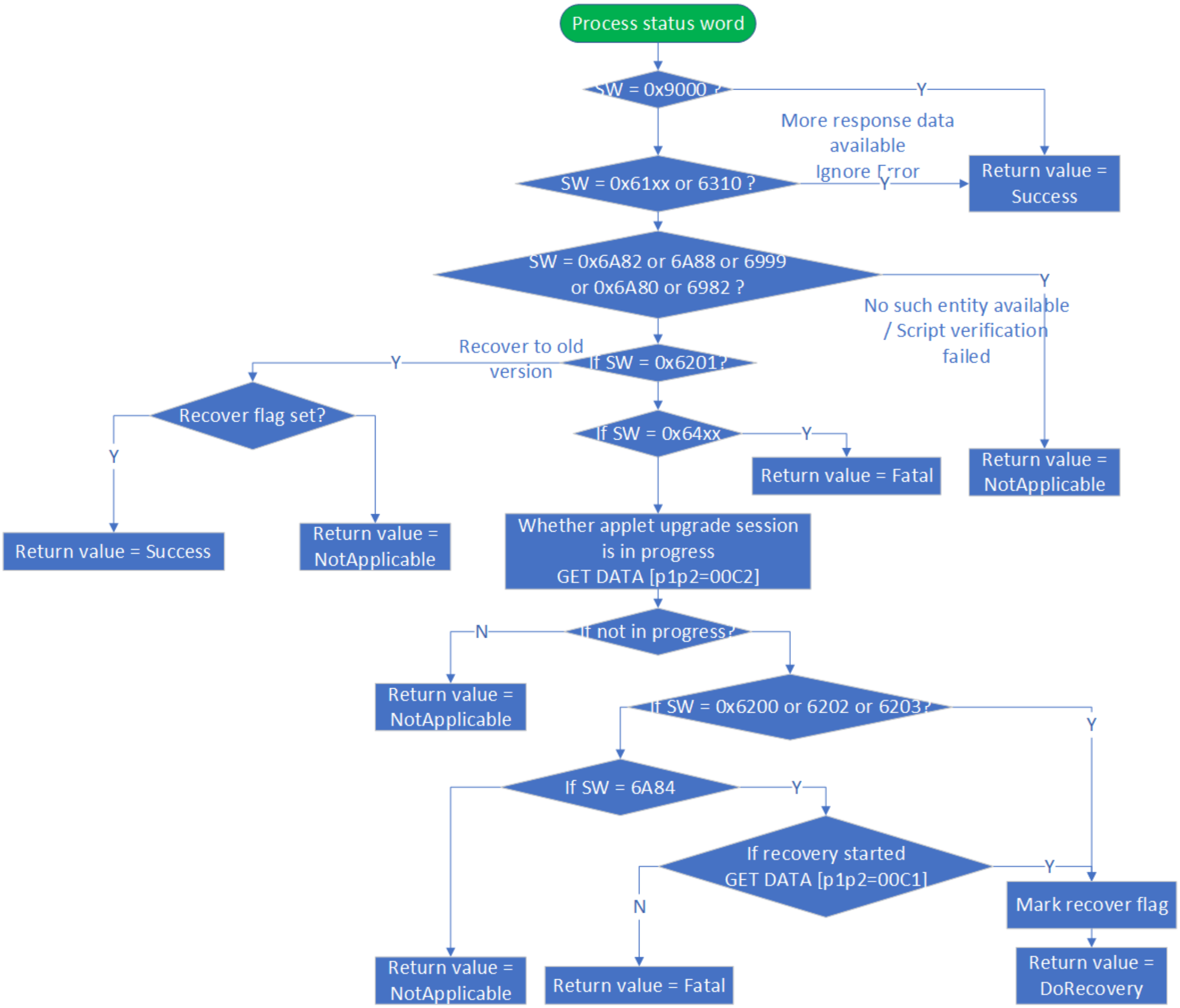

sems_lite_agent_dispatcher
Stream type = = Network
N
Stream type = = Package
Decode Request (handle_requests)
Decode Endpoint request (handle_request_payload)
Encode response
Return


handle_requests
If no next record
Decode Endpoint request (handle_request_payload)
End
handle_request_payload
If AgentHelloRequest
If AgentGoodbyeRequest
Process AgentHelloRequest
Process AgentGoodbyRequest
Find endpoint by type and ID
Call endpoint handler
For SEMSLite agent it's
iot_agent_keystore_sss_se05x_handle_request (Note 1)
Encode response
Encode response
End

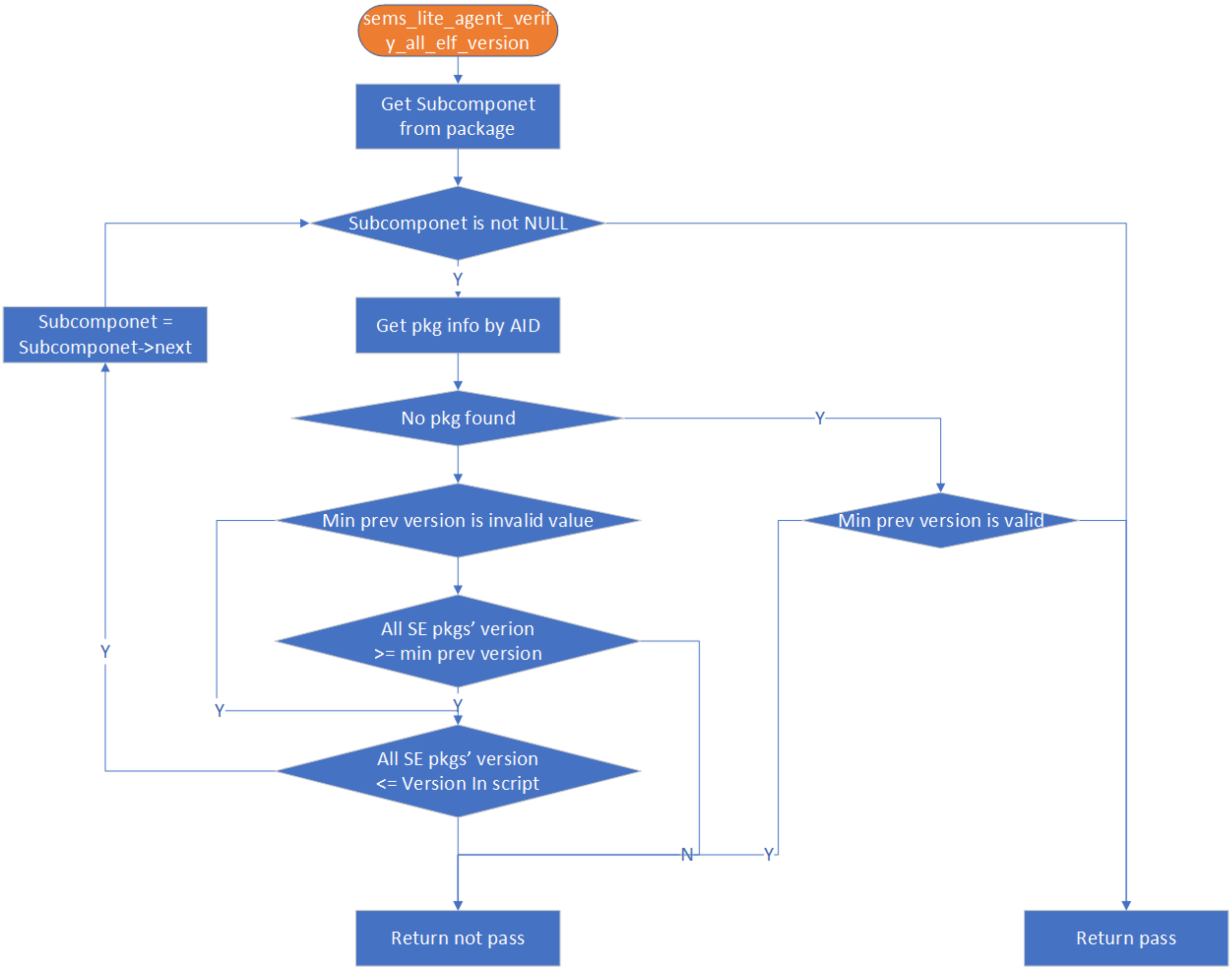
- **Flowchart Part 3:**



- **Flowchart Part 4:**


Process status word
SW = 0x9000 ?
Y
More response data available
Ignore Error
Y
Return value = Success
SW = 0x61xx or 6310 ?
SW = 0x6A82 or 6A88 or 6999 or 0x6A80 or 6982 ?
Y
No such entity available / Script verification failed
Return value = NotApplicable
Recover to old version
Y
If SW = 0x6201?
Recover flag set?
Y
Return value = Success
Return value = NotApplicable
If SW = 0x64xx
Y
Return value = Fatal
Whether applet upgrade session is in progress GET DATA [p1p2=00C2]
If not in progress?
N
Return value = NotApplicable
If SW = 0x6200 or 6202 or 6203?
Y
If SW = 6A84
Y
If recovery started GET DATA [p1p2=00C1]
N
Y
Mark recover flag
Return value = NotApplicable
Return value = Fatal
Return value = DoRecovery

- **Flowchart Part 5:**


sems_lite_agent_verify_all_elf_version
Get Subcomponet from package
Subcomponet is not NULL
Y
Get pkg info by AID
Subcomponet = Subcomponet->next
No pkg found
Y
Min prev version is invalid value
Min prev version is valid
All SE pkgs' verion >= min prev version
Y
Y
Y
All SE pkgs' version <= Version In script
N
Y
Return not pass
Return pass

Note 1: SEMS Lite agent and iot hub module share protobuf stream processing function. In this function, several keystore endpoints could attach to the dispatcher. But in SEMS Lite agent case, there is only one keystore endpoint which is sems lite agent.

7.6 SEMSLite Types and APIs

7.6.1 SEMSLite Agent Types

group **`sems_lite_agent_types`**

SEMSLite Types to be used with SEMSLite APIs.

Typedefs

`typedef` *sems_lite_SEAppInfoList_t* **`sems_lite_PKGInfoList_t`**

Same as sems_lite_SEAppInfoList_t for for list of installed packages

Enums

`enum _sems_lite_recovery_status_t`

Values:

`sems_lite_recovery_not_started` = 0

Recovery Not Started

`sems_lite_recovery_started` = 1

Recovery Started

`enum _sems_lite_status`

Status of SEMS Lite update operation

Values:

`kStatus_SEMS_Lite_Success` = 0x00

Operation was successful

`kStatus_SEMS_Lite_ERR_COM`

Communication Error

`kStatus_SEMS_Lite_ERR_DoReRun`

Update not completed please provide update package again.

`kStatus_SEMS_Lite_ERR_NotApplicable`

Update not applicable on this Chip/type.

`kStatus_SEMS_Lite_ERR_DoRecovery`

Update can not be completed. Please provide recovery package, to roll back to last working version.

`kStatus_SEMS_Lite_ERR_Fatal`

Unresolvable error.

`kStatus_SEMS_Lite_ERR_NotEnoughNVMemory`

Not enough NV memory.

`kStatus_SEMS_Lite_ERR_NotEnoughTransientMemory`

Not enough transient memory.

`kStatus_SEMS_Lite_ERR_MinPreviousVersion`

Current SE version not meet min previous version request.

`kStatus_SEMS_Lite_ERR_OlderVersion`

Older than current SE version

`kStatus_SEMS_Lite_ERR_General`

General error.

`enum _sems_lite_tearDown_status_t`

Check Tear down Amd-I section 4.14

Values:

`sems_lite_notear` = 0

The script has been completely executed

sems_lite_tear = 1
Script execution was interrupted because of teardown.

sems_lite_tearDown_status_invalid = 0x7F

enum _sems_lite_upgradeProgress_status_t
Values:

sems_lite_upgrade_not_inProgress = 0
Upgrade session Not in Progress

sems_lite_upgrade_inProgress = 1
Upgrade session In Progress

sems_lite_upgrade_invalid = 0x7F

enum _sems_lite_version_check_result_t
Status of SEMS Lite version check result

Values:

kStatus_SEMS_Lite_Version_Pass = 0x00
Operation was successful

kStatus_SEMS_Lite_Version_ERR_MIN
Failed due to min previous version.

kStatus_SEMS_Lite_Version_ERR_Downgrade
Failed due to downgrade.

struct _sems_lite_available_mem_t

Public Members

uint32_t **availableCODMemory**

uint32_t **availableCORMemory**

uint32_t **availableIDX**

uint32_t **availablePersistentMemory**

uint32_t **freePHeapCentralGap**

uint32_t **freeTransient**

struct _sub_component_metaData_t

Public Members

size_t **aidLen**

uint8_t **minimumPreviousVersion**[2]

size_t **nameLen**

const uint8_t ***pAid**

char ***pName**

struct *_sub_component_metaData_t* ***pNextSubComponentMetaData**

uint8_t **version**[2]

struct multicast_package_t

Public Members

size_t **`multicastCommandsLen`**

size_t **`multicastPackageNameLen`**

uint8_t **`multicastPackageVersion`**[2]

`const` uint8_t ***`pMulticastCommands`**

`const` char ***`pMulticastPackageName`**

`const` uint8_t ***`pSignatureOverCommands`**

`const` sub_component_metaData_t ***`pSubComponentMetaData`**

uint32_t **`requiredFreeBytesNonVolatileMemory`**

uint32_t **`requiredFreeBytesTransientMemory`**

uint32_t **`semsLiteAPIVersion`**

size_t **`signatureOverCommandsLen`**

uint8_t **`target12Nc`**[6]

uint8_t **`targetEntityID`**[16]

`struct sems_lite_agent_ctx_t`

Public Members

uint32_t **`freePHeapCentralGap`**

uint32_t **`freeTransient`**

Se05xSession_t ***`pS05x_Ctx`**
Boot context

bool **`recovery_executed`**
Flag for get recovery script

bool **`session_opened`**
Flag for session status: Open/Close

bool **`skip_next_commands`**
Skip following commands

Internal state variable.

When one APDU in this APDU stream has failed, skip through all the next APDUs (do not send them) and return back to the caller.

uint32_t **`status_word`**
Status word of last R-APDU.

`struct sems_lite_agent_request_ctx_t`

Public Members

int **`checkpoint_index`**

int **`current_command_index`**

int **`retry_count`**

`struct sems_lite_SEAppInfoList_t`

#include <sems_lite_api.h> Information of about Applet/Package

See Table 11-36: GlobalPlatform Registry Data (TLV), GPCardSpc_v2.2.pdf

The response from Applet is put to rspBuf

After parsing that response, the pointers to respective members is set and it points to relevant part in rspBuf, this way saving memory. However, the Length is updated so that application use this information.

Public Members

uint8_t **`AIDLen`**
Length of the Applet ID

uint8_t **`LifeCycleState`**
Life-cycle state

uint8_t **`LoadFileAIDLen`**
Length of LoadFileAID.

uint8_t **`LoadFileVersionNumberLen`**
Length of pLoadFileVersionNumber.

uint8_t ***`pAID`**
Applet ID

uint8_t ***`pLoadFileAID`**
Application’s Executable Load File AID.

uint8_t ***`pLoadFileVersionNumber`**
Executable Load File Version Number.

uint8_t ***`pPriviledges`**
Privileges.

uint8_t **`PriviledgesLen`**
Length of Privileges

uint8_t ***`pSecurityDomainAID`**
Associated Security Domain’s AID.

uint8_t **`rspBuf`**[(256 + 5)]
Response from Applet.

size_t **`rspBufLen`**
Length of response from Applet.

uint8_t **`SecurityDomainAIDLen`**
Length of SecurityDomainAID.

7.6.2 SEMSLite Agent APIs

group **`sems_lite_agent`**
API to load an available update package on the SE.

Functions

sss_status_t **`sems_lite_agent_init_context`**(*sems_lite_agent_ctx_t *context*, *sss_session_t *boot_ctx*)

Initialize SEMS Lite agent context.

This function is used to initialize SEMS Lite agent context.

Return Status of the operation

Parameters

- `context`: Pointer to sems lite agent context.
- `boot_ctx`: Pointer to sss session context

Return Value

- `kStatus_SEMS_Lite_Success`: The operation has completed successfully.
- `kStatus_SEMS_Lite_ERR_General`: The operation has failed.

sems_lite_status_t **`sems_lite_agent_load_package`**(*sems_lite_agent_ctx_t *context*, *multicast_package_t *multiPkgBuf*)

Load Applet package.

This function load an available update package on the SE and assure the tearing safe update of the SE.

Return Status of the operation

Note More return codes would be added to request host to either retry or install older package.

Parameters

- `context`: Pointer to sems lite agent context.
- `pkgBuf`: Pointer to package. It must follow the format defined in multicast_package_t.

Return Value

- `kStatus_SEMS_Lite_Success`: The operation has completed successfully.
- `kStatus_SEMS_Lite_ERR_COM`: Communication to SE failed.
- `kStatus_SEMS_Lite_ERR_DoReRun`: Update not completed please provide update package again.
- `kStatus_SEMS_Lite_ERR_NotApplicable`: Update not applicable on this Chip/type.
- `kStatus_SEMS_Lite_ERR_DoRecovery`: Update can not be completed. Please provide recovery package, to roll back to last working version.
- `kStatus_SEMS_Lite_ERR_Fatal`: Unresolvable error. (This category of errors can only appear in testing of an update package, in the case of NXP updates this is testes before by NXP)
- `kStatus_SEMS_Lite_ERR_NotEnoughNVMemory`: Don't have has enough NV memory for the SEMS Lite Script.
- `kStatus_SEMS_Lite_ERR_NotEnoughTransientMemory`: Don't have enough transient memory for the SEMS Lite Script .

sss_status_t **`sems_lite_agent_session_close`**(*sems_lite_agent_ctx_t *context*)

Close the connection to SEMS Lite Applet.

Return The api status.

Parameters

- `context`: The context

Return Value

- `kStatus_SEMS_Lite_Success`: Could close connection 1.
- `kStatus_SEMS_Lite_ERR_General`: Could not close connection 1.

sss_status_t **`sems_lite_agent_session_open`** (*sems_lite_agent_ctx_t *context*)

Open a Physical connection to SEMS Lite Applet.

Calling this API opens Locical Connection 1 and selecs the SEMS Lite applet.

Return The api status.

Parameters

- `context`: SEMS Lite Agent Context

Return Value

- `kStatus_SEMS_Lite_Success`: Could connect to SEMS Lite Applet.
- `kStatus_SEMS_Lite_ERR_General`: Could not connect to SEMS Lite Applet.

sss_status_t **`sems_lite_check_AppletRecoveryStatus`** (*sems_lite_agent_ctx_t *pContext*, sems_lite_recovery_status_t **pRecoveryStatus*)

Check Applet Recovery Status.

This API will return the status of applet recovery status

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRecoveryStatus`: Pointer to recovery status.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_check_AppletUpgradeProgress`** (*sems_lite_agent_ctx_t *pContext*, sems_lite_upgradeProgress_status_t **pUpgradeStatus*)

Check Applet Upgrade Progress.

This API will return the status of applet upgrade progress status

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pUpgradeStatus`: Pointer to upgrade status.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_check_Tear`** (*sems_lite_agent_ctx_t *pContext*, sems_lite_tearDown_status_t **pTearStatus*)

Check Tear during script execution.

This API will check whether there was tear during script execution

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pTearStatus`: Pointer to tear status.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_AgentVersion`** (uint8_t **pRspBuf*, size_t **pRspBufLen*)

Get the SEMS Lite Agent version.

This API will return the SEMS Lite Agent Version no.

Return Status of the operation

Parameters

- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_AppletVersion`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Get the Applet version.

This API will return the SEMS Lite Applet Version no.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_available_mem`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pAvailableMem*)

{ function_description }

Return The sss status.

Parameters

- `context`: The context
- `pAvailableMem`: Availalbe Memory Space Information

sss_status_t **`sems_lite_get_CA_identifier`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Get the CA Identifier.

This API will return the CA Identifier.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_ENCIdentifier`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Get the ENC Identifier.

This API will return the ENC Identifier.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_FIPS_EC_parameter_type`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pParamType*)

Get Configured EC domain parameter type.

This API will return Configured EC domain parameter type

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pParamType`: Pointer to parameter type.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.

- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_FIPS_info`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pFIPSInfo*)

Get Configured FIPS Information.

This API will return Configured FIPS Information

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pFIPSInfo`: Pointer to FIPS Info.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_Publickey`** (*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Read Public Key.

This API will read root certificates public key of the device.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_SEAppInfo`** (*sems_lite_agent_ctx_t *pContext*, **`const`** uint8_t **searchAID*, uint8_t *searchAidLen*, *sems_lite_SEAppInfoList_t *pAppInfo*, size_t **pAppInfoLen*)

Low level API to get App INFO from the SE according to format mentioned in - Table 11-36: GlobalPlatform Registry Data (TLV), GPCardSpc_v2.2.pdf.

This API will read the currently present Applications ELF/ELM AIDs and versions as well as the present instances from the SE.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `[in] searchAID`: The search aid
- `[in] searchAidLen`: The search aid length
- `pAppInfo`: Parsed structures
- `[inout] pAppInfoLen`: Length of parsed structures.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_SEAppInfoRAW`** (*sems_lite_agent_ctx_t *pContext*, **`const`** uint8_t **searchAID*, uint8_t *searchAidLen*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Low level API to get Raw App INFO from the SE.

This API will read the currently present Applications ELF/ELM AIDs and versions as well as the present instances from the SE.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `[out] pRspBuf`: Pointer to response Buffer.
- `[in] searchAID`: The search aid
- `[in] searchAidLen`: The search aid length
- `[inout] pRspBufLen`: Pointer to length of the response Buffer.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_SEPkgInfo`** (*sems_lite_agent_ctx_t *pContext*, **`const`** uint8_t **searchAID*, uint8_t *searchAidLen*, *sems_lite_SEAppInfoList_t *pAppInfo*, size_t **pAppInfoLen*)

Low level API to get PKG INFO from the SE according to format mentioned in - Table 11-36: GlobalPlatform Registry Data (TLV), GPCardSpc_v2.2.pdf.

This API will read the currently present Applications ELF/ELM AIDs and versions as well as the present instances from the SE.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `[in] searchAID`: The search aid
- `[in] searchAidLen`: The search aid length
- `pAppInfo`: Parsed structures
- `[inout] pAppInfoLen`: Length of parsed structures.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_SEPkgInfoRAW`**(*sems_lite_agent_ctx_t *pContext*, **`const`** uint8_t **searchAID*, uint8_t *searchAidLen*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Low level API to get RAW PKG INFO from the SE.

This API will read the currently present Applications ELF/ELM AIDs and versions as well as the present instances from the SE.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `[in] searchAID`: The search aid
- `[in] searchAidLen`: The search aid length
- `[out] pRspBuf`: Pointer to response Buffer.
- `[inout] pRspBufLen`: Pointer to length of the response Buffer.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_SignatureofLastScript`**(*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Get the signature of last executed script.

This API will called in case there is tear down

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

sss_status_t **`sems_lite_get_UUID`**(*sems_lite_agent_ctx_t *pContext*, uint8_t **pRspBuf*, size_t **pRspBufLen*)

Retrieve UUID from SE.

This API read UUID of the SE.

Return Status of the operation

Parameters

- `pContext`: Pointer to sems lite agent context.
- `pRspBuf`: Pointer to response Buffer.
- `pRspBufLen`: Pointer to length of the response Buffer.

Return Value

- `kStatus_SSS_Success`: The operation has completed successfully.
- `kStatus_SSS_Fail`: The operation has failed.

7.7 SEMS Lite Known Issue

7.7.1 Signature for rerun script is incorrect occasionally

- Issue description: In case of tear (e.g. unexpected power off when upgrading SE), when user tries to load new script, SEMS Lite agent will only allow the re-run script. This script should be the one that is interrupted. But in special case of very early tearing, SEMS Lite agent may expected the user to re-run the script that's already existed in SE before upgrade start.
- Issue workaround: Using sems_lite_get_SignatureofLastScript() to get the signature of the expected script. Find the script and load it.

7.8 SEMS Lite DEMOs

The DEMOs applicable to SEMS Lite are listed at Section 5.1.1 *SEMS Demos*

CHAPTER

EIGHT

PLUGINS / ADD-INS

Plugins / Add-ins for other platforms

8.1 Introduction on OpenSSL engine

Starting with OpenSSL 0.9.6 an 'Engine interface' was added to OpenSSL allowing support for alternative cryptographic implementations. This Engine interface can be used to interface with external crypto devices. The key injection process is secure module specific and is not covered by the Engine interface.

Depending on the capabilities of the attached secure element (e.g. SE050_C, A71CH, . . .) the following functionality can be made available over the OpenSSL Engine interface:

- EC crypto
  - EC sign/verify
  - ECDH compute key
  - Montgomory ECDH
- RSA crypto
  - RSA sign/verify
  - RSA priv_key_decrypt/pub_key_encrypt
- Fetching random data

8.1.1 General

OpenSSL versions

The OpenSSL Engine is compatible with OpenSSL versions 1.0.2 or 1.1.1.

OpenSSL Configuration file

It's possible to add OpenSSL engine specific extensions to the OpenSSL configuration file. Using these extensions one can control whether the supported crypto functionality is delegated to the Secure Element or whether it is handled by the OpenSSL SW implementation.

The actual contents of the configuration file depends on the OpenSSL version and the attached secure element (SE050 or A71CH). The `demos/linux/common folder` of this SW package contains 4 reference configuration files covering both SE050 and A71CH for the two supported OpenSSL versions.

The following configuration file fragment (extracted from `openssl11_sss_se050.cnf`) highlights the required changes to enable the full functionality of the SE050_C OpenSSL Engine on an iMX Linux system:

```
...
# System default
openssl_conf = nxp_engine
...

...
[nxp_engine]
engines = engine_section

[engine_section]
e4sss_se050 = e4sss_se050_section

[e4sss_se050_section]
engine_id = e4sss
dynamic_path = /usr/local/lib/libsss_engine.so
init = 1
default_algorithms = RAND,RSA,EC
```

One overrules the default OpenSSL configuration file by setting the environment variable `OPENSSL_CONF` to the path of the custom configuration file.

Platforms

The OpenSSL engine can be used on iMX boards (running Linux) or on Raspberry Pi (running Raspbian).

8.1.2 Keys

Key Management

The cryptographic functionality offered by the OpenSSL engine requires a reference to a key stored inside the Secure Element (exception is RAND_Method). These keys are typically inserted into the Secure Element in a secured environment during production.

OpenSSL requires a key pair, consisting of a private and a public key, to be loaded before the cryptographic operations can be executed. This creates a challenge when OpenSSL is used in combination with a secure element as the private key cannot be extracted out from the Secure Element.

The solution is to populate the OpenSSL Key data structure with only a reference to the Private Key inside the Secure Element instead of the actual Private Key. The public key as read from the Secure Element can still be inserted into the key structure.

OpenSSL crypto API's are then invoked with these data structure objects as parameters. When the crypto API is routed to the Engine, the OpenSSL engine implementation decodes these key references and invokes the SSS API with correct Key references for a cryptographic operation. If the input key is not reference key, execution will roll back to openssl software implementation

EC Reference key format

The following provides an example of an EC reference key. The value reserved for the private key has been used to contain:

- a pattern of `0x10..00` to fill up the datastructure MSB side to the desired key length

- a 32 bit key identifier (in the example below `0x7DCCBBAA`)
- a 64 bit magic number (always `0xA5A6B5B6A5A6B5B6`)
- a byte to describe the key class (`0x10` for Key pair and `0x20` for Public key)
- a byte to describe the key index (use a reserved value `0x00`)

```
Private-Key: (256 bit)
priv:
    10:00:00:00:00:00:00:00:00:00:00:00:00:00:00:
    00:00:00:7D:CC:BB:AA:A5:A6:B5:B6:A5:A6:B5:B6:
    kk:ii
pub:
    04:1C:93:08:8B:26:27:BA:EA:03:D1:BE:DB:1B:DF:
    8E:CC:87:EF:95:D2:9D:FC:FC:3A:82:6F:C6:E1:70:
    A0:50:D4:B7:1F:F2:A3:EC:F8:92:17:41:60:48:74:
    F2:DB:3D:B4:BC:2B:F8:FA:E8:54:72:F6:72:74:8C:
    9E:5F:D3:D6:D4
ASN1 OID: prime256v1
```

Note:

- The key identifier `0x7DCCBBAA` (stored in big-endian convention) is in front of the magic number `0xA5A6B5B6A5A6B5B6`
- The padding of the private key value and the magic number make it unlikely a normal private key value matches a reference key.
- Ensure the value reserved for public key and ASN1 OID contain the values matching the stored key.

Note:

- For EC montgomery curves, openssl allows only the private key to be set. So the reference key created will not have the valid public key.

RSA Reference key format

The following provides an example of an RSA reference key.

- The value reserved for ‘p’ (aka ‘prime1’) is used as a magic number and is set to ‘1’
- The value reserved for ‘q’ (aka ‘prime2’) is used to store the 32 bit key identifier (in the example below 0x6DCCBB11)
- The value reserved for ‘(inverse of q) mod p’ (aka ‘IQMP’ or ‘coefficient’) is used to store the magic number 0xA5A6B5B6

```
Private-Key: (2048 bit)
modulus:
    00:b5:48:67:f8:84:ca:51:ac:a0:fb:d8:e0:c9:a7:
    72:2a:bc:cb:bc:93:3a:18:6a:0f:a1:ae:d4:73:e6:
    ...
publicExponent: 65537 (0x10001)
privateExponent:
    58:7a:24:39:90:f4:13:ff:bf:2c:00:11:eb:f5:38:
```

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```
    b1:77:dd:3a:54:3c:f0:d5:27:35:0b:ab:8d:94:93:
    ...
prime1: 1 (0x1)
prime2: 1842133777(0x6DCCBB11)
exponent1:
    00:c1:c9:0a:cc:9f:1a:c5:1c:53:e6:c1:3f:ab:09:
    db:fb:20:04:38:2a:26:d5:71:33:cd:17:a0:94:bd:
    ...
exponent2:
    24:95:f0:0b:b0:78:a9:d9:f6:5c:4c:e0:67:d8:89:
    c1:eb:df:43:54:74:a0:1c:43:e3:6f:d5:97:88:55:
    ...
coefficient: 2779166134 (0xA5A6B5B6)
```

Note:

- Ensure keylength, the value reserved for (private key) modulus and public exponent match the stored key.
- The mathematical relation between the different key components is not preserved.
- Setting prime1 to ‘1’ makes it impossible that a normal private key matches a reference key.

8.1.3 Building the OpenSSL engine

The cmake build system will create an OpenSSL engine for supported platforms. The resulting OpenSSL engine will be copied to the SW tree in directory `simw-top/sss/plugin/openssl/bin`.

A subsequent `make install` will copy the OpenSSL engine to a standard directory on the file system, in case of iMX Linux e.g. `/usr/local/lib`.

Note: Ensure the following flag is defined when building an application that will be linked against the engine: `-DOPENSSL_LOAD_CONF`

8.1.4 Sample scripts to demo OpenSSL Engine

The directory `simw-top/sss/plugin/openssl/scripts` contains a set of python scripts. These scripts use the OpenSSL Engine in the context of standard OpenSSL utilities. They illustrate using the OpenSSL Engine for fetching random data, EC or RSA crypto operations. The scripts that illustrate EC or RSA crypto operations depend on prior provisioning of the secure element.

As an example, the following set of commands first creates and provisions EC key material. Then it invokes the OpenSSL Engine for ECDSA sign / verify operations and ECDH calculations. It assumes an SE050 is connected via I2C to an iMX6UL-EVK board:

```
python3 openssl_provisionEC.py --key_type prime256v1
python3 openssl_EccSign.py --key_type prime256v1
python3 openssl_Ecdh.py --key_type prime256v1
```

Further details on using these scripts can be found in the following:

openssl_rnd.py

usage: openssl_rnd.py [-h] [–connection_data CONNECTION_DATA]

Generate few random numbers from the attached secure element.

optional arguments:

-h, --help show this help message and exit

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

Example invocation:

```
python openssl_rnd.py --connection_data 127.0.0.1:8050
```

openssl_provisionEC.py

usage: openssl_provisionEC.py [-h] –key_type KEY_TYPE [–connection_type CONNECTION_TYPE] [–connection_data CONNECTION_DATA] [–subsystem SUBSYSTEM] [–auth_type AUTH_TYPE] [–scpkey SCPKEY]

Provision attached secure element with EC keys

This example generates a complete set of ECC key files (*.pem) (existing ones overwritten). Performs debug reset the attached secure element. Attached secure element provisioned with EC key. Creates reference key from the injected EC key.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `prime192v1`, `secp224r1`, `prime256v1`, `secp384r1`, `secp521r1`, `brainpoolP160r1`, `brainpoolP192r1`, `brainpoolP224r1`, `brainpoolP256r1`, `brainpoolP320r1`, `brainpoolP384r1`, `brainpoolP512r1`, `secp160k1`, `secp192k1`, `secp224k1`, `secp256k1`

optional arguments:

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--subsystem SUBSYSTEM Supported subsystem => `se050`, `a71ch`, `mbedtls`. Default: `se050`

--auth_type AUTH_TYPE Supported subsystem => `None`, `PlatformSCP`, `UserID`, `ECKey`, `AESKey`. Default: `None`

–scpkey SCPKEY

Example invocation:

```
python openssl_provisionEC.py --key_type prime256v1
python openssl_provisionEC.py --key_type prime256v1 --connection_data 169.254.0.1:8050
python openssl_provisionEC.py --key_type secp224k1  --connection_type jrcpv2 --
↪connection_data 127.0.0.1:8050
python openssl_provisionEC.py --key_type brainpoolP256r1 --connection_data COM3
python openssl_provisionEC.py --key_type prime256v1 --subsystem a71ch
```

openssl_EccSign.py

usage: openssl_EccSign.py [-h] –key_type KEY_TYPE [–connection_data CONNECTION_DATA] [–disable_sha1 DISABLE_SHA1]

Validation of Sign Verify with OpenSSL engine using EC Keys

This example showcases sign using reference key, then verify using openssl and vice versa.

Precondition:

- Inject keys using `openssl_provisionEC.py`.

optional arguments:

-h, --help	show this help message and exit

required arguments:

--key_type KEY_TYPE	Supported key types => `prime192v1`, `secp224r1`, `prime256v1`, `secp384r1`, `secp521r1`, `brainpoolP160r1`, `brainpoolP192r1`, `brainpoolP224r1`, `brainpoolP256r1`, `brainpoolP320r1`, `brainpoolP384r1`, `brainpoolP512r1`, `secp160k1`, `secp192k1`, `secp224k1`, `secp256k1`

optional arguments:

--connection_data CONNECTION_DATA	Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`
--disable_sha1 DISABLE_SHA1	Parameter to disable SHA1 => eg. `True`, `False`. Default: `False`

Example invocation:

```
python openssl_EccSign.py --key_type prime256v1
python openssl_EccSign.py --key_type secp160k1 --connection_data 127.0.0.1:8050
```

openssl_Ecdh.py

usage: openssl_Ecdh.py [-h] –key_type KEY_TYPE [–connection_data CONNECTION_DATA] [–disable_sha1 DISABLE_SHA1]

Validation of ECDH with OpenSSL engine using EC keys

This example showcases ECDH between openssl engine and openssl.

Precondition:

- Inject keys using `openssl_provisionEC.py`.

optional arguments:

-h, --help	show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `prime192v1`, `secp224r1`, `prime256v1`, `secp384r1`, `secp521r1`, `brainpoolP160r1`, `brainpoolP192r1`, `brainpoolP224r1`, `brainpoolP256r1`, `brainpoolP320r1`, `brainpoolP384r1`, `brainpoolP512r1`, `secp160k1`, `secp192k1`, `secp224k1`, `secp256k1`

optional arguments:

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--disable_sha1 DISABLE_SHA1 Parameter to disable SHA1 => eg. `True`, `False`. Default: `False`

Example invocation:

```
python openssl_Ecdh.py --key_type prime256v1
python openssl_Ecdh.py --key_type secp160k1 --connection_data 127.0.0.1:8050
```

ecc_all.py

usage: ecc_all.py [-h] [–connection_type CONNECTION_TYPE] [–connection_data CONNECTION_DATA] [–subsystem SUBSYSTEM] [–auth_type AUTH_TYPE] [–scpkey SCPKEY] [–disable_sha1 DISABLE_SHA1] [–fips FIPS]

Validation of OpenSSL Engine using EC keys

This example injects keys with different supported EC Curves, then showcases ECDH & ECDSA using those keys.

optional arguments:

-h, --help show this help message and exit

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--subsystem SUBSYSTEM Supported subsystem => `se051`, `se050`, `a71ch`. Default: `se050`

--auth_type AUTH_TYPE Supported subsystem => `None`, `PlatformSCP`, `UserID`, `ECKey`, `AESKey`. Default: `None`

–scpkey SCPKEY –disable_sha1 DISABLE_SHA1

Parameter to disable SHA1 => eg. `True`, `False`. Default: `False`

--fips FIPS FIPS Testing => eg. `True`, `False`. Default: `False`

Example invocation:

```
python ecc_all.py
python ecc_all.py --connection_data 169.254.0.1:8050
python ecc_all.py --connection_data 127.0.0.1:8050 --connection_type jrcpv2
python ecc_all.py --connection_data COM3
```

openssl_provisionRSA.py

usage: openssl_provisionRSA.py [-h] –key_type KEY_TYPE [–connection_type CONNECTION_TYPE] [–connection_data CONNECTION_DATA] [–subsystem SUBSYSTEM] [–auth_type AUTH_TYPE] [–scpkey SCPKEY]

Provision attached secure element with RSA keys

This example generates a complete set of RSA key files (*.pem) (existing ones overwritten). Performs debug reset the attached secure element. Attached secure element provisioned with RSA key. Creates reference key from the injected RSA key.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `rsa1024`, `rsa2048`, `rsa3072`, `rsa4096`

optional arguments:

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--subsystem SUBSYSTEM Supported subsystem => `se050`, `mbedtls`. Default: `se050`

--auth_type AUTH_TYPE Supported subsystem => `None`, `PlatformSCP`, `UserID`, `ECKey`, `AESKey`. Default: `None`

–scpkey SCPKEY

Example invocation:

```
python openssl_provisionRSA.py --key_type rsa1024
python openssl_provisionRSA.py --key_type rsa2048 --connection_data 169.254.0.1:8050
python openssl_provisionRSA.py --key_type rsa2048 --connection_data 127.0.0.1:8050 --
↪connection_type jrcpv2
python openssl_provisionRSA.py --key_type rsa2048 --connection_data COM3
```

openssl_RSA.py

usage: openssl_RSA.py [-h] –key_type KEY_TYPE [–connection_data CONNECTION_DATA] [–disable_sha1 DISABLE_SHA1]

Validation of OpenSSL Engine using RSA keys

This example showcases crypto operations and sign verify operations using RSA keys.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `rsa1024`, `rsa2048`, `rsa3072`, `rsa4096`

optional arguments:

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--disable_sha1 DISABLE_SHA1 Parameter to disable SHA1 => eg. `True`, `False`. Default: `False`

Example invocation:

```
python openssl_RSA.py --key_type rsa2048
python openssl_RSA.py --key_type rsa4096 --connection_data 127.0.0.1:8050
```

rsa_all.py

usage: rsa_all.py [-h] [–connection_data CONNECTION_DATA] [–connection_type CONNECTION_TYPE] [–subsystem SUBSYSTEM] [–auth_type AUTH_TYPE] [–scpkey SCPKEY] [–disable_sha1 DISABLE_SHA1] [–fips FIPS]

Validation of OpenSSL Engine using RSA keys

This example injects keys with different supported RSA keys, then showcases Crypto & sign verify operations using those keys.

optional arguments:

-h, --help show this help message and exit

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--subsystem SUBSYSTEM Supported subsystem => `se050`. Default: `se050`

--auth_type AUTH_TYPE Supported subsystem => `None`, `PlatformSCP`, `UserID`, `ECKey`, `AESKey`. Default: `None`

–scpkey SCPKEY –disable_sha1 DISABLE_SHA1

Parameter to disable SHA1 => eg. `True`, `False`. Default: `False`

--fips FIPS FIPS Testing => eg. `True`, `False`. Default: `False`

Example invocation:

```
python rsa_all.py
python rsa_all.py --connection_data 169.254.0.1:8050
python rsa_all.py --connection_data 127.0.0.1:8050 --connection_type jrcpv2
python rsa_all.py --connection_data COM3
```

openssl_provisionEC_mont.py

usage: openssl_provisionEC_mont.py [-h] –key_type KEY_TYPE [–connection_type CONNECTION_TYPE] [–connection_data CONNECTION_DATA] [–subsystem SUBSYSTEM] [–auth_type AUTH_TYPE] [–scpkey SCPKEY]

Provision attached secure element with EC montogomery keys

This example generates EC montogomery key files (*.pem) (existing ones overwritten). Performs debug reset the attached secure element. Attached secure element provisioned with EC montogomery key. Creates reference key from the injected EC montogomery key.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `x25519`, `x448`

optional arguments:

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

--subsystem SUBSYSTEM Supported subsystem => `se050`, `a71ch`, `mbedtls`. Default: `se050`

--auth_type AUTH_TYPE Supported subsystem => `None`, `PlatformSCP`, `UserID`, `ECKey`, `AESKey`. Default: `None`

–scpkey SCPKEY

Example invocation:

```
python openssl_provisionEC_mont.py --key_type x25519
python openssl_provisionEC_mont.py --key_type x25519 --connection_data 169.254.0.
↪1:8050
python openssl_provisionEC_mont.py --key_type x448  --connection_type jrcpv2 --
↪connection_data 127.0.0.1:8050
python openssl_provisionEC_mont.py --key_type x448 --connection_data COM3
```

openssl_Ecdh_mont.py

usage: openssl_Ecdh_mont.py [-h] –key_type KEY_TYPE [–connection_type CONNECTION_TYPE] [–connection_data CONNECTION_DATA]

Validation of Montgomery ECDH with OpenSSL engine using EC mont keys

This example showcases montogomery ECDH between openssl engine and openssl.

Precondition:

- Inject keys using `openssl_provisionEC_mont.py`.

optional arguments:

-h, --help show this help message and exit

required arguments:

--key_type KEY_TYPE Supported key types => `x25519`, `x448`

optional arguments:

--connection_type CONNECTION_TYPE Supported connection types => `t1oi2c`, `sci2c`, `vcom`, `jrcpv1`, `jrcpv2`, `pcsc`. Default: `t1oi2c`

--connection_data CONNECTION_DATA Parameter to connect to SE => eg. `COM3`, `127.0.0.1:8050`, `none`. Default: `none`

Example invocation:

```
python openssl_Ecdh_mont.py --key_type x448
python openssl_Ecdh_mont.py --key_type x25519 --connection_type jrcpv2 --connection_
↪data 127.0.0.1:8050
```

8.2 Introduction on mbedTLS ALT Implementation

MbedTLS ALT implementation allows mbedTLS stack use the secure element access using SSS layer. Crypto operations performed during TLS handshake between client and server are performed using the secure element.

8.2.1 SE05X usage in TLS handshake (ECC Ciphersuites)

SE05X is used for following operations during TLS handshake

1) Verification using root CA pub key (root CA public key provisioned in SE05X)
2) Calculate shared key using sss_derive_key_dh (only for ECDH cipher suites. For ECDHE, ecc key and shared secret are generated on host).
3) Sign handshake messages using provisioned client key.
4) Optional - All public key ECDSA verify operation.

8.2.2 SE05X usage in TLS handshake (RSA Ciphersuites)

SE05X is used for following operations during TLS handshake

1) Verification using root CA pub key (root CA public key provisioned in SE05X).
2) Sign handshake messages using provisioned client key.
3) Optional - All public key ECDSA verify operation. Public key is set during TLS handshake.

8.2.3 Using SE05X for all Public key ECDSA verify operation

With default mbedtls config file, SE05X is used only for Root CA public key verify operation. To use secure element for all public key ecdsa verify operation, enable `MBEDTLS_ECDSA_VERIFY_ALT` in mbedtls config file.

This feature will add some limitations as explained below.

1) NVM writes will be observed when public key is set in secured element during TLS handshake.
2) NVM writes can be avoided by overwriting the existing keys without deleting the last created key. But this limits the number of key types that can be used for handshake due to limited transient memory.

To avoid the NVM writes, modify the function *mbedtls_ecdsa_verify* in `sss/plugin/mbedtls/ecdsa_verify_alt.c`. Create the required key type object in your application and use this key object in function *mbedtls_ecdsa_verify* for verify operation. Do not delete the keyobject at the end of verify operation.

Also when `MBEDTLS_ECDSA_VERIFY_ALT` is enabled, set the sss key store from application using api *sss_mbedtls_set_sss_keystore*. Refer example `sss/ex/mbedtls/ex_sss_ssl2.c`.

```
sss_mbedtls_set_sss_keystore(&pCtx->ks);
```

8.2.4 Using mbedTLS ALT

For reference, let's look at the `sss/ex/mbedtls/ex_sss_ssl2.c`. The important sections of the file are.

Here we initialize the keys and relevent objects.

```
        /* pex_sss_demo_tls_ctx->obj will have the private key handle */
        status = sss_key_object_init(&pex_sss_demo_tls_ctx->obj, &pCtx->ks);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_init for keyPair Failed...\n");
            return kStatus_SSS_Fail;
        }

        status = sss_key_object_get_handle(&pex_sss_demo_tls_ctx->obj, SSS_KEYPAIR_
↪INDEX_CLIENT_PRIVATE);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_get_handle  for keyPair Failed...\n");
            return kStatus_SSS_Fail;
        }

        /*
        * All ecdsa verification is done using the esdsa_alt file. No need to␣
↪associate the root ca pub key.
        */
#if !defined(MBEDTLS_ECDSA_VERIFY_ALT)
        /* pex_sss_demo_tls_ctx->pub_obj will have the root CA public key */
        status = sss_key_object_init(&pex_sss_demo_tls_ctx->pub_obj, &pCtx->ks);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_init for Pub key Failed...\n");
            return kStatus_SSS_Fail;
        }

        status = sss_key_object_get_handle(&pex_sss_demo_tls_ctx->pub_obj, SSS_PUBKEY_
↪INDEX_CA);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_get_handle  for extPubkey Failed...\n");
            return kStatus_SSS_Fail;
        }
#endif

        /* pex_sss_demo_tls_ctx->dev_cert will have the our device certificate */
        status = sss_key_object_init(&pex_sss_demo_tls_ctx->dev_cert, &pCtx->ks);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_init for Pub key Failed...\n");
            return kStatus_SSS_Fail;
        }
        status = sss_key_object_get_handle(&pex_sss_demo_tls_ctx->dev_cert, SSS_
↪CERTIFICATE_INDEX);
        if (status != kStatus_SSS_Success) {
            printf(" sss_key_object_get_handle  for client Cert Failed...\n");
            return kStatus_SSS_Fail;
        }
```

Here, we tell mbedTLS to use the root CA public key from the SE.

```
mbedtls_pk_free(&cacert.pk);
ret = sss_mbedtls_associate_pubkey(&cacert.pk, &pex_sss_demo_tls_ctx->pub_obj);
```

Here, get certificate in DER format from the SE, and then convert it to PEM and share it with the mbedTLS stack.

```
size_t KeyBitLen = SIZE_CLIENT_CERTIFICATE * 8;
size_t KeyByteLen = SIZE_CLIENT_CERTIFICATE;

ret_code = sss_key_store_get_key(
    &pCtx->ks, &pex_sss_demo_tls_ctx->dev_cert, aclient_cer, &KeyByteLen, &KeyBitLen);

ret = mbedtls_x509_crt_parse_der(&clicert,
    (const unsigned char *)aclient_cer,
    sizeof(aclient_cer));
if ((ret_code == kStatus_SSS_Success) && (ret == 0)) {
    client_certificate_loaded = 1;
}
```

Here, we tell mbedTLS to use the device private key from the SE, generally for signing any contents.

```
sss_mbedtls_associate_keypair(&pkey, &pex_sss_demo_tls_ctx->obj);
```

Here, we tell mbedTLS to use the private key from the SE for ECDH handshake.

```
sss_mbedtls_associate_ecdhctx(ssl.handshake, &pex_sss_demo_tls_ctx->obj, &pCtx->host_
↪ks);
```

8.2.5 Testing

Building mbedTLS SSL/DTLS server for testing

Build mbedTLS server using the VS solution: CMake configurations: - `RTOS_Default`: ON - `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON - `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

- Project: `mbedtls_ex_orig_ssl_server2` / `mbedtls_ex_orig_dtls_server`

Building mbedTLS SSL/DTLS client (with SSS-APIs integration)

Build mbedTLS client using the VS solution: CMake configurations: - `RTOS_Default`: ON - `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON - `SSS_HAVE_MBEDTLS_ALT_SSS`: ON

- Project: `mbedtls_ex_sss_ssl2_client` / `mbedtls_ex_sss_dtls_client`

Testings mbedTLS ALT

Directory `simw-top\sss\plugin\mbedtls\scripts` contains test scripts for starting mbedTLS server and client applications with different cipher suites. Before executing some test scripts, the secure element must first be provisioned.

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) Provision secure element using python scripts in directory `simw-top\sss\plugin\mbedtls\scripts`. Run the following commands in virtual environment:

   To provision secure element for ECC `python3 create_and_provision_ecc_keys.py <keyType> <connection_type> <connection_string> <iot_se (optional. Default - se050)> <auth (optional. Default - None)> <auth_key>`

To configure secure element for RSA `python3 create_and_provision_rsa_keys.py <keyType> <connection_type> <connection_string> <auth (optional. Default - None)> <auth_key>`

To see possible values of input arguments, run without any parameters `create_and_provision_ecc_keys.py.` or `create_and_provision_rsa_keys.py`

Note: Once provisioning is done the virtual environment is not needed anymore.

---

3) Starting mbedTLS SSL client and server applications:

```
python3 start_ssl2_server.py <ec_curve>/<rsa_type>
python3 start_ssl2_client.py <ec_curve>/<rsa_type> <cipher suite> <connection_
↪string>
```

4) Starting mbedTLS DTLS client and server applications:

```
python3 start_dtls_server.py <ec_curve>/<rsa_type>
python3 start_dtls_client.py <ec_curve>/<rsa_type> <cipher suite> <connection_
↪string>
```

Note: Ensure that `ec_curve/rsa_type` used in server and client applications is the same as used while provisioning the SE in step 2.

8.2.6 SE050 Performance Measurements

The following measurements are performed on K-64 board with SE050 connected via T10I2C.

TLS1.2 using ECC Nist256 Keys (Using MbedTLS Alt)

Ciphersuite used for TLS - TLS-ECDH-ECDSA-WITH-AES-128-CBC-SHA

Read the numbers as MIN - AVG - MAX milliseconds.

Operation	SE05X (Auth - None)	K64 (with O0)	K64 (with O2)
Server Certificate Verification	49 - 49.6 - 50	1885 - 1885.4 - 1887	754 - 754.2 - 755
DH key generation	54 - 54 - 54	911 - 913.8 - 915	363 - 364.4 - 366
Sign Operation	50 - 51.8 - 59	952 - 956 - 959	382 - 384 - 386

sss_derive_key_dh is used for DH calulation. Time measured includes - set other party public key on host, Derive key, Get DH key from host.

TLS1.2 using RSA2048 (CRT) Keys (Using MbedTLS Alt)

Ciphersuite used for TLS - TLS-ECDHE-RSA-WITH-CHACHA20-POLY1305-SHA256

Read the numbers as MAX - AVG - MIN milliseconds.

Operation	SE05X (Auth - None)	K64 (with O0)	K64 (with O2)
Server Certificate Verification	49 - 49.8 - 50	172 - 172.2 - 172	26 - 26.8 - 27
DH key generation	NA - NA - NA	3151 - 3157.4 - 3179	813 - 834.6 - 847
Sign Operation	102 - 102.4 - 103	8450 - 8521 - 8571	1143 - 1152 - 1164

Secp521r1 key is used for DH.

8.2.7 mbedTLS ALT APIs

group **`ax_mbed_tls`**

mbedTLS ALT implementation.

Description Implementation of key association between NXP Secure Element and mbedtls.

History 1.0 30-jan-2018 : Initial version

Functions

int **`sss_mbedtls_associate_ecdhctx`** (mbedtls_ssl_handshake_params **handshake*, *sss_object_t *pkeyObject*, *sss_key_store_t *hostKs*)

Update ECDSA HandShake key with given inded.

Return 0 if successful, or 1 if unsuccessful

Parameters

- `[inout] handshake`: Pointer to the mbedtls_ssl_handshake_params which will be associated with data corresponding to the key index
- `[in] pkeyObject`: The object that we are going to be use.
- `[in] hostKs`: Keystore to host for session key.

int **`sss_mbedtls_associate_keypair`** (mbedtls_pk_context **pkey*, *sss_object_t *pkeyObject*)

Associate a keypair provisioned in the secure element for subsequent operations.

Return 0 if successful, or 1 if unsuccessful

Parameters

- `[out] pkey`: Pointer to the mbedtls_pk_context which will be associated with data corresponding to the key_index
- `[in] pkeyObject`: The object that we are going to be use.

int **`sss_mbedtls_associate_pubkey`** (mbedtls_pk_context **pkey*, *sss_object_t *pkeyObject*)

Associate a pubkey provisioned in the secure element for subsequent operations.

Return 0 if successful, or 1 if unsuccessful

Parameters

- `[out] pkey`: Pointer to the mbedtls_pk_context which will be associated with data corresponding to the key index
- `[in] pkeyObject`: The object that we are going to be use.

8.3 Platform Security Architecture

The Platform Security Architecture (PSA) by ARM is a holistic set of threat models, security analyses, hardware and firmware architecture specifications, and an open source firmware reference implementation.

ARMmbed provides an interface for PSA APIs as a part of its mbed-crypto project. Also, it supports SE driver interface which allows the user to use its own implementation for PSA cryptographic functions. This is useful for integrating Secure Element with mbed-crypto provided PSA interface.

For details on PSA specification, refer to ARMmbed PSA Specification.

8.3.1 PSA SE Driver Interface

The SE Driver interface allows the user to register Secure Element drivers for various cryptographic operations. It is not necessary that one driver should offer all cryptographic functionalities, we can register up to 4 drivers which may offer different functionalities.

Cryptographic APIs are split in to the following :

- SE_KEY_MANAGEMENT - Key management APIs like import/generate/destroy
- SE_MAC - Mac operations
- SE_CIPHER - Symmetric encrypt/decrypt operations
- SE_AEAD - AEAD/GCM operations
- SE_ASYMMETRIC - Asymmetric sign/verify/encrypt/decrypt operations
- SE_KEY_DERIVATION - Key derivation operations

The driver may support any subset of cryptographic functionalities, mbed-crypto offers software fall-back for APIs unavailable from SE.

Note: For SE interface, currently only SE_KEY_MANAGEMENT APIs, and asymmetric sign and asymmetric verify APIs are supported.

8.3.2 PSA Concepts

Location The location of an SE driver is the unique identifier it is registered with. To access any functionality this value is checked by the PSA stack.

Lifetime The lifetime of an object refers to its persistence. An object can either be `PERSISTENT` or `VOLATILE`. Lifetime identifies the scope of an object (where the object is stored and which operations are available for it). For SE driver objects, this value is defined as `(PSA_ALT_SE05X_LOCATION << 8) + PERSISTENCE_VALUE` where `PERSISTENCE_VALUE` indicates the `psa_key_persistence_t` value of the object (volatile/persistent). This is used while performing any operation on an object. We can use different lifetimes while performing operations with the same object as long as different drivers can access the object.

Slot ID This is a 64-bit ID indicating where the object is loaded in the library. PSA offers a maximum of 31 slots, which indicates that at a time, a maximum of 31 objects can be used for any operation. If an object is not being used, the object handle can be closed to free the slot. Since there is no concept of an object being loaded for SE, the Slot ID will refer to the Key ID of the object. Any application will remain unaware of Slot ID and this should be managed internally. PSA library should use this value to refer to any object.

For SSS based PSA implementation, we have a 1:1 mapping of Slot ID from Key ID.

Also see *Managing KeyIDs*.

Key ID This is a 32-bit ID indicating the file name of the object which will be stored on the file system. Apart from the actual object, PSA also maintains an object file which will store metadata of the object such as policies and supported algorithms. Before performing any operation, these values are validated. The applications will use this value to refer to any object.

For SSS based PSA implementation, the contents of this file may also stored on SE.

Also see *Managing KeyIDs*.

PSA Objects

- **LIFETIME_FILE** - This is SE specific file which can contain SE(driver) specific persistent data
- **TRANSACTION_FILE** - This is a temporary file created at the time of any operation. It will be deleted after the operation. This is also used to continue a pending operation if, in case, the system reboots.
- **OBJECT_FILE** - This file corresponds to any object we create inside the SE. It will store data about policy, supported algorithms, etc.

  (keyID range is 0x20000000 - 0x2FFFFFFF)
- **OBJECT** - This is the actual object created inside the SE.

  (keyID range is 0x30000000 - 0x3FFFFFFF)

For any provided Key ID, the most significant nibble is masked out. The effective Key ID is 28-bit long. Also see *Managing KeyIDs*.

> **Warning:** This logic of managing KeyIDs of various PSA objects is temporary and it will be changed in the future.

8.3.3 Managing KeyIDs

Application can provide any keyID to be used with SE. This will be mapped directly (1:1) with the slotID. For internal usage, it is mapped to a 28-bit ID, masking out the most significant nibble. Of all PSA objects, **lifetime file**, **transaction file** and **secure objects** will always be stored in secure element. The application has an option to choose the storage for object metadata files.

Providing the mask `#define PSA_ALT_ITS_SE_FLAG ((0x1) << 28)` in the keyID will ensure that object file is stored in secure element. If this flag is not set, object file will be stored in flash memory.

Flash storage currently has support to store only up to 8 object files.

8.3.4 Building PSA for TrustZone

PSA library is intended to run in ARM TrustZone. All examples will run in normal world and link to PSA library to perform cryptographic operations. Build the library for TrustZone with the following CMake configurations:

- `Host=lpcxpresso55s_s`
- `HostCrypto=MBEDTLS`
- `mbedTLS_ALT=PSA`
- `RTOS=Default`
- `SMCOM=T1oI2C`

- `PROJECT=PSA_ALT`

8.4 Android Key master

See *Android: Hikey960*

8.5 Introduction on Open62541 (OPC UA stack)

Open62541 is an open source C implementation of OPC UA stack. Open62541 supports binary encoding of messages with the following security profiles and modes.

Security Profiles

1) None
2) Basic256
3) Basic256SHA256

Security Modes

1) None
2) Sign
3) Sign and Encrypt

8.5.1 Integrating SE050 in Open62541

Open62541 stack uses mbedtls for all crypto operations in security profile plugins by default. For integrating with SE050, in the security profile plugins of Open62541 (`simw-top\ext\open62541\plugins\securityPolicies`), specific mbedtls functions used for private key operations, are replaced by calls to SSS APIs. Only the `Basic256SHA256` security profile (uses RSA2048 keys) has been updated to support SE050 integration: private key operations - RSA Sign and RSA Decrypt - are now performed using SE050. The modified security profile plugin files are placed at `simw-top\sss\plugin\open62541`.

For the server application, a reference key file is used to pass the key id information to the security profile plugins layer.

Note: Please refer to the demonstrator built on top of the Open62541 OPC UA stack for further details (*OPC UA (Open62541) Demo*)

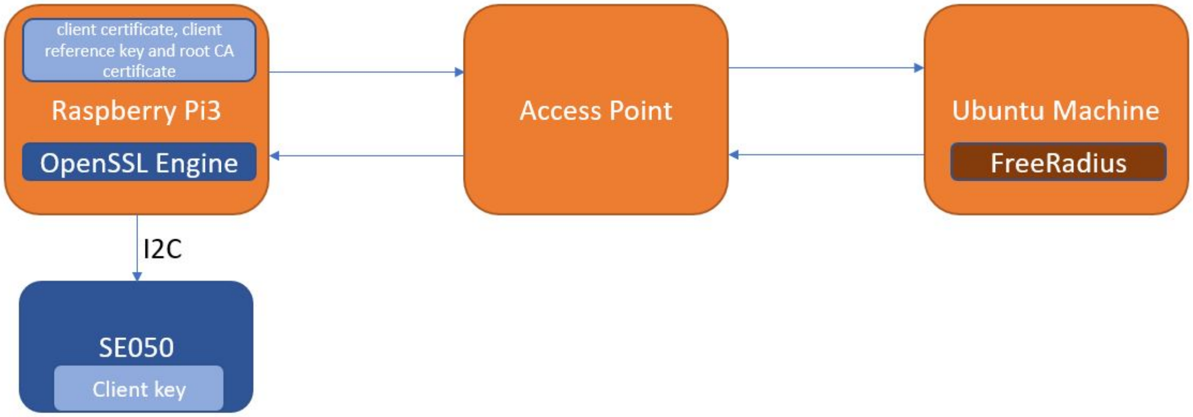
8.6 WiFi EAP Demo with Raspberry Pi3

8.6.1 Prerequisites

- Rsapberry pi3 with raspbian OS installed.
- Ubuntu machine to run freeRadius
- Access point (WPA/WPA2 Enterprise capable)

8.6.2 Introduction

The image shows the wifi EAP demo set up



8.6.3 Setting up Access point

1) Connect Access point (WPA/WPA2 Enterprise capable) and Linux machine over a ethernet cable,
2) Log in to access point
3) Under wireless settings change security to `WPA/WPA2 Enterprise` and give the ip address of Ubuntu machine to RADIUS Server IP
4) RADIUS Server Port - 1812
5) Enter any password in RADIUS Server password field

8.6.4 Setting up freeradius Server on Ubuntu

1) **Install freeradius server on ubuntu machine.** `sudo apt-get install freeradius`

   Freeradius is installed at /etc/freeradius

2) Now add the access point ip address and radius password to client configuration file - `/etc/freeradius/clients.conf`

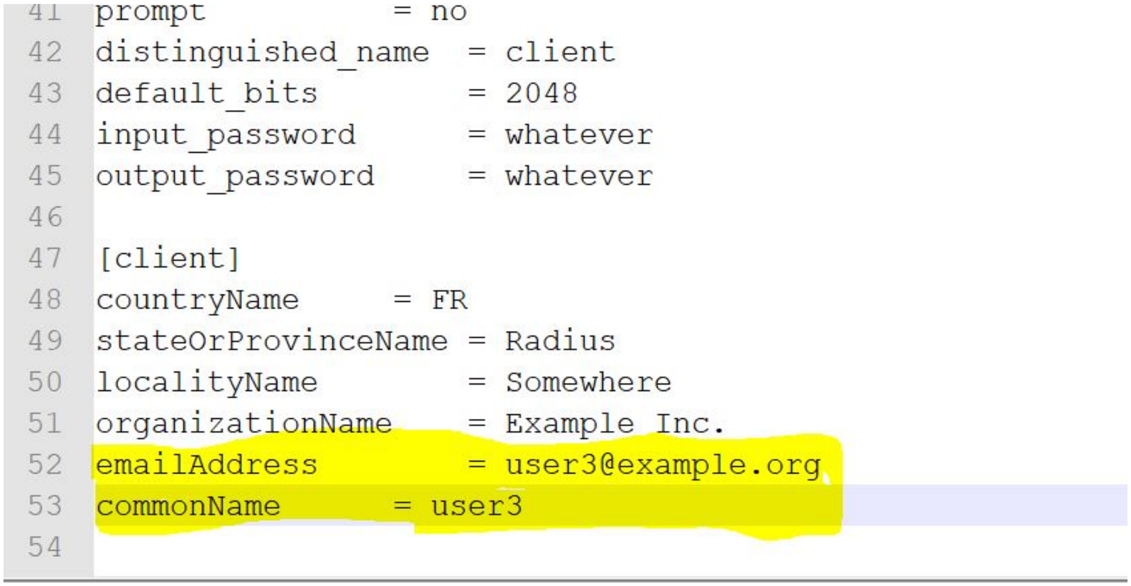
```
For freeradius 2.2.8 add,
    client 192.168.2.1/16 {
        secret      = <radius server password mentioned in previous section>
        shortname   = <Any short name>
    }

For freeradius 3.0 add,
    client router {
        ipaddr      = 192.168.2.1
        secret      = <radius server password mentioned in previous section>
    }
```

3) Generate client and server keys. Scripts to generate keys and certificates are available in freeradius source code

```
git clone https://github.com/FreeRADIUS/freeradius-server.git
cd freeradius-server
```

4) **Add client email address and common name in `/freeradius-server/raddb/certs/client.cnf`**



```
prompt              = no
distinguished_name  = client
default_bits        = 2048
input_password      = whatever
output_password     = whatever

[client]
countryName       = FR
stateOrProvinceName = Radius
localityName        = Somewhere
organizationName    = Example Inc.
emailAddress        = user3@example.org
commonName        = user3
```

5) Execute bootstrap script at /freeradius-server/raddb/certs

```
./bootstrap
```

6) Keys and certificates are generated in folder `/freeradius-server/raddb/certs`

7) Copy root ca cert, server key and server certificate to installed freeradius path

```
cp /freeradius-server/raddb/certs/ca.pem /etc/freeradius/certs/
cp /freeradius-server/raddb/certs/server.key /etc/freeradius/certs/
cp /freeradius-server/raddb/certs/server.pem /etc/freeradius/certs/
cp /freeradius-server/raddb/certs/dh /etc/freeradius/certs/
```

8) Add client details to user configuration file

```
For freeradius 2.2.8, add details in /etc/freeradius/users file

    <user_name> Cleartext-password := <user_password>
    Reply-Message = "<message>"


For freeradius 3.0 add details in /etc/freeradius/mods-config/files/authorize file

    <user_name> Auth-Type := Accept, Cleartext-password := <user_password>
    Reply-Message = "<message>"
```

9) Make the following changes to freeradius conf file at

For freeradius 2.2.8 - `/etc/freeradius/eap.conf`.

For freeradius 3.0 - `/etc/freeradius/mods-available/eap`.

```
    @@ -199,6 +199,7 @@ eap {
        #  *one* CA certificate.
        #
        # ca_file = /etc/ssl/certs/ca-certificates.crt
+       ca_file = /etc/freeradius/3.0/certs/ca.pem

        #  OpenSSL will automatically create certificate chains,
        #  unless we tell it to not do that.  The problem is that
@@ -498,7 +499,7 @@ eap {
            #
            #  You should also delete all of the files
            #  in the directory when the server starts.
-   #       tmpdir = /tmp/radiusd
+           tmpdir = /tmp/radiusd

            #  The command used to verify the client cert.
            #  We recommend using the OpenSSL command-line
@@ -703,7 +704,8 @@ eap {
        # client certificate with EAP-TTLS, so this option is unlikely
        # to be usable for most people.
        #
-   #   require_client_cert = yes
+       EAP-TLS-Require-Client-Cert = Yes
+       require_client_cert = yes
    }
```

10) Create a radiusd directory in /tmp and assign permission for freerad user

```
mkdir tmp/radiusd
sudo chown freerad:freerad tmp/radiusd
```

11) Start free radius server as

```
sudo freeradiux -X
```

8.6.5 Setting up Raspberry Pi3

1) Copy plug and trust middleware package to rpi3 at `/home/pi` location
2) Modify the openssl engine id to `pkcs11` in openssl engine header file `ax_embSeEngine.h`.

   Location: `simw-top/sss/plugin/openssl/engine/inc/ax_embSeEngine.h`
3) Build openssl engine

```
cd simw-top
python scripts/create_cmake_projects.py
cd ../simw-top_build/raspbian_native_se050_t1oi2c
make install
ldconfig /usr/local/lib
```

4) Copy client key (client.key), client certificate (client.crt), Root CA certificate (ca.pem) from ubuntu machine (`freeradius-server/certs/`) to raspberry pi at location `/home/pi/wifiEAP`
5) Refer to *CLI Tool* for ssscli tool setup. Using ssscli tool, create a reference pem file for client key

```
cd /home/pi/wifiEAP
openssl rsa -in client.key -out client.pem
ssscli connect se05x t1oi2c none
ssscli set rsa pair 0x1234 client.pem
ssscli refpem rsa pair 0x1234 client_ref.pem
```

6) Add folowing network configuration to wpa_supplicant.conf file (`/etc/wpa_supplicant`)

```
pkcs11_engine_path=/usr/local/lib/libsss_engine.so
pkcs11_module_path=/usr/local/lib/libsss_engine.so

network={
    ssid="<SSID>"
    priority=1
    engine=1
    key_mgmt=WPA-EAP
    pairwise=CCMP TKIP
    auth_alg=OPEN
    eap=TTLS                                # When using freeradius 2.2.8, use TLS
    identity="<user_name>"                  # from user configuration file
    password="<user_password>"              # from user configuration file

    ca_cert="/home/pi/wifiEAP/<ROOT_CA_CERT_FILE>"
    client_cert="/home/pi/wifiEAP/<CLIENT_CERT_FILE>"
    private_key="/home/pi/wifiEAP/<CLIENT_KEY_REFERENCE_FILE>"
    private_key_passwd="<PRIVATE_KEY_PASSWORD>"                   # If key file is not encrypte

    ca_cert2="/home/pi/wifiEAP/<ROOT_CA_CERT_FILE>"
    client_cert2="/home/pi/wifiEAP/<CLIENT_CERT_FILE>"
    private_key2="/home/pi/wifiEAP/<CLIENT_KEY_REFERENCE_FILE>"
    private_key_passwd="<PRIVATE_KEY_PASSWORD>"                   # If key file is not encrypte
}
```

7) Change the engine_id to `pkcs11` in openssl configuration file (/simw-top/demos/linux/common/openssl11_sss_se050.cnf)

```
[e4sss_se050_section]
engine_id = pkcs11
dynamic_path = /usr/local/lib/libsss_engine.so
init = 1
default_algorithms = RAND,RSA,EC
```

8) Set the openssl config path as call:

```
$ export OPENSSL_CONF=/simw-top/demos/linux/common/openssl11_sss_se050.cnf
```

9) kill wpa_supplicant process as

```
pkill wpa_supplicant
```

10) Restart wpa_supplicant process as

```
wpa_supplicant -c/etc/wpa_supplicant/wpa_supplicant.conf -iwlan0 -Dwext
```

11) On successful TLS handshake, Rpi should be assigned with a valid IP address.

Note:

1) Tested with openssl version of 1.1.0j on raspberry pi.
2) Ip address mentioned above is for illustrative purpose.

8.7 PKCS#11 Standalone Library

PKCS#11(v2.40) is a Public-Key Cryptography Standard for cryptographic data manipulation. It is mainly used with Hardware Security Modules and smart cards.

PKCS#11 standalone library is supported with SE05x for Linux based platforms.

8.7.1 PKCS#11 Label Handling

PKCS#11 library has three ways to calculate keyId through `LabelToKeyId()`:

1) **If `labelSize == 0`**
    - keyId is generated through a random generator.
2) **If CKA_LABEL starts with `sss`:**
    - keyID is generated by interpreting following string as hex value of the keyID. Example - If CKA_LABEL is `sss:20181001`, keyID is 0x01101820

    Note: keyID is interpreted as little endian uint32_t value when reading attribute CKA_LABEL or attribute CKA_ID. Also, keyID is the value used to reference objects inside SE05x and is handled internally. This value should not be confused with CKA_ID or CKA_LABEL.

3) **Any other CKA_LABEL**
    - KeyId is generated as the last 4 bytes of SHA512 digest of label.

8.7.2 PKCS#11 Object cacheing

PKCS#11 library supports cacheing objects during `C_FindObjects()` operation which can improve execution time of subsequent functions. The objects are cached during `C_FindObjects()` operation and are valid until `C_FindObjectsFinal()` is called. On calling `C_FindObjectsFinal()`, the cached objects are invalidated.

Maximum objects that can be cached is 200. By default only 1 object is cached to save memory. However, this can be increased in `sss_pkcs11_pal.h` for platforms which do not have a memory constraint:

```
/* Define max objects to read during C_FindObjects
 * Should not be more than MAX_ID_LIST_SIZE
 */
#define USER_MAX_ID_LIST_SIZE 1
```

8.7.3 PKCS#11 specifications

Token Label *SSS_PKCS11*

Pin Not required

Supported Mechanisms

- **RSA Mechanisms**
    - CKM_RSA_PKCS
    - CKM_SHA1_RSA_PKCS
    - CKM_SHA224_RSA_PKCS
    - CKM_SHA256_RSA_PKCS
    - CKM_SHA384_RSA_PKCS
    - CKM_SHA512_RSA_PKCS
    - CKM_RSA_PKCS_PSS
    - CKM_SHA1_RSA_PKCS_PSS
    - CKM_SHA224_RSA_PKCS_PSS
    - CKM_SHA256_RSA_PKCS_PSS
    - CKM_SHA384_RSA_PKCS_PSS
    - CKM_SHA512_RSA_PKCS_PSS
    - CKM_RSA_PKCS_OAEP
- **AES Mechanisms**
    - CKM_AES_ECB
    - CKM_AES_CBC
    - CKM_AES_CTR
- **Digest Mechanisms**
    - CKM_SHA_1
    - CKM_SHA224
    - CKM_SHA256
    - CKM_SHA384
    - CKM_SHA512
- **ECDSA Mechanisms**
    - CKM_ECDSA
    - CKM_ECDSA_SHA1
- **Key Generation Mechanisms**
    - CKM_EC_KEY_PAIR_GEN
    - CKM_RSA_PKCS_KEY_PAIR_GEN
    - CKM_AES_KEY_GEN
    - CKM_DES2_KEY_GEN
    - CKM_DES3_KEY_GEN
- **Key Derivation Mechanisms**
    - CKM_ECDH1_DERIVE

Supported API

- **General-purpose functions**
    - C_Initialize
    - C_Finalize
    - C_GetInfo
    - C_GetFunctionList
- **Slot and token management functions**
    - C_GetSlotList
    - C_GetSlotInfo
    - C_GetTokenInfo
    - C_GetMechanismList
    - C_GetMechanismInfo
- **Session management functions**
    - C_OpenSession
    - C_CloseSession
    - C_GetSessionInfo
    - C_Login
    - C_Logout
- **Object management functions**
    - C_CreateObject
    - C_DestroyObject
    - C_GetAttributeValue
    - C_FindObjectsInit
    - C_FindObjects
    - C_FindObjectsFinal
- **Encryption functions**
    - C_EncryptInit
    - C_Encrypt
- **Decryption functions**
    - C_DecryptInit
    - C_Decrypt
- **Message digesting functions**
    - C_DigestInit
    - C_Digest
    - C_DigestUpdate
    - C_DigestFinal
- **Signing and MACing functions**

    - C_SignInit
    - C_Sign
    - C_VerifyInit
    - C_Verify
  - **Key management functions**
    - C_GenerateKey
    - C_GenerateKeyPair
    - C_DeriveKey
  - **Random number generation functions**
    - C_SeedRandom
    - C_GenerateRandom

8.7.4 Building on Linux/Raspberry Pi3

PKCS#11 standalone shared library can be built on Linux platforms and Raspberry Pi3.

Build PKCS#11 library for Raspberry pi 3 with the following CMake configurations:

- `RTOS_Default`: ON
- `SSS_HAVE_HOSTCRYPTO_MBEDTLS`: ON
- Project: `sss_pkcs11`

Note: The PKCS#11 library is not completely standalone as mbedTLS library is also used for parsing data.

Note: While using PKCS#11 as a library on multithreaded systems, the application must ensure proper locking is used. Calling multiple APIs from the library from different threads without proper locks can lead to unexpected behaviour.

8.7.5 Using with pkcs11-tool

Install `pkcs11-tool` by running:

```
sudo apt-get install opensc-pkcs11
```

Set environment variable to the installed PKCS#11 shared library:

```
export PKCS11_MODULE=/usr/local/lib/libsss_pkcs11.so
```

The *.so* file is available in `binaries/pkcs11` directory.

Generating new keypair:

```
pkcs11-tool --module $PKCS11_MODULE --keypairgen --key-type rsa:1024 --label␣
↪"sss:20202020"
```

Signing:

```
pkcs11-tool --module $PKCS11_MODULE --sign --label sss:20181001 -m SHA256-RSA-PKCS --
↪slot 1 -i in.der -o signature.der
```

Decryption:

```
pkcs11-tool --module $PKCS11_MODULE --decrypt --label sss:20202020 -m SHA256-RSA-PKCS␣
↪--slot 1 -i in.der -o decrypt.der
```

Hashing:

```
pkcs11-tool --module $PKCS11_MODULE --hash -m SHA256 -i in.der -o hash.der
```

8.7.6 Notes

The monotonic counter will increase by one each time its value is read as specificed in “PKCS #11 Cryptographic Token Interface Base Specification Version 2.40”. This will cause NVM write accesses.

See also *Android: Hikey960*

CHAPTER

NINE

CLI TOOL

9.1 Introduction

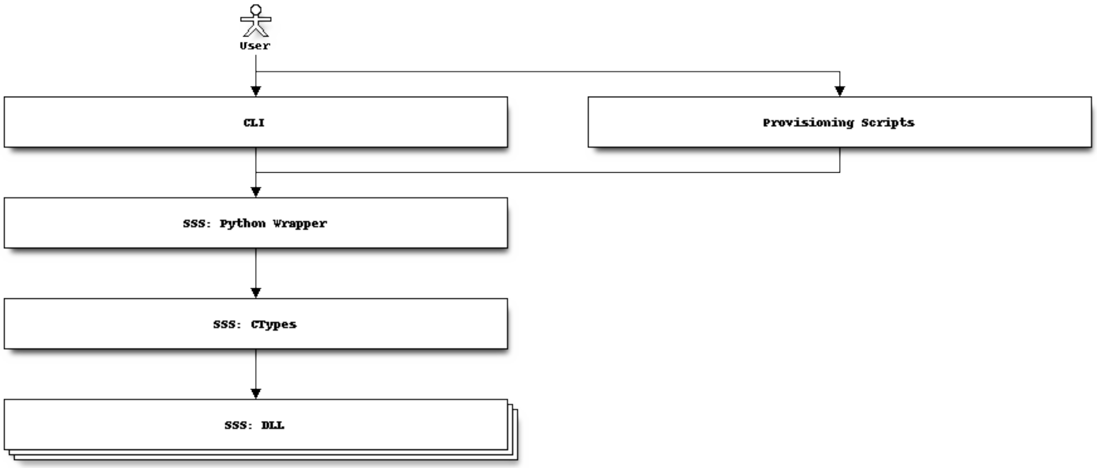
The `ssscli` tool is a Python based tool to manipulate the SE050 Secure Element.

It can be used to:

- Insert Keys, Certficates
- Generate Keys
- Attach policies to objects
- Control Cloud for CLI (To Be Done)

It's written in Python to enable the tool and corresponding scripts to be run on Windows/Linux/OS X and other embedded devices. Because of Python language, the tool also enables us to generate complex provisioning scripts and schemas for testing various provisioning scenarios.

9.2 Block Diagram



Name	Description
User	User who runs the scripts
CLI	CLI Interface. Simple commands to interact with the SE.
Provisioning Scripts	Provisioning scripts for various use cases.
SSS: Python Wrapper	Python middleware for SSS features. This is a functional abstraction layer over the raw CTypes wrapper.
SSS: CTypes	CTypes wrapper for SSS APIs. The wrapper is machine generated from SSS Header files.
SSS: DLL	Native DLL on top of the SSS Layer. See *Plug & Trust MW : Block Diagram*. Based on the selection of the platform/interface, this DLL needs to be re-compiled.

9.3 Steps needed before running `ssscli` tool

9.3.1 Once per installation

The following steps are needed once per installation.

Windows

1) Ensure 32 bit PYTHON 3 is installed.

   You can download it from https://www.python.org/downloads/.

2) Environment to build host library is setup (GCC/MinGW/Visual Studio)

   Note: This is required so that DLL/.SO can be prepared to be used by the CLI Tool.

3) Follow Section 4.1 *Windows Build* and build the `sssapisw`.

4) It is recommended to install the cli tool via virtualenv.

   See https://virtualenv.pypa.io/en/latest/ and https://docs.python-guide.org/dev/virtualenvs/#lower-level-virtualenv to understand more about virtualenv

   Run:

```
pip3 install virtualenv
```

5) Once virtualenv is installed, create a new virtual environemnt:

```
python -m virtualenv venv
```

6) To activate the new created virtual ENV Run:

```
call venv\Scripts\activate.bat
```

7) **In the new installed virtualenv, install required packages. This includes click, cryptography and func-timeout.**

   - click: To parse command line parameter.
   - cryptography: Load keys, certificates and generate reference keys.
   - func-timeout: ssscli recovery mechanism in case of no response from hardware.

Change directory to `<SE05X_root_folder>/simw-top/pycli` and run:

```
pip install -r requirements.txt
```

8) To install `ssscli` tool, run the following commands:

```
cd src
pip install --editable .
```

9) Alternately can install `ssscli` tool, by running following commands:

```
cd src
python setup.py develop
```

i.MX

1) Ensure PYTHON 3 is installed.

   refer to Section 11.5.1 *platform-imx-linux*

2) Ensure func-timeout module is installed:

```
pip3 install func-timeout
```

3) Follow Section 4.4 *i.MX Linux Build* and build the `sssapisw`.

4) To install `ssscli` tool, change directory to `<SE05X_root_folder>/simw-top/pycli/src` and run the following command:

```
python3 setup.py develop
```

Raspberry Pi

1) Ensure PYTHON 3 is installed.

2) Ensure python3-pip, python3-dev and libffi-dev are installed:

```
sudo apt-get install python3-pip python3-dev libffi-dev
```

3) Follow Section 4.5 *Raspberry Pi Build* and build the `sssapisw`.

4) Ensure click, cryptography and func-timeout modules are installed. To install these modules, change directory to `<SE05X_root_folder>/simw-top/pycli` and run the following command:

```
pip3 install -r requirements.txt
```

5) To install `ssscli` tool, run the following commands:

```
cd src
sudo python3 setup.py develop
```

9.3.2 Communication interface (cmake SMCOM setting)

The communication interface to the secure element used by the `ssscli` tool is determined by the native shared library used. The communication interface supported by the shared library is controlled by the cmake `SMCOM` value.

To change the communication interface only the native `ssscli` DLL / .so needs to be rebuilt.

The shared library can be compiled with MSVC/MinGW/XCode/GCC based on the selected platform.

9.4 Running the `ssscli` tool - Windows

1) To activate the new created virtual ENV Run:

```
call venv\Scripts\activate.bat
```

2) To connect to the SE, call:

```
ssscli connect se05x vcom COM13
```

3) To dis-connect to the SE, call:

```
ssscli disconnect
```

9.5 CLI Provisioning

9.5.1 Generating keys and certificates

For generating keys and certificates, following scripts generates using openssl.

- `GenerateAWSCredentials.py`
- `GenerateAZURECredentials.py`
- `GenerateGCPCredentials.py`
- `GenerateIBMCredentials.py`

The generated keys and certificates shall be available in `pycli/Provisioning/gcp`, `pycli/Provisioning/ibm`, `pycli/Provisioning/azure` and `pycli/Provisioning/aws` directories.

9.5.2 Provisioning for the demo

Generated keys and certificates are used to provision the secure element using `ResetAndUpdate_GCP.py`, `ResetAndUpdate_IBM.py`, `ResetAndUpdate_AZURE.py` and `ResetAndUpdate_AWS.py` scripts for gcp, ibm, azure and aws cloud demo respectively.

Note: Default auth type in provisoning script is always `None`

9.5.3 Steps to provision your device for demo on Windows

Provisioning on windows can be done in two ways.

- Using precompiled binaries
- Using python scripts

Using precompiled binaries

Precompiled binaries available in `binaries/PCWindows/ssscli` directory. Can generate certificates and provision the secure element by simply running these binaries.

1) For GCP, create certificate and provision, call:

```
Provision_GCP.exe <COM_PORT>
```

2) For IBM, create certificate and provision, call:

```
Provision_IBM.exe <COM_PORT>
```

3) For AWS, create certificate and provision, call:

```
Provision_AWS.exe <COM_PORT>
```

4) For AZURE, create certificate and provision, call:

```
Provision_AZURE.exe <COM_PORT>
```

The generated keys and certificates shall be available in `binaries/PCWindows/ssscli/gcp`, `binaries/PCWindows/ssscli/ibm`, `binaries/PCWindows/ssscli/aws` and `binaries/PCWindows/ssscli/azure` directories.

Using Python scripts

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) from `pycli` directory, run:

```
call venv\Scripts\activate.bat
cd Provisioning
```

3) Check the vcom port number
4) For GCP, create certificate and provision, call:

```
python GenerateGCPCredentials.py <COM_PORT>
python ResetAndUpdate_GCP.py <COM_PORT>
```

5) For IBM, create certificate and provision, call:

```
python GenerateIBMCredentials.py <COM_PORT>
python ResetAndUpdate_IBM.py <COM_PORT>
```

6) For AWS, create certificate and provision, call:

```
python GenerateAWSCredentials.py <COM_PORT>
python verification_certificate.py <interCA_Certificate> <interCA_Keypair>
↪<verification_code>
python ResetAndUpdate_AWS.py <COM_PORT>
```

7) For AZURE, create certificate and provision, call:

```
python GenerateAZURECredentials.py <COM_PORT>
python verification_certificate.py <interCA_Certificate> <interCA_Keypair>
 ↪<verification_code>
python ResetAndUpdate_AZURE.py <COM_PORT>
```

8) Flash the demo on to the board

9.5.4 Steps to provision your device for demo on iMX or Raspberry Pi

1) Complete Section 9.3 *Steps needed before running ssscli tool*
2) from `pycli` directory, run:

```
cd Provisioning
```

3) For GCP, create certificate and provision, call:

```
python3 GenerateGCPCredentials.py
python3 ResetAndUpdate_GCP.py
```

4) For IBM, create certificate and provision, call:

```
python3 GenerateIBMCredentials.py
python3 ResetAndUpdate_IBM.py
```

5) For AWS, create certificate and provision, call:

```
python3 GenerateAWSCredentials.py
python3 verification_certificate.py <interCA_Certificate> <interCA_Keypair>
 ↪<verification_code>
python3 ResetAndUpdate_AWS.py
```

6) For AZURE, create certificate and provision, call:

```
python3 GenerateAZURECredentials.py
python3 verification_certificate.py <interCA_Certificate> <interCA_Keypair>
 ↪<verification_code>
python3 ResetAndUpdate_AZURE.py
```

7) Flash the demo on to the board

9.6 Usage Examples

9.6.1 SE05X: VCOM Interface

Provisioning ECC Pair and Certificate:

```
ssscli connect se05x vcom COM5
ssscli se05x reset
ssscli set ecc pair 0x20181001 tstData\tls_client_key.pem
ssscli set cert 0x20181002 tstData\tls_client.cer
ssscli disconnect
```

Generating ecc key and retrive public key:

```
ssscli connect se05x vcom COM5
ssscli se05x reset
ssscli generate ecc 0x20181006 NIST_P256
ssscli get ecc pair 0x20181006 data\tls_key.pem
ssscli disconnect
```

Inject and retrieve certificate:

```
ssscli connect se05x vcom COM5
ssscli set cert 0x20181004 tstData\tls_client.cer
ssscli get cert 0x20181004 data\extracted_certificate.cer
ssscli disconnect
```

Erase key, Inject ecc Key and Sign certificate:

```
ssscli connect se05x vcom COM5
ssscli erase 0x20181001
ssscli set ecc pair 0x20181001 tstData\tls_client_key.pem
ssscli sign 0x20181001 tstData\tls_client.cer data\signed_data.pem
ssscli disconnect
```

Inject and Retrieve AES key:

```
ssscli connect se05x vcom COM5
ssscli se05x reset
ssscli set aes 0x40100000 tstData\aes.der
ssscli get aes 0x40100000 data\extracted_aes_key.cer
ssscli disconnect
```

Inject ECC Public Key:

```
ssscli connect se05x vcom COM5
ssscli set ecc pub 0x20181010 tstData\tls_client_key_pub.pem
ssscli disconnect
```

Generate RSA Key and Get public key in DER format:

```
ssscli connect se05x vcom COM5
ssscli generate rsa 0x20182001 2048
ssscli get rsa pub 0x20182001 data\rsa_pub_2048.der --format DER
ssscli disconnect
```

Generate ecc Koblitz 256 Key, Sign Binary data and verify:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 12E41001 Secp256k1
ssscli sign 12E41001 tstData\binary_data.bin signed_data_ecc_secp256k1.pem
ssscli verify 12E41001 tstData\binary_data.bin signed_data_ecc_secp256k1.pem
ssscli disconnect
```

Generate ecc Brainpool192 Key and Sign and verify certificate using SHA512 has algorithm:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 0x2E101501 Brainpool192
ssscli sign 0x2E101501 tstData\tls_client.cer data\signed_data.pem --hashalgo=SHA512
ssscli verify 0x2E101501 tstData\tls_client.cer data\signed_data.pem --hashalgo=SHA512
ssscli disconnect
```

Read Cert UID of 10 bytes long:

```
ssscli connect se05x vcom COM5
ssscli se05x certuid
```

Read UID of 18 bytes long:

```
ssscli connect se05x vcom COM5
ssscli se05x uid
```

Session open with auth type as Platform SCP, generate ecc Brainpool192 Key:

```
ssscli connect se05x vcom COM5 --auth_type PlatformSCP --scpkey "c:/_ddm/scpkey.txt"
ssscli se05x reset
ssscli generate ecc 2E10D532 Brainpool192
ssscli disconnect
```

Generate ecc Koblitz256 key and create reference key:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 7A10D838 Secp256k1
ssscli refpem ecc pair 7A10D838 data\refkey_secp256k1.pem
ssscli disconnect
```

Generate rsa 4096 key and create reference key in pkcs12 format:

```
ssscli connect se05x vcom COM5
ssscli generate rsa 0x70102040 4096
ssscli refpem rsa pair 0x70102040 rsa_4096_rekey.pfx --password nxp
ssscli disconnect
```

Generate ecc Brainpool 256 key and create pkcs12 format reference key extracted to pem format:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 70102050 Brainpool256
ssscli refpem ecc pair 70102050 ecc_bp256_rekey.pem  --format PKCS12 --password nxp
ssscli disconnect
```

Generate ecc ED25519 key and sign certificate:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 70102060 ED25519
ssscli sign 70102060 tstData\tls_client.cer data\signed_data_using_ed25519.pem
ssscli disconnect
```

Generate ecc MONTH DH 25519 key:

```
ssscli connect se05x vcom COM5
ssscli generate ecc 70102080 ED25519
ssscli sign 70102080 tstData\tls_client.cer data\signed_data_using_ed25519.pem
ssscli disconnect
```

Perform Encrypt and Decrypt using RSA 2048:

```
ssscli connect se05x vcom COM5
ssscli generate rsa 0x20182001 2048
ssscli get rsa pub 0x20182001 rsa_pub_2048.pem
ssscli set rsa pub 0x20184120 rsa_pub_2048.pem
```

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```
ssscli encrypt 0x20184120 "Welcome to NXP" rsa_2048_encrypted_data.pem
ssscli decrypt 0x20182001 rsa_2048_encrypted_data.pem decrypted_data.txt
ssscli disconnect
```

Provision and Retrieve Binary data:

```
ssscli connect se05x vcom COM5
ssscli set bin 0x20191005 tstData\binary_data.hex
ssscli get bin 0x20191005 binary_data.hex
ssscli disconnect
```

9.6.2 SE05X: PCSC interface

Provisioning ECC Pair and Certificate:

```
ssscli connect se05x pcsc NXP
ssscli se05x reset
ssscli set ecc pair 0x20181001 tstData\tls_client_key.pem
ssscli set cert 0x20181002 tstData\tls_client.cer
ssscli disconnect
```

Inject ECC Public Key:

```
ssscli connect se05x pcsc NXP
ssscli set ecc pub 0x20181010 tstData\tls_client_key_pub.pem
ssscli disconnect
```

9.6.3 se05x: JRCPV2 interface

Provisioning ECC Pair and Certificate:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli se05x reset
ssscli set ecc pair 0x20181001 tstData\tls_client_key.pem
ssscli set cert 0x20181002 tstData\tls_client.cer
ssscli disconnect
```

Generating ecc key and retrive public key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli se05x reset
ssscli generate ecc 0x40100000 NIST_P256
ssscli get ecc pair 0x40100000 data\tls_key.pem
ssscli disconnect
```

Set and retrieve certificate:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli set cert 0x20181002 tstData\tls_client.cer
ssscli get cert 0x20181002 data\extracted_certificate.cer
ssscli disconnect
```

Erase a key, Inject ecc Key and Sign certificate:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli erase 0x20181001
ssscli set ecc pair 0x20181001 tstData\tls_client_key.pem
ssscli sign 0x20181001 tstData\tls_client.cer data\signed_data.pem
ssscli disconnect
```

Inject and Retrieve AES key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli se05x reset
ssscli set aes 0x40200000 tstData\aes.der
ssscli get aes 0x40200000 data\extracted_aes_key.cer
ssscli disconnect
```

Inject ECC Public Key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli set ecc pub 0x20181010 tstData\tls_client_key_pub.pem
ssscli disconnect
```

Generate RSA Key and Get public key in PEM format:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate rsa 0x20182001 2048
ssscli get rsa pub 0x20182001 data\rsa_pub_2048.pem --format PEM
ssscli disconnect
```

Generate ecc Koblitz 256 Key, Sign Binary data and verify:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 12E41001 Secp256k1
ssscli sign 12E41001 tstData\binary_data.bin signed_data_ecc_secp256k1.pem
ssscli verify 12E41001 tstData\binary_data.bin signed_data_ecc_secp256k1.pem
ssscli disconnect
```

Generate ecc Brainpool192 Key and Sign and verify certificate using SHA512 has algorithm:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 0x2E101501 Brainpool192
ssscli sign 0x2E101501 tstData\tls_client.cer data\signed_data.pem --hashalgo=SHA512
ssscli verify 0x2E101501 tstData\tls_client.cer data\signed_data.pem --hashalgo=SHA512
ssscli disconnect
```

Read Cert UID of 10 bytes long:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli se05x certuid
```

Read UID of 18 bytes long:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli se05x uid
```

Session open with auth type as Platform SCP, generate ecc Brainpool192 Key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050 --auth_type PlatformSCP  --scpkey␣
↪"c:/_ddm/scpkey.txt"
ssscli se05x reset
ssscli generate ecc 2E10D532 Brainpool192
ssscli disconnect
```

Generate ecc Koblitz256 key and create reference key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 7A10D838 Secp256k1
ssscli refpem ecc pair 7A10D838 data\refkey_secp256k1.pem
ssscli disconnect
```

Generate rsa 4096 key and create reference key in pkcs12 format:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate rsa 0x70102040 4096
ssscli refpem rsa pair 0x70102040 rsa_4096_rekey.pfx --password nxp
ssscli disconnect
```

Generate ecc Brainpool 256 key and create pkcs12 format reference key extracted to pem format:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 70102050 Brainpool256
ssscli refpem ecc pair 70102050 ecc_bp256_rekey.pem  --format PKCS12 --password nxp
ssscli disconnect
```

Generate ecc ED25519 key and sign certificate:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 70102060 ED25519
ssscli sign 70102060 tstData\tls_client.cer data\signed_data_using_ed25519.pem
ssscli disconnect
```

Generate ecc MONTH DH 25519 key:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate ecc 70102080 ED25519
ssscli sign 70102080 tstData\tls_client.cer data\signed_data_using_ed25519.pem
ssscli disconnect
```

Perform Encrypt and Decrypt using RSA 2048:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli generate rsa 0x20182001 2048
ssscli get rsa pub 0x20182001 rsa_pub_2048.pem
ssscli set rsa pub 0x20184120 rsa_pub_2048.pem
ssscli encrypt 0x20184120 "Welcome to NXP" rsa_2048_encrypted_data.pem
ssscli decrypt 0x20182001 rsa_2048_encrypted_data.pem decrypted_data.txt
ssscli disconnect
```

Provision and Retrieve Binary data:

```
ssscli connect se05x jrcpv2 127.0.0.1:8050
ssscli set bin 0x20191005 tstData\binary_data.hex
ssscli get bin 0x20191005 binary_data.hex
ssscli disconnect
```

9.6.4 A71CH: VCOM Interface

Provisioning ECC Pair and Certificate:

```
ssscli connect a71ch vcom COM7
ssscli a71ch reset
ssscli set ecc pair 0x20181003 tstData\tls_client_key.pem
ssscli set cert 0x20181004 tstData\tls_client.cer
ssscli disconnect
```

Generating ecc key and retrive public key:

```
ssscli connect a71ch vcom COM7
ssscli a71ch reset
ssscli generate ecc 0x20181003 NIST_P256
ssscli get ecc pair 0x20181003 data\tls_key.pem
ssscli disconnect
```

Set certificate and retrieve certificate:

```
ssscli connect a71ch vcom COM7
ssscli set cert 0x20181004 tstData\tls_client.cer
ssscli get cert 0x20181004 data\extracted_certificate.cer
ssscli disconnect
```

Erase a key, Inject ecc Key and Sign certificate:

```
ssscli connect a71ch vcom COM7
ssscli erase 0x20181005
ssscli set ecc pair 0x20181005 tstData\tls_client_key.pem
ssscli sign 0x20181005 tstData\tls_client.cer data\signed_data.pem
ssscli disconnect
```

9.6.5 A71CH: SCI2C interface

Provisioning ECC Pair and Certificate:

```
ssscli connect a71ch sci2c none
ssscli a71ch reset
ssscli set ecc pair 0x20181005 tstData/tls_client_key.pem
ssscli set cert 0x20181002 tstData/tls_client.cer
ssscli disconnect
```

Generating ecc key and retrive public key:

```
ssscli connect a71ch sci2c none
ssscli a71ch reset
ssscli generate ecc 0x40100000 NIST_P256
ssscli get ecc pair 0x40100000 data/tls_key.pem
ssscli disconnect
```

Set certificate and retrieve certificate:

```
ssscli connect a71ch sci2c none
ssscli set cert 0x20181002 tstData/tls_client.cer
ssscli get cert 0x20181002 data/extracted_certificate.cer
ssscli disconnect
```

Erase a key, Inject ecc Key and Sign certificate:

```
ssscli connect a71ch sci2c none
ssscli erase 0x20181001
ssscli set ecc pair 0x20181001 tstData/tls_client_key.pem
ssscli sign 0x20181001 tstData/tls_client.cer data/signed_data.pem
ssscli disconnect
```

9.6.6 MBEDTLS

Provisioning ECC Pair and Certificate:

```
ssscli connect mbedtls none data
ssscli set ecc pair 0x20181005 tstData\tls_client_key.pem
ssscli set cert 0x20181002 tstData\tls_client.cer
ssscli disconnect
```

Generating ecc key and retrive public key:

```
ssscli connect mbedtls none data
ssscli generate ecc 0x20181003 NIST_P256
ssscli get ecc pair 0x20181003 data\tls_key.pem
ssscli disconnect
```

Set certificate and retrieve certificate:

```
ssscli connect mbedtls none data
ssscli set cert 0x20181004 tstData\tls_client.cer
ssscli get cert 0x20181004 data\extracted_certificate.cer
ssscli disconnect
```

Erase key, provisioning ecc Key and Sign certificate:

```
ssscli connect mbedtls none data
ssscli erase 0x20181005
ssscli set ecc pair 0x20181005 tstData\tls_client_key.pem
ssscli sign 0x20181005 tstData\tls_client.cer data\signed_data.pem
ssscli disconnect
```

9.7 List of `ssscli` commands

ssscli uses PEM, DER and HEX data formats for keys and certificates. Refer *CLI Data formats*.

Note: Linux Environment

You can `source pycli/ssscli-bash-completion.sh` for auto-completion on bash with linux/posix based environemnt.

9.7.1 ssscli Commands

These are the top level commands accepted by the ssscli Tool.

1) `ssscli`:

```
Usage: ssscli [OPTIONS] COMMAND [ARGS]...

  Command line interface for SE050

Options:
  -v, --verbose  Enables verbose mode.
  --version      Show the version and exit.
  --help         Show this message and exit.

Commands:
  a71ch       A71CH specific commands
  cloud       (Not Implemented) Cloud Specific utilities.
  connect     Open Session.
  decrypt     Decrypt Operation
  disconnect  Close session.
  encrypt     Encrypt Operation
  erase       Erase ECC/RSA/AES Keys or Certificate (contents)
  generate    Generate ECC/RSA Key pair
  get         Get ECC/RSA/AES Keys or certificates
  policy      Create/Dump Object Policy
  refpem      Create Reference PEM/DER files (For OpenSSL Engine).
  se05x       SE05X specific commands
  set         Set ECC/RSA/AES Keys or certificates
  sign        Sign Operation
  verify      verify Operation
```

2) `ssscli connect`:

```
Usage: ssscli connect [OPTIONS] subsystem method port_name

  Open Session.

  subsystem = Security subsystem is selected to be used. Can be one of "se05x,
  auth, a71ch, mbedtls, openssl"

  method = Connection method to the system. Can be one of "none, sci2c, vcom,
  t1oi2c, jrcpv1, jrcpv2, pcsc"

  port_name = Subsystem specific connection parameters. Example: COM6,
  127.0.0.1:8050. Use "None" where not applicable. e.g. SCI2C/T1oI2C. Default
  i2c port (i2c-1) will be used for port name = "None".

Options:
  --auth_type [None|PlatformSCP|UserID|ECKey|AESKey|UserID_PlatformSCP|ECKey_
↪PlatformSCP|AESKey_PlatformSCP]
                                  Authentication type. Default is "None". Can
                                  be one of "None, UserID, ECKey, AESKey,
                                  PlatformSCP, UserID_PlatformSCP,
                                  ECKey_PlatformSCP, AESKey_PlatformSCP"
  --scpkey TEXT                   File path of the platformscp keys for
                                  platformscp session
  --help                          Show this message and exit.
```

3) `ssscli disconnect`:

```
Usage: ssscli disconnect [OPTIONS]
```

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```
  Close session.

Options:
  --help  Show this message and exit.
```

4) `ssscli set:`

```
Usage: ssscli set [OPTIONS] COMMAND [ARGS]...

  Set ECC/RSA/AES Keys or certificates

Options:
  --help  Show this message and exit.

Commands:
  aes   Set AES Keys
  bin   Set Binary
  cert  Set Certificate
  ecc   Set ECC Keys
  hmac  Set HMAC Keys
  rsa   Set RSA Keys
```

5) `ssscli get:`

```
Usage: ssscli get [OPTIONS] COMMAND [ARGS]...

  Get ECC/RSA/AES Keys or certificates

Options:
  --help  Show this message and exit.

Commands:
  aes   Get AES Keys
  bin   Get Binary
  cert  Get Certificate
  ecc   Get ECC Keys
  rsa   Get RSA Keys
```

6) `ssscli generate:`

```
Usage: ssscli generate [OPTIONS] COMMAND [ARGS]...

  Generate ECC/RSA Key pair

Options:
  --help  Show this message and exit.

Commands:
  ecc  Generate ECC Key
  pub  Generate ECC Public Key to file
  rsa  Generate RSA Key
```

7) `ssscli erase:`

```
Usage: ssscli erase [OPTIONS] keyid
```

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```
  Erase ECC/RSA/AES Keys or Certificate (contents)

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

Options:
  --help  Show this message and exit.
```

8) `ssscli cloud`:

```
Usage: ssscli cloud [OPTIONS] COMMAND [ARGS]...

   (Not Implemented) Cloud Specific utilities.

  This helps to handle GCP/AWS/Watson specific settings.

Options:
  --help  Show this message and exit.

Commands:
  aws  (Not Implemented) AWS (Amazon Web Services) Specific utilities
  gcp  (Not Implemented) GCP (Google Cloud Platform) Specific utilities
  ibm  (Not Implemented) IBM Watson Specific utilities
```

9) `ssscli a71ch`:

```
Usage: ssscli a71ch [OPTIONS] COMMAND [ARGS]...

  A71CH specific commands

Options:
  --help  Show this message and exit.

Commands:
  reset  Debug Reset A71CH
  uid    Get A71CH Unique ID
```

10) `ssscli se05x`:

```
Usage: ssscli se05x [OPTIONS] COMMAND [ARGS]...

  SE05X specific commands

Options:
  --help  Show this message and exit.

Commands:
  certuid     Get SE05X Cert Unique ID (10 bytes)
  readidlist  Read contents of SE050
  reset       Reset SE05X
  uid         Get SE05X Unique ID (18 bytes)
```

11) `ssscli refpem`:

```
Usage: ssscli refpem [OPTIONS] COMMAND [ARGS]...

  Create Reference PEM/DER files (For OpenSSL Engine).
```

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```
Options:
  --help  Show this message and exit.

Commands:
  ecc  Refpem ECC Keys
  rsa  Refpem RSA Keys
```

12) `ssscli sign`:

```
Usage: ssscli sign [OPTIONS] keyid input_file signature_file

  Sign Operation

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  input_file = Input file to sign. By default filename with extension .pem and
  .cer considered as PEM format, others as DER/BINARY format.

  signature_file = File name to store signature data. By default filename with
  extension .pem in PEM format and others in DER format.

Options:
  --informat TEXT   Input format. TEXT can be "DER" or "PEM".
  --outformat TEXT  Output file format. TEXT can be "DER" or "PEM"
  --hashalgo TEXT   Hash algorithm. TEXT can be one of "SHA1, SHA224, SHA256,
                    SHA384, SHA512,  RSASSA_PKCS1_V1_5_SHA1,
                    RSASSA_PKCS1_V1_5_SHA224,  RSASSA_PKCS1_V1_5_SHA256,
                    RSASSA_PKCS1_V1_5_SHA384,  RSASSA_PKCS1_V1_5_SHA512,
                    RSASSA_PKCS1_PSS_MGF1_SHA1,  RSASSA_PKCS1_PSS_MGF1_SHA224,
                    RSASSA_PKCS1_PSS_MGF1_SHA256,
                    RSASSA_PKCS1_PSS_MGF1_SHA384,
                    RSASSA_PKCS1_PSS_MGF1_SHA512"
  --help            Show this message and exit.
```

13) `ssscli verify`:

```
Usage: ssscli verify [OPTIONS] keyid input_file signature_file

  verify operation

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  input_file = Input file to verify. By default filename with extension .pem
  and .cer considered as PEM format, others as DER/BINARY format.

  filename = signature_file data file for verification. By default filename
  with extension .pem in PEM format and others in DER format.

Options:
  --format TEXT    input_file and signature file format. TEXT can be "DER" or
                   "PEM"
  --hashalgo TEXT  Hash algorithm. TEXT can be one of "SHA1, SHA224, SHA256,
                   SHA384, SHA512,  RSASSA_PKCS1_V1_5_SHA1,
                   RSASSA_PKCS1_V1_5_SHA224,  RSASSA_PKCS1_V1_5_SHA256,
                   RSASSA_PKCS1_V1_5_SHA384,  RSASSA_PKCS1_V1_5_SHA512,
                   RSASSA_PKCS1_PSS_MGF1_SHA1,  RSASSA_PKCS1_PSS_MGF1_SHA224,
```

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```
                     RSASSA_PKCS1_PSS_MGF1_SHA256, RSASSA_PKCS1_PSS_MGF1_SHA384,
                     RSASSA_PKCS1_PSS_MGF1_SHA512"
  --help             Show this message and exit.
```

14) `ssscli encrypt`:

```
Usage: ssscli encrypt [OPTIONS] keyid input_data filename

  Sign Operation

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  input_data = Input data to Encrypt. can be raw string or in file.

  filename = Output file name to store encrypted data. Encrypted data will be
  stored in DER format.

Options:
  --algo TEXT  Algorithm. TEXT can be one of "oaep", "rsaes"
  --help       Show this message and exit.
```

15) `ssscli decrypt`:

```
Usage: ssscli decrypt [OPTIONS] keyid encrypted_data filename

  Sign Operation

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  encrypted_data = Encrypted data to Decrypt. can be raw data or in file.
  Input data should be in DER format.

  filename = Output file name to store Decrypted data.

Options:
  --algo TEXT  Algorithm. TEXT can be one of "oaep", "rsaes"
  --help       Show this message and exit.
```

16) `ssscli policy`:

```
Usage: ssscli policy [OPTIONS] COMMAND [ARGS]...

  Create/Dump Object Policy

Options:
  --help  Show this message and exit.

Commands:
  asymkey  Create Asymmetric Key Object Policy
  counter  Create Counter Object Policy
  dump     Display Created Object Policy
  file     Create Binary file Object Policy
  pcr      Create PCR Object Policy
  symkey   Create Symmetric Key Object Policy
  userid   Create User ID Object Policy
```

9.7.2 Set Commands

These commands are used to set/put objects/keys to the target secure subsystem.

1) `ssscli set aes:`

```
Usage: ssscli set aes [OPTIONS] keyid key

  Set AES Keys

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be in file or raw key in DER or HEX format

Options:
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

2) `ssscli set hmac:`

```
Usage: ssscli set hmac [OPTIONS] keyid key

  Set HMAC Keys

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be in file or raw key in DER or HEX format

Options:
  --help  Show this message and exit.
```

3) `ssscli set cert:`

```
Usage: ssscli set cert [OPTIONS] keyid key

  Set Certificate

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be raw certificate (DER format) or in file. For file, by default
  filename with extension .pem and .cer considered as PEM format and others as
  DER format.

Options:
  --format TEXT       Input certificate format. TEXT can be "DER" or "PEM"
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

4) `ssscli set ecc pair:`

```
Usage: ssscli set ecc pair [OPTIONS] keyid key

  Set ECC Key pair

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be raw key (DER format) or in file. For file, by default filename
  with extension .pem considered as PEM format and others as DER format.
```

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```
Options:
  --format TEXT       Input key format. TEXT can be "DER" or "PEM"
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

5) `ssscli set ecc pub`:

```
Usage: ssscli set ecc pub [OPTIONS] keyid key

  Set ECC Public Keys

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be raw key (DER format) or in file. For file, by default filename
  with extension .pem considered as PEM format and others as DER format.

Options:
  --format TEXT       Input key format. TEXT can be "DER" or "PEM"
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

6) `ssscli set rsa pair`:

```
Usage: ssscli set rsa pair [OPTIONS] keyid key

  Set RSA Key Pair

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be raw key (DER format) or in file. For file, by default filename
  with extension .pem considered as PEM format and others as DER format.

Options:
  --format TEXT       Input key format. TEXT can be "DER" or "PEM"
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

7) `ssscli set rsa pub`:

```
Usage: ssscli set rsa pub [OPTIONS] keyid key

  Set RSA Public Keys

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  key = Can be raw key (DER format) or in file. For file, by default filename
  with extension .pem considered as PEM format and others as DER format.

Options:
  --format TEXT       Input key format. TEXT can be "DER" or "PEM"
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

8) `ssscli set bin`:

```
Usage: ssscli set bin [OPTIONS] keyid data

  Set Certificate

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  data = Can be raw binary or in file

Options:
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

9.7.3 Get Commands

These commands are used to retereive/get objects/keys from the target secure subsystem.

1) `ssscli get aes`:

```
Usage: ssscli get aes [OPTIONS] keyid filename

  Get AES Keys

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data can be in PEM or DER format based on
  file extension. By default filename with extension .pem in PEM format and
  others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

2) `ssscli get cert`:

```
Usage: ssscli get cert [OPTIONS] keyid filename

  Get Certificate

  keyid = 32bit Key ID. Should be in hex format. Example: 401286E6

  filename = File name to store certificate. Data can be in PEM or DER format
  based on file extension. By default filename with extension .pem and .cer in
  PEM format and others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

3) `ssscli get ecc pair`:

```
Usage: ssscli get ecc pair [OPTIONS] keyid filename

  Get ECC Pair

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

```

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```
  filename = File name to store key. Data can be in PEM or DER format based on
  file extension. By default filename with extension .pem in PEM format and
  others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

4) `ssscli get ecc pub`:

```
Usage: ssscli get ecc pub [OPTIONS] keyid filename

  Get ECC Pub

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data can be in PEM or DER format based on
  file extension. By default filename with extension .pem in PEM format and
  others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

5) `ssscli get rsa pair`:

```
Usage: ssscli get rsa pair [OPTIONS] keyid filename

  Get RSA Pair

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data can be in PEM or DER format based on
  file extension. By default filename with extension .pem in PEM format and
  others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

6) `ssscli get rsa pub`:

```
Usage: ssscli get rsa pub [OPTIONS] keyid filename

  Get RSA Pub

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data can be in PEM or DER format based on
  file extension. By default filename with extension .pem in PEM format and
  others in DER format.

Options:
  --format TEXT  Output file format. TEXT can be "DER" or "PEM"
  --help         Show this message and exit.
```

7) `ssscli get bin`:

```
Usage: ssscli get bin [OPTIONS] keyid filename

  Get Binary

  keyid = 32bit Key ID. Should be in hex format. Example: 401286E6

  filename = File name to store binary data.

Options:
  --help  Show this message and exit.
```

9.7.4 Generate Commands

These commands are used to generate objects/keys inside the target secure subsystem.

1) `ssscli generate ecc`:

```
Usage: ssscli generate ecc [OPTIONS] keyid {NIST_P192|NIST_P224|NIST_P256|NIST
                           _P384|NIST_P521|Brainpool160|Brainpool192|Brainpool
                           224|Brainpool256|Brainpool320|Brainpool384|Brainpoo
                           l512|Secp160k1|Secp192k1|Secp224k1|Secp256k1|ED_255
                           19|MONT_DH_25519|MONT_DH_448|BN_P256}

  Generate ECC Key

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  curvetype = ECC Curve type. can be one of "NIST_P192, NIST_P224, NIST_P256,
  NIST_P384, NIST_P521, Brainpool160, Brainpool192, Brainpool224,
  Brainpool256, Brainpool320, Brainpool384, Brainpool512, Secp160k1,
  Secp192k1, Secp224k1, Secp256k1, ED_25519, MONT_DH_25519, MONT_DH_448"

Options:
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

2) `ssscli generate rsa`:

```
Usage: ssscli generate rsa [OPTIONS] keyid {1024|2048|3072|4096}

  Generate RSA Key

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  bits = Number of bits. can be one of "1024, 2048, 3072, 4096"

Options:
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

9.7.5 Refpem Commands

These commands are used to get Reference/masked Keys usable by openssl engines.

1) `ssscli refpem ecc pair`:

```
Usage: ssscli refpem ecc pair [OPTIONS] keyid filename

  Create reference PEM file for ECC Pair

  keyid = 32bit Key ID. Should be in hex format. Example: 0x20E8A001

  filename = File name to store key. Can be in PEM or DER or PKCS12 format
  based on file extension. By default filename with extension .pem in PEM
  format, .pfx or .p12 in PKCS12 format and others in DER format.

Options:
  --format TEXT    Output file format. TEXT can be "DER" or "PEM" or "PKCS12"
  --password TEXT  Password used for PKCS12 format.
  --cert TEXT      Certificate for PKCS12 format.
  --help           Show this message and exit.
```

2) `ssscli refpem ecc pub`:

```
Usage: ssscli refpem ecc pub [OPTIONS] keyid filename

  Create reference PEM file for ECC Pub

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data Can be in PEM or DER format or
  PKCS12 format based on file extension. By default filename with extension
  .pem in PEM format, .pfx or .p12 in PKCS12 format and others in DER format.

Options:
  --format TEXT    Output file format. TEXT can be "DER" or "PEM" or "PKCS12"
  --password TEXT  Password used for PKCS12 format.
  --cert TEXT      Certificate for PKCS12 format.
  --help           Show this message and exit.
```

3) `ssscli refpem rsa pair`:

```
Usage: ssscli refpem rsa pair [OPTIONS] keyid filename

  Create reference PEM file for RSA Pair

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  filename = File name to store key. Data Can be in PEM or DER format or
  PKCS12 format based on file extension. By default filename with extension
  .pem in PEM format, .pfx or .p12 in PKCS12 format and others in DER format.

Options:
  --format TEXT    Output file format. TEXT can be "DER" or "PEM" or "PKCS12"
  --password TEXT  Password used for PKCS12 format.
  --cert TEXT      Certificate for PKCS12 format.
  --help           Show this message and exit.
```

9.7.6 Se05x Commands

These are the SE05x specific commands.

1) `ssscli se05x uid`:

```
Usage: ssscli se05x uid [OPTIONS]

  Get 18 bytes Unique ID from the SE05X Secure Module.

Options:
  --help  Show this message and exit.
```

2) `ssscli se05x certuid`:

```
Usage: ssscli se05x certuid [OPTIONS]

  Get 10 bytes Cert Unique ID from the SE05X Secure Module. The cert uid is a
  subset of the Secure Module Unique Identifier

Options:
  --help  Show this message and exit.
```

3) `ssscli se05x reset`:

```
Usage: ssscli se05x reset [OPTIONS]

  Resets the SE05X Secure Module to the initial state.

  This command uses ``Se05x_API_DeleteAll_Iterative`` API of the SE05X MW to
  iterately delete objects provisioned inside the SE.  Because of this, some
  objects are purposefully skipped from deletion.

  It does not use the low level SE05X API ``Se05x_API_DeleteAll``

  For more information, see documentation/implementation of the
  ``Se05x_API_DeleteAll_Iterative`` API.

Options:
  --help  Show this message and exit.
```

4) `ssscli se05x readidlist`:

```
Usage: ssscli se05x readidlist [OPTIONS]

  Read contents of SE050

Options:
  --help  Show this message and exit.
```

9.7.7 A71CH Commands

These are the A71CH specific commands.

1) `ssscli a71ch uid`:

```
Usage: ssscli a71ch uid [OPTIONS]

  Get uid from the A71CH Secure Module.

Options:
  --help  Show this message and exit.
```

2) `ssscli a71ch reset:`

```
Usage: ssscli a71ch reset [OPTIONS]

  Resets the A71CH Secure Module to the initial state.

Options:
  --help  Show this message and exit.
```

9.7.8 POLICY Commands

These are Policy commands.

1) `ssscli policy asymkey:`

```
Usage: ssscli policy asymkey [OPTIONS] policy_name auth_obj_id

  Create Asymmetric key object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --sign BOOLEAN                  Object policy Allow Sign. Enabled by Default
  --verify BOOLEAN                Object policy Allow Verify. Enabled by
                                  Default
  --encrypt BOOLEAN               Object policy Allow Encryption. Enabled by
                                  Default
  --decrypt BOOLEAN               Object policy Allow Decryption. Enabled by
                                  Default
  --key_derive BOOLEAN            Object policy Allow Key Derivation. Disabled
                                  by Default
  --wrap BOOLEAN                  Object policy Allow Wrap. Disabled by
                                  Default
  --generate BOOLEAN              Object policy Allow Generate. Enabled by
                                  Default
  --write BOOLEAN                 Object policy Allow Write. Enabled by
                                  Default
  --read BOOLEAN                  Object policy Allow Read. Enabled by Default
  --import_export BOOLEAN         Object policy Allow Import Export. Disabled
                                  by Default
  --key_agreement BOOLEAN         Object policy Allow Key Agreement. Disabled
                                  by Default
  --attest BOOLEAN                Object policy Allow attestation. Disabled by
                                  Default
  --forbid_derived_output BOOLEAN
                                  Object policy Forbid Derived Output.
                                  Disabled by Default
  --forbid_all BOOLEAN            Object policy forbid all. Disabled by
                                  Default
  --delete BOOLEAN                Object policy Allow Delete. Enabled by
                                  Default
  --req_sm BOOLEAN                Object policy Require Secure Messaging.
                                  Disabled by Default
  --req_pcr_val BOOLEAN           Object policy Require PCR Value. Disabled by
```

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```
                                  Default
  --pcr_obj_id TEXT               Object policy PCR object ID in HEX format.
                                  Zero by Default
  --pcr_expected_value TEXT       Object policy PCR Expected in Hex byte
                                  string Value. Zero by Default
  --help                          Show this message and exit.
```

2) `ssscli policy symkey`:

```
Usage: ssscli policy symkey [OPTIONS] policy_name auth_obj_id

  Create Symmetric key object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --sign BOOLEAN                  Object policy Allow Sign. Enabled by Default
  --verify BOOLEAN                Object policy Allow Verify. Enabled by
                                  Default
  --encrypt BOOLEAN               Object policy Allow Encryption. Enabled by
                                  Default
  --decrypt BOOLEAN               Object policy Allow Decryption. Enabled by
                                  Default
  --key_derive BOOLEAN            Object policy Allow Key Derivation. Disabled
                                  by Default
  --wrap BOOLEAN                  Object policy Allow Wrap. Disabled by
                                  Default
  --generate BOOLEAN              Object policy Allow Generate. Disabled by
                                  Default
  --write BOOLEAN                 Object policy Allow Write. Enabled by
                                  Default
  --read BOOLEAN                  Object policy Allow Read. Enabled by Default
  --import_export BOOLEAN         Object policy Allow Import Export. Disabled
                                  by Default
  --desfire_auth BOOLEAN          Object policy Allow to perform DESFire
                                  authentication. Disabled by Default
  --desfire_dump BOOLEAN          Object policy Allow to dump DESFire session
                                  keys. Disabled by Default
  --forbid_derived_output BOOLEAN
                                  Object policy Forbid Derived Output.
                                  Disabled by Default
  --kdf_ext_random BOOLEAN        Object policy Allow key derivation ext
                                  random. Disabled by Default
  --tls_kdf BOOLEAN               Object policy Allow tls kdf. Disabled by
                                  Default
  --tls_pms_kd BOOLEAN            Object policy Allow tls pms kd. Disabled by
                                  Default
  --hkdf BOOLEAN                  Object policy Allow hkdf. Enabled by Default
  --pbkdf BOOLEAN                 Object policy Allow pbkdf. Disabled by
                                  Default
  --desfire_kd BOOLEAN            Object policy Allow desfire kd. Disabled by
                                  Default
  --forbid_external_iv BOOLEAN    Object policy forbid external IV. Disabled
                                  by Default
```

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```
  --usage_hmac_pepper BOOLEAN     Object policy Allow usage hmac as pepper.
                                  Disabled by Default
  --desfire_change_key BOOLEAN    Object policy Allow desfire change key.
                                  Disabled by Default
  --derived_input BOOLEAN         Object policy Allow derived input. Disabled
                                  by Default
  --desfire_auth_id TEXT          32 bit desfire auth id for
                                  desfire_change_key policy
  --source_key_id TEXT            32 bit source key id for derived_input
                                  policy
  --forbid_all BOOLEAN            Object policy forbid all. Disabled by
                                  Default
  --delete BOOLEAN                Object policy Allow Delete. Enabled by
                                  Default
  --req_sm BOOLEAN                Object policy Require Secure Messaging.
                                  Disabled by Default
  --req_pcr_val BOOLEAN           Object policy Require PCR Value. Disabled by
                                  Default
  --pcr_obj_id TEXT               Object policy PCR object ID in HEX format.
                                  Zero by Default
  --pcr_expected_value TEXT       Object policy PCR Expected in Hex byte
                                  string Value. Zero by Default
  --help                          Show this message and exit.
```

3) `sscli policy file`:

```
Usage: ssscli policy file [OPTIONS] policy_name auth_obj_id

  Create Binary file object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --write BOOLEAN              Object policy Allow Write. Enabled by Default
  --read BOOLEAN               Object policy Allow Read. Enabled by Default
  --forbid_all BOOLEAN         Object policy forbid all. Disabled by Default
  --delete BOOLEAN             Object policy Allow Delete. Enabled by Default
  --req_sm BOOLEAN             Object policy Require Secure Messaging. Disabled
                               by Default
  --req_pcr_val BOOLEAN        Object policy Require PCR Value. Disabled by
                               Default
  --pcr_obj_id TEXT            Object policy PCR object ID in HEX format. Zero
                               by Default
  --pcr_expected_value TEXT    Object policy PCR Expected in Hex byte string
                               Value. Zero by Default
  --help                       Show this message and exit.
```

4) `ssscli policy counter`:

```
Usage: ssscli policy counter [OPTIONS] policy_name auth_obj_id

  Create Counter object policy.

  policy_name = File name of the policy to be created. This policy name should
```

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```
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --write BOOLEAN             Object policy Allow Write. Enabled by Default
  --read BOOLEAN              Object policy Allow Read. Enabled by Default
  --forbid_all BOOLEAN        Object policy forbid all. Disabled by Default
  --delete BOOLEAN            Object policy Allow Delete. Enabled by Default
  --req_sm BOOLEAN            Object policy Require Secure Messaging. Disabled
                              by Default
  --req_pcr_val BOOLEAN       Object policy Require PCR Value. Disabled by
                              Default
  --pcr_obj_id TEXT           Object policy PCR object ID in HEX format. Zero
                              by Default
  --pcr_expected_value TEXT  Object policy PCR Expected in Hex byte string
                              Value. Zero by Default
  --help                      Show this message and exit.
```

5) `ssscli policy userid`:

```
Usage: ssscli policy userid [OPTIONS] policy_name auth_obj_id

  Create user id object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --write BOOLEAN             Object policy Allow Write. Enabled by Default
  --forbid_all BOOLEAN        Object policy forbid all. Disabled by Default
  --delete BOOLEAN            Object policy Allow Delete. Enabled by Default
  --req_sm BOOLEAN            Object policy Require Secure Messaging. Disabled
                              by Default
  --req_pcr_val BOOLEAN       Object policy Require PCR Value. Disabled by
                              Default
  --pcr_obj_id TEXT           Object policy PCR object ID in HEX format. Zero
                              by Default
  --pcr_expected_value TEXT  Object policy PCR Expected in Hex byte string
                              Value. Zero by Default
  --help                      Show this message and exit.
```

6) `ssscli policy pcr`:

```
Usage: ssscli policy pcr [OPTIONS] policy_name auth_obj_id

  Create PCR object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --write BOOLEAN             Object policy Allow Write. Enabled by Default
```

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```
  --read BOOLEAN            Object policy Allow Read. Enabled by Default
  --forbid_all BOOLEAN      Object policy forbid all. Disabled by Default
  --delete BOOLEAN          Object policy Allow Delete. Enabled by Default
  --req_sm BOOLEAN          Object policy Require Secure Messaging. Disabled
                            by Default
  --req_pcr_val BOOLEAN     Object policy Require PCR Value. Disabled by
                            Default
  --pcr_obj_id TEXT         Object policy PCR object ID in HEX format. Zero
                            by Default
  --pcr_expected_value TEXT Object policy PCR Expected in Hex byte string
                            Value. Zero by Default
  --help                    Show this message and exit.
```

7) `ssscli policy dump`:

```
Usage: ssscli policy dump [OPTIONS] policy_name

  Display Created object policy.

  policy_name = File name of the policy to be displayed.

Options:
  --help  Show this message and exit.
```

9.8 CLI Data formats

9.8.1 DER

DER or Distinguished Encoding Rules files are digital certificates in binary format, instead of the ASCII PEM format. DER files may end with .der or .cer, so to differentiate between DER.cer and PEM.cer files, you may need to use a text editor to read the file. A DER file should not have any BEGIN/END statements and will show garbled binary content.

The file as seen in *hexl-mode* of emacs would look as below:

```
00000000: 3081 8702 0100 3013 0607 2a86 48ce 3d02  0.....0...*.H.=.
00000010: 0106 082a 8648 ce3d 0301 0704 6d30 6b02  ...*.H.=....m0k.
00000020: 0101 0420 084f 2d70 eee4 09b9 5546 462e  ... .O-p....UFF.
00000030: 2cca 12e0 a046 90a3 3bea 8252 eeb5 4ff5  ,....F..;..R..O.
00000040: a4e9 b2d6 a144 0342 0004 633e 938a 67a7  .....D.B..c>..g.
00000050: a9e6 f35f c369 3b51 3c88 6a0d c260 16f3  ..._.i;Q<.j..`..
00000060: 5e8c 2c0b 491b 2392 7af0 371d 28b1 1bfb  ^.,.I.#.z.7.(...
00000070: e8f4 2e9c 5b0f 2897 c516 ec3e 7d62 97e4  ....[.(....>}b..
00000080: c06f 936d ba9d ac8a bcd8                 .o.m......
-UU=:----F1  ecc_NIST_P256_prv_pkcs8.der   All L1     (Hexl) ---------------
```

9.8.2 PEM

PEM or Privacy Enhanced Mail is a Base64 encoded DER certificate. PEM certificates are frequently used for web servers as they can easily be translated into readable data using a simple text editor. PEM file extension may contain .pem or .cer, so to differentiate when a PEM encoded file is opened in a text editor, it contains very distinct headers and footers.

Example:

```
-----BEGIN PRIVATE KEY-----
MIGHAgEAMBMGByqGSM49AgEGCCqGSM49AwEHBG0wawIBAQQgCE8tcO7kCblVRkYu
LMoS4KBGkKM76oJS7rVP9aTpstahRANCAARjPpOKZ6ep5vNfw2k7UTyIag3CYBbz
XowsC0kbI5J68DcdKLEb++j0LpxbDyiXxRbsPn1il+TAb5Ntup2sirzY
-----END PRIVATE KEY-----
```

9.8.3 HEX

Hex or Hexadecimal (base 16) is a positional system that represents numbers using a base of 16.

Example:

```
308187020100301306072a8648ce3d020106082a8648ce3d030107046d306b02
01010420084f2d70eee409b95546462e2cca12e0a04690a33bea8252eeb54ff5
a4e9b2d6a14403420004633e938a67a7a9e6f35fc3693b513c886a0dc26016f3
5e8c2c0b491b23927af0371d28b11bfbe8f42e9c5b0f2897c516ec3e7d6297e4
c06f936dba9dac8abcd8
```

9.8.4 REFERENCE KEY

- Refer to Section 8.1.2 *EC Reference key format* for EC reference key format.
- Refer to Section 8.1.2 *RSA Reference key format* for RSA reference key format.

9.9 Object Policies Through ssscli

Applying policy to objects through ssscli shall be done in two steps.

- Create object policy
- Attach policy to object

9.9.1 Create object policy

Object policy shall be created using following command:

```
ssscli policy
```

The create command has `symkey, asymkey, userid, file, counter` and `pcr` sub commands.

- `symkey` -> Symmetric key object policy (AES, DES, HMAC)
- `asymkey` -> Asymmetric key object policy (RSA, EC)
- `userid` -> User ID Object Policy
- `file` -> Binary file Object Policy
- `counter` -> Counter Object Policy
- `pcr` -> PCR Object Policy

Each command has mandatory arguments for `policy_name` and `auth_object_id`.

- `policy_name` -> Name of the policy to be created. This policy name should be given as input while provisioning.
- `auth_object_id` -> Auth object id for each Object Policy

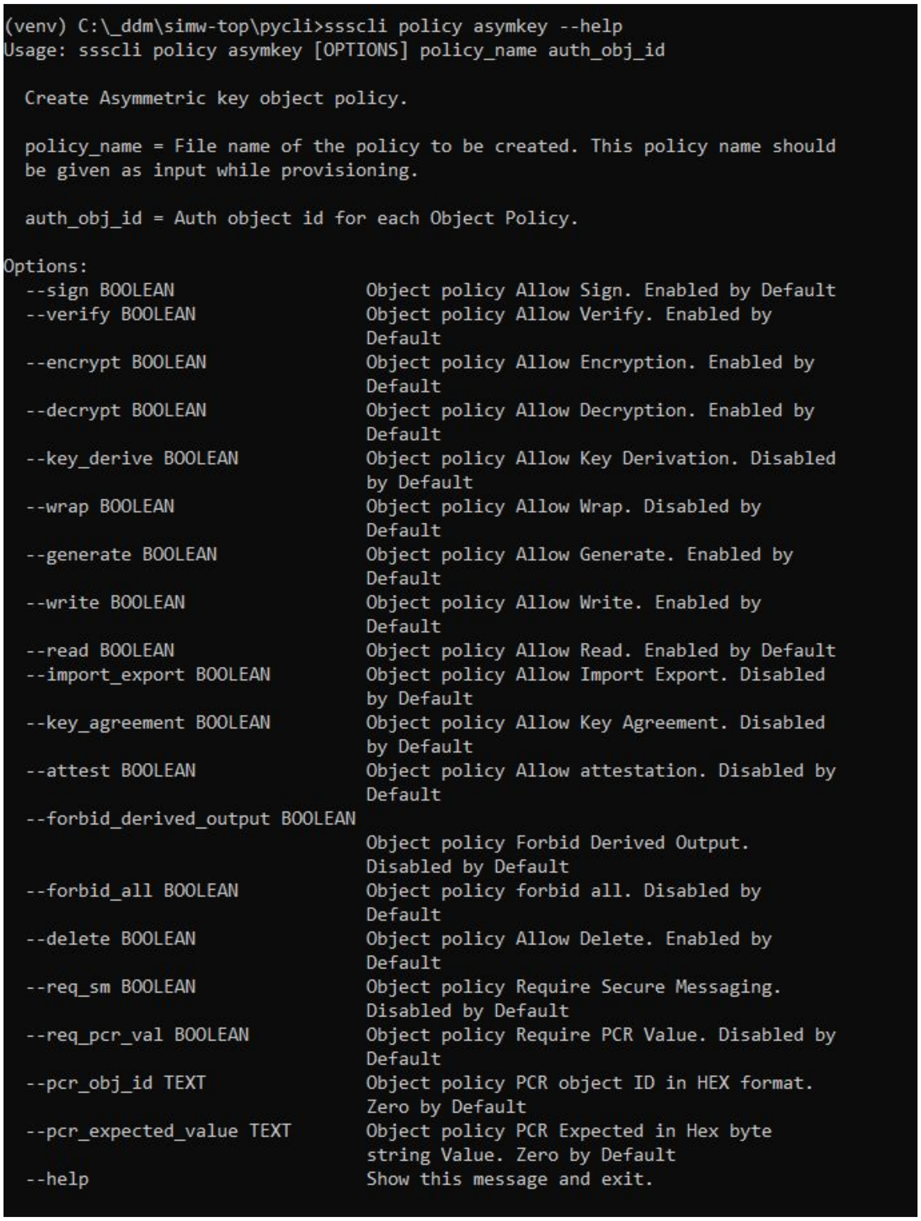
Create policy command shall have following optional arguments based on the sub command selected and applet version of secure element:

- `--sign` -> Object policy Allow Sign. Enabled by Default. Parameter type is boolean.
- `--verify` -> Object policy Allow Verify. Enabled by Default. Parameter type is boolean.
- `--encrypt` -> Object policy Allow Encryption. Enabled by Default. Parameter type is boolean.
- `--decrypt` -> Object policy Allow Decryption. Enabled by Default. Parameter type is boolean.
- `--key_derive` -> Object policy Allow Key Derivation. Disabled by Default. Parameter type is boolean.
- `--wrap` -> Object policy Allow Wrap. Disabled by Default. Parameter type is boolean.
- `--generate` -> Object policy Allow Generate. Enabled by Default. Parameter type is boolean.
- `--write` -> Object policy Allow Write. Enabled by Default. Parameter type is boolean.
- `--read` -> Object policy Allow Read. Enabled by Default. Parameter type is boolean.
- `--import_export` -> Object policy Allow Import Export. Disabled by Default. Parameter type is boolean.
- `--key_agreement` -> Object policy Allow Key Agreement. Disabled by Default. Parameter type is boolean.
- `--attest` -> Object policy Allow attestation. Disabled by Default. Parameter type is boolean.
- `--desfire_auth` -> Object policy Allow to perform DESFire authentication. Disabled by Default. Parameter type is boolean.
- `--desfire_dump` -> Object policy Allow to dump DESFire session keys. Disabled by Default. Parameter type is boolean.
- `--forbid_derived_output` -> Object policy forbid derived output. Disabled by Default. Parameter type is boolean.
- `--kdf_ext_random` -> Object policy key derivation external random. Disabled by Default. Parameter type is boolean.
- `--tls_kdf` -> Object policy Allow tls kdf. Disabled by Default. Parameter type is boolean.
- `--tls_pms_kd` -> Object policy Allow tls pms kd. Disabled by Default. Parameter type is boolean.
- `--hkdf` -> Object policy Allow hkdf. Enabled by Default. Parameter type is boolean.
- `--pbkdf` -> Object policy Allow pbkdf. Disabled by Default. Parameter type is boolean.
- `--desfire_kd` -> Object policy Allow desfire kd. Disabled by Default. Parameter type is boolean.
- `--forbid_external_iv` -> Object policy forbid external IV. Disabled by Default. Parameter type is boolean.
- `--usage_hmac_pepper` -> Object policy Allow usage hmac as pepper. Disabled by Default. Parameter type is boolean.
- `--desfire_change_key` -> Object policy Allow desfire change key. Disabled by Default. Parameter type is boolean.
- `--derived_input` -> Object policy Allow derived input. Disabled by Default. Parameter type is boolean.
- `--desfire_auth_id` -> 32 bit desfire auth id for desfire_change_key policy. Parameter type is hexdecimal.
- `--source_key_id` -> 32 bit source key id for derived_input policy. Parameter type is hexdecimal.

- `--forbid_all` -> Object policy forbid all. Disabled by Default. Parameter type is boolean.
- `--delete` -> Object policy Allow Delete. Enabled by Default. Parameter type is boolean.
- `--req_sm` -> Object policy Allow req_sm. Disabled by Default. Parameter type is boolean.
- `--req_pcr_val` -> Object policy Require PCR Value. Disabled by Default. Parameter type is boolean.
- `--pcr_obj_id` -> Object policy PCR object ID. Zero by Default. Parameter type is hexdecimal.
- `--pcr_expected_value` -> Object policy PCR Expected Value. Zero by Default. Parameter type is hexdecimal byte array.

The created object policy stored in the system in pickle file format.

Command Sample:



```
(venv) C:\_ddm\simw-top\pycli>ssscli policy asymkey --help
Usage: ssscli policy asymkey [OPTIONS] policy_name auth_obj_id

  Create Asymmetric key object policy.

  policy_name = File name of the policy to be created. This policy name should
  be given as input while provisioning.

  auth_obj_id = Auth object id for each Object Policy.

Options:
  --sign BOOLEAN                  Object policy Allow Sign. Enabled by Default
  --verify BOOLEAN                Object policy Allow Verify. Enabled by
                                  Default
  --encrypt BOOLEAN               Object policy Allow Encryption. Enabled by
                                  Default
  --decrypt BOOLEAN               Object policy Allow Decryption. Enabled by
                                  Default
  --key_derive BOOLEAN            Object policy Allow Key Derivation. Disabled
                                  by Default
  --wrap BOOLEAN                  Object policy Allow Wrap. Disabled by
                                  Default
  --generate BOOLEAN              Object policy Allow Generate. Enabled by
                                  Default
  --write BOOLEAN                 Object policy Allow Write. Enabled by
                                  Default
  --read BOOLEAN                  Object policy Allow Read. Enabled by Default
  --import_export BOOLEAN         Object policy Allow Import Export. Disabled
                                  by Default
  --key_agreement BOOLEAN         Object policy Allow Key Agreement. Disabled
                                  by Default
  --attest BOOLEAN                Object policy Allow attestation. Disabled by
                                  Default
  --forbid_derived_output BOOLEAN
                                  Object policy Forbid Derived Output.
                                  Disabled by Default
  --forbid_all BOOLEAN            Object policy forbid all. Disabled by
                                  Default
  --delete BOOLEAN                Object policy Allow Delete. Enabled by
                                  Default
  --req_sm BOOLEAN                Object policy Require Secure Messaging.
                                  Disabled by Default
  --req_pcr_val BOOLEAN           Object policy Require PCR Value. Disabled by
                                  Default
  --pcr_obj_id TEXT               Object policy PCR object ID in HEX format.
                                  Zero by Default
  --pcr_expected_value TEXT       Object policy PCR Expected in Hex byte
                                  string Value. Zero by Default
  --help                          Show this message and exit.
```

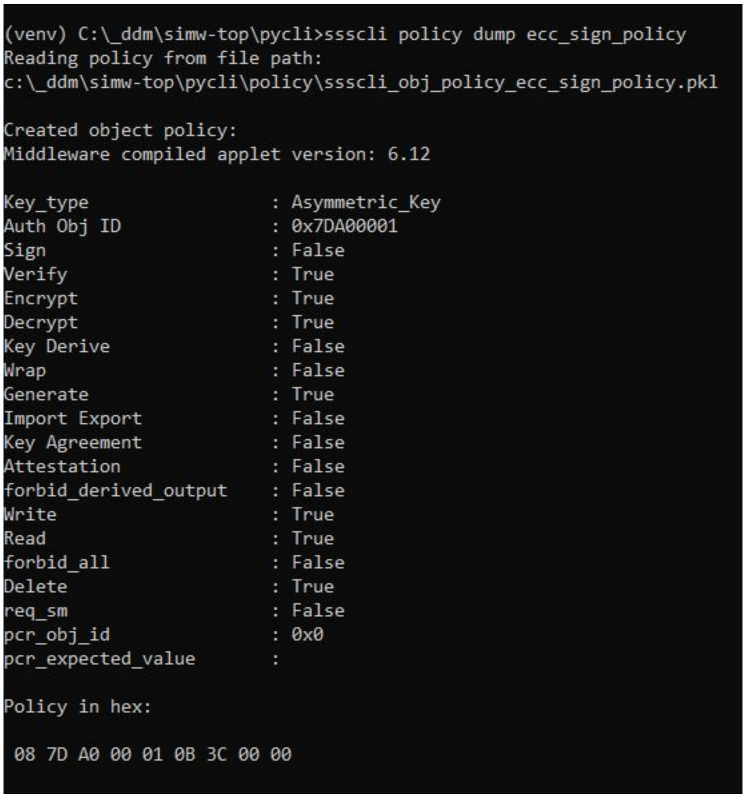
Usage example:

```
ssscli policy asymkey ecc_sign_policy 0x7DA00001 --sign 0
```

Created object policy shall be displayed using following command:

```
ssscli policy dump <policy_name>
```

Usage example:

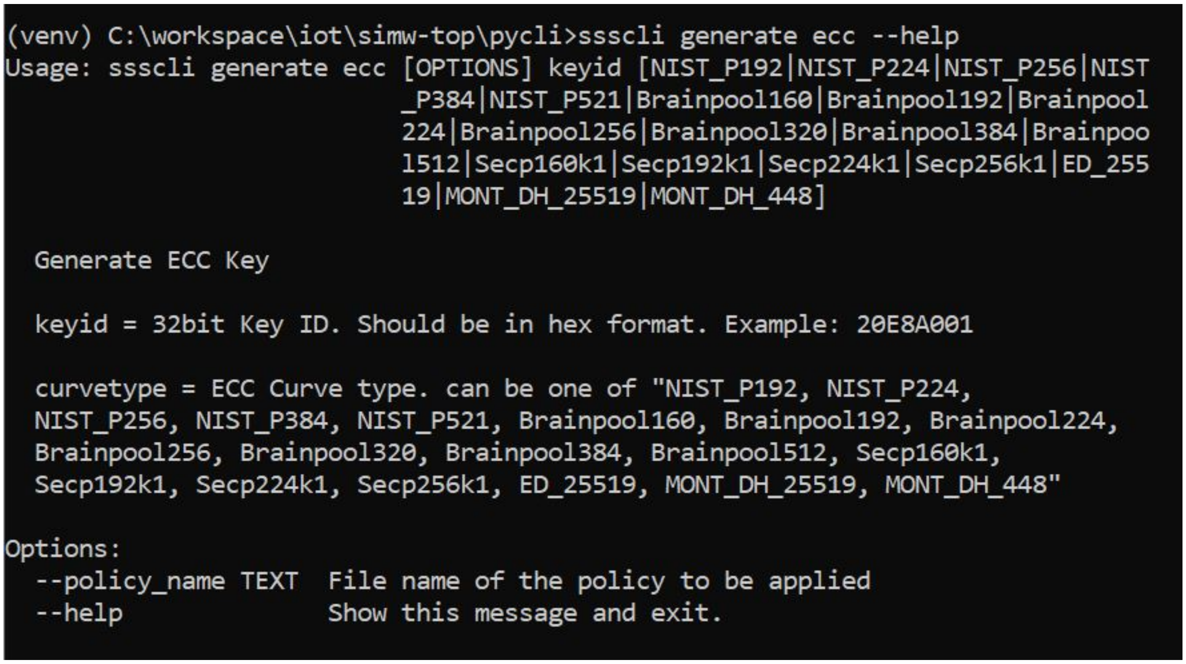


```
(venv) C:\_ddm\simw-top\pycli>ssscli policy dump ecc_sign_policy
Reading policy from file path:
c:\_ddm\simw-top\pycli\policy\ssscli_obj_policy_ecc_sign_policy.pkl

Created object policy:
Middleware compiled applet version: 6.12

Key_type                  : Asymmetric_Key
Auth Obj ID               : 0x7DA00001
Sign                      : False
Verify                    : True
Encrypt                   : True
Decrypt                   : True
Key Derive                : False
Wrap                      : False
Generate                  : True
Import Export             : False
Key Agreement             : False
Attestation               : False
forbid_derived_output     : False
Write                     : True
Read                      : True
forbid_all                : False
Delete                    : True
req_sm                    : False
pcr_obj_id                : 0x0
pcr_expected_value        :

Policy in hex:

 08 7D A0 00 01 0B 3C 00 00
```

9.9.2 Attach policy to object

Created object policy shall be applied it to the object along with generate or set command using `--policy_name` optional parameter.

Command Sample:



```
(venv) C:\workspace\iot\simw-top\pycli>ssscli generate ecc --help
Usage: ssscli generate ecc [OPTIONS] keyid [NIST_P192|NIST_P224|NIST_P256|NIST
                           _P384|NIST_P521|Brainpool160|Brainpool192|Brainpool
                           224|Brainpool256|Brainpool320|Brainpool384|Brainpoo
                           l512|Secp160k1|Secp192k1|Secp224k1|Secp256k1|ED_255
                           19|MONT_DH_25519|MONT_DH_448]

  Generate ECC Key

  keyid = 32bit Key ID. Should be in hex format. Example: 20E8A001

  curvetype = ECC Curve type. can be one of "NIST_P192, NIST_P224,
  NIST_P256, NIST_P384, NIST_P521, Brainpool160, Brainpool192, Brainpool224,
  Brainpool256, Brainpool320, Brainpool384, Brainpool512, Secp160k1,
  Secp192k1, Secp224k1, Secp256k1, ED_25519, MONT_DH_25519, MONT_DH_448"

Options:
  --policy_name TEXT  File name of the policy to be applied
  --help              Show this message and exit.
```

Usage example:

```
ssscli generate ecc 0x20181001 NIST_P256 --policy_name ecc_sign_policy
ssscli set ecc pair 0x20182010 nistp521_key.pem --policy_name ecc_sign_policy
```

9.10 Upload keys and certificates to SE05X using ssscli tool

1) Refer to *CLI Tool* for ssscli tool setup
2) Keys and Cerificates can be uploaded to SE05X using the ssscli tool

```
ssscli connect se05x vcom <COMPORT>
ssscli se05x reset
ssscli set ecc pair <KEYID> path-to-key/<KEY_FILE>.pem
ssscli set cert <KEYID> path-to-certificate/<CERTIFICATE_FILE>.crt
ssscli disconnect
```

Note: `ssscli se05x reset` will delete all the existing keys and certificates

CHAPTER

TEN

A71CH

10.1 A71CH and SSS API

10.1.1 Introduction

The Plug&Trust Middleware provides support for the A71CH secure element through the SSS API. The full scope of the A71CH legacy API or the HLSE API is not covered by the SSS API. For use cases where this applies it's possible to use both SSS and A71CH API's (*Mixing SSS API and A71CH API*).

The A71CH support as included in the Plug&Trust Middleware, is derived from the `A71CH Host Software package` as available on www.nxp.com/a71ch. The `hostlib` directory contains refactored code that was previously published on www.nxp.com/a71ch.

This Plug&Trust Middleware provides the following additional functionality related to the A71CH:

- Compatibility with OpenSSL 1.1
- Support for the SSS API
- Cloud demos using SSS API
- OpenSSL Engine using SSS API

The following - as previously contained in the `A71CH Host Software package` - is no longer supported:

- Cloud demos using A71CH API (replaced by SSS API based cloud demos)

The SW build system is based upon cmake.

10.1.2 A71CH API to SSS API mapping

The following table provides an overview of the A71CH API's that can be replaced by SSS API's. As the usage of the SSS API is conceptually different from the A71CH API, there is no one-to-one replacement of API calls. Please consult *SSS APIs* for an introduction on using the SSS API and the applicable examples in Section 5.2.1 *SSS API Examples*.

The SSS Session concept - as applicable to A71CH - is restricted to establishing a connection between Host and Secure Element. Establishing an SCP03 session is orthogonal to the Session concept.

SSS specific policies are not applicable to A71CH.

`A71CH or HLSE API`	`SSS equivalent available`	
a71ch_crypto_derive		
A71_HkdfExpandSymKey	YES	sss_derive_key_*

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Table 1 – continued from previous page

A71_HkdfSymKey	YES	sss_derive_key_*
A71_PskDeriveMasterSecret	NO	
A71_EcdhPskDeriveMasterSecret	NO	
A71_GetHmacSha256	YES	sss_mac_*
A71_HmacSha256Init	YES	sss_mac_*
A71_HmacSha256Update	YES	sss_mac_*
A71_HmacSha256Final	YES	sss_mac_*
a71ch_crypto_ecc		
A71_GenerateEccKeyPair	YES	sss_key_store_generate_key
A71_GenerateEccKeyPairWithChallenge	NO	
A71_GenerateEccKeyPairWithCode	NO	
A71_EccSign	YES	sss_asymmetric_sign_digest
A71_EccNormalizedAsnSign	NO	
A71_EccRestrictedSign	NO	
A71_EccVerify	YES	sss_asymmetric_verify_digest
A71_EcdhGetSharedSecret	YES	sss_derive_key_*
a71ch_module		
A71_GetCredentialInfo	NO	
A71_GetModuleInfo	NO	
A71_GetUniqueID	YES	sss_session_prop_get_au8
A71_GetCertUid	YES	sss_session_prop_get_au9
A71_GetUnlockChallenge	NO	
A71_GetKeyPairChallenge	NO	
A71_GetPublicKeyChallenge	NO	
A71_GetRandom	YES	sss_rng_get_random
A71_CreateClientHelloRandom	NO	
A71_GetRestrictedKeyPairInfo	NO	
A71_GetSha256	YES	sss_digest_one_go
A71_Sha256Init/Update/Final	YES	sss_digest_*
A71_InjectLock	NO	
A71_LockModule	NO	
A71_UnlockModule	NO	
A71_SetTlsLabel	NO	
A71_EccVerifyWithKey	NO	
a71ch_sst		
A71_Erase_*_WithChallenge	NO	
A71_Erase_*_WithCode	NO	
A71_EraseEccKeyPair	YES	sss_key_store_erase_key
A71_EraseEccPublicKey	YES	sss_key_store_erase_key
A71_EraseSymKey	NO	
A71_Freeze_*_WithChallenge	NO	
A71_Freeze_*_WithCode	NO	
A71_FreezeEccKeyPair	YES	sss_key_store_freeze_key
A71_FreezeEccPublicKey	YES	sss_key_store_freeze_key
A71_FreezeGpData	NO	
A71_FreezeSymKey	NO	
A71_GetCounter	NO	

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Table 1 – continued from previous page

A71_GetEccKeyPairUsage	NO	
A71_GetEccPublicKey	YES	sss_key_store_get_key
A71_GetGpData	NO	
A71_GetPublicKeyEccKeyPair	YES	sss_key_store_get_key
A71_IncrementCounter	NO	
A71_SetConfigKey	NO	
A71_SetCounter	NO	
A71_SetEccKeyPair	YES	sss_key_store_set_key
A71_SetEccPublicKey	YES	sss_key_store_set_key
A71_SetGpData	NO	
A71_SetGpDataWithLockCheck	NO	
A71_SetRfc3394WrappedAesKey	NO	
A71_SetRfc3394WrappedConfigKey	NO	
A71_SetSymKey	YES	sss_key_store_set_key
HLSE		
HLSE_GetObjectAttribute		
HLSE_SetObjectAttribute		
HLSE_EraseObject		
HLSE_CreateObject		

10.1.3 Mixing SSS API and A71CH API

The Plug&Trust Middleware contains two examples illustrating how to use both the SSS API and the A71CH API from the same application.

ECC Example

The example uses the SSS API to sign and verify the digest. The example is available at `.../simw-top/demos/a71ch/ex_a71ch_sss_ecc.c`.

```
    status = sss_asymmetric_context_init(&ctx_asymm, &pCtx->session, &keyPair,␣
↪kAlgorithm_SSS_SHA256, kMode_SSS_Sign);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    signatureLen = sizeof(signature);
    /* Do Signing */
    LOG_I("Do Signing");
    LOG_MAU8_I("digest", digest, digestLen);
    status = sss_asymmetric_sign_digest(&ctx_asymm, digest, digestLen, signature, &
↪signatureLen);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
    LOG_MAU8_I("signature", signature, signatureLen);
    LOG_I("Signing Successful !!!");
    sss_asymmetric_context_free(&ctx_asymm);
```

Next the example uses an A71CH API (A71_GetPublicKeyEccKeyPair) to retrieve the public key from the A71CH. The A71CH specific key index is retrieved from the SSS object matching the key pair.

```
    /* Access the A71CH with the (legacy) Host API */
    SST_Index_t keyIdx = (((sss_sscp_object_t *)&keyPair)->slotId) & 0x0F;
```

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```
    U8 pubEccKeyScratch[128];
    U16 pubEccKeyScratchLen = 0;

    LOG_I("A71_GetPublicKeyEccKeyPair(0x%02x)", keyIdx);
    pubEccKeyScratchLen = sizeof(pubEccKeyScratch);
    sw                  = A71_GetPublicKeyEccKeyPair(keyIdx, pubEccKeyScratch, &
↪pubEccKeyScratchLen);
    status              = ((sw == SW_OK) ? kStatus_SSS_Success : kStatus_SSS_Fail);
```

AES key wrapping Example

The example uses the SSS API to set the AES key and the A71CH API to set the same AES key which is wrapped. Further to verify if the wrapped key is injected properly, a hkdf key is derived using both AES keys. The example is available at `.../simw-top/demos/a71ch/ex_a71ch_sss_aes_wrap_key`.

Injecting wrapped AES key starts with setting AES key which is used as KEK,

```
    status = sss_key_object_init(&aesObj1, &pCtx->ks);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_object_allocate_handle(&aesObj1,
        MAKE_TEST_ID(__LINE__),
        kSSS_KeyPart_Default,
        kSSS_CipherType_AES,
        sizeof(aesKey),
        kKeyObject_Mode_Persistent);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_store_set_key(&pCtx->ks, &aesObj1, aesKey, sizeof(aesKey),␣
↪sizeof(aesKey) * 8, NULL, 0);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
```

Now inject the wrapped AES key using the A71CH API - A71_SetRfc3394WrappedAesKey. Wrapped key length should be 24 bytes. Large keys can be set by calling the A71_SetRfc3394WrappedAesKey API multiple times and by incrementing the key index every time.

```
    keyIdx = (((sss_sscp_object_t *)&aesObj1)->slotId) & 0x0F;

    /* Set wrapped aes key - aesKey1 */
    sw     = A71_SetRfc3394WrappedAesKey(keyIdx, wapped_AesKey1_0, sizeof(wapped_
↪AesKey1_0));
    status = ((sw == SW_OK) ? kStatus_SSS_Success : kStatus_SSS_Fail);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    sw     = A71_SetRfc3394WrappedAesKey(keyIdx + 1, wapped_AesKey1_1, sizeof(wapped_
↪AesKey1_1));
    status = ((sw == SW_OK) ? kStatus_SSS_Success : kStatus_SSS_Fail);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);
```

Now verify if wrapped key injected is set correctly.

```
    /* 1 - Calculate HKDF key with wrapped AES key injected - aesKey1 */
    status = calculate_hkdf_key(pCtx, aesObj1, MAKE_TEST_ID(__LINE__), HkdfKey1, &
↪HkdfKey1Len);

```

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```
    /* 2 - Inject aesKey1 AES key and calculate HKDF key */
    status = sss_key_object_init(&aesObj2, &pCtx->ks);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_object_allocate_handle(&aesObj2,
        MAKE_TEST_ID(__LINE__),
        kSSS_KeyPart_Default,
        kSSS_CipherType_AES,
        sizeof(aesKey1),
        kKeyObject_Mode_Persistent);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = sss_key_store_set_key(&pCtx->ks, &aesObj2, aesKey1, sizeof(aesKey1),␣
↪sizeof(aesKey1) * 8, NULL, 0);
    ENSURE_OR_GO_CLEANUP(status == kStatus_SSS_Success);

    status = calculate_hkdf_key(pCtx, aesObj2, MAKE_TEST_ID(__LINE__), HkdfKey2, &
↪HkdfKey2Len);

    /* 3 - compare both hkdf keys generated */
    if (0 != memcmp(HkdfKey1, HkdfKey2, HkdfKey1Len)) {
        status = kStatus_SSS_Fail;
    }
```

10.1.4 SSS Object Identifier to A71CH Internal storage mapping

The SSS API uses a 32 bit unsigned value as key (object) identifier. The A71CH GP Storage contains the mapping between these key identifiers and A71CH internal storage as a dedicated data object of 160 byte.

The resulting A71CH KeyStore can contain upto:

- 4 ECC Key Pairs
- 3 ECC Public Keys
- 8 Symmetric Keys
- 4 Certificates

Any additional data object storage is only available through HLSE API calls (*A71CH Legacy HLSE (Generic) API*).

10.2 Miscellaneous

10.2.1 Demos and examples supported on A71CH

Refer to *DEMO List* to see the list of demo applications supported on A71CH. Make the following changes when testing with A71CH.

1) Set the Applet to A71CH and SMCOM to SCI2C in the build configuration and rebuild the middleware.
2) To provision A71CH for cloud application, change the *subsystem* to *a71ch* in …/simw-top/pycli/src/Provision/Provision_config.py file.

```
SUBSYSTEM = "a71ch"
```

3) When testing cloud application on linux platform, set the OPENSSL_CONF to A71CH specific openssl config files - openssl_sss_a71ch.cnf (for openssl 1.0) / openssl11_sss_a71ch.cnf (for openssl 1.1).

10.2.2 OpenSSL Engine

The Plug&Trust MW comes with two OpenSSL Engine implementations, both implementations support OpenSSL 1.1.1:

- SSS API based (A71CH SSS OpenSSL Engine)
- A71CH Legacy API based (A71CH Legacy OpenSSL Engine)

The reference key format and the tools supporting the reference keys are **different and incompatible**.

The implementation using the SSS API is documented in *Introduction on OpenSSL engine* and resides in `.../sss/plugin/openssl`. The functionality of the engine is restricted to EC NIST P-256 keys.

The implementation using the A71CH Legacy API resides in `.../hostlib/hostlib/embSeEngine`.

The reference key format used by the SSS OpenSSL Engine refers to the stored EC key by SSS Object Identifier. It relies upon the `SSS Object Identifier to A71CH Internal storage mapping table` (*A71CH and SSS API*) to locate the stored EC key in the attached A71CH.

The reference key format used by the A71CH Legacy OpenSSL Engine refers to the stored EC key by key class and key index. Both key class and index are specific to the A71CH secure element. The following provides an example of reference key format used by the A71CH Legacy OpenSSL Engine. The value reserved for the private key has been used to contain:

- a pattern of `0x10..00` to fill up the datastructure MSB side to the desired key length
- a 64 bit magic number (always `0xA5A6B5B6A5A6B5B6`)
- a byte (0xkk) to contain the key class (`0x10` for key pair and `0x20` for public key)
- a byte (0xii) to contain the key index (`0x00 to 0x03` for key pair and `0x00 to 0x02` for public key)

```
Private-Key: (256 bit)
priv:
    10:00:00:00:00:00:00:00:00:00:00:00:00:00:00:
    00:00:00:00:00:00:00:A5:A6:B5:B6:A5:A6:B5:B6:
    kk:ii
pub:
    04:1C:93:08:8B:26:27:BA:EA:03:D1:BE:DB:1B:DF:
    8E:CC:87:EF:95:D2:9D:FC:FC:3A:82:6F:C6:E1:70:
    A0:50:D4:B7:1F:F2:A3:EC:F8:92:17:41:60:48:74:
    F2:DB:3D:B4:BC:2B:F8:FA:E8:54:72:F6:72:74:8C:
    9E:5F:D3:D6:D4
ASN1 OID: prime256v1
```

10.2.3 A71CH and SCP03

Enabling SCP03 channel encryption on the A71CH is a two step process:

- [Phase-0] First the SCP03 keys must be set on the A71CH. The SCP03 keys can only be set once!
- [Phase-1] Once the SCP03 keys are set on the A71CH an SCP03 channel can be established between Host and A71CH. In case an SCP03 channel has been established successfully, the use of SCP03 becomes mandatory for all subsequent communication between Host and A71CH.

In the SSS API based example applications, two utility functions are used to support SCP03 channel encryption:

- `ex_a71ch_SetSeScp03Keys` is used to set the keys as required for [Phase-0]
- `SCP_Authenticate` is used to establish the SCP03 channel [Phase-1]

The example code (`sss/ex/inc/ex_sss_main_inc.h`) always combines these two steps and depends on the 'Debug Reset' command for this. In a product deployment the two phases must be distinct. [Phase-0] is only executed once. Ensure that the SCP03 keys are securely and persistently stored on the host.

To enable SCP03 in the SSS API examples one must set the following Cmake options:

```
-DA71CH_AUTH=SCP03
-DSCP=SCP03_HostCrypto
```

Please refer to *CMake Options* for more details and an overview of all available Cmake options.

Note: The Plug&Trust MW also contains example code illustrating the setting up of an SCP03 channel between Host and Secure Element for applications based upon the A71CH API: please refer to `hostlib/a71ch/ex/mainA71CH.c`

10.2.4 A71CH on Raspberry Pi

When building the stack for A71CH on Raspberry Pi, set the following cmake options

```
cmake -DApplet=A71CH -DSMCOM=SCI2C .
```

The default i2c master of Raspberry Pi doesn't support the SMBUS 'block read' feature required for the sci2c protocol. As a workaround a software implementation of an i2c master must be used.

Add the following line to `/boot/config.txt` on the Raspberry Pi SD card and reboot:

```
dtoverlay=i2c-gpio,bus=4,i2c_gpio_delay_us=1,_i2c_gpio_sda=23,i2c_gpio_scl=24
```

This will create a `/dev/i2c-4` i2c port on Raspberry Pi.

Modify `.../simw-top/hostlib/hostLib/platform/linux/i2c_a7.c` for correct i2c port

```
static char* default_axSmDevice_name = "/dev/i2c-4";
```

The following table illustrates the connections to make between the Raspberry Pi Header and the A71CH.

Table 2: A71CH pin connections

Raspberry Pi Header	A71CH
Pin# 1	Power
Pin# 6	Ground
Pin# 16	I2C Data
Pin# 18	I2C Clock

10.3 A71CH Legacy API

10.3.1 Introduction

The A71CH Legacy API encapsulates the APDU calls supported by the A71CH security module. The standard A71CH security module supports the following functionality:

- Secure storage, generation, insertion or deletion of ECC key pairs (ECC NIST P-256).
- Secure storage, insertion or deletion of ECC public keys.
- Signature generation and verification (ECDSA)
- Shared secret calculation for Key Agreement (ECDH or ECDH-E)
- Secure storage and use of monotonic counters (32 bits each)
- Secure storage, insertion or deletion of symmetric keys (128 bits); symmetric keys can be concatenated to form longer keys
- Retrieval of unique chip ID.
- HKDF using the symmetric secrets as key, Extract & Expand or Expand only.
- HMAC SHA256 calculation
- Freezing of credentials (= OTP behavior)
- An optional secure channel with the host MCU (conform Global Platform SCP03).

The Debug Mode variant of the A71CH security module, which can be ordered on evaluation kits, supports the following additional functionality:

- A set of debug commands to facilitate integration of the A71CH in a host application.
- Possibility to permanently disable these debug commands

Note: In the remainder of this document the A71CH Legacy API is simply called A71CH API

10.3.2 A71CH API

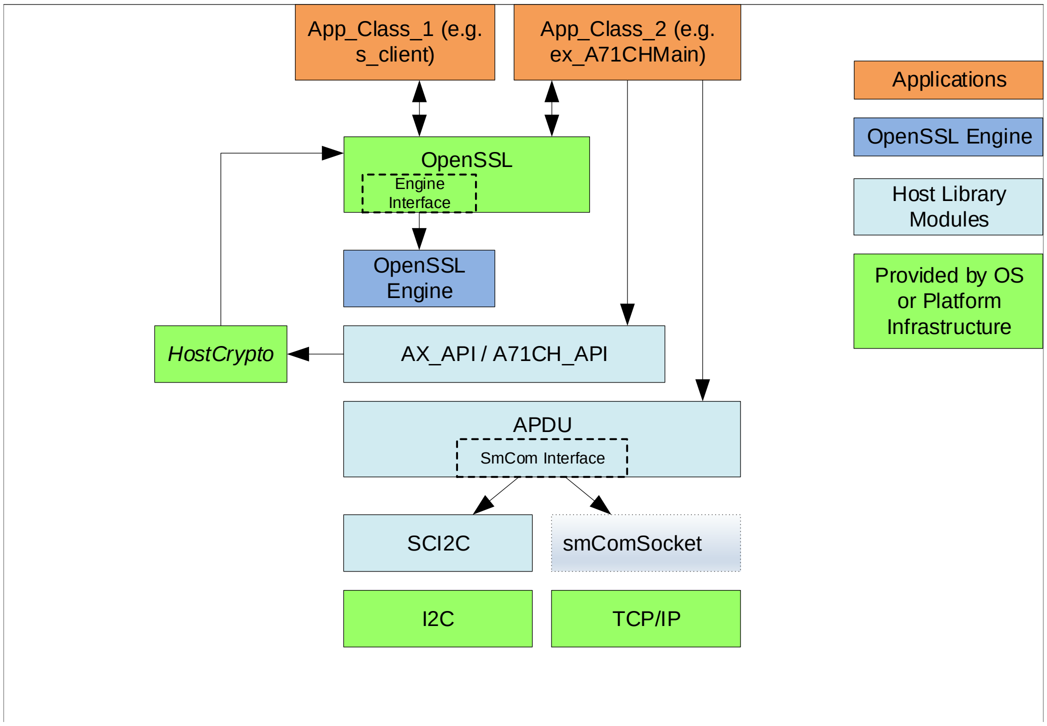
The A71CH API is made up of four parts:

- A71CH specific functionality (`.../hostlib/inc/a71ch_api.h`)
  - *Crypto Derive API* deals with deriving secrets, hmacs etc. from stored secrets
  - *Ecc Key API* deals with ECC crypto building blocks as ECDSA signing and verification and ECDH
  - *Module API* deals with functions not related to stored crypto credentials
  - *Secure Storage (SST) API* deals with storing, retrieving, erasing and locking credentials
- Data link communication functionality (*sm_connect.c*)
- Secure channel functionality (ax_scp.h). The implementation resides in *ax_scp.c* and *scp_a7x.c*.
- A71CH Debug Mode variant functionality (*a71_debug.c*)

10.3.3 SW structure

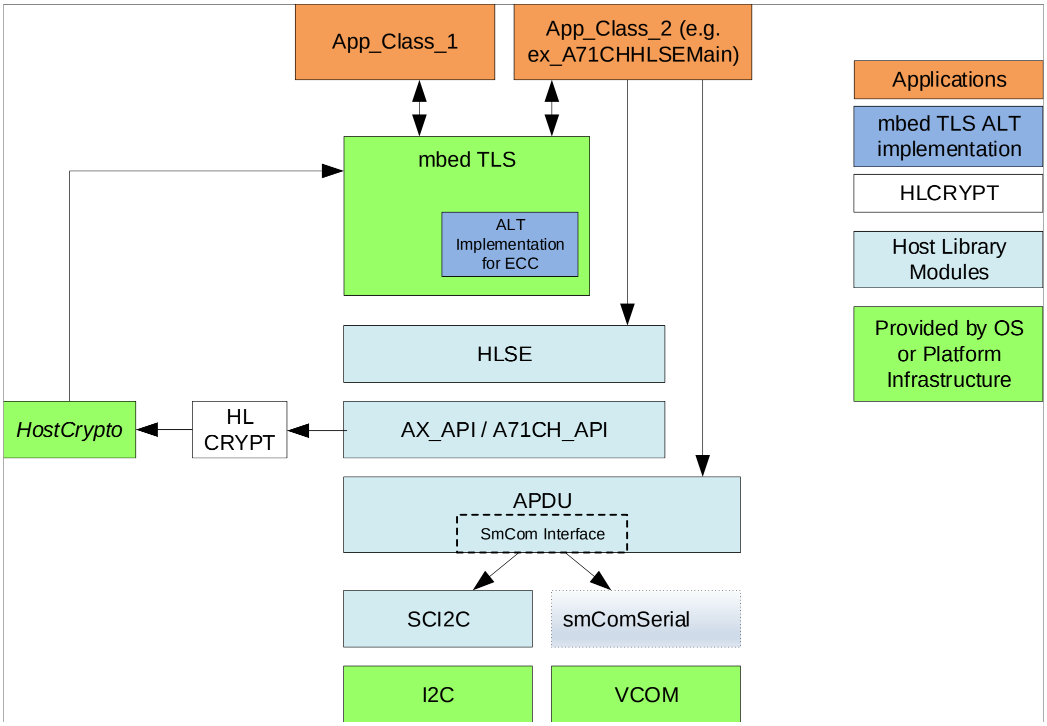
OpenSSL

The following picture illustrates the Host Library in the context of the Host SW with OpenSSL



mbed TLS

The following picture illustrates the Host Library in the context of the Host SW with mbed TLS



10.3.4 API details

Module API

Description Wrap module centric APDU functionality of the A71CH

Functions

U16 **`A71_GetCredentialInfo`**(U8 **map*, U16 **mapLen*)

Get credential info from Module (in raw format)

Parameters

- `[inout] map`:
- `[inout] mapLen`:

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetModuleInfo`**(U16 **selectResponse*, U8 **debugOn*, U8 **restrictedKpIdx*, U8 **transportLockState*, U8 **scpState*, U8 **injectLockState*, U16 **gpStorageSize*)

Get info on Module

Parameters

- `[out] selectResponse`: Encodes applet revision and whether Debug Mode is available
- `[out] debugOn`: Equals 0x01 when the Debug Mode is available
- `[out] restrictedKpIdx`: Either the index of the restricted keypair or A71CH_NO_RESTRICTED_KP
- `[out] transportLockState`: The value retieved is one of A71CH_TRANSPORT_LOCK_STATE_LOCKED, A71CH_TRANSPORT_LOCK_STATE_UNLOCKED or A71CH_TRANSPORT_LOCK_STATE_ALLOW_LOCK
- `[out] scpState`: The value retrieved is on of A71CH_SCP_MANDATORY, A71CH_SCP_NOT_SET_UP or A71CH_SCP_KEYS_SET
- `[out] injectLockState`: The value retrieved is one of A71CH_INJECT_LOCK_STATE_LOCKED or A71CH_INJECT_LOCK_STATE_UNLOCKED
- `[out] gpStorageSize`: Total storage size (in byte) of the General Purpose data store

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetUniqueID`**(U8 **uid*, U16 **uidLen*)

Get Unique Identifier from the Secure Module

Parameters

- `[inout] uid`: IN: buffer to contain uid; OUT: uid retrieved from Secure Module
- `[inout] uidLen`: IN: Size of buffer provided (at least A71CH_MODULE_UNIQUE_ID_LEN byte); OUT: length of retrieved unique identifier (expected to be A71CH_MODULE_UNIQUE_ID_LEN byte)

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_WRONG_RESPONSE`: In case an identifier with a length different from A71CH_MODULE_UNIQUE_ID_LEN was retrieved

U16 **`A71_GetCertUid`**(U8 **certUid*, U16 **certUidLen*)

Get cert uid from the Secure Module. The cert uid is a subset of the Secure Module Unique Identifier

Parameters

- `[inout] certUid`: IN: buffer to contain cert uid; OUT: cert uid retrieved from Secure Module
- `[inout] certUidLen`: IN: Size of buffer provided (at least A71CH_MODULE_CERT_UID_LEN byte); OUT: length of retrieved unique identifier (expected to be A71CH_MODULE_CERT_UID_LEN byte)

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_WRONG_RESPONSE`: In case the Secure Module Unique Identifier (i.e. the base uid) did not have the expected length

U16 **`A71_GetUnlockChallenge`**(U8 **challenge*, U16 **challengeLen*)

Get Unlock challenge from the Secure Module

Parameters

- `[inout] challenge`: IN: buffer to contain challenge; OUT: challenge retrieved from Secure Module
- `[inout] challengeLen`: IN: Size of buffer provided (at least A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte); OUT: length of retrieved unique identifier (must be A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte)

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_WRONG_RESPONSE`: In case an identifier with a length different from A71CH_MODULE_UNLOCK_CHALLENGE_LEN was retrieved

U16 **`A71_GetKeyPairChallenge`**(U8 **challenge*, U16 **challengeLen*)

Get Unlock challenge for a Keypair

Parameters

- `[inout] challenge`: IN: buffer to contain challenge; OUT: challenge retrieved from Secure Module
- `[inout] challengeLen`: IN: Size of buffer provided (at least A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte); OUT: length of retrieved unique identifier (must be A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte)

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_WRONG_RESPONSE`: In case an identifier with a length different from A71CH_MODULE_UNLOCK_CHALLENGE_LEN was retrieved

U16 **`A71_GetPublicKeyChallenge`**(U8 **challenge*, U16 **challengeLen*)

Get Unlock challenge for a Public Key

Parameters

- `[inout] challenge`: IN: buffer to contain challenge; OUT: challenge retrieved from Secure Module

- `[inout] challengeLen`: IN: Size of buffer provided (at least A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte); OUT: length of retrieved unique identifier (must be A71CH_MODULE_UNLOCK_CHALLENGE_LEN byte)

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_WRONG_RESPONSE`: In case an identifier with a length different from A71CH_MODULE_UNLOCK_CHALLENGE_LEN was retrieved

U16 **`A71_GetRandom`**(U8 **random*, U8 *randomLen*)

Retrieves a random byte array of size randomLen from the Secure Module. The maximum amount of data that can be retrieved depends on whether an authenticated channel (SCP03) has been set up. In case SCP03 has been set up, this (worst-case) maximum is A71CH_SCP03_MAX_PAYLOAD_SIZE

Parameters

- `[inout] random`: IN: buffer to contain random value (at least of size randomLen); OUT: retrieved random data
- `[in] randomLen`: Amount of byte to retrieve

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_CreateClientHelloRandom`**(U8 **clientHello*, U8 *clientHelloLen*)

Updates a 32 byte random value inside the A71CH and returns this value to the caller.

Post A71CH is in a state it will accept A71_PskDeriveMasterSecret or A71_EcdhPskDeriveMasterSecret as an API call.

Parameters

- `[inout] clientHello`: IN: buffer to contain random value (at least of size randomLen); OUT: retrieved random data
- `[in] clientHelloLen`: Amount of byte to retrieve (must be equal to AX_TLS_PSK_HELLO_RANDOM_LEN)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetRestrictedKeyPairInfo`**(U8 **idx*, U16 **nBlocks*, U8 **blockInfo*, U16 **blockInfoLen*)

Get the index of the restricted key pair (`idx`) together with the number of modifiable blocks (`nBlocks`) in the locked GP storage area that is associated with the restricted key pair. Detailed info on block offset and block length is contained in the `blockInfo` byte array. Per block 2 bytes indicate the offset into GP storage and two bytes indicate the length of the modifiable block.

Parameters

- `[out] idx`: Index of restricted key pair. A71CH_NO_RESTRICTED_KP in case there is no restricted key pair
- `[out] nBlocks`: Number of modifiable blocks
- `[inout] blockInfo`: IN: Storage to contain blockInfo; OUT: Raw info on block offset and block lenght per block.
- `[inout] blockInfoLen`: IN: Size of blockInfo (in byte); OUT: effective size of blockInfo

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetSha256`**(U8 **data*, U16 *dataLen*, U8 **sha*, U16 **shaLen*)

Calculates the SHA256 value of the data provided as input.

Parameters

- `[in] data`: Data buffer for which the SHA256 must be calculated
- `[in] dataLen`: The length of data passed as argument
- `[inout] sha`: IN: caller passes a buffer of at least 32 byte; OUT: contains the calculated SHA256
- `[inout] shaLen`: IN: length of the sha buffer passed; OUT: because SHA256 is used this is 32 byte exact

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_Sha256Init`**(void)

Initialise multistep SHA256.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_Sha256Update`**(U8 **data*, U16 *dataLen*)

Update the data for calulating SHA256 value (in multistep).

Parameters

- `[in] data`: Data buffer for which the SHA256 must be calculated
- `[in] dataLen`: The length of data passed as argument

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_Sha256Final`**(U8 **sha*, U16 **shaLen*)

calulating SHA256 value (in multistep).

Parameters

- `[inout] sha`: IN: caller passes a buffer of at least 32 byte; OUT: contains the calculated SHA256
- `[inout] shaLen`: IN: length of the sha buffer passed; OUT: because SHA256 is used this is 32 byte exact

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_InjectLock`**()

This function disables - at device level - the ability to

- Set symmetric keys without prior wrapping
- Erase symmetric keys
- Set ECC key pairs (private key part) without prior wrapping
- Set ECC public key without prior wrapping

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_LockModule`**`()`

This function locks the module (typically to protect the module during transport to production facilities). When the A71CH is locked the functionality is reduced to the following subset:

- A71_GetUniqueID
- A71_GetUnlockChallenge
- A71_UnlockModule
- A71_GetModuleInfo

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_UnlockModule`**`(`U8 **code*, U16 *codeLen*`)`

This function unlocks the module provided the correct code is provided as input argument. The A71CH can only be unlocked once: if the device is already unlocked, the device cannot be locked or unlocked again (it will remain unlocked).

The unlock code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index A71CH_CFG_KEY_IDX_MODULE_LOCK).
- The decrypted value is the unlock `code`

  Parameters

  - `[in] code`: Value of unlock code
  - `[in] codeLen`: Length of unlock code (must be 16)

  Return Value

  - `::SW_OK`: Upon successful execution

U16 **`A71_SetTlsLabel`**`(`**`const`** U8 **label*, U16 *labelLen*`)`

Sets the label that is used when calling A71_EcdhPskDeriveMasterSecret or A71_PskDeriveMasterSecret. Calling this function is optional. By default the label used by the A71CH is `'master` secret' (no quotes) as applicable for TLS 1.2. The maximum size of the label that can be set is 24 byte.

Parameters

- `[in] label`: Value to be stored and used as 'label' in TLS 1.2 protocol
- `[in] labelLen`: Length of label (less than or equal to A71CH_TLS_MAX_LABEL)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EccVerifyWithKey`**`(`**`const`** U8 **pKeyData*, U16 *keyDataLen*, **`const`** U8 **pHash*, U16 *hashLen*, **`const`** U8 **pSignature*, U16 *signatureLen*, U8 **pResult*`)`

Verifies whether `pSignature` is the signature of `pHash` using `pKeyData` as the verifying public key.

As opposed to function A71_EccVerify the public key value is passed as an argument to the A71CH.

Parameters

- `[in] pKeyData`: Public key passed as byte array in ANSI X9.62 uncompressed format
- `[in] keyDataLen`: Length of public key passed as argument

- `[in] pHash`: Pointer to the provided hash (or any other bytestring).
- `[in] hashLen`: Length of the provided hash.
- `[in] pSignature`: Pointer to the provided signature.
- `[in] signatureLen`: Length of the provided signature.
- `[out] pResult`: Pointer to the computed result of the verification. Points to a value of 0x01 in case of successful verification

Return Value

- `::SW_OK`: Upon successful execution

Ecc Key API

Description Wrap the ECC cryptographic functionality of the A71CH.

Functions

U16 **`A71_GenerateEccKeyPair`**(SST_Index_t *index*)

Generates an ECC keypair at storage location `index`.

Pre INJECTION_LOCKED has not been set

Parameters

- `[in] index`: Storage index of the keypair to be created.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GenerateEccKeyPairWithChallenge`**(SST_Index_t *index*, **`const`** U8 **configKey*, U16 *configKeyLen*)

Generates an ECC keypair at storage location `index`. This function must be called instead of A71_GenerateEccKeyPair in case INJECTION_LOCKED was set.

To use this function the value of the Key Pair configuration key must be known on the host. If this is not the case use A71_GenerateEccKeyPairWithCode instead.

Parameters

- `[in] index`: Storage index of the keypair to be created.
- `[in] configKey`: Value of Key Pair configuration key. This value has a high level of confidentiality and may not be available to the Host.
- `[in] configKeyLen`: Length of Key Pair configuration key

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GenerateEccKeyPairWithCode`**(SST_Index_t *index*, **`const`** U8 **code*, U16 *codeLen*)

Generates an ECC keypair at storage location `index`. This function must be called instead of A71_GenerateEccKeyPair in case INJECTION_LOCKED was set.

The assumption is the value of the Key Pair configuration key is not known on the host. If this does not apply use A71_GenerateEccKeyPairWithChallenge instead.

The code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index ::A71XX_CFG_KEY_IDX_PRIVATE_KEYS).
- The decrypted value is the value of `code`

Parameters

- `[in] index`: Storage index of the keypair to be created.
- `[in] code`: Value of unlock code.
- `[in] codeLen`: Length of unlock code (must be 16)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EccSign`**(SST_Index_t *index*, **`const`** U8 **pHash*, U16 *hashLen*, U8 **pSignature*, U16 **pSignatureLen*)

Signs the hash `pHash` using the keypair at the indicated index.

Parameters

- `[in] index`: Storage index of the keypair (private key) to be used.
- `[in] pHash`: Pointer to the provided hash (or any other bytestring).
- `[in] hashLen`: Length of the provided hash.
- `[inout] pSignature`: Pointer to the computed signature.
- `[inout] pSignatureLen`: Pointer to the length of the computed signature.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EccNormalizedAsnSign`**(SST_Index_t *index*, **`const`** U8 **pHash*, U16 *hashLen*, U8 **pSignature*, U16 **pSignatureLen*)

Signs the hash `pHash` using the keypair at the indicated index.

The integer representation of the ECDSA signatures' r and s component is modified to be in line with ASN.1 (Ensuring an integer value is always encoded in the smallest possible number of octets)

Parameters

- `[in] index`: Storage index of the keypair (private key) to be used.
- `[in] pHash`: Pointer to the provided hash (or any other bytestring).
- `[in] hashLen`: Length of the provided hash.
- `[inout] pSignature`: Pointer to the computed signature.
- `[inout] pSignatureLen`: Pointer to the length of the computed signature.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EccRestrictedSign`**(SST_Index_t *index*, **`const`** U8 **updateBytes*, U16 *updateBytesLen*, U8 **invocationCount*)

Patches a predetermined fixed size memory region in GP storage with the byte array `updateBytes` Creates a signed certificate - in place in GP storage - using a predetermined block of GP storage data

Parameters

- `[in] index`: Storage index of the keypair (private key) to be used.
- `[in] updateBytes`: Byte array to be written into GP storage
- `[in] updateBytesLen`: Length of the provided byte array (`updateBytes`).
- `[out] invocationCount`: Amount of times the underlying APDU has been called succesfully.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EccVerify`** (SST_Index_t *index*, **`const`** U8 **pHash*, U16 *hashLen*, **`const`** U8 **pSignature*, U16 *signatureLen*, U8 **pResult*)

Verifies whether `pSignature` is the signature of `pHash` using the public key stored under `index` as the verifying public key.

The index refers to an instance of the PUBLIC_KEY secure storage class on the A71CH.

Note The public key of an ECC key pair cannot be used for a verify operation.

Note A71_EccVerifyWithKey allows to pass the value of the public key rather than use a stored public key.

Parameters

- `[in] index`: Storage index of the key used for the verification.
- `[in] pHash`: Pointer to the provided hash (or any other bytestring).
- `[in] hashLen`: Length of the provided hash (`pHash`).
- `[in] pSignature`: Pointer to the provided signature.
- `[in] signatureLen`: Length of the provided signature (`pSignature`)
- `[out] pResult`: Pointer to the computed result of the verification. Points to a value of 0x01 in case of successful verification

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EcdhGetSharedSecret`** (U8 *index*, **`const`** U8 **pOtherPublicKey*, U16 *otherPublicKeyLen*, U8 **pSharedSecret*, U16 **pSharedSecretLen*)

Generates and retrieves a shared secret ECC point `pSharedSecret` using the private key stored at `index` and a public key `pOtherPublicKey` passed as argument.

Parameters

- `[in] index`: to the key pair (private key to be used)
- `[in] pOtherPublicKey`: Pointer to the given public key.
- `[in] otherPublicKeyLen`: Length of the given public key.
- `[inout] pSharedSecret`: Pointer to the computed shared secret.
- `[inout] pSharedSecretLen`: Pointer to the length of the computed shared secret.

Return Value

- `::SW_OK`: Upon successful execution

Crypto Derive API

Description Wrap the key derivation functionality of the A71CH.

Functions

U16 **A71_HkdfExpandSymKey**(SST_Index_t *index*, U8 *nBlock*, **const** U8 **info*, U16 *infoLen*, U8 **derivedData*, U16 *derivedDataLen*)

The HMAC Key Derivation function derives a key from a stored secret using SHA256 as hash function according to [RFC5869]. Only the expand step will be executed.

The secret is stored in the SYM key store. It can be either 16, 32, 48 or 64 byte long. The Most Significant part of the secret resides in the storage location with the lowest index. The subsequent parts reside in the next storage locations. The nBlock parameter is equal to the length of the secret divided by 16. A secret with length 64 can only start at Index 0 of the SYM key store: a secret can not be stored wrapped around in the SYM key store.

Note infoLen must be smaller than 254 byte.

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] info`: Context and application specific information used in expand step
- `[in] infoLen`: The length of the info data passed as argument
- `[inout] derivedData`: IN: caller passes a buffer of at least derivedDataLen; OUT: contains the calculated derived data
- `[in] derivedDataLen`: IN: length of the requested derivedData. Must be smaller than 256 byte.

Return Value

- `::SW_OK`: Successfull execution

U16 **A71_HkdfSymKey**(SST_Index_t *index*, U8 *nBlock*, **const** U8 **salt*, U16 *saltLen*, **const** U8 **info*, U16 *infoLen*, U8 **derivedData*, U16 *derivedDataLen*)

The HMAC Key Derivation function derives a key from a stored secret using SHA256 as hash function according to [RFC5869]. Both the extract and expand steps will be executed.

In case a zero length salt value is passed as argument, this function is equivalent to A71_HkdfExpandSymKey: i.e. the extract step is skipped. To enforce the usage of the default salt value (a Bytestring of 32 zeroes) the caller must explicitly pass this default salt value as argument to this function.

The secret is stored in the SYM key store. It can be either 16, 32, 48 or 64 byte long. The Most Significant part of the secret resides in the storage location with the lowest index. The subsequent parts reside in the next storage locations. The nBlock parameter is equal to the length of the secret divided by 16. A secret with length 64 can only start at Index 0 of the SYM key store: a secret can not be stored wrapped around in the SYM key store.

Note The sum of saltLen and infoLen must be smaller than 254 byte.

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] salt`: Salt data used in extract step
- `[in] saltLen`: The length of the salt data passed as argument
- `[in] info`: Context and application specific information used in expand step
- `[in] infoLen`: The length of the info data passed as argument

- `[inout] derivedData`: IN: caller passes a buffer of at least derivedDataLen; OUT: contains the calculated derived data
- `[in] derivedDataLen`: IN: length of the requested derivedData. Must be smaller than 256 byte.

Return Value

- `::SW_OK`: Successfull execution

U16 **`A71_PskDeriveMasterSecret`**(SST_Index_t *index*, U8 *nBlock*, **`const`** U8 **serverHelloRnd*, U16 *serverHelloRndLen*, U8 **masterSecret*)

This function calculates the PRF according to TLS1.2 [RFC5246]. The pre-master secret is formed - based upon a pre-shared secret (PSK) stored in the secure module - according to [RFC4279].

The pre-shared secret is stored in the SYM key store. It can be either 16, 32, 48 or 64 byte long. The Most Significant part of the pre-shared secret resides in the storage location with the lowest index. The subsequent parts reside in the next storage locations. The nBlock parameter is equal to the length of the PSK divided by 16.

A PSK cannot be stored wrapped around in the SYM key store.

The PRF creating the masterSecret also takes as parameter the concatentation of label ("master_secret"), ClientHello.random and ServerHello.random. This function only takes ServerHello.random as parameter: ClientHello.random has already been set by a call to A71_CreateClientHelloRandom, the value of the label (default is "master_secret") can be overruled by a call to A71_SetTlsLabel.

Pre This call must be preceded by a call to A71_CreateClientHelloRandom, no other A71CH API call (implying an APDU exchange between Host and A71CH) may be executed in between the invocation of A71_CreateClientHelloRandom and A71_PskDeriveMasterSecret

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] serverHelloRnd`: ServerHello.random (concatenated with values already contained in A71CH)
- `[in] serverHelloRndLen`: The length of serverHelloRnd passed as an argument
- `[inout] masterSecret`: IN: caller passes a buffer of at least 48 byte; OUT: contains the calculated master Secret, TLS 1.2 mandates this to be 48 byte exact

Return Value

- `::SW_OK`: Successfull execution

U16 **`A71_EcdhPskDeriveMasterSecret`**(SST_Index_t *indexKp*, **`const`** U8 **publicKey*, U16 *publicKeyLen*, SST_Index_t *index*, U8 *nBlock*, **`const`** U8 **serverHelloRnd*, U16 *serverHelloRndLen*, U8 **masterSecret*)

This function calculates the PRF according to TLS1.2 [RFC5246]. The pre-master secret is formed - based upon a pre-shared secret (PSK) stored in the secure module and on an ECDH calculation - according to [RFC5489].

The pre-shared secret is stored in the SYM key store. It can be either 16, 32, 48 or 64 byte long. The Most Significant part of the pre-shared secret resides in the storage location with the lowest index. The subsequent parts reside in the next storage locations. The nBlock parameter is equal to the length of the PSK divided by 16.

A PSK cannot be stored wrapped around in the SYM key store.

The PRF creating the masterSecret also takes as parameter the concatentation of label ("master_secret"), ClientHello.random and ServerHello.random. This function only takes ServerHello.random as parameter: ClientHello.random has already been set by a call to A71_CreateClientHelloRandom, the value of the label (default is "master_secret") can be overruled by a call to A71_SetTlsLabel.

Pre This call must be preceded by a call to A71_CreateClientHelloRandom, no other A71CH API call (implying an APDU exchange between Host and A71CH) may be executed in between the invocation of A71_CreateClientHelloRandom and A71_EcdhPskDeriveMasterSecret

Parameters

- `[in] indexKp`: Index of the ECC keypair whose private key is used in the ECDH operation
- `[in] publicKey`: Value of the public key to be used in ECDH operation
- `[in] publicKeyLen`: Length of publicKey in byte
- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] serverHelloRnd`: ServerHello.random (concatenated with values already contained in A71CH)
- `[in] serverHelloRndLen`: The length of serverHelloRnd passed as an argument
- `[inout] masterSecret`: IN: caller passes a buffer of at least 48 byte; OUT: contains the calculated master Secret, TLS 1.2 mandates this to be 48 byte exact

Return Value

- `::SW_OK`: Successfull execution

U16 **`A71_GetHmacSha256`**(SST_Index_t *index*, U8 *nBlock*, **`const`** U8 **data*, U16 *dataLen*, U8 **hmac*, U16 **hmacLen*)

Calculates the HMAC on `data` using SHA256 as Hash Function according to [RFC2104]. The secret is stored in the SYM key store. It can be either 16, 32, 48 or 64 byte long. The Most Significant part of the secret resides in the storage location with the lowest index. The subsequent parts reside in the next storage locations. The nBlock parameter is equal to the length of the secret divided by 16. A secret with length 64 can only start at Index 0 of the SYM key store: a secret can not be stored wrapped around in the SYM key store.

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] data`: Data buffer for which the HMAC-SHA256 must be calculated
- `[in] dataLen`: The length of data passed as argument
- `[inout] hmac`: IN: caller passes a buffer of at least 32 byte; OUT: contains the calculated hmac
- `[inout] hmacLen`: IN: length of the hmac buffer passed; OUT: because SHA256 is used this is 32 byte exact

Return Value

- `::SW_OK`: Successfull execution

U16 **`A71_HmacSha256Init`**(SST_Index_t *index*, U8 *nBlock*)

Initialise multistep HMACSHA256.

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_HmacSha256Update`**(SST_Index_t *index*, U8 *nBlock*, U8 **data*, U16 *dataLen*)

Update the data for calulating HMACSHA256 value (in multistep).

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[in] data`: Data buffer for which the HMACSHA256 must be calculated
- `[in] dataLen`: The length of data passed as argument

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_HmacSha256Final`**(SST_Index_t *index*, U8 *nBlock*, U8 **hmac*, U16 **hmacLen*)

calulating HMACSHA256 value (in multistep).

Parameters

- `[in] index`: Index of the SYM key store containing the MSB part of the pre-shared secret
- `[in] nBlock`: Amount of blocks, equivalent to the pre-shared secret length when multiplied by 16
- `[inout] hmac`: IN: caller passes a buffer of at least 32 byte; OUT: contains the calculated HMAC-SHA256
- `[inout] hmacLen`: IN: length of the sha buffer passed; OUT: because HMACSHA256 is used this is 32 byte exact

Return Value

- `::SW_OK`: Upon successful execution

Secure Storage (SST) API

Description Wrap the secure storage functionality of the A71CH.

Functions

U16 **`A71_SetEccKeyPair`**(SST_Index_t *index*, **`const`** U8 **publicKey*, U16 *publicKeyLen*, **`const`** U8 **privateKey*, U16 *privateKeyLen*)

Sets an ECC Key pair at storage location `index` with the provided values for public and private key. The private key can optionally be RFC3944 wrapped. Whether wrapping is applied or not is implicit in the length of the private key.

Parameters

- `[in] index`: Storage index of the keypair to be created.
- `[in] publicKey`: Pointer to the byte array containing the public key. The public key must be in ANSI X9.62 uncompressed format (including the leading 0x04 byte).
- `[in] publicKeyLen`: Length of the public key (65 byte)
- `[in] privateKey`: Pointer to the byte array containing the private key. The private key may be RFC3394 wrapped using the config key stored at index A71CH_CFG_KEY_IDX_PRIVATE_KEYS
- `[in] privateKeyLen`: Length of the private key (either 32 byte for keys in plain format or 40 byte for keys in RFC3944 wrapped format)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetPublicKeyEccKeyPair`**(SST_Index_t *index*, U8 **publicKey*, U16 **publicKeyLen*)

Retrieves the ECC Public Key - from a key pair - from the storage location `index` into the provided buffer. The public key retrieved is in ANSI X9.62 uncompressed format (including the leading 0x04 byte).

Parameters

- `[in] index`: Storage index of the key pair
- `[inout] publicKey`: IN: buffer to contain public key byte array; OUT: public key
- `[inout] publicKeyLen`: IN: size of provided buffer; OUT: Length of the retrieved public key

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_BUF_TOO_SMALL`: `publicKey` buffer is too small

U16 **`A71_GetEccKeyPairUsage`**(SST_Index_t *index*, U8 **restricted*, U16 **usedCnt*, U16 **maxUseCnt*)

Retrieve the usage counter (i.e. how much times the key pair has been used so far to sign) and the maximum usage counter. If the key pair is NOT restricted, usage counter and maximum usage counter will be set to 0 and the restricted parameter will be 0 (otherwise it is 1)

Parameters

- `[in] index`: Storage index of the key pair
- `[out] restricted`: 0 when the key pair on `index` is not restricted; 1 if it is restricted. A restricted key pair is a key pair that can only be used to sign a dedicated area in GP storage.
- `[out] usedCnt`: Number of times the key pair on `index` has been used to sign (assuming it is a restricted key pair)
- `[out] maxUseCnt`: Indicates the maximum amount of signing operations associated with the key pair at `index`. In case the value is zero, there is no limit on the amount of signing operations.

U16 **`A71_FreezeEccKeyPair`**(SST_Index_t *index*)

Freezes an ECC key pair at storage location `index`. This means that the key pair can no longer be erased or its value changed.

Pre INJECTION_LOCKED has not been set

Parameters

- `[in] index`: Storage index of the key pair to be frozen.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_FreezeEccKeyPairWithChallenge`**(SST_Index_t *index*, U8 **configKey*, U16 *configKeyLen*)

Freezes an ECC key pair at storage location `index`. This means that the key pair can no longer be erased or its value changed. This function must be called instead of A71_FreezeEccKeyPair in case INJECTION_LOCKED was set

The assumption is the value of the Key Pair configuration key is known on the host. If this does not apply use A71_FreezeEccKeyPairWithCode instead.

Parameters

- `[in] index`: Storage index of the key pair to be frozen.

- `[in] configKey`: Value of Key Pair configuration key. This value has a high level of confidentiality and may not be available to the Host.
- `[in] configKeyLen`: Length of Key Pair configuration key

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_FreezeEccKeyPairWithCode`**(SST_Index_t *index*, U8 **code*, U16 *codeLen*)

Freezes an ECC key pair at storage location `index` provided the correct code value is passed as argument. Freezing the key pair means that it can no longer be erased or its value changed. This function must be called instead of A71_FreezeEccKeyPair in case INJECTION_LOCKED was set.

The assumption is the value of the Key Pair configuration key is not known on the host. If this does not apply use A71_FreezeEccKeyPairWithChallenge instead.

The code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index A71CH_CFG_KEY_IDX_PRIVATE_KEYS).
- The decrypted value is the value of `code`

Parameters

- `[in] index`: Storage index of the key pair to be frozen.
- `[in] code`: Value of unlock code
- `[in] codeLen`: Length of unlock code (must be 16)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccKeyPair`**(SST_Index_t *index*)

Erases an ECC key pair at storage location `index`. This means that the key pair can no longer be used before a new value is set.

Pre INJECTION_LOCKED has not been set

Parameters

- `[in] index`: Storage index of the key pair to be frozen.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccKeyPairWithChallenge`**(SST_Index_t *index*, U8 **configKey*, U16 *configKeyLen*)

Erases an ECC key pair at storage location `index`. This means that the key pair can no longer be used before a new value is set. This function must be called instead of A71_EraseEccKeyPair in case INJECTION_LOCKED was set.

The assumption is the value of the Key Pair configuration key is known on the host. If this does not apply use A71_EraseEccKeyPairWithCode instead.

Parameters

- `[in] index`: Storage index of the key pair to be frozen.
- `[in] configKey`: Value of Key Pair configuration key. This value has a high level of confidentiality and may not be available to the Host.

- `[in] configKeyLen`: Length of Key Pair configuration key

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccKeyPairWithCode`**(SST_Index_t *index*, U8 **code*, U16 *codeLen*)

Erases an ECC key pair at storage location `index`. This means that the key pair can no longer be used before a new value is set. This function must be called instead of A71_EraseEccKeyPair in case INJECTION_LOCKED was set.

The assumption is the value of the Key Pair configuration key is not known on the host. If this does not apply use A71_EraseEccKeyPairWithChallenge instead.

The code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index A71CH_CFG_KEY_IDX_PRIVATE_KEYS).
- The decrypted value is the value of `code`

Parameters

- `[in] index`: Storage index of the key pair to be frozen.
- `[in] code`: Value of unlock code
- `[in] codeLen`: Length of unlock code (must be 16)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetEccPublicKey`**(SST_Index_t *index*, **`const`** U8 **publicKey*, U16 *publicKeyLen*)

Sets an ECC Public Key at storage location `index` with the provided value for public key either in plain ANSI X9.62 uncompressed format or wrapped. Whether RFC3944 wrapping is applied or not is implicit in the length of the public key. In case RFC3944 wrapping is applied the first byte of the public key (the one indicating the public key format) is removed before applying wrapping.

Parameters

- `[in] index`: Storage index of the public key to be set.
- `[in] publicKey`: Pointer to the byte array containing the public key. The public key may be RFC3394 wrapped using the config key stored at index A71CH_CFG_KEY_IDX_PUBLIC_KEYS
- `[in] publicKeyLen`: Length of the public key (either 65 byte for keys in plain format or 72 byte for keys in RFC3944 wrapped format)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetEccPublicKey`**(SST_Index_t *index*, U8 **publicKey*, U16 **publicKeyLen*)

Retrieves the ECC Public Key from the storage location `index` into the provided buffer. The public key is in ANSI X9.62 uncompressed format (including the leading 0x04 byte).

Parameters

- `[in] index`: Storage index of the public key to be retrieved.
- `[inout] publicKey`: IN: buffer to contain public key byte array; OUT: public key
- `[inout] publicKeyLen`: IN: size of provided buffer; OUT: Length of the retrieved public key

Return Value

- `::SW_OK`: Upon successful execution
- `::ERR_BUF_TOO_SMALL`: `publicKey` buffer is too small

U16 **`A71_FreezeEccPublicKeyWithChallenge`** (SST_Index_t *index*, U8 **configKey*, U16 *configKeyLen*)

Freezes an ECC public key at storage location `index`. This means that the public key can no longer be erased or its value changed. This function must be called instead of A71_FreezeEccPublicKey in case INJECTION_LOCKED was set.

The assumption is the value of the Public Key configuration key is known on the host. If this does not apply use A71_FreezeEccPublicKeyWithCode instead.

Parameters

- `[in] index`: Storage index of the public key to be frozen.
- `[in] configKey`: Value of Public Key Pair key. This value has a high level of confidentiality and may not be available to the Host.
- `[in] configKeyLen`: Length of Public Key configuration key

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_FreezeEccPublicKeyWithCode`** (SST_Index_t *index*, U8 **code*, U16 *codeLen*)

Freezes an ECC public key at storage location `index` provided the correct code value is passed as argument. Freezing the public key means that it can no longer be erased or its value changed. This function must be called instead of A71_FreezeEccPublicKey in case INJECTION_LOCKED was set.

The assumption is the value of the Public Key configuration key is not known on the host. If this does not apply use A71_FreezeEccPublicKeyWithChallenge instead.

The code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index A71CH_CFG_KEY_IDX_PUBLIC_KEYS).
- The decrypted value is the value of `code`

  Parameters

  - `[in] index`: Storage index of the key pair to be frozen.
  - `[in] code`: Value of unlock code
  - `[in] codeLen`: Length of unlock code (must be 16)

  Return Value

  - `::SW_OK`: Upon successful execution

U16 **`A71_FreezeEccPublicKey`** (SST_Index_t *index*)

Freezes an ECC public key at storage location `index`. This means that the public key can no longer be erased or its value changed.

Parameters

- `[in] index`: Storage index of the public key to be frozen.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccPublicKey`**(SST_Index_t *index*)

Erases an ECC public key at storage location `index`. This means that the public key can no longer be used before a new value is set.

Pre INJECTION_LOCKED has not been set

Parameters

- `[in] index`: Storage index of the public key to be frozen.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccPublicKeyWithChallenge`**(SST_Index_t *index*, U8 **configKey*, U16 *configKeyLen*)

Erases an ECC public key at storage location `index`. This means that the public key can no longer be used before a new value is set. This function must be called instead of A71_EraseEccPublicKey in case INJECTION_LOCKED was set.

The assumption is the value of the Public Key configuration key is known on the host. If this does not apply use A71_EraseEccPublicKeyWithCode instead.

Parameters

- `[in] index`: Storage index of the public key to be frozen.
- `[in] configKey`: Value of Public Key Pair key. This value has a high level of confidentiality and may not be available to the Host.
- `[in] configKeyLen`: Length of Public Key configuration key

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseEccPublicKeyWithCode`**(SST_Index_t *index*, U8 **code*, U16 *codeLen*)

Erases an ECC public key at storage location `index`. This means that the public key can no longer be used before a new value is set. This function must be called instead of A71_EraseEccPublicKey in case INJECTION_LOCKED was set.

The assumption is the value of the Public Key configuration key is not known on the host. If this does not apply use A71_EraseEccPublicKeyWithChallenge instead.

The code is calculated as follows:

- Request a challenge from A71CH using A71_GetUnlockChallenge.
- Decrypt the challenge in ECB mode using the appropriate configuration key value (the same as stored at index A71CH_CFG_KEY_IDX_PUBLIC_KEYS).
- The decrypted value is the value of `code`

  Parameters

  - `[in] index`: Storage index of the key pair to be frozen.
  - `[in] code`: Value of unlock code
  - `[in] codeLen`: Length of unlock code (must be 16)

  Return Value

  - `::SW_OK`: Upon successful execution

U16 **`A71_SetSymKey`**(SST_Index_t *index*, **`const`** U8 **key*, U16 *keyLen*)

Sets a symmetric key at storage location `index` with the key value. The key locations indexed are the same as the one referenced by A71_SetRfc3394WrappedAesKey

Parameters

- `[in] index`: Storage index of the symmetric key to be set.
- `[in] key`: Pointer to the byte array containing the symmetric key
- `[in] keyLen`: Length of the symmetric key (must be 16)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetRfc3394WrappedAesKey`**(SST_Index_t *index*, **`const`** U8 **key*, U16 *keyLen*)

Sets an RFC3394 wrapped AES key in secure storage. The key value being set, must be wrapped with the value already stored at `index`. The key locations indexed are the same as the one referenced by A71_SetSymKey

Parameters

- `[in] index`: index of the key to be set. At the same time the index of the wrapping key.
- `[in] key`: Pointer to the supplied key data.
- `[in] keyLen`: Length of the supplied key data.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_FreezeSymKey`**(SST_Index_t *index*)

Freezes a symmetric key at storage location `index`. This means the value of the key at the specified index can no longer be changed.

Parameters

- `[in] index`: Storage index of the symmetric key to be frozen.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_EraseSymKey`**(SST_Index_t *index*)

Erases the symmetric key at storage location `index`. This means the value of the key at the specified index is cleared. The value must be set anew before the key can be used.

Parameters

- `[in] index`: Storage index of the symmetric key to be set.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_IncrementCounter`**(SST_Index_t *index*)

Increments the monotonic counter at storage location index by one.

Parameters

- `[in] index`: Storage index of the counter.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetCounter`**(SST_Index_t *index*, U32 *value*)

Sets the value of the monotonic counter at storage location ‘index’ with the value passed as parameter.

Parameters

- `[in] index`: Storage index of the counter.
- `[in] value`: Counter value to be set

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetCounter`**(SST_Index_t *index*, U32 **pValue*)

Gets the value of the monotonic counter at storage location ‘index’.

Parameters

- `[in] index`: Storage index of the counter.
- `[out] pValue`: Counter value retrieved

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_DbgEraseCounter`**(SST_Index_t *index*)

Sets the value of the monotonic counter at storage location ‘index’ to zero.

Note Only available when the applet is in Debug Mode.

Parameters

- `[in] index`: Storage index of the counter.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetGpData`**(U16 *dataOffset*, **const** U8 **data*, U16 *dataLen*)

Sets a data chunk of General Purpose storage in the security module. Depending on the size of the chunk, this requires one or more APDU exchanges with the security module.

Pre The addressed General Purpose storage is not locked.

Note In case part of the addressed General Purpose storage is locked, only part of the provided data will have been written most likely leading to an inconsistent data set stored in General Purpose storage.

Parameters

- `[in] dataOffset`: Offset for the data in the GP Storage.
- `[in] data`: IN: buffer containing data to write
- `[in] dataLen`: Amount of data to write

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetGpDataWithLockCheck`**(U16 *dataOffset*, **const** U8 **data*, U16 *dataLen*)

Sets a data chunk of General Purpose storage in the security module. Depending on the size of the chunk, this requires one or more APDU exchanges with the security module.

Pre The addressed General Purpose storage is not locked.

Note In case more than one apdu is required, this function first validates that each of the chunks of the addressed General Purpose storage is not locked, and only in that case try to write the provided data using A71_SetGpData()

Parameters

- `[in] dataOffset`: Offset for the data in the GP Storage.
- `[in] data`: IN: buffer containing data to write
- `[in] dataLen`: Amount of data to write

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_GetGpData`** (U16 *dataOffset*, U8 **data*, U16 *dataLen*)
Retrieve a chunk of data from general purpose (GP) storage.

Parameters

- `[in] dataOffset`: Offset for the data in the GP Storage.
- `[inout] data`: IN: buffer to contain data; OUT: retrieved data
- `[in] dataLen`: Amount of data to retrieve

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_FreezeGpData`** (U16 *dataOffset*, U16 *dataLen*)
Mark a chunk in GP storage as frozen (meaning further modification of the GP storage area is disallowed). Both the `dataOffset` and `dataLen` must be aligned on A71CH_GP_STORAGE_GRANULARITY

Parameters

- `[in] dataOffset`: Offset for the data in the GP Storage.
- `[in] dataLen`: Amount of data to freeze

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetConfigKey`** (SST_Index_t *index*, **`const`** U8 **key*, U16 *keyLen*)
Sets a config key at storage location `index` with the key value. The key locations indexed are the same as the one referenced by A71_SetRfc3394WrappedConfigKey

Parameters

- `[in] index`: Storage index of the config key to be set.
- `[in] key`: Pointer to the byte array containing the config key
- `[in] keyLen`: Length of the config key (must be 16)

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_SetRfc3394WrappedConfigKey`** (SST_Index_t *index*, **`const`** U8 **key*, U16 *keyLen*)
Sets an RFC3394 wrapped config key in secure storage. The key value being set, must be wrapped with the value already stored at the `index`. The key locations indexed are the same as the one referenced by A71_SetConfigKey

Parameters

- `[in] index`: index of the key to be set. At the same time the index of the wrapping key.
- `[in] key`: Pointer to the supplied key data.
- `[in] keyLen`: Length of the supplied key data.

Return Value

- `::SW_OK`: Upon successful execution

sm_connect.c

Description Implementation of basic communication functionality between Host and A71CH. (This file was renamed from `a71ch_com.c` into `sm_connect.c`.)

Functions

U16 **`SM_RjctConnect`**(void ***conn_ctx*, **`const`** char **connectString*, SmCommState_t **commState*, U8 **atr*, U16 **atrLen*)

U16 **`SM_I2CConnect`**(void ***conn_ctx*, SmCommState_t **commState*, U8 **atr*, U16 **atrLen*, **`const`** char **pConnString*)

U16 **`SM_Connect`**(void **conn_ctx*, SmCommState_t **commState*, U8 **atr*, U16 **atrLen*)

Establishes the communication with the Security Module (SM) at the link level and selects the A71CH applet on the SM. The physical communication layer used (e.g. I2C) is determined at compilation time.

Parameters

- `[inout] commState`:
- `[inout] atr`:
- `[inout] atrLen`:

Return Value

- `::SW_OK`: Upon successful execution

U16 **`SM_Close`**(void **conn_ctx*, U8 *mode*)

Closes the communication with the Security Module A new connection can be established by calling SM_Connect

Parameters

- `[in] mode`: Specific information that may be required on the link layer

Return Value

- `::SW_OK`: Upon successful execution

U16 **`SM_SendAPDU`**(U8 **cmd*, U16 *cmdLen*, U8 **resp*, U16 **respLen*)

Sends the command APDU to the Secure Module and retrieves the response APDU. The latter consists of the concatenation of the response data (possibly none) and the status word (2 bytes).

The command APDU and response APDU are not interpreted by the host library.

The command/response APDU sizes must lay within the APDU size limitations

Parameters

- `[in] cmd`: command APDU

- `[in] cmdLen`: length (in byte) of `cmd`
- `[inout] resp`: response APDU (response data || response status word)
- `[inout] respLen`: IN: Length of resp buffer (`resp`) provided; OUT: effective length of response retrieved.

Return Value

- `::SW_OK`: Upon successful execution

ax_scp.c

Description Set up the SCP03 communication channel.

Functions

U16 **`SCP_HostLocal_GetSessionState`** (ChannelId_t *channelId*, Scp03SessionState_t **pSession*)

Copy the session state into `pSession`. Caller must allocate memory of `pSession`.

Parameters

- `[in] channelId`: Either ::AX_HOST_CHANNEL or ::AX_ADMIN_CHANNEL. Must be ::AX_HOST_CHANNEL in case of A71CH.
- `[inout] pSession`: IN: pointer to allocated ::Scp03SessionState_t structure; OUT: retrieved state

Return Value

- `::SW_OK`: Upon successful execution
- `::SCP_UNDEFINED_CHANNEL_ID`: In case an undefined ::ChannelId_t type was passed as parameter

U16 **`SCP_GetScpSessionState`** (Scp03SessionState_t **scp03state*)

Retrieve the SCP03 session state of the host - secure module channel from the Host Library.

Return ::SW_OK

Parameters

- `[inout] scp03state`: IN: pointer to allocated structure; OUT: datastructure contains SCP03 session state

void **`SCP_SetScpSessionState`** (Scp03SessionState_t **scp03state*)

Sets SCP03 session state of the host - secure module channel of the Host Library. Can be used in a scenario where e.g. the bootloader has established the SCP03 link between host and secure module and the Host OS must re-establish the communication with the secure module without breaking the SCP03 session.

Parameters

- `[in] scp03state`: IN: SCP03 session state

U16 **`SCP_GP_ExternalAuthenticate`** (ChannelId_t *channelId*, U8 **hostCryptogram*)

U16 **`SCP_GP_InitializeUpdate`** (ChannelId_t *channelId*, U8 **hostChallenge*, U16 *hostChallengeLen*, U8 **keyDivData*, U16 **pKeyDivDataLen*, U8 **keyInfo*, U16 **pKeyInfoLen*, U8 **cardChallenge*, U16 **pCardChallengeLen*, U8 **cardCryptoGram*, U16 **pCardCryptoGramLen*, U8 **seqCounter*, U16 **pSeqCounterLen*)

U16 **`SCP_GP_PutKeys`**(U8 *keyVersion*, U8 **keyEnc*, U8 **keyMac*, U8 **keyDek*, U8 **currentKeyDek*, U16 *keyBytes*)

Persistently stores the provided SCP03 base key set in the security module.

This method must be called once before the Host - Secure Module SCP channel can be established.

Return ::SW_OK upon success

Parameters

- `[in] keyVersion`:
- `[in] keyEnc`: SCP03 channel encryption base key
- `[in] keyMac`: SCP03 authentication base key
- `[in] keyDek`: SCP03 data encryption base key
- `[in] currentKeyDek`: Value of the data encryption base key already stored in secure module, may be NULL in case no key is currently stored.
- `[in] keyBytes`: Length (in byte) of the keys being set. Typically 16 (corresponding to 128 bits)

U16 **`SCP_Authenticate`**(U8 **keyEnc*, U8 **keyMac*, U8 **keyDek*, U16 *keyBytes*, U8 **sCounter*, U16 **sCounterLen*)

Performs an SCP03 authentication with the SM and - when successful - computes the SCP03 session keys and initializes the current Session state.

Parameters

- `[in] keyEnc`: SCP03 channel encryption base key (aka static key) (16 bytes)
- `[in] keyMac`: SCP03 authentication base key (aka static key) (16 bytes)
- `[in] keyDek`: SCP03 data encryption base key (aka static key) (16 bytes)
- `[in] keyBytes`: Must be 16
- `[inout] sCounter`: SCP03 sequence counter (3 bytes)
- `[inout] sCounterLen`:

scp_a7x.c

Description Conditionally apply SCP03 channel encryption (This file was renamed from `scp.c` into `scp_a7x.c`.)

a71_debug.c

Description Wrap Debug Mode specific APDU's of A71CH.

Functions

U16 **`A71_DbgReset`**(void)

Resets the Secure Module to the initial state.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_DbgDisableDebug`**(void)

Permanently disables the Debug API.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_DbgGetFreePersistentMemory`**(S16 **freeMem*)

Reports the available persistent memory in the Security Module.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_DbgGetFreeTransientMemory`**(S16 **freeMem*)

Reports the available transient memory in the Security Module.

Return Value

- `::SW_OK`: Upon successful execution

U16 **`A71_DbgReflect`**(U8 **sndBuf*, U16 *sndBufLen*, U8 **rcvBuf*, U16 **rcvBufLen*)

Invokes data reflection APDU (facilitates link testing). No check of data payload returned

Return

Parameters

- `[in] sndBuf`:
- `[in] sndBufLen`:
- `[inout] rcvBuf`:
- `[inout] rcvBufLen`:

10.4 A71CH Legacy HLSE (Generic) API

10.4.1 HLSE API

The API is designed to be generic for Secure Elements that hold cryptographic information and perform cryptographic functions. It isolates an application from the details of the cryptographic device such that it does not have to change to interface to a different type of cryptographic device.

This generic layer intends to abstract both the different APDU specs of applets, and the ?file system? details, i.e., how each ?object? is stored on the SE. For example, in order to enumerate the certificate objects on the card, the implementation should know where the objects are located, how many there are, what their type is, etc. This abstract layer is important for, e.g. a PKCS#11 layer, and for TLS engines that will have to access objects on the Secure Element.

The HLSE API is written in **C** allowing maximal portability across different platforms.

Each typedef, enum and function starts with the HLSE (=Host Library Secure Element) prefix.

The various Secure Element entities are referred to as Objects. Every Object (e.g. Key) has a unique handle (HLSE_OBJECT_HANDLE) and a set of attributes (HLSE_ATTRIBUTE) whose values can be retrieved (Get) and Set. An HLSE_OBJECT_HANDLE can be obtained in two ways: Either returned by HLSE_EnumerateObjects() if the Object exists on the Secure Element, or returned by HLSE_CreateObject() for a new Object. This is an abstraction of the actual way in which the API implements these handles.

An HLSE_ATTRIBUTE is defined as:

```
typedef struct HLSE_ATTRIBUTE {
    HLSE_ATTRIBUTE_TYPE     type;
    void*                   value;
    U16                     valueLen;
} HLSE_ATTRIBUTE;
```

For example, a Private RSA key may have the HLSE_ATTR_RSA_MODULUS and HLSE_ATTR_RSA_PUBLIC_EXPONENT attributes, and their values can be extracted or set.

Key Generation can be obtained by passing a NULL parameter in the HLSE_ATTR_OBJECT_VALUE attribute. This enables to create the key with a generated random data, or to re-generate an existing key by passing NULL in this attribute's parameter.

A set of functions is responsible for performing cryptographic operations:

- HLSE_Digest()
- HLSE_Sign()
- HLSE_VerifySignature()
- HLSE_DeriveKey()
- HLSE_Encrypt()
- HLSE_Decrypt()

The cryptographic algorithm is controlled by a HLSE_MECHANISM_INFO, defined as:

```
typedef struct HLSE_MECHANISM_INFO {
    HLSE_MECHANISM_TYPE    mechanism;
    void*                  pParameter;
    U16                    ulParameterLen;
} HLSE_MECHANISM_INFO;
```

A list of the supported mechanisms, either by the library or by a specific key, can be obtained by calling HLSE_GetSupportedMechanisms() or HLSE_GetSupportedMechanismsForObject(), respectively.

The HLSE API is made up of four parts:

- Operations on Objects (*HLSEObjects.h*)
- Cryptographic operations (*HLSECrypto.h*)
- Secure Element Communication and Secure Channel management functions (*HLSEComm.h*)
- Debug Mode variant and miscellaneous functionality (*HLSEMisc.h*)

An additional file `.../hostLib/inc/HLSEAPI.h` serves as an entry point to the full API. The implementation of the API dealing with A71CH specific functionality is in `.../hostLib/api/src/A71HLSEWrapper.c`.

10.4.2 Logical objects

The HLSE API allows to create logical objects in the GP Storage. They can be of HLSE_CERTIFICATE or HLSE_DATA object type. The abstraction for various objects that reside in the GP Storage area is achieved by maintaining a lookup table (mapping) at the end of the GP Storage area to hold information about the logical objects that exist in the GP Storage. The structure of the table is as follows:

```
Notes:
    X+1 is the address of the last byte of the GP Storage.
    N is the object number from 1 to N
```

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```

Address     Value
-------     ----------------------
X-N*6+0     N'th Object Class       - 1 byte
X-N*6+1     N'th Object Index       - 1 byte
X-N*6+2     N'th Object Length MSB  - 1 byte
X-N*6+3     N'th Object Length LSB  - 1 byte
X-N*6+4     N'th Object Offset MSB  - 1 byte
X-N*6+5     N'th Object Offset LSB  - 1 byte
            ?
X-1*6+0     First Object Class      - 1 byte
X-1*6+1     First Object Index      - 1 byte
X-1*6+2     First Object Length MSB - 1 byte
X-1*6+3     First Object Length LSB - 1 byte
X-1*6+4     First Object Offset MSB - 1 byte
X-1*6+5     First Object Offset LSB - 1 byte

X           Update Counter          - 1 byte
X+1         Number of table entries - 1 byte
End of GP Storage
```

The table will be written so that the 'Number of table entries' byte is the last byte of the GP Data (to allow the map to grow dynamically as long as there is enough free space), preceded by one byte of the Update Counter and then preceded by 6-tuples of entries.

The Class byte is equivalent to the object type using a single byte (0x09 for Certificate, 0x0A for Data).

The order of the 6-tuple entries is not important, as each object is identified by its Class and Index. In cases where the length of an object is not known at the time the lookup table entry is created, the MSBit (0x8000) can be set in the length as an indicator that the data is in TLV format and that the actual length must be obtained by reading the first bytes of the object's data.

For objects of type 'Certificate' the provisioned 'Object Length' value must be one of the following:

- The reserved object storage length (allowing for a possible increase in size of the certificate or for die-individual variance of the certificate size).
- The actual certificate length
- In the exceptional case neither a reserved certificate object storage length nor the effective certificate length can be determined one can use the value '0x8000' to indicate the 'Object Size' is unknown at the time of provisioning.

When reading a certificate from GP storage with the HLSE API, the size of the certificate is always determined by the length value of the certificate's initial TL(V) header.

The host library reads the total number of entries in the table from the last byte of the GP Data, followed by parsing/reading the 6-tuple entries. Up to 254 (0xFE) objects are assumed. A value of 0xFF in the number of entries indicates that the table is absent (uninitialized) or invalid.

Class and Index value of 0xFF indicates an invalid entry (i.e. of a deleted object).

The Update Counter is initially set to 0 and it is incremented on each table update. This serves as an indication to a GP Storage's change when there is more than one application updating the SE concurrently.

The value of 'object offset' must be a multiple of 32.

It is not allowed to create a data object of size 0.

Object creation

The library supports a dynamic number of objects in the GP Storage, according to the memory availability.

Creating an object through HLSE_CreateObject() requires the following attributes to be passed:

1. HLSE_ATTR_OBJECT_TYPE ? currently HLSE_CERTIFICATE or HLSE_DATA;
2. HLSE_ATTR_OBJECT_INDEX ? will be the Tag of the object, 1 byte;
3. HLSE_ATTR_OBJECT_VALUE ? the object's value.

An additional attribute that can only be passed in Create is HLSE_ATTR_READ_ONLY. Setting this value to 1 will lock ('freeze') the memory associated with the object (once it has been created) so it cannot be modified. The HLSE_ATTR_READ_ONLY attribute is not explicitly stored in the GP Storage lookup table.

Note that this attribute cannot be set after object creation. If not passed, it has a default value of 0 (can be modified).

Creation fails if there is not enough continuous unlocked space for the new object's value.

Value Update

It is possible to change the object's value by calling HLSE_SetObjectAttribute() with HLSE_ATTR_OBJECT_VALUE. If the object needs to be enlarged, it is only permitted if enough memory is available for the object to grow, case as follows:

1. Within the same GP Storage's chunk size (32 bytes), so that the same amount of storage chunks will be used - For example, if the size was originally 21 bytes then the object occupies 1 chunk, and it is possible to enlarge it up to 32 bytes. 2. Up to the offset of the next allocated object in the GP memory.

If a larger size is required, the object must first be erased and then re-created (assuming a sufficiently large continuous unlocked space is available in GP memory).

Direct Access Value Update

It is possible to change a sub section of a Data object's value by calling HLSE_SetObjectAttribute() with HLSE_ATTR_DIRECT_ACCESS_OBJECT_VALUE, where the value should point to a HLSE_DIRECT_ACCESS_ATTRIBUTE_VALUE structure that passes the offset, number of bytes to read and the buffer. The update is only permitted within the object's GP Storage's chunk boundary.

Erasing an object

To erase an object first fetch its handle with HLSE_EnumerateObjects() and call HLSE_EraseObject(). Erasing an object only invalidates its lookup table entry, it does not erase its value contents in the GP Storage, due to performance reasons.

Interoperability of Object storage and locked chunks

The following defines the behavior of the HLSE API when updating (full/partial) or erasing partially locked objects stored in GP memory:

1. When updating an object (by definition this concerns the complete object) the HLSE API first checks that no chunk of the object is locked before updating the object.
2. When doing a partial update of an object the HLSE API does not check whether the affected memory chunks(s) are locked or unlocked. The partial update will fail or succeed accordingly. Consequently one must only issue a partial update of an object for chunks that are unlocked.

3. When erasing an object, the HLSE_EnumerateObjects() API checks whether the first chunk of the object is locked. If the first chunk is not locked the entry corresponding to the object is removed from the GP lookup table. If the first chunk is locked, the object is considered 'read-only' and the object is not removed from the GP lookup table. As explained above, erasing an object does not erase the value associated with the object.
4. Locking the GP storage chunks containing the lookup table (even a partial lock) will make it impossible to remove, add or update objects.

Notes

1. If the applet is Trust Provisioned prior to being shipped to the user, with e.g. one or more certificate(s), then the lookup table is expected to be in the GP Data.
2. If the lookup table is missing (invalid value), then it is automatically created by the host library upon the first call to CreateObject of such an object.
3. When reading a certificate, the response omits any trailing padding at the end of the certificate. The size of the certificate is determined by the length value of the certificates initial TL(V) header.
4. When updating an Object - the length in the GP table will be kept as the maximum size of the existing and new the object. As a consequence, it's not possible to shrink the size of an object by updating it.
5. Don't use direct A71CH API access in combination with the HLSE Object API as one can damage the lookup table or the value of stored objects.

10.4.3 API details

HLSEObjects.h

Description Host Lib wrapper API: Object Operations

Functions

HLSE_RET_CODE **`HLSE_EnumerateObjects`**(HLSE_OBJECT_TYPE *objectType*, HLSE_OBJECT_HANDLE **objectHandles*, U16 **objectHandlesLen*)

Enumerates all the Objects that currently exist on the Secure Element and have `objectType` type. A list of object handles is returned in `objectsHandles`.

In order to enumerate all the Objects, set HLSE_ANY_TYPE in `objectType`.

Each object has a unique HLSE_OBJECT_HANDLE value - this value depends on the library implementation.

If `objectHandles` is NULL, then all that the function does is return (in `*objectHandlesLen`) a number of HLSE_OBJECT_HANDLE which would suffice to hold the returned list. HLSE_SW_OK is returned by the function.

If `objectHandles` is not NULL, then `*objectHandlesLen` must contain the number of handles in the buffer `objectHandles`. If that buffer is large enough to hold number of handles to be returned, then the handles are copied to `objectHandles`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*objectHandlesLen` is set to hold the exact number of handles to be returned.

Parameters

- `[in] objectType`: The type of the Objects to be enumerated

- `[inout] objectHandles`: IN: caller passes a buffer of at least *objectHandlesLen; OUT: contains the handles of the objects
- `[inout] objectHandlesLen`: IN: number of handles in objectHandles. OUT: set to hold the exact number of handles in objectHandles.

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_BUF_TOO_SMALL`: Buffer is too small to return the handles
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_CreateObject`**(HLSE_ATTRIBUTE **attributes*, U16 *attributesNum*, HLSE_OBJECT_HANDLE **hObject*)

Creates or Generates an Object on the Secure Element, and returns a handle to it.

If the object already exists, it depends on the Secure Element behavior whether this function succeeds (e.g. set a new value) or fail with an error.

`attributes` is an array of attributes that the object should be created with. Some of the attributes may be mandatory, such as HLSE_ATTR_OBJECT_TYPE and HLSE_ATTR_OBJECT_INDEX (the id of the object), and some are optional.

In case there is a conflict in the attribute list (e.g. 2 differnt object types) it is the responsibility of the library to detect it and return an error.

Parameters

- `[in] attributes`: The attributes to be used in creating the Object
- `[in] attributesNum`: The number of attributes in `attributes`
- `[inout] hObject`: IN: A pointer to a handle (must not be NULL); OUT: The handle of the created Object

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_EraseObject`**(HLSE_OBJECT_HANDLE *hObject*)

Erases an object from the Secure Element.

This means the object with the specified handle can no longer be used.

Parameters

- `[in] hObject`: The handle of the Object to be erased

Return Value

- `HLSE_SW_OK`: Successfull execution

HLSE_RET_CODE **`HLSE_SetObjectAttribute`**(HLSE_OBJECT_HANDLE *hObject*, HLSE_ATTRIBUTE **attribute*)

Sets the requested Attribute of the Object.

The parameter `attribute` may convey additinal information (e.g. a key value), in addition to the attribute's type.

Parameters

- `[in] hObject`: The handle of the Object that its attribute should be set

- `[in] attribute`: The attribute to be Set

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_GetObjectAttribute`**(HLSE_OBJECT_HANDLE *hObject*, HLSE_ATTRIBUTE **attribute*)

Obtains the value of the Object's requested Attribute.

The parameter `attribute` specifies the Type of the attribute to be returned, and the data is returned in the attribute's value and valueLen members.

If `attribute->value` is NULL, then all that the function does is return (in `*attribute->valueLen`) a number of bytes which would suffice to hold the value to be returned. HLSE_SW_OK is returned by the function.

If `attribute->value` is not NULL, then `*attribute->valueLen` must contain the number of bytes in the buffer `attribute->value`. If that buffer is large enough to hold the value be returned, then the data is copied to `attribute->value`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*attribute->valueLen` is set to hold the exact number of bytes to be returned.

Parameters

- `[in] hObject`: The handle of the Object that its attribute's value should be obtained
- `[inout] attribute`: The attribute to be obtained

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_BUF_TOO_SMALL`: `attribute->value` is too small to return the data
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`Debug_ForceReadGPDataTable`**(void)

Debug Utility

Force Read of GPDataTable from gp storage even if already in global memory variable

NOTE!! : To be used only for internal testing and Debugging

currently used to test the GP Table manipulation

Return Value

- `HLSE_SW_OK`: Successfull execution

HLSECrypto.h

Description Host Lib wrapper API: Cryptographic functions

Functions

HLSE_RET_CODE **`HLSE_GetSupportedMechanisms`**(HLSE_MECHANISM_TYPE **mechanisms*, U16 **mechanismNum*)

Enumerates all the Cryptographic Mechanisms that are supported by the library. A list of mechanisms is returned in `mechanisms`.

If `mechanisms` is NULL, then all that the function does is return (in `*mechanismNum`) the number of HLSE_MECHANISM_TYPE which would suffice to hold the returned list. HLSE_SW_OK is returned by the function.

If `mechanisms` is not NULL, then `*mechanismNum` must contain the number of mechanisms in the buffer `mechanisms`. If that buffer is large enough to hold number of mechanisms to be returned, then the mechanisms are copied to `mechanisms`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*mechanismNum` is set to hold the exact number of mechanisms to be returned.

Parameters

- `[inout] mechanisms`: IN: caller passes a buffer of at least *mechanismNum; OUT: contains the mechanisms supported
- `[inout] mechanismNum`: IN: number of mechanisms in mechanisms; OUT: set to hold the exact number of mechanisms

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_BUF_TOO_SMALL`: Buffer is too small to return the mechanisms
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_GetSupportedMechanismsForObject`**(HLSE_OBJECT_HANDLE *hObject*, HLSE_MECHANISM_TYPE **mechanism*, U16 **mechanismLen*)

Enumerates all the Cryptographic Mechanisms that are supported by the Object. A list of mechanisms is returned in `mechanisms`.

If `mechanism` is NULL, then all that the function does is return (in `*mechanismLen`) the number of HLSE_MECHANISM_TYPE which would suffice to hold the returned list. HLSE_SW_OK is returned by the function.

If `mechanism` is not NULL, then `*mechanismLen` must contain the number of mechanisms in the buffer `mechanisms`. If that buffer is large enough to hold number of mechanisms to be returned, then the mechanisms are copied to `mechanisms`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*mechanismLen` is set to hold the exact number of mechanisms to be returned.

Parameters

- `[in] hObject`: The handle of the Object that the Mechanisms it supports should be returned
- `[inout] mechanism`: IN: caller passes a buffer of at least *mechanismNum; OUT: contains the mechanisms supported
- `[inout] mechanismLen`: IN: number of mechanisms in mechanisms. OUT: set to hold the exact number of mechanisms

Return Value

- `HLSE_SW_OK`: Successfull execution
- `HLSE_ERR_BUF_TOO_SMALL`: Buffer is too small to return the mechanisms
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_Digest`** (HLSE_MECHANISM_INFO **pMechanismType*, U8 **inData*, U16 *inDataLen*, U8 **outDigest*, U16 **outDigestLen*)

Calculates the Digest (e.g. Sha256) value of the data provided as input.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter.

If additional information is required by the specific digest mechanism, is will be conveyed in `pMechanismType->pParameter`.

If `outDigest` is NULL, then all that the function does is return (in `*outDigestLen`) a number of bytes which would suffice to hold the digest value. HLSE_SW_OK is returned by the function.

If `outDigest` is not NULL, then `*outDigestLen` must contain the number of bytes in the buffer `outDigest`. If that buffer is large enough to hold the digest value be returned, then the data is copied to `outDigest`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*outDigestLen` is set to hold the exact number of bytes to be returned.

Parameters

- `[in] pMechanismType`: The Digest Cryptographic Mechanism to be used
- `[in] inData`: Data buffer for which the digest must be calculated
- `[in] inDataLen`: The length of data passed as argument
- `[inout] outDigest`: IN: caller passes a buffer to hold the digest value; OUT: contains the calculated digest
- `[inout] outDigestLen`: IN: length of the `outDigest` buffer passed; OUT: the number of bytes returned in `outDigest`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_BUF_TOO_SMALL`: `outDigest` is too small to return the digest
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_Sign`** (HLSE_MECHANISM_INFO **pMechanismType*, HLSE_OBJECT_HANDLE *hObject*, U8 **inData*, U16 *inDataLen*, U8 **outSignature*, U16 **outSignatureLen*)

Signs the data provided using the Object key and the requested mechanism.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter. A handle to the key to sign the data with is provided by `hObject`.

If additional information is required by the specific signing mechanism, is will be conveyed in `pMechanismType->pParameter`.

If `outSignature` is NULL, then all that the function does is return (in `*outSignatureLen`) a number of bytes which would suffice to hold the signature. HLSE_SW_OK is returned by the function.

If `outSignature` is not NULL, then `*outSignatureLen` must contain the number of bytes in the buffer `outSignature`. If that buffer is large enough to hold the signature be returned, then the data is copied to `outSignature`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*outSignatureLen` is set to hold the exact number of bytes to be returned.

Parameters

- `[in] pMechanismType`: The signing Cryptographic Mechanism to be used

- `[in] hObject`: The handle of the Object key to sign with
- `[in] inData`: Data buffer for that should be signed (e.g. a digest)
- `[in] inDataLen`: The length of data passed as argument
- `[inout] outSignature`: IN: caller passes a buffer to hold the signature; OUT: contains the calculated signature
- `[inout] outSignatureLen`: IN: length of the `outSignature` buffer passed; OUT: the number of bytes returned in `outSignature`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_BUF_TOO_SMALL`: `outSignature` is too small to return the signature
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_VerifySignature`**(HLSE_MECHANISM_INFO **pMechanismType*, HLSE_OBJECT_HANDLE *hObject*, U8 **inData*, U16 *inDataLen*, U8 **inSignature*, U16 *inSignatureLen*)

Verifies whether `inSignature` is the signature of `inData` using the public key object referenced by `hObject` as the verifying public key.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter.

Parameters

- `[in] pMechanismType`: The signing Cryptographic Mechanism that was used
- `[in] hObject`: The handle of the Object public key to verify with
- `[in] inData`: The data that was signed (e.g. a digest)
- `[in] inDataLen`: The length of data passed as argument
- `[in] inSignature`: Pointer to the provided signature.
- `[in] inSignatureLen`: Length of the provided signature (`pSignature`)

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_GENERAL_ERROR`: if the verification fails

HLSE_RET_CODE **`HLSE_VerifySignatureWithExternalKey`**(HLSE_MECHANISM_INFO **pMechanismType*, U8 **inExtKey*, U16 *inExtKeyLen*, U8 **inData*, U16 *inDataLen*, U8 **inSignature*, U16 *inSignatureLen*)

Verifies whether `inSignature` is the signature of `inData` using an external public key object as the verifying public key.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter.

Parameters

- `[in] pMechanismType`: The signing Cryptographic Mechanism that was used
- `[in] inExtKey`: The value of the external public key to verify with
- `[in] inExtKeyLen`: The length in bytes of the external key
- `[in] inData`: The data that was signed (e.g. a digest)

- `[in] inDataLen`: The length of data passed as argument
- `[in] inSignature`: Pointer to the provided signature.
- `[in] inSignatureLen`: Length of the provided signature (`pSignature`)

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_GENERAL_ERROR`: if the verification fails

HLSE_RET_CODE **`HLSE_DeriveKey`** (HLSE_MECHANISM_INFO **pMechanismType*, HLSE_OBJECT_HANDLE *hObject*, U8 **outDerivedKey*, U16 **outDerivedKeyLen*)

Derives the key referenced by the `hObject` handle using the requested mechanism and return the derived key in `outDerivedKey`.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter.

If additional information is required by the specific signing mechanism, is will be conveyed in `pMechanismType->pParameter`.

If `outDerivedKey` is NULL, then all that the function does is return (in `*outDerivedKeyLen`) a number of bytes which would suffice to hold the derived key. HLSE_SW_OK is returned by the function.

If `outDerivedKey` is not NULL, then `*outDerivedKeyLen` must contain the number of bytes in the buffer `outDerivedKey`. If that buffer is large enough to hold the derived key, then the data is copied to `outDerivedKey`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*outDerivedKeyLen` is set to hold the exact number of bytes of the derived key.

Parameters

- `[in] pMechanismType`: The signing Cryptographic Mechanism to be used
- `[in] hObject`: The handle of the Object key to be derived
- `[inout] outDerivedKey`: IN: caller passes a buffer to hold the derived key; OUT: contains the derived key
- `[inout] outDerivedKeyLen`: IN: length of the `outDerivedKey` buffer passed; OUT: the number of bytes returned in `outDerivedKey`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_BUF_TOO_SMALL`: `outDerivedKey` is too small to return the derived key
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_Encrypt`** (HLSE_MECHANISM_INFO **pMechanismType*, HLSE_OBJECT_HANDLE *hObject*, U8 **inData*, U16 *inDataLen*, U8 **outData*, U16 **outDataLen*)

Encrypts the data provided using the Object key and the requested mechanism.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter. A handle to the key to encrypt the data with is provided by `hObject`.

If additional information is required by the specific encryption mechanism, is will be conveyed in `pMechanismType->pParameter`.

If `outData` is NULL, then all that the function does is return (in `*outDataLen`) a number of bytes which would suffice to hold the return value. HLSE_SW_OK is returned by the function.

If `outData` is not NULL, then `*outDataLen` must contain the number of bytes in the buffer `outData`. If that buffer is large enough to hold the data be returned, then the data is copied to `outData`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*outDataLen` is set to hold the exact number of bytes to be returned.

Parameters

- `[in] pMechanismType`: The encryption Cryptographic Mechanism to be used
- `[in] hObject`: The handle of the Object key to encrypt with
- `[in] inData`: Data buffer for that should be encrypted
- `[in] inDataLen`: The length of data passed as argument
- `[inout] outData`: IN: caller passes a buffer to hold the data to be returned; OUT: contains the encrypted data
- `[inout] outDataLen`: IN: length of the `outData` buffer passed; OUT: the number of bytes returned in `outData`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_BUF_TOO_SMALL`: `outData` is too small to return the data
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_Decrypt`**(HLSE_MECHANISM_INFO **pMechanismType*, HLSE_OBJECT_HANDLE *hObject*, U8 **inData*, U16 *inDataLen*, U8 **outData*, U16 **outDataLen*)

Decrypts the data provided using the Object key and the requested mechanism.

The Cryptographic Mechanism to be used is passed in the `type` member of the `pMechanismType` parameter. A handle to the key to decrypt the data with is provided by `hObject`.

If additional information is required by the specific decryption mechanism, is will be conveyed in `pMechanismType->pParameter`.

If `outData` is NULL, then all that the function does is return (in `*outDataLen`) a number of bytes which would suffice to hold the return value. HLSE_SW_OK is returned by the function.

If `outData` is not NULL, then `*outDataLen` must contain the number of bytes in the buffer `outData`. If that buffer is large enough to hold the data be returned, then the data is copied to `outData`, and HLSE_SW_OK is returned by the function. If the buffer is not large enough, then HLSE_ERR_BUF_TOO_SMALL is returned. In either case, `*outDataLen` is set to hold the exact number of bytes to be returned.

Parameters

- `[in] pMechanismType`: The decryption Cryptographic Mechanism to be used
- `[in] hObject`: The handle of the Object key to decrypt with
- `[in] inData`: Data buffer for that should be decrypted
- `[in] inDataLen`: The length of data passed as argument
- `[inout] outData`: IN: caller passes a buffer to hold the data to be returned; OUT: contains the decrypted data
- `[inout] outDataLen`: IN: length of the `outData` buffer passed; OUT: the number of bytes returned in `outData`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_BUF_TOO_SMALL`: `outData` is too small to return the data
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSEComm.h

Description Host Lib wrapper API: Communication and Secure Channel functions

Functions

HLSE_RET_CODE **`HLSE_Connect`** (HLSE_CONNECTION_PARAMS **params*, HLSE_COMMUNICATION_STATE **commState*)

Establishes the communication with the Secure Element accroding to the requested `type`. Additional parameters required for establishing the communication are passed in `params`.

The physical communication layer used (e.g. SCI2C) is determined at compilation time.

Parameters

- `[inout] params`: Additional parameters for opening the commuication
- `[inout] commState`: Points to a HLSE_COMMUNICATION_STATE which returns the communication state (e.g. ATR)

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_CloseConnection`** (HLSE_CLOSE_CONNECTION_MODE *mode*)

Closes the communication with the Secure Element.

Parameters

- `[in] mode`: Specific information that may be required on the link layer

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_ResumeConnection`** (HLSE_COMMUNICATION_STATE **commState*, HLSE_SECURE_CHANNEL_SESSION_STATE **smState*)

Resumes the communication with the Secure Element including the secure channel from the previously retrieved communication state and secure channel session state.

Parameters

- `[in] commState`: communication state
- `[in] smState`: secure channel session state

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_SendAPDU`** (U8 **cmd*, U16 *cmdLen*, U8 **resp*, U16 **respLen*)

Sends the command APDU to the Secure Element and retrieves the response APDU. The latter consists of the concatenation of the response data (possibly none) and the status word (2 bytes).

The command APDU and response APDU are not interpreted by the host library.

The command/response APDU sizes must lay within the APDU size limitations

Parameters

- `[in] cmd`: command APDU
- `[in] cmdLen`: length (in byte) of `cmd`
- `[inout] resp`: response APDU (response data || response status word)
- `[inout] respLen`: IN: Length of resp buffer (`resp`) provided; OUT: effective length of response retrieved.

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_SCP_Subscribe`** (HLSE_SCP_SignalFunction *callback*, void **context*)

Subscribe a HLSE_SCP_SignalFunction function to receive messages from the Secure Channel.

Parameters

- `[in] callback`: The function
- `[in] context`: Optional context information that the function is subsrcibed with and called with

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_SMChannelAuthenticate`** (HLSE_SECURE_CHANNEL_ESTABLISH_PARAMS **params*, HLSE_SECURE_CHANNEL_STATE **channelState*)

Establishes a Secure Channel with the Secure Element, and when successful initializes the current Session Channel state.

Parameters

- `[in] params`: Data required to establish the Secure Channel
- `[inout] channelState`: Returns the Secure Channel state

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_SMChannelGetScpSessionState`** (HLSE_SECURE_CHANNEL_SESSION_STATE **channelSessionState*)

Retrieve the Secure Channel Session state from the Host Library.

Parameters

- `[inout] channelSessionState`: IN: pointer to allocated structure; OUT: contains the session state

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_SMChannelSetScpSessionState`** (HLSE_SECURE_CHANNEL_SESSION_STATE **channelSessionState*)

Sets the Secure Channel Session state of the Host Library. Can be used in a scenario where e.g. the bootloader has established the Secure Channel link between host and secure element and the Host OS must re-establish the communication with the secure element without breaking the session.

Parameters

- `[in] channelSessionState`: Contains the session state information

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSEMisc.h

Description Host Lib wrapper API: Miscellaneous functions

Functions

HLSE_RET_CODE **`HLSE_DisablePlainInjectionMode`** (void)

Permanently disables the Plain Injection mode

Return Value

- `HLSE_SW_OK`: Upon successful execution

HLSE_RET_CODE **`HLSE_ResetContents`** (void)

Clears all user data.

Return Value

- `HLSE_SW_OK`: Upon successful execution

HLSE_RET_CODE **`HLSE_DbgDisableDebug`** (void)

Permanently disables the Debug API.

Return Value

- `HLSE_SW_OK`: Upon successful execution

HLSE_RET_CODE **`HLSE_DbgReflect`** (U8 **inData*, U16 *inDataLen*, U8 **outData*, U16 **outDataLen*)

Invokes data reflection APDU (facilitates link testing). No check of data payload returned

Parameters

- `[in] inData`: The data to be sent to the Secure Element
- `[in] inDataLen`: The length of `inData`
- `[inout] outData`: IN: caller passes a buffer to hold the data to be returned; OUT: contains the retruend data

- `[inout] outDataLen`: IN: length of the `outData` buffer passed; OUT: the number of bytes returned in `outData`

Return Value

- `HLSE_SW_OK`: Upon successful execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

HLSE_RET_CODE **`HLSE_DbgReset`** (void)

Resets the Secure Module to the initial state.

Return Value

- `HLSE_SW_OK`: Upon successful execution

HLSE_RET_CODE **`HLSE_NormalizeECCSignature`** (U8 **signature*, U16 *signatureLen*, U8 **normalizedSignature*, U16 **normalizedSignatureLen*)

The purpose of this function is to turn the proprietary ECDSA signature format - that may be returned by the applet - into a normalized ASN.1 format.

Parameters

- `[in] signature`: buffer containing the ECDSA signature in the applet specific format; OUT: Signature compliant to ASN.1
- `[in] signatureLen`: length of ECDSA signature length
- `[inout] normalizedSignature`: IN: caller passes a buffer to hold the data to be returned; OUT: contains the retruend data
- `[inout] normalizedSignatureLen`: IN: length of the `outData` buffer passed; OUT: the number of bytes returned in `outData`

Return Value

- `HLSE_SW_OK`: upon successfull execution
- `HLSE_ERR_API_ERROR`: Invalid function arguments

10.5 A71CH Legacy Configure Tool

10.5.1 Introduction

The A71CH Configure Tool is a command line tool that supports the insertion of credentials into the A71CH. It can also report on the value and status of the stored credentials and on the status of the device. The tool is provided in source code (`.../hostlib/a71ch/app`) and can be deployed in one of the following configurations:

- Installed on a development PC communicating over TCP/IP with the embedded target
- Standalone on an embedded target

In *Tool deployment* we go into more detail on this.

Simply invoking the tool in standalone mode on an MCIMX6UL-EVKB board results in the following output (some output edited away):

```
root@imx6ulevk:~# ./a71chConfig_i2c_imx
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
...
```

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```
Applet-Rev:SecureBox-Rev    : 0x0131:0x0000
****************************
Usage: a71chConfig␣
↪[apdu|debug|erase|gen|info|interactive|lock|rcrt|scp|set|wcrt|help] <OptArg>
    apdu -cmd <hexval> -sw <hexval>
    debug [permanently_disable_debug|reset]
    ecrt -x <int>
    erase [cnt|pair|pub|sym] -x <int>
    gen pair -x <int>
    get pub -c <hex_value> -x <int> -k <keyfile.pem>
    info [all|cnt|device|objects|pair|pub|status]
    info gp -h <hexvalue_offset> -n <segments>
    interactive
    lock [pair|pub] -x <int>
    lock gp -h <hexvalue_offset> -n <segments>
    lock inject_plain
    obj erase -x <int>
    obj get -x <int> [-h <hexvalue_offset>] [-s <hexvalue_size>] [-f <data.txt> -t␣
↪[hex_16|hex_32]]
    obj update -x <int> -h <hexvalue_offset> [-f <data.txt> -t [hex_16|hex_32] | -h
↪<hexvalue_data>]
    obj write -x <int> [-f <data.txt> -t [hex_16|hex_32] | -h <hexvalue_data> | -n
↪<segments>]
    rcrt -x <int> [-c <certfile.crt>]
    refpem -c <hex_value> -x <int> [-k <keyfile.pem>] -r <ref_keyfile.pem>
    script -f <script.txt>
    scp [put|auth] -h <hexvalue_keyversion> -k <keyfile>
    set gp -h <hexvalue_offset> -h <hexvalue_data>
    set pair -x <int> [-k <keyfile.pem> | -h <hexvalue_pub> -h <hexvalue_priv>] [-w
↪<hexvalue_wrap_key>]
    set pub  -x <int> [-k <keyfile.pem> | -h <hexvalue>] [-w <hexvalue_wrap_key>]
    set [cfg|cnt|sym]  -x <int> -h <hexvalue> [-w <hexvalue_wrap_key>]
    transport [lock|unlock -h <hexvalue_tpkey>]
    ucrt -x <int> [-c <certfile.crt> | -h <hexvalue_data> | -p <certfile.pem>]
    wcrt -x <int> [-c <certfile.crt> | -h <hexvalue_data> | -p <certfile.pem>] [-n
↪<padding-segments>]
****************************
```

The tool provides an overview of the available command line options. We'll go into more detail on the syntax in *Command reference*.

The easiest way to get familiar with the A71CH configure tool is to open it in interactive mode. Be sure to connect to an A71CH with the Debug Mode still available so you can easily revert to the initial state of the component. The following captures a session with a brand new A71CH with the Debug Mode active:

```
root@imx6ulevk:~/axHostSw/linux# ./a71chConfig_i2c_imx interactive
a71chConfig (Rev 1.00) .. connect to A71CH. Chunksize at link layer = 256.
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
SCI2C_ATR=0xB8.03.11.01.05.B9.02.01.01.BA.01.01.BB.0C.41.37.30.30.35.43.47.32.34.32.
↪52.31.BC.00.
HostLib Version              : 0x0130
Applet-Rev:SecureBox-Rev    : 0x0131:0x0000
>>> info device
A71CH in Debug Mode Version (SCP03 is not set up)
```

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```
selectResponse:   0x0131
transportLockState: 0x03 (Transport Lock NOT YET set)
injectLockState:    0x02 (Unlocked)
gpStorageSize:      4096
uid (LEN=18):
47:90:51:68:47:91:12:10:23:41:00:53:66:96:47:51:48:12
>>> info pair
Public Keys from ECC key pairs:
    idx=0x00 n.a.
    idx=0x01 n.a.
    idx=0x02 n.a.
    idx=0x03 n.a.
>>> gen pair -x 0
>>> info pair
Public Keys from ECC key pairs:
    idx=0x00 ECC_PUB (LEN=65):
04:0A:81:86:1D:0C:E6:F6:E4:57:65:8B:51:92:E9:D1:CB:AF:96:12:C6:71:FB:79:F1:3D:C9:64:4D:56:CC:87:
2E:8C:32:9B:0A:F8:BB:4B:79:56:7D:F0:9D:C2:D2:B8:96:E0:04:B7:D9:50:F5:EC:C2:50:99:25:6B:5B:4B:E1:
3B
    idx=0x01 n.a.
    idx=0x02 n.a.
    idx=0x03 n.a.
>>> quit
root@imx6ulevk:~/axHostSw/linux#
```

10.5.2 Usage modes

The A71CH Configure Tool can be used in:

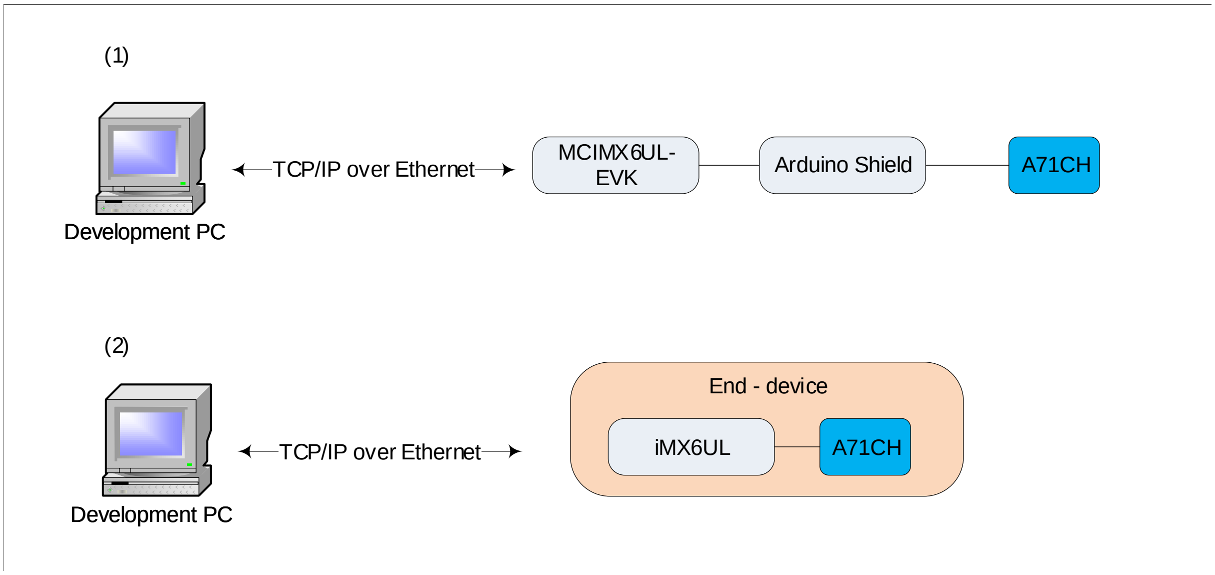
- Interactive mode. The tool opens a communication session with the A71CH, the user can issue configure commands in this session. The syntax to be used is identical to the syntax used in the command line mode.
- Command line mode: passing parameters as command line arguments. Each invocation of the tool establishes a new communication session between Host and A71CH.
- Batch file mode: this is a special variant of the command line mode where multiple configure commands are bundled in a file that is passed as a command line argument. All commands contained in the file are handled in the same communication session between Host and A71CH.

Note: On POSIX platforms like LINUX or Cygwin the interactive mode supports simple command line completion and command history (navigateable with the up and down arrows). It also stores a list of executed commands in a file called ‘a71chConfigCmdHistory.txt’.

10.5.3 Tool deployment

HW Setup for iMX

The HW setup, when using the Configure tool is illustrated the following figure. In case (1) the A71CH has not been integrated into an end-device yet. In case (2) the A71CH is already integrated into the end-device (e.g. an IoT Appliance)

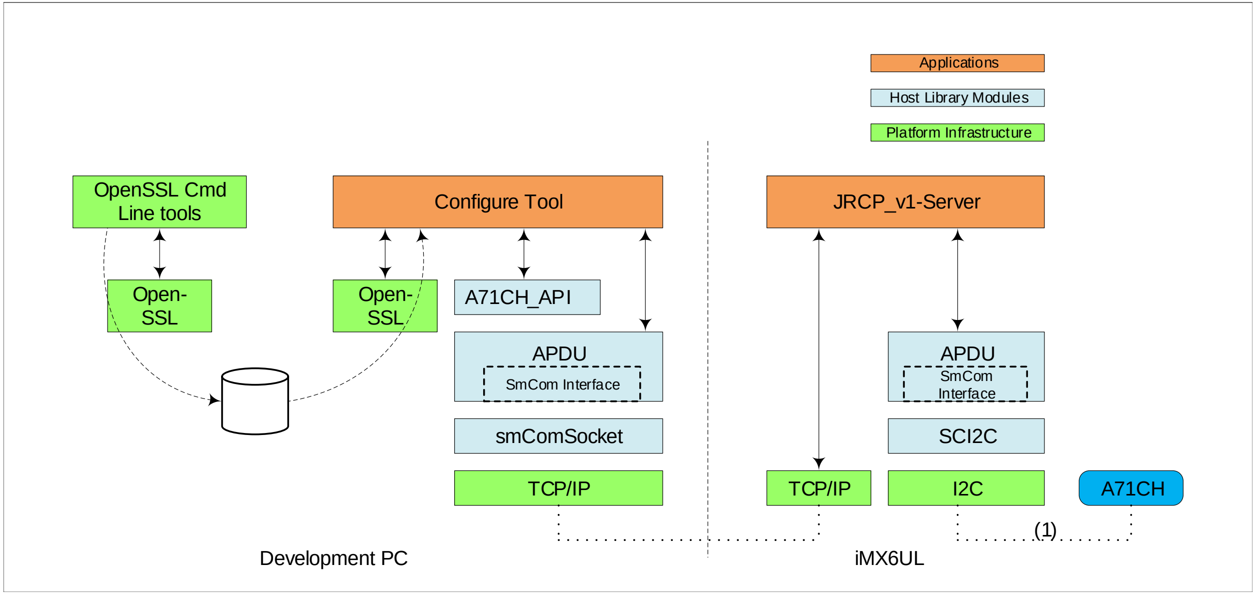


HW Setup for Kinetis

For running the configure tool with a Kinetis system, USB-VCOM Interface to PC is used. In this combination the VCOM Application needs to be running on kinetis. For more information, see *SW layers and communication for Kinetis*.

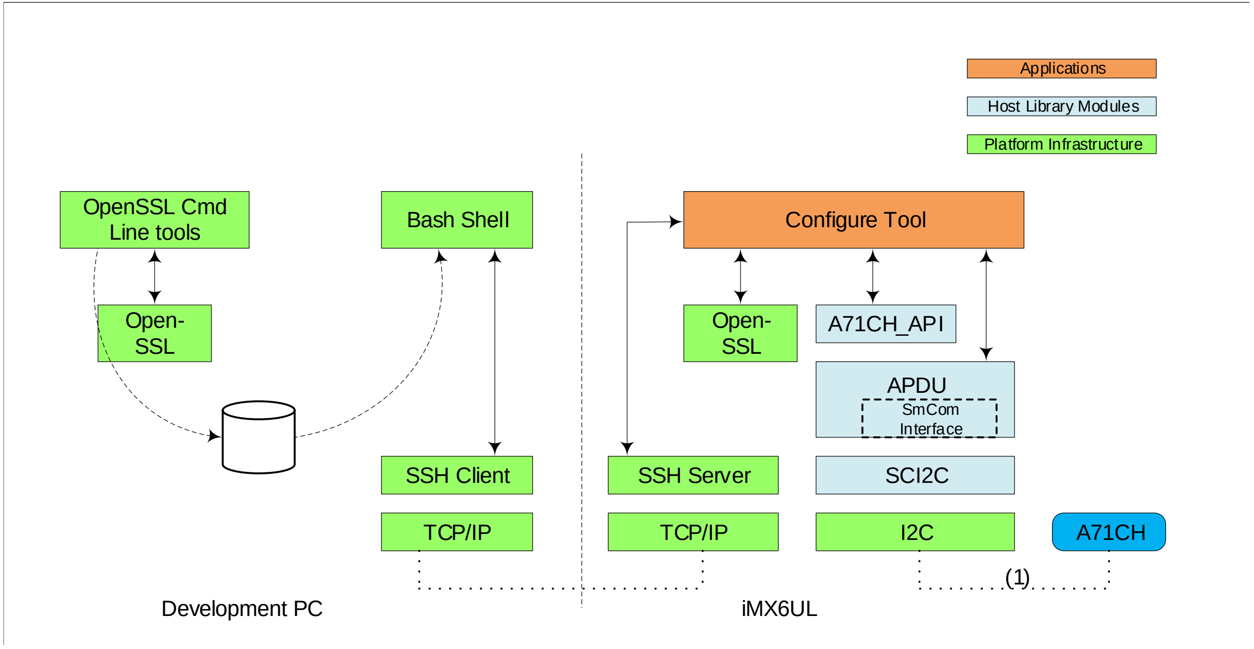
SW layers and communication for iMX

In case the Configure Tool is installed on a development PC, the iMX6UL must run an RJCT-server process that will deal with the unpacking of the incoming commands and the communication over SCI2C with the A71CH.



Note: Refer to *JRCP_v1 Server* for more information on the RJCT server.

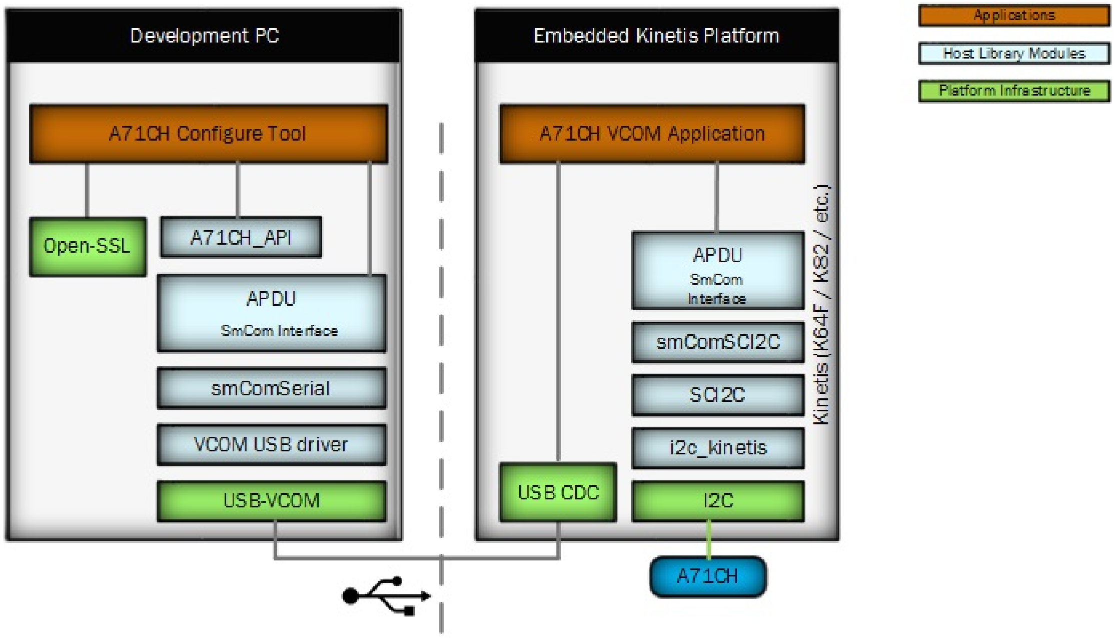
In case the Configure Tool is installed on the embedded target, a development PC will typically be used to run a console that provides access via SSH to the embedded target.



SW layers and communication for Kinetis

For Kinetis based embedded systems, the configuration tool can only be run from the PC. Also, the configuration tool is only compiled with OpenSSL (not with mbedTLS). VCOM needs to be running on the Kinetis platform and the communication between HostPC and Kinetis happens over USB VCOM.

The Kinetis platform will that care of SCI2C protocol communication with the A71CH.



10.5.4 Command reference

Overall introduction

A command has the following general structure: a mandatory command name `<cmd-n>` is followed by an optional command qualifier `<cmd-q>`, followed by '0 to n' (option, value) pairs.

```
<cmd-n> [<cmd-q>] [-option <option-value>]*
```

The command names `<cmd-n>` are further listed and explained in detail in the remainder of this section.

```
<cmd-n> = {apdu, debug, erase, gen, info, ...}
```

Legal values for command qualifiers `<cmd-q>` depend on the actual command name `<cmd-n>`.

```
<cmd-q> = {cnt, gp, pair, pub, sym, ...}
    cfg = configure key
    cnt = monotonic counter
    gp = general purpose data
    pair = ECC key pair
    pub = ECC public key
    sym = Symmetric secret

<cmd-q> = {permanently_disable_debug, reset, all, ...}
```

Legal (option, value) pairs again depend on the preceding `<cmd-n>` or `<cmd-n> <cmd-q>`. The order of the (option, value) pairs after the `<cmd-n>` or `<cmd-n> <cmd-q>` needs to be strictly respected. The type of the value, can be any of the following

```
<hexvalue> = [0-9A-F][0-9A-F]([0-9A-F][0-9A-F])*
    examples of legal hexvalue's are
        0A0B0C0D
        00112233445566778899AABBCCDDEEFF
    the following hexvalue's are not allowed
        0x0A0B0C0D # leading '0x' decorator is not supported
        0A1        # odd number of ascii characters is not supported

<int> = integer (currently only positive integers are supported)

<filename> = further explained with the individual commands
```

apdu

```
apdu -cmd <hexvalue> -sw <hexvalue>
```

The `apdu` command allows to exchange an APDU (in 'raw' format) between the Host and the A71CH. It's mandatory to specify the expected status word that will be returned by the A71CH, if the actual returned status word is different this will be flagged as an execution error.

Note: This low level command can be used to extend the functionality of the Config Tool. In order to use this command one needs to consult the A71CH APDU specification. This command is not required for normal provisioning use cases.

In the following example the host requests the A71CH the SHA256 value of “F0F1F2F3”. The APDU command and response are printed on the console. The last two byte contained in the response

```
>>> apdu -cmd 8096000004F0F1F2F300 -sw 9000
cmd (LEN=10):
8096000004F0F1F2F300
rsp (LEN=34):
FEA4CE6719F1FDB6D2E30CFB86C2E797DBD4A3247FF2B0EFC15A814C5B25C75E9000
```

connect

```
connect [close|open]
```

The `connect` command allows to close or re-open the connection with an attached secure element. This command can be used in an interactive workflow where several instance of an A71CH are being configured. Before detaching a configured A71CH one calls `connect close`; after attaching another A71CH one calls `connect open`.

In the following example a connection is opened.

```
>>> connect open
I2CInit: opening /dev/i2c-1
I2C driver: PEC flag cleared
I2C driver supports plain i2c-level commands.
I2C driver supports Read Block.
```

debug

```
debug [permanently_disable_debug|reset]
```

The `debug` command can be used to permanently switch of the Debug Mode of the A71CH (the Debug Mode of the A71CH is a convience mode that can be used during product development). It can also be used - assuming the Debug Mode is still on - to bring the A71CH back to its initial state.

Note: Issuing a debug reset also erases all stored credentials.

In the following example a debug reset is issued.

```
>>> debug reset
```

ecrt

The `ecrt` command erases a certificate from the GP storage area by index.

```
ecrt -x <int>
```

Note: The valid index range for certificates is is limited only by memory size.

In the following `ecrt` example the certificate at index 3 is erased from the A71CH.

```
>>> ecrt -x 3
```

erase

The `erase` command erases (deletes the value) of the specified stored credential. A locked credential can not be erased. Erasing a monotonic counter value is only possible when the Debug Mode of the A71CH is available.

```
erase [cnt|pair|pub|sym] -x <int>
```

In the following example the ECC key pair stored on index 0 is erased.

```
erase pair -x 0
```

gen

The `gen` command makes the A71CH create a valid ECC key pair on the indicated index.

```
gen pair -x <int>
```

In the following example a new ECC keypair is created and stored on index 1

```
gen pair -x 1
```

get

The `get` command retrieves the public key value from either a public key or key pair at the index passed as argument and stores it - in pem format - in a file provided as argument.

Note: The parameter passed after the c option represents the key type and can be either 0x10 for public pair or 0x20 for public key.

```
get pub -c <hex_value> -x <int> -k <keyfile.pem>
```

In the following example the ECC public key stored at index 0 is stored to PEM file keyfile.pem

```
get pub -c 20 -x 0 -k keyfile.pem
```

info

The `info` command can be used to echo the value and/or status of the A71CH or its stored credentials to the console. Issuing an ‘info all’ will echo the same information as issuing ‘info device’, ‘info cnt’, ‘info pair’, ‘info pub’, ‘info gp -h 0000 -n <all>’ in sequence. The value of secret credentials like the private part of a keypair, a symmetric key or a configuration key can not be retrieved from the A71CH. The ‘info status’ command will report on the Initialized/Empty and Locked/Open status of all credentials. It’s possible to echo the value of consecutive 32 byte data segments from general purpose data storage by specifying the hexadecimal offset (specified with 4 hexadecimal digits) into the data store and the amount of segments to display.

```
info [all|device|cnt|pair|pub|sym|status]
info gp -h <hexvalue_offset> -n <segments>
```

In the following example the credential status is requested. The output corresponds to the status of a new device.

```
>>> info status
SCP03 is Not enabled
Key Pair status:
        Index=0: Empty Open
        Index=1: Empty Open
        Index=2: Empty Open
        Index=3: Empty Open
Public Key status:
        Index=0: Empty Open
        Index=1: Empty Open
        Index=2: Empty Open
Config Key status:
        Index=0: Empty Open
        Index=1: Empty Open
        Index=2: Empty Open
Sym Secret status:
        Index=0: Empty Open
        Index=1: Empty Open
        Index=2: Empty Open
        Index=3: Empty Open
Counter status:
        Index=0: Initialized Open
        Index=1: Initialized Open
Certificate Objects:
        0 Absolute offset = 0x00 Actual Size = 0x313
        1 Absolute offset = 0x320 Actual Size = 0x313
Data Objects:
    0 Absolute offset = 0x640 Actual Size = 0x09
    1 Absolute offset = 0x660 Actual Size = 0x09
General Purpose Storage status:
        Offset=0x0000: Open     Offset=0x0020: Open     Offset=0x0040: Open    ␣
↪Offset=0x0060: Open
        Offset=0x0080: Open     Offset=0x00A0: Open     Offset=0x00C0: Open    ␣
↪Offset=0x00E0: Open
        Offset=0x0100: Open     Offset=0x0120: Open     Offset=0x0140: Open    ␣
↪Offset=0x0160: Open
        Offset=0x0180: Open     Offset=0x01A0: Open     Offset=0x01C0: Open    ␣
↪Offset=0x01E0: Open
        Offset=0x0200: Open     Offset=0x0220: Open     Offset=0x0240: Open    ␣
↪Offset=0x0260: Open
        Offset=0x0280: Open     Offset=0x02A0: Open     Offset=0x02C0: Open    ␣
↪Offset=0x02E0: Open
        Offset=0x0300: Open     Offset=0x0320: Open     Offset=0x0340: Open    ␣
↪Offset=0x0360: Open
        Offset=0x0380: Open     Offset=0x03A0: Open     Offset=0x03C0: Open    ␣
↪Offset=0x03E0: Open
```

In the following example the contents from two 32 byte data segments is requested starting from general purpose storage offset 0x0010:

```
>>> info gp -h 0010 -n 2
GP Storage Data (2 segments from offset 0x0010):
        0x0010 (LEN=32):␣
↪0000000000000000000000000000000000000000000000000000000000000000
        0x0030 (LEN=32):␣
↪0000000000000000000000000000000000000000000000000000000000000000
```

interactive

Used to start the interactive mode from the command line

lock

The `lock` commands allows to lock individual credentials (ECC public keys and ECC key pairs). It allows to lock data segments of 32 byte in general purpose storage (on offsets that are multiples of 0x0020). It's also possible to forbid the injection of unwrapped ECC public keys, ECC key pairs and symmetric secrets at the device level.

```
lock [pair|pub] -x <int>
lock gp -h <hexvalue_offset> -n <segments>
lock inject_plain
```

The following example locks the ECC key pair at index 0

```
>>> lock pair -x 0
```

The following example locks 2 data segments of 32 byte in general purpose data storage starting from offset 0x0060

```
>>> lock gp -h 0060 -n 2
```

obj erase

The `obj erase` command erases the object at the provided index.

```
obj erase -x <int>
```

Note: Upon erasing an object it cannot be reconstructed.

In the following `obj erase` example the object at index 0 is erased.

```
>>> obj erase -x 0
```

obj get

The `obj get` command gets the value of a data object, it retrieves the data from a specific offset within the data object (fetching the specified amount of byte). Optionally, the data is written to file. The type file could be 16 or 32 bytes at a line. If no type is specified the default would be 32 bytes.

```
obj get -x <int> [-h <hexvalue_offset>] [-s <hexvalue_size>] [-f <data.txt> -t [hex_
↪16|hex_32]]
```

Note: The offset is relative to the start location of the object and must be specified as a 4 digit hexadecimal value.

In the following `obj get` example the value of the object at index 0 is read out.

```
>>> obj get -x 0 -h 0000 -s 0009
>>> 112233445566778899
```

obj update

The `obj update` command updates the value of a data object. It updates the data relative to an internal offset passed as a parameter. The data can be passed on the command line or be contained in a file.

```
obj update -x <int> -h <hexvalue_offset> [-f <data.txt> -t [hex_16|hex_32] | -h
↪<hexvalue_data>]
```

Note: The data in the file must be binary and not textual. An object must already exist at the specified index. If data is read from file it can be set with lines in length of 16 or 32 bytes (i.e. hex_16 or hex_32). The default value is lines of 32 bytes.

In the following `obj update` example the value of the object at index 0 is updated.

```
>>> obj update -x 0 -h 0000 -h 998877665544332211
```

obj write

The `obj write` command creates an object. The value of the object to be created can be passed on the command line or contained in a file. When using the `-n` option the requested segments will be reserved for the data object and filled with zeros. If data is read from file it can be set with lines in length of 16 or 32 bytes (i.e. hex_16 or hex_32). The default value is lines of 32 bytes.

```
obj write -x <int> [-f <data.txt> -t [hex_16|hex_32] | -h <hexvalue_data> | -n
↪<segments>]
```

In the following `obj write` example an zero filled object is created at index 0 with a size of 5 segments.

```
>>> obj write -x 0 -n 5
```

rcrt

The `rcrt` command reads a certificate from the GP storage area by index. Optionally, the command can save the certificate read to a CRT file.

```
rcrt -x <int> [-c <certfile.crt>]
```

Note: The certificate data will be presented whether it was written to a file or not. The valid index range for certificates is is limited only by memory size.

In the following `rcrt` example the certificate at index 3 is read from the A71CH, upon success it is also written to a CRT file.

```
>>> rcrt -x 3 -c certificate.crt
CER_DATA (LEN=520):
30820204308201A9020900CFD5820FFEC40937300A06082A8648CE3D04030230
8189310B30090603550406130242453116301406035504080C0D566C61616D73
42726162616E74310F300D06035504070C064C657576656E3111300F06035504
0A0C084E58502D44656D6F31163014060355040B0C0D4E58502D44656D6F2D55
6E6974310D300B06035504030C0464656D6F3117301506092A864886F70D0109
```

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```
01160864656D6F406E7870301E170D3135313230373130353132395A170D3136
313230363130353132395A308188310B30090603550406130242453116301406
035504080C0D566C61616D7342726162616E74310F300D06035504070C064C65
7576656E310E300C060355040A0C05697063616D31123010060355040B0C0969
7063616D556E69743112301006035504030C09697063616D44656D6F31183016
06092A864886F70D0109011609697063616D406E78703059301306072A8648CE
3D020106082A8648CE3D03010703420004DB4CDB6C5A96C1615895095222AA0E
A3BC6F9E714D6438F0B120D691F18D7E7410EE04BE71D33A2D8B2D3B66F7174A
9654536965AFD2ABADB55269C6A6C0085E300A06082A8648CE3D040302034900
304602210083AA91AE33396825D560390952AEE91C64814C7CA681BA50589558
D681F974270221009BA1CF31A823B96C391E3C4F839666AECE9949639D796B24
A5B987A92E6F1CFA
```

refpem

Note: The reference keys created by the `refpem` command are **only** compatible with the A71CH OpenSSL Engine based upon the A71CH Legacy API. The A71CH OpenSSL Engine based upon the SSS API use a different reference key format, these keys must be created with the `ssscli` tool.

The `refpem` command allows to create A71CH OpenSSL Engine specific reference pem files. It can be used in a mode that fetches the public key value from the attached A71CH:

```
refpem -c <hex_value> -x <int> -r <ref_keyfile.pem>
```

Or it can be used in a ‘not-connected’ mode that fetches the public key value from a pem file (containing an EC key pair) supplied as an argument.

```
refpem -c <hex_value> -x <int> -k <keyfile.pem> -r <ref_keyfile.pem>
```

The value following the `-c` switch must be either 10 (create a reference to a key pair) or 20 (create a reference to a public key). The value following the `-x` switch is the storage index of either key pair or public key.

The following command creates a reference pem file ‘my_ref_keyfile.pem’ referring to a keypair stored at index 1.

```
refpem -c 10 -x 1 -r my_ref_keyfile.pem
```

script

The `script` command can be used to issue the Configure tool commands contained in a file.

```
script -f <script.txt>
```

An example of script file (script_example.txt)

```
root@imx6ulevk:~# cat script_example.txt
# Simple example script
info pair
gen pair -x 0
info pair       # This will illustrate a key pair was created
```

The following example issues the commands contained in the script file above (script_example.txt)

```
>>> script -f script_example.txt
>> # Simple example script

>> info pair

Public Keys from ECC key pairs:
        idx=0x00 n.a.
        idx=0x01 n.a.
>> gen pair -x 0

>> info pair       # This will illustrate a key pair was created

Public Keys from ECC key pairs:
        idx=0x00 ECC_PUB (LEN=65):
04:A4:B3:3B:A3:D4:23:BD:19:C3:CB:20:DB:6F:D3:80:46:73:06:56:2F:83:B2:B1:AE:86:9A:EF:E9:7A:62:A3:
04:E7:C1:42:31:97:D5:19:5A:80:27:74:DC:20:EC:B7:93:9B:E5:C1:22:22:6B:E3:49:A4:FB:3A:5C:26:08:85:
B5
        idx=0x01 n.a.
```

scp

The `scp` command can be used to write a set of SCP03 keys to the A71CH (‘scp put . . . ’) or to establish an active SCP03 channel between Host and A71CH (‘scp auth . . . ’). The ‘scp clear_host’ command will force the Host to issue commands in the clear again.

```
scp [put|auth] -h <hexvalue_keyversion> -k <keyfile>
scp clear_host
```

An example of a keyfile containing a set of SCP03 keys:

```
root@imx6ulevk:~# cat scp_keyfile_example.txt
# This is a comment, empty lines and comment lines allowed.
ENC AA112233445566778899AABBCCDDEEFF # Trailing comment
MAC BB112233445566778899AABBCCDDEEFF # Optional trailing comment
DEK CC112233445566778899AABBCCDDEEFF # Optional trailing comment
```

set

The `set` command can be used to set a credential stored on the A71CH to a specific value.

Note: The `set gp` command can only be used to set a maximum of 32 byte of data at a time.

The value of a key pair or public key can either be passed as command line parameters or be contained in a pem-file (containing an EC key pair).

The command line value of the private key (set by the `set pair` command) can be either in the clear or wrapped with the Configuration key stored at index 1. Wrapping is according to RFC3394.

The command line value of the public key (set by the `set pub` command) can be either in the clear or wrapped with the Configuration key stored at index 2. In case RFC3394 wrapping is applied the first byte of the public key (the one indicating the public key format) is removed before applying wrapping.

The value of the configure key, the monotonic counter or the symmetric secret can only be passed explicitly as a command line parameter. The configure and symmetric keys can also be set wrapped (with the stored value of the key) according to RFC3394.

Whether an argument is wrapped is implicit in the lenght of the provided argument.

```
set gp -h <hexvalue_offset> -h <hexvalue_data>
set pair -x <int> [-k <keyfile.pem> | -h <hexvalue_pub> -h <hexvalue_priv>]
set pub  -x <int> [-k <keyfile.pem> | -h <hexvalue>]
set [cfg|cnt|sym]  -x <int> -h <hexvalue>
```

The following example writes 5 byte of data at offset 0004 into the General Purpose data store. The data written (4137314348) is the equivalent of the ASCII encoding of the string ‘A71CH’. The command itself is preceded and followed by an info statement covering the general purpose storage segment of interest.

```
>>> info gp -h 0000 -n 1
GP Storage Data (1 segments from offset 0x0000):
        0x0000 (LEN=32):␣
↪0000000000000000000000000000000000000000000000000000000000000000
>>> set gp -h 0004 -h 4137314348
>>> info gp -h 0000 -n 1
GP Storage Data (1 segments from offset 0x0000):
        0x0000 (LEN=32):␣
↪0000000041373143480000000000000000000000000000000000000000000000
```

The following example set the key pair at index 1 from the value contained in file keyfile_ecc_nist_256_1.pem. The command itself is preceded and followed by an info statement on the stored key pairs.

```
>>> info pair
Public Keys from ECC key pairs:
        idx=0x00 n.a.
        idx=0x01 n.a.
>>> set pair -x 1 -k keyfile_ecc_nist_256_1.pem
ECCPrivateKey (LEN=32):
21:AF:C1:1E:F5:64:61:3D:2E:96:4D:8B:93:19:CC:AB:38:E0:7A:6E:35:3A:21:A3:D1:69:8B:19:13:DF:1D:FF

ECCPublicKey (LEN=65):
04:74:E2:1E:54:6C:C1:9E:31:58:55:B6:D5:45:D3:0D:3F:48:79:D4:64:5D:3F:67:73:75:FB:0B:2C:80:43:1E:
8D:34:95:71:0E:71:E1:E3:F8:93:62:75:B4:AC:F1:52:E3:DE:55:CC:1D:86:5E:B0:D1:22:A8:CF:35:EC:47:31:
F8
>>> info pair
Public Keys from ECC key pairs:
        idx=0x00 n.a.
        idx=0x01 ECC_PUB (LEN=65):
04:74:E2:1E:54:6C:C1:9E:31:58:55:B6:D5:45:D3:0D:3F:48:79:D4:64:5D:3F:67:73:75:FB:0B:2C:80:43:1E:
8D:34:95:71:0E:71:E1:E3:F8:93:62:75:B4:AC:F1:52:E3:DE:55:CC:1D:86:5E:B0:D1:22:A8:CF:35:EC:47:31:
F8

The value contained in file keyfile\_ecc\_nist\_256\_1.pem is
```

```
$ cat keyfile_ecc_nist_256_1.pem
-----BEGIN EC PRIVATE KEY-----
MHcCAQEEICGvwR71ZGE9LpZNi5MZzKs44HpuNToho9FpixkT3x3/oAoGCCqGSM49
AwEHoUQDQgAEdOIeVGzBnjFYVbbVRdMNP0h51GRdP2dzdfsLLIBDHo00lXEOceHj
+JNidbSs8VLj3lXMHYZesNEiqM817Ecx+A==
-----END EC PRIVATE KEY-----
```

The following example sets the public key at index 0 to the provided public key value (in the clear, ANSI X9.62 uncompressed format). The command itself is preceded and followed by an info statement on the stored public key.

```
>>> info pub
Public Keys:
        idx=0x00 n.a.
        idx=0x01 n.a.
>>> set pub -x 0 -h␣
↪043802B1164C30860AC913F5F997B84158C40CFFCC1D3A4359BC22574A4FC95E628933A9E95820AD6B96A1DA106BDD5D6A
>>> info pub
Public Keys:
        idx=0x00 ECC_PUB (LEN=65):
04:38:02:B1:16:4C:30:86:0A:C9:13:F5:F9:97:B8:41:58:C4:0C:FF:CC:1D:3A:43:59:BC:22:57:4A:4F:C9:5E:
62:89:33:A9:E9:58:20:AD:6B:96:A1:DA:10:6B:DD:5D:6A:8E:55:6A:78:AE:95:9C:59:33:6F:E5:3E:3A:1D:9E:
D4
        idx=0x01 n.a.
```

The following example sets the monotonic counter at index 0 to 00E0. The command itself is preceded and followed by an info statement on the stored monotonic counters.

```
>>> info cnt
Monotonic counter values:
        idx=0x00 0x00000000
        idx=0x01 0x00000000
>>> set cnt -x 0 -h 000000E0
>>> info cnt
Monotonic counter values:
        idx=0x00 0x000000E0
        idx=0x01 0x00000000
```

transport

The `transport lock` command can be used to enable the transport lock on the A71CH. To disable the transport lock one needs to pass the transport key as an option value to the `transport unlock` command.

Note: A precondition to enable the transport lock is that the Transport Configuration key has been set: use 'set cfg -x 0 -h <hexvalue_tpkey>' to achieve this. Furthermore the transport lock / unlock cycle can only be initiated once.

```
transport [lock|unlock -h <hexvalue_tpkey>]
```

The following example sets the Transport Configuration key, locks the device and finally unlocks the device. The `info device` command is used to illustrate the value of the transportLockState of the device.

```
>>> info device
...
transportLockState: 0x03 (Transport Lock NOT YET set)
...
>>> set cfg -x 0 -h AA112233445566778899AABBCCDDEEFF
>>> transport lock
>>> info device
...
transportLockState: 0x01 (Transport Lock is set)
...
>>> transport unlock -h AA112233445566778899AABBCCDDEEFF
>>> info device
A71CH in Debug Mode Version (SCP03 is not set up)
selectResponse:   0x0111
```

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```
transportLockState: 0x02 (Open device, Transport Lock can no longer be set)
injectLockState:    0x02 (Unlocked)
gpStorageSize:      1024
uid (LEN=18):
47:90:70:02:47:91:12:10:20:89:00:50:36:91:64:23:00:00
```

ucrt

The `ucrt` command updates a certificate to the GP storage area by index. The certificate can be provided as raw data (-h option), as a file in PEM format (-p option) or as a file in DER format (-c option).

```
ucrt -x <int> [-c <certfile.crt> | -h <hexvalue_data> | -p <certfile.pem>]
```

Note: In case the certificate to be written is in PEM format it will be stored into the A71CH in DER format. The valid index range for certificates is is limited only by memory size.

In the following `ucrt` example a certificate contained in a PEM file (c:\certificate.pem) is stored into the A71CH at index 3.

```
>>> ucrt -x 3 -p c:\certificate.pem
Filename: c:\certificate.pem
Certificate Size (DER format) = 493 byte
```

wcrt

The `wcrt` command writes a certificate to the GP storage area by index. The certificate can be provided as raw data (-h option), as a file in PEM format (-p option) or as a file in DER format (-c option).

```
wcrt -x <int> [-c <certfile.crt> | -h <hexvalue_data> | -p <certfile.pem>] [-n
↪<padding-segments>]
```

Note: Writing to an existing index will fail. Use the `ucrt` command to update the certificate (taking into account certificate size constraints) or use the `ecrt` command to erase and then write the new certificate. The valid index range for certificates is is limited only by memory size. Using padding segments parameter creates an extra place holder for future updates with larger certificates at the same index without the need for erasing it first.

In case the certificate to be written is in PEM format it will be stored into the A71CH in DER format.

The `rcrt` command allows to read out a certificate by index.

In the following `wcrt` example a certificate contained in a PEM file (c:\certificate.pem) is stored into the A71CH at index 3.

```
>>> wcrt -x 3 -p c:\certificate.pem
Filename: c:\certificate.pem
Certificate Size (DER format) = 493 byte
```

10.5.5 Not connected mode

When starting up the A71CH Configure Tool it is possible to indicate no attached A71CH device is required. This is achieved by preceding the command (on the command line only) by the keyword `nc` (not connected).

Currently the only application of this feature is the creation of Reference Pem files where the public key value is contained in a Pem file (containing an EC key pair) passed as argument.

The following command creates a reference pem file ‘my_ref_keyfile.pem’ referring to a public key (stored or to be stored) at index 0 whose value is contained in ‘kp_keyfile.pem’

```
root@imx6ulevk:~# ./a71chConfig_i2c_imx nc refpem -c 20 -x 0 -k kp_keyfile.pem -r my_
↪ref_keyfile.pem
a71chConfig (Rev 0.94) .. NOT connecting to A71CH.
ECCPublicKey (LEN=65):
04:7C:59:16:D4:F5:46:B3:D3:17:20:78:F8:AD:41:84:9A:79:46:6B:5B:0B:FC:39:3D:4C:E1:A8:53:F5:4F:8D:
C2:98:65:F8:84:E9:9E:28:38:09:FF:29:34:B6:97:27:DB:6C:0A:F3:79:B0:D7:2C:16:25:B5:CB:B8:A2:CB:70:
89
```

CHAPTER

ELEVEN

APPENDIX

11.1 Glossary

Table 1: Glossary

Term	Definition
EAR	Eary Access Release
SE	Secure Element

11.2 APDU Commands over VCOM

Sending and Receiving Applet APDU Commands on VCOM using a Serial Terminal Emulator.

11.2.1 COM port parameters

Parameter	Value
Baud Rate	115200 bit/s
Data bits	8 Databits
Parity	No Parity
Stop Bits	1 Stop bit
FlowControl	Enable DTR

11.2.2 VCOM Format

Each APDU/command to be sent over the VCOM bridge has a 4 bytes header, the APDU to send follows as payload. The response contains the same header, followed by the response payload.

Byte	Description
`1`	Command • `00`: SoftReset / Fetch ATR • `01`: Other commands
`2`	Node Address
`3`	Len MSB
`4`	Len LSB

11.2.3 Example Commands

The example shows the commands strings to be sent over VCOM and some parsing of the commands/responses

Soft Reset/ATR Response

- Soft Reset / Request ATR .

Field	Bytes in Hex
Command	`00 00 00 00`
VCOM Header	-
APDU	-
Response	`00 00 00 23 00 A0 00 00 03 96 04 03 E8 00 FE 02 0B 03 E8 08 01 00 00 00 00 64 00 00 0A 4A 43 4F 50 34 20 41 54 50 4F`
VCOM Header	`00 00 00 23`
Atr Response	`-- -- -- -- 00 A0 00 00 03 96 04 03 E8 00 FE 02 0B 03 E8 08 01 00 00 00 00 64 00 00 0A 4A 43 4F 50 34 20 41 54 50 4F`

Select IOT Applet

Select the SE050 IoT applet

Field	Bytes in Hex
Command	`01 00 00 15 00 A4 04 00 0F A0 00 00 03 96 54 53 00 00 00 01 03 00 00 00 00`
VCOM Header	`01 00 00 15`
APDU	`-- -- -- -- 00 A4 04 00 0F A0 00 00 03 96 54 53 00 00 00 01 03 00 00 00 00`
Response	`01 00 00 09 03 01 00 3F FF 01 0B 90 00`
VCOM Header	`01 00 00 09`
APDU Response	`-- -- -- -- 03 01 00 3F FF 01 0B 90 00`
applet Version	appletVersion in TLV with Tag1, (Len=7) `-- -- -- -- -- -- -- -- 03 01 00 3F FF 01 0B`

Get applet Version

Gets the applet version information.

Field	Bytes in Hex
Command	`01 00 00 04 80 04 00 20`
VCOM Header	`01 00 00 04`
APDU	`-- -- -- -- 80 04 00 20`
Response	`01 00 00 0D 41 82 00 07 03 01 00 3F FF 01 0B 90 00`
VCOM Header	`01 00 00 0D`
APDU Response	`-- -- -- -- 41 82 00 07 03 01 00 3F FF 01 0B 90 00`
applet Version	appletVersion in TLV with Tag1, (Len=7) `-- -- -- -- -- -- -- -- 03 01 00 3F FF 01 0B`

GetRandom

Gets x(8) byte random data from the SE050.

Field	Bytes in Hex
Command	`01 00 00 0D 80 04 00 49 00 00 04 41 02 00 08 00 00`
VCOM Header	`01 00 00 0D`
APDU	`-- -- -- -- 80 04 00 49 00 00 04 41 02 00 08 00 00`
Response	`01 00 00 0E 41 82 00 08 B5 47 3C 8C A5 16 AC 31 90 00`
VCOM Header	`01 00 00 0E`
APDU Response	`-- -- -- -- 41 82 00 08 B5 47 3C 8C A5 16 AC 31 90 00`
RandomData	`-- -- -- -- -- -- -- -- B5 47 3C 8C A5 16 AC 31`

GetUID

UID is an object with Object ID = `0x7FFF0206`.

Field	Bytes in Hex
Command	`01 00 00 13 80 02 00 00 00 00 0A 41 04 7F FF 02 06 43 02 00 12 00 00`
VCOM Header	`01 00 00 13`
APDU	`-- -- -- -- 80 02 00 00 00 00 0A 41 04 7F FF 02 06 43 02 00 12 00 00`
Response	`01 00 00 18 41 82 00 12 04 00 50 01 55 55 55 55 55 55 55 04 FF FF FF FF FF FA 90 00`
VCOM Header	`01 00 00 18`
APDU Response	`-- -- -- -- 41 82 00 12 04 00 50 01 55 55 55 55 55 55 55 04 FF FF FF FF FF FA 90 00`
UID	UID in TLV with Tag1 `-- -- -- -- -- -- -- -- 04 00 50 01 55 55 55 55 55 55 55 04 FF FF FF FF FF FA`

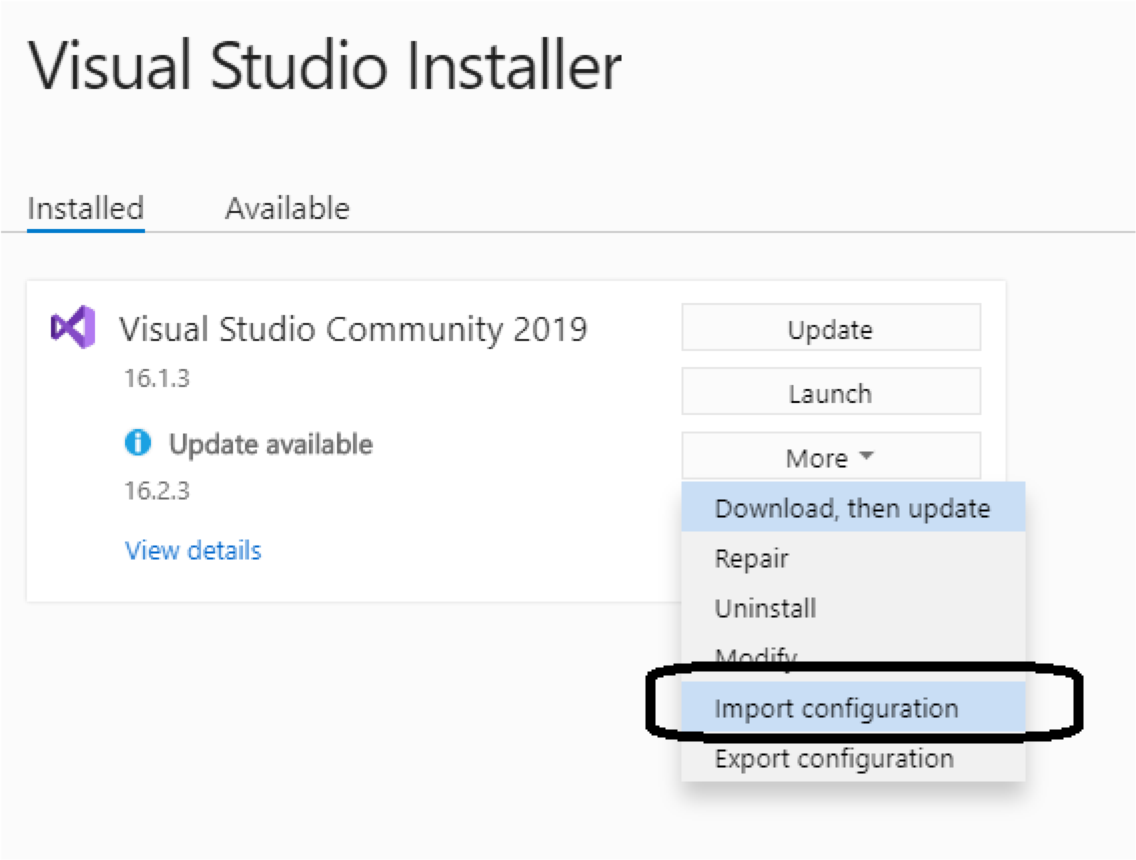
11.3 Visual Studio 2019 Setup

11.3.1 Prerequisites

Install any edition of Visual Studio 2019, It will install the visual studio installer application.

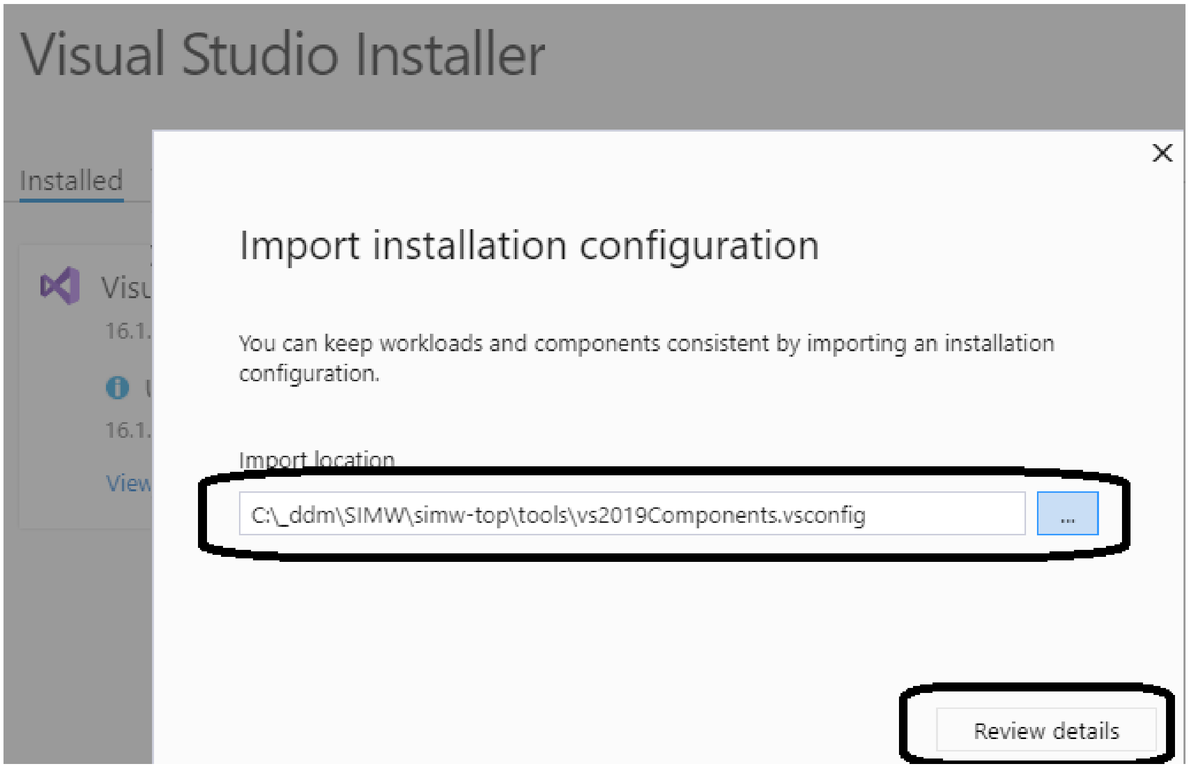
11.3.2 Installing the components

1) Open Visual Studio Installer, click on more and then import configuration.



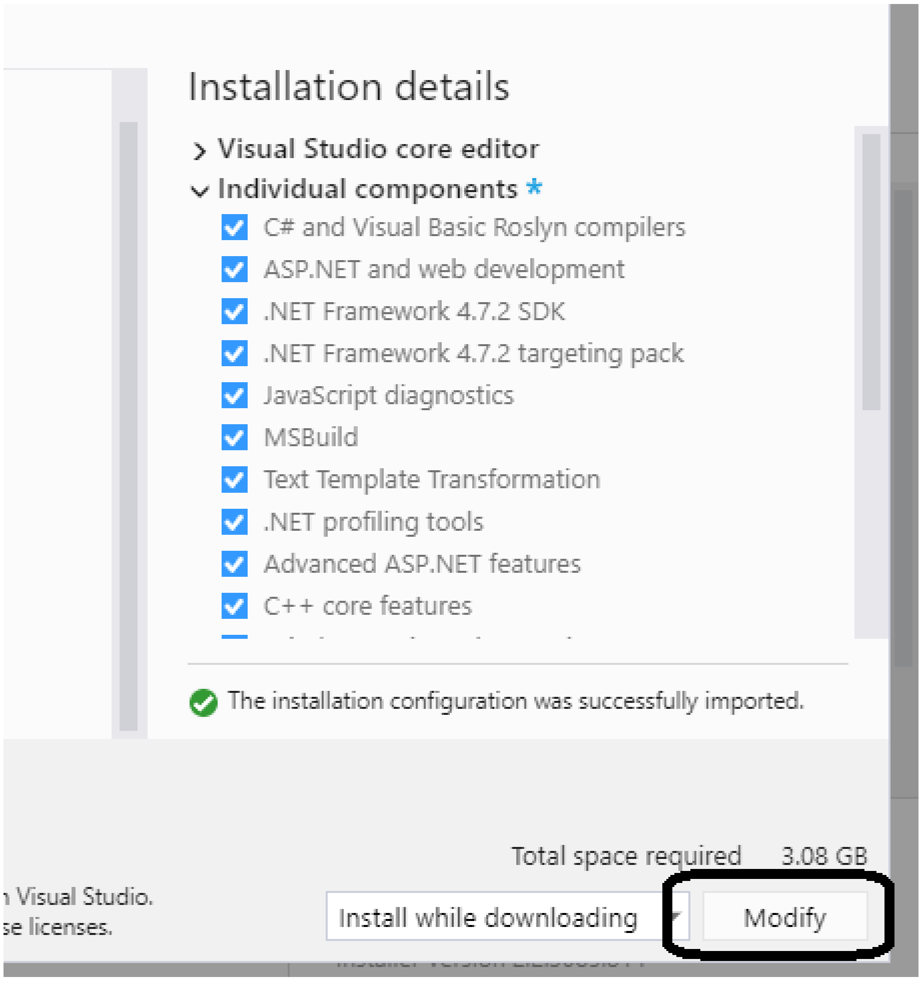
2) In the dialogue box give the path to the configuration file present in tools folder.

`tools/vs2019Components.vsconfig`


Visual Studio Installer
Installed
Visu
16.1.
16.1.
View
×
Import installation configuration
You can keep workloads and components consistent by importing an installation configuration.
Import location
...
Review details

C:_ddm\SIMW\simw-top\tools\vs2019Components.vsconfig

3) click on modify.



Installation details

☑ C# and Visual Basic Roslyn compilers
☑ ASP.NET and web development
☑ .NET Framework 4.7.2 SDK
☑ .NET Framework 4.7.2 targeting pack
☑ JavaScript diagnostics
☑ MSBuild
☑ Text Template Transformation
☑ .NET profiling tools
☑ Advanced ASP.NET features
☑ C++ core features

The installation configuration was successfully imported.

Total space required 3.08 GB

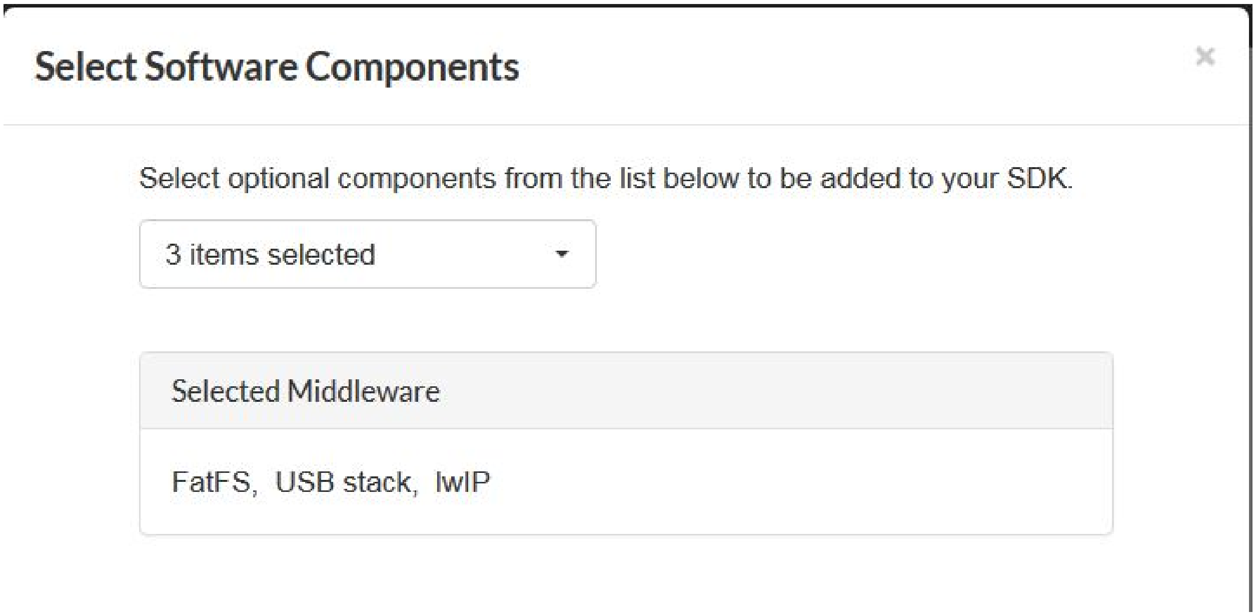
11.4 Setting up MCUXPresso IDE

1. Download MCUXpresso from: https://www.nxp.com/support/developer-resources/software-development-tools/mcuxpresso-software-and-tools/mcuxpresso-integrated-development-environment-ide:MCUXpresso-IDE
2. For additional help please refer to: https://www.nxp.com/docs/en/user-guide/MCUXpresso_IDE_User_Guide.pdf

11.4.1 To Download and install MCUXpresso IDE:

To create and install board specific SDK

- Login/create an account on the SDKBuilder website https://mcuxpresso.nxp.com/en/select .
- Select your Board i.e. FRDM-K64F or EVK-MIMXRT1060.
- Click on Build MCUXpresso SDK.
- Select Software Components.



Select Software Components

Select optional components from the list below to be added to your SDK.

3 items selected

Selected Middleware

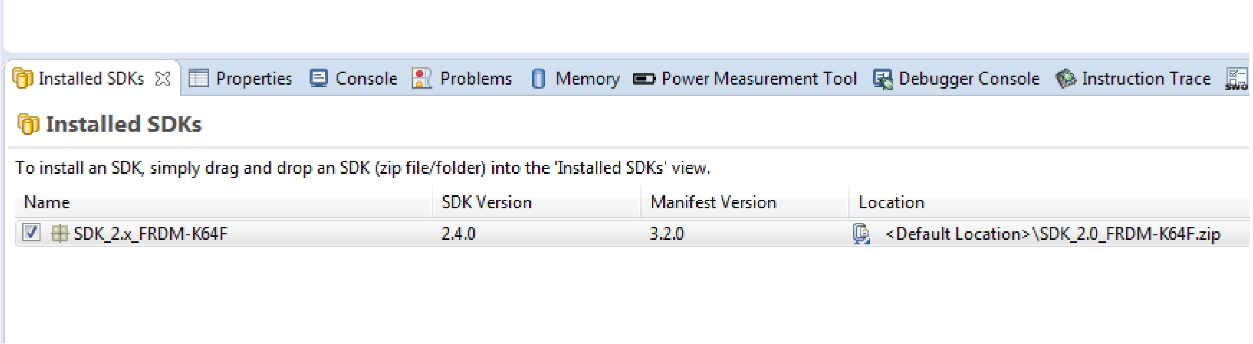
FatFS, USB stack, lwIP

Note: MCUXpresso SDK Builder has a limitation with the components getting selected as on today, So to be on the safer side, all the Middleware components have been selected to generate the SDK.

- Download the SDK

11.4.2 To Install board specific SDK in MCUXpresso

- In MCUXpresso IDE, install the downloaded SDK by dragging and dropping it into the Installed SDK's tab.



Installed SDKs

To install an SDK, simply drag and drop an SDK (zip file/folder) into the 'Installed SDKs' view.

Name	SDK Version	Manifest Version	Location
☑ SDK_2.x_FRDM-K64F	2.4.0	3.2.0	<Default Location>\SDK_2.0_FRDM-K64F.zip

11.5 Development Platforms

11.5.1 Setup `i.MX 8MQuad - MCIMX8M-EVK`

This section explains how to create an SD card image (including native compilation tools) and a cross-compilation environment for the `MCIMX8M-EVK`.

Note: Evaluation Board Type

This guidelines refers to the `MCIMX8M-EVK` evaluation board. Please refer to the bottom of this page for guidelines on connecting the SE050 Arduino shield to the `MCIMX8M-EVK`

Downloading and Installing Yocto for `MCIMX8M-EVK`

Please consult first the detailed information that can be found on https://www.nxp.com. Download the L5.4.70_2.3.4_LINUX_DOCS documentation package (available on https://www.nxp.com/design/software/embedded-software/i-mx-software/embedded-linux-for-i-mx-applications-processors:IMXLINUX?tab=Documentation_Tab under the **Supporting Information** header) and take the **i.MX Yocto Project User's Guide** as a starting point.

Yocto must be installed on a Linux PC (consult the documentation for the Linux distributions officially supported), it's possible to use a Virtual PC environment as e.g. Virtual Box. The Linux PC must have access to the internet to retrieve additional packages, tools and sources.

Having set-up all tools and packages required by Yocto, initialize a local git repository as follows:

```
mkdir -p ~/projects/imx-yocto-bsp-5-4-70-2-3-4
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-linux-
↪zeus -m imx-5.4.70-2.3.4.xml
repo sync
```

Add a custom Yocto layer. This custom Yocto layer is part of the Plug&Trust SW distribution (`simw_top/scripts/yocto/layers/meta-custom.tgz`) and must be copied and unpacked into the sources directory created above. Note: this custom layer adds a Python package (func-timeout):

```
cp␣
↪<PlugTrust>/simw_top/scripts/yocto/layers/meta-custom.tgz ~/projects/imx-yocto-bsp-5-4-70-2-3-4/sou
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4/sources
tar xzvf meta-custom.tgz
```

Prepare an embedded Linux distribution for the `MCIMX8M-EVK` board

The bitbake target `core-image-full-cmdline` created for `MCIMX8M-EVK` contains a busybox implementation of the usual Unix command line tools. It assumes you will interact with the embedded system over the command line:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
DISTRO=fsl-imx-wayland MACHINE=imx8mqevk source imx-setup-release.sh -b build-wayland-
↪imx8mqevk
```

Now, before issuing the bitbake command, edit two configuration files.

First edit the `build-wayland-imx8mqevk/conf/bblayers.conf` so it contains a reference to the custom layer. Add the following line at the end of the file:

```
BBLAYERS += " ${BSPDIR}/sources/meta-custom"
```

The resulting `build-wayland-imx8mqevk/conf/bblayers.conf` file will look as follows:

```
LCONF_VERSION = "6"

BBPATH = "${TOPDIR}"
BSPDIR := "${@os.path.abspath(os.path.dirname(d.getVar('FILE', True)) + '/../..')}"
```

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```
BBFILES ?= ""
BBLAYERS = " \
  ${BSPDIR}/sources/poky/meta \
  ${BSPDIR}/sources/poky/meta-poky \
  \
  ${BSPDIR}/sources/meta-openembedded/meta-oe \
  ${BSPDIR}/sources/meta-openembedded/meta-multimedia \
  \
  ${BSPDIR}/sources/meta-freescale \
  ${BSPDIR}/sources/meta-freescale-3rdparty \
  ${BSPDIR}/sources/meta-freescale-distro \
"

# i.MX Yocto Project Release layers
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-bsp "
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-sdk "
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-ml "

BBLAYERS += "${BSPDIR}/sources/meta-browser"
BBLAYERS += "${BSPDIR}/sources/meta-rust"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-gnome"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-networking"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-python"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-filesystems"
BBLAYERS += "${BSPDIR}/sources/meta-qt5"

# +SIMW
BBLAYERS += " ${BSPDIR}/sources/meta-custom"
# -SIMW
```

Next edit the file `build-wayland-imx8mqevk/conf/local.conf` so it matches the following:

```
MACHINE ??= 'imx8mqevk'
DISTRO ?= 'fsl-imx-wayland'
PACKAGE_CLASSES ?= 'package_rpm'

# EXTRA_IMAGE_FEATURES ?= "debug-tweaks"
# + SIMW: Extended EXTRA_IMAGE_FEATURES
EXTRA_IMAGE_FEATURES ?=␣
↪"debug-tweaks dev-pkgs tools-debug tools-sdk tools-testapps package-management"


USER_CLASSES ?= "buildstats image-mklibs image-prelink"
PATCHRESOLVE = "noop"
BB_DISKMON_DIRS ??= "\
    STOPTASKS,${TMPDIR},1G,100K \
    STOPTASKS,${DL_DIR},1G,100K \
    STOPTASKS,${SSTATE_DIR},1G,100K \
    STOPTASKS,/tmp,100M,100K \
    ABORT,${TMPDIR},100M,1K \
    ABORT,${DL_DIR},100M,1K \
    ABORT,${SSTATE_DIR},100M,1K \
    ABORT,/tmp,10M,1K"
PACKAGECONFIG_append_pn-qemu-system-native = " sdl"
PACKAGECONFIG_append_pn-nativesdk-qemu = " sdl"
CONF_VERSION = "1"
```

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```
DL_DIR ?= "${BSPDIR}/downloads/"
ACCEPT_FSL_EULA = "1"


# +SIMW
IMAGE_ROOTFS_EXTRA_SPACE = "640000"

IMAGE_INSTALL_append += " rng-tools openssl-bin"
IMAGE_INSTALL_append += " cmake curl git subversion "
# If you want git-submodule
# IMAGE_INSTALL_append += " git-perltools findutils "
IMAGE_INSTALL_append +=␣
↪" python3-pip python3-click python3-cryptography python3-pycparser python3-cffi "
# opcua
IMAGE_INSTALL_append += " python-logging "

IMAGE_INSTALL_append += " e2fsprogs-resize2fs func-timeout "
IMAGE_INSTALL_append += " i2c-tools "
IMAGE_INSTALL_append += " python3-misc"
IMAGE_INSTALL_append += " opensc "
# -SIMW
```

Note: At this stage it's possible to also include the Plug&Trust package as a Yocto recipe. Refer to *Alternative approach to create SD card: use Yocto recipe for Plug&Trust package* on how to do this.

The above local.conf file prepares an embedded Linux distribution with native development tools

After updating the file `build-wayland-imx8mqevk/conf/local.conf` issue the following command:

```
bitbake core-image-full-cmdline
```

Note: Output Directory

The directory *build-wayland-imx8mqevk* will contain downloaded sources and build artefacts.

When the above bitbake command finished successfully a compressed sdcard image containing bootloader, filesystem and linux kernel is available under `~/projects/imx-yocto-bsp-5-4-70-2-3-4/build-wayland-imx8mqevk/tmp/deploy/images/imx8mqevk/core-image-full-cmdline-imx8mqevk.wic.bz2`.

`core-image-full-cmdline-imx8mqevk.wic.bz2` is a symbolic link to the actual file name - which has a timestamp as part of the filename e.g. `core-image-full-cmdline-imx8mqevk-20191204234929.rootfs.wic.bz2`. Copy the **unzipped** sdcard image to a microSD card either with the method described in the 'i.MX Yocto Project User's Guide' or on a Windows PC with e.g. the Win32DiskImager tool.

Note: The embedded linux system prepared has a user `root` that does not require a password. Please define a password at your earliest convenience.

Create and install SDK and Root file system on Host

To populate SDK, run:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
MACHINE=imx8mqevk source setup-environment build-wayland-imx8mqevk
bitbake -c populate_sdk core-image-full-cmdline
```

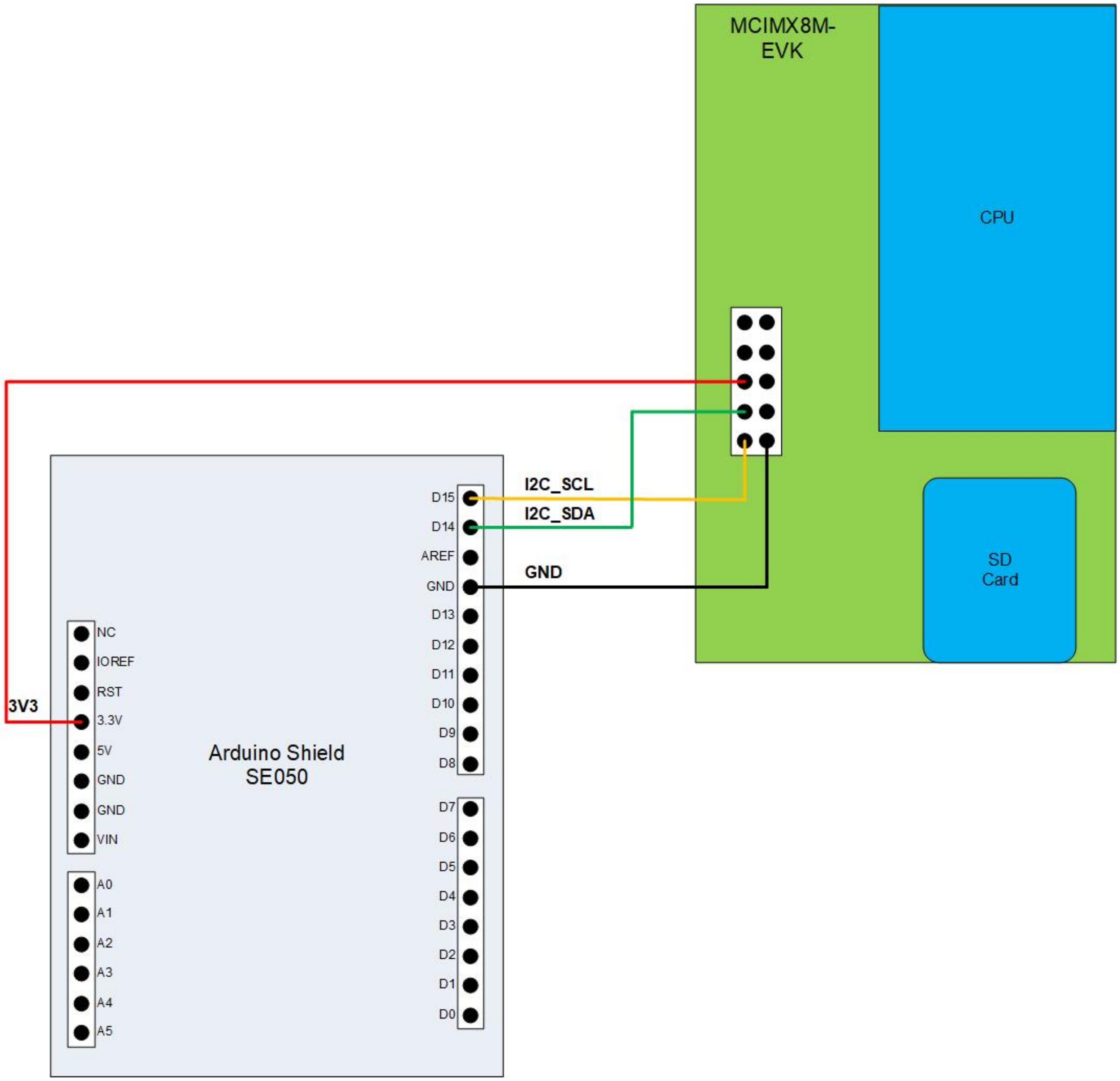
To install the SDK in the default location `/opt/fsl-imx-wayland/4.19-warrior`:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4/build-wayland-imx8mqevk/tmp/deploy/sdk/
./fsl-imx-wayland-glibc-x86_64-core-image-full-cmdline-aarch64-toolchain-4.19-warrior.
↪sh
```

You have now installed a set of cross-compilation tools for the `MCIMX8M-EVK` board on the Linux Host PC.

Connecting the `MCIMX8M-EVK` to the SE050 Arduino shield

The `MCIMX8M-EVK` does not come with an Arduino connector, the following figure illustrates how to make the connection with jump wires.



The same information summarized in a table.

Pin Function	OM-SE050ARD pins	MCIMX8M-EVK
I2C_SCL	J2-10	J801-I2C-1
I2C_SDA	J2-9	J801-I2C-3
GND	J2-7	J801-I2C-2
3V3	J8-4	J801-I2C-5

Alternative approach to create SD card: use Yocto recipe for Plug&Trust package

The Plug&Trust MW package also includes a recipe.

- Download the Plug&Trust MW from www.nxp.com/se050 and ensure the package version (e.g. 04.00.00) is appended to the file name. (For example: SE050-PLUG-TRUST-MW-v04.00.00.zip)

- Put the se05x recipe (se05x_4.0.0.bb), the source code package (SE050-PLUG-TRUST-MW-v04.00.00.zip) and (if applicable) patches into the existing `.../sources/meta-custom/recipes directory` of the Yocto development PC (recipe and patches are available in `simw-top/scripts/yocto/v04.00.00`)

The resulting imx-yocto-bsp-5-4-70-2-3-4/sources/meta-custom directory on the Yocto development PC should look like:

```
├── conf
│   └── layer.conf
├── README
└── recipes
    ├── func-timeout
    │   └── func-timeout_4.3.3.bb
    └── se05x
        ├── files
        │   └── SE050-PLUG-TRUST-MW-v04.00.00.zip
        └── se05x_4.0.0.bb
```

To add the Plug&Trust MW to the image to be created add the following line at the end of the `build-wayland-imx8mqevk/conf/local.conf` file:

```
IMAGE_INSTALL_append += " se05x"
```

11.5.2 Setup `i.MX6UL` - `MCIMX6UL-EVK`

This section explains how to create an SD card image (including native compilation tools) and a cross-compilation environment for the `MCIMX6UL-EVK`.

Note: *Setup i.MX 8MQuad - MCIMX8M-EVK* is the current default version of the board used with the Plug & Trust MW.

Downloading and Installing Yocto for `MCIMX6UL-EVK`

Please consult first the detailed information that can be found on https://www.nxp.com. Download the L5.4.70_2.3.4_LINUX_DOCS documentation package (available on https://www.nxp.com/design/software/embedded-software/i-mx-software/embedded-linux-for-i-mx-applications-processors:IMXLINUX?tab=Documentation_Tab under the **Supporting Information** header) and take the **i.MX Yocto Project User's Guide** as a starting point.

Yocto must be installed on a Linux PC (consult the documentation for the Linux distributions officially supported), it's possible to use a Virtual PC environment as e.g. Virtual Box. The Linux PC must have access to the internet to retrieve additional packages, tools and sources.

Having set-up all tools and packages required by Yocto, initialize a local git repository as follows:

```
mkdir -p ~/projects/imx-yocto-bsp-5-4-70-2-3-4
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
repo init -u https://source.codeaurora.org/external/imx/imx-manifest -b imx-linux-
↪zeus -m imx-5.4.70-2.3.4.xml
repo sync
```

Add a custom Yocto layer. This custom Yocto layer is part of the Plug&Trust SW distribution (`simw_top/scripts/yocto/layers/meta-custom.tgz`) and must be copied and unpacked into the sources directory created above. Note: this custom layer adds a Python package (func-timeout):

```
cp␣
↪<PlugTrust>/simw_top/scripts/yocto/layers/meta-custom.tgz ~/projects/imx-yocto-bsp-5-4-70-2-3-4/sou
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4/sources
tar xzvf meta-custom.tgz
```

Prepare an embedded Linux distribution for the `MCIMX6UL-EVK` board

The bitbake target `core-image-full-cmdline` created for `MCIMX6UL-EVK` contains a busybox implementation of the usual Unix command line tools. It assumes you will interact with the embedded system over the command line:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
DISTRO=fsl-imx-fb MACHINE=imx6ulevk source imx-setup-release.sh -b build-fb-6ul
```

Now, before issuing the bitbake command, edit two configuration files.

First edit the `build-fb-6ul/conf/bblayers.conf` so it contains a reference to the custom layer. Add the following line at the end of the file:

```
BBLAYERS += " ${BSPDIR}/sources/meta-custom"
```

The resulting `build-fb-6ul/conf/bblayers.conf` file will look as follows:

```
LCONF_VERSION = "7"

BBPATH = "${TOPDIR}"
BSPDIR := "${@os.path.abspath(os.path.dirname(d.getVar('FILE', True)) + '/../..')}"

BBFILES ?= ""
BBLAYERS = " \
  ${BSPDIR}/sources/poky/meta \
  ${BSPDIR}/sources/poky/meta-poky \
  \
  ${BSPDIR}/sources/meta-openembedded/meta-oe \
  ${BSPDIR}/sources/meta-openembedded/meta-multimedia \
  \
  ${BSPDIR}/sources/meta-freescale \
  ${BSPDIR}/sources/meta-freescale-3rdparty \
  ${BSPDIR}/sources/meta-freescale-distro \
"

# i.MX Yocto Project Release layers
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-bsp "
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-sdk "
BBLAYERS += " ${BSPDIR}/sources/meta-fsl-bsp-release/imx/meta-ml "

BBLAYERS += "${BSPDIR}/sources/meta-browser"
BBLAYERS += "${BSPDIR}/sources/meta-rust"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-gnome"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-networking"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-python"
BBLAYERS += "${BSPDIR}/sources/meta-openembedded/meta-filesystems"
BBLAYERS += "${BSPDIR}/sources/meta-qt5"

# +SIMW
```

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```
BBLAYERS += " ${BSPDIR}/sources/meta-custom"
# -SIMW
```

Next edit the file `build-fb-6ul/conf/local.conf` so it matches the following:

```
MACHINE ??= 'imx6ulevk'
DISTRO ?= 'fsl-imx-fb'
PACKAGE_CLASSES ?= "package_rpm"

# EXTRA_IMAGE_FEATURES ?= "debug-tweaks"
# + SIMW: Extended EXTRA_IMAGE_FEATURES
EXTRA_IMAGE_FEATURES ?=␣
↪"debug-tweaks dev-pkgs tools-debug tools-sdk tools-testapps package-management"
USER_CLASSES ?= "buildstats image-mklibs image-prelink"
PATCHRESOLVE = "noop"
BB_DISKMON_DIRS ??= "\
    STOPTASKS,${TMPDIR},1G,100K \
    STOPTASKS,${DL_DIR},1G,100K \
    STOPTASKS,${SSTATE_DIR},1G,100K \
    STOPTASKS,/tmp,100M,100K \
    ABORT,${TMPDIR},100M,1K \
    ABORT,${DL_DIR},100M,1K \
    ABORT,${SSTATE_DIR},100M,1K \
    ABORT,/tmp,10M,1K"
PACKAGECONFIG_append_pn-qemu-system-native = " sdl"
PACKAGECONFIG_append_pn-nativesdk-qemu = " sdl"
CONF_VERSION = "1"

DL_DIR ?= "${BSPDIR}/downloads/"
ACCEPT_FSL_EULA = "1"


# +SIMW
IMAGE_ROOTFS_EXTRA_SPACE = "640000"

IMAGE_INSTALL_append += " rng-tools openssl-bin"
IMAGE_INSTALL_append += " cmake curl git subversion"
IMAGE_INSTALL_append +=␣
↪" python3-pip python3-click python3-cryptography python3-pycparser python3-cffi"
IMAGE_INSTALL_append += " e2fsprogs-resize2fs func-timeout i2c-tools"
# -SIMW
```

Note: At this stage it's possible to also include the Plug&Trust package as a Yocto recipe. Refer to *Alternative approach to create SD card: use Yocto recipe for Plug&Trust package* on how to do this.

The above local.conf file prepares an embedded Linux distribution with native development tools

After updating the file `build-fb-6ul/conf/local.conf` issue the following command:

```
bitbake core-image-full-cmdline
```

Note: Output Directory

The directory *build-fb-6ul* will contain downloaded sources and build artefacts.

When the above bitbake command finished successfully a compressed sdcard image containing bootloader, filesystem and linux kernel is available under `~/projects/imx-yocto-bsp-5-4-70-2-3-4/build-fb-6ul/tmp/deploy/images/imx6ulevk/core-image-full-cmdline-imx6ulevk.wic.bz2`.

`core-image-full-cmdline-imx6ulevk.wic.bz2` is a symbolic link to the actual file name - which has a timestamp as part of the filename e.g. `core-image-full-cmdline-imx6ulevk-20191204234929.rootfs.wic.bz2`. Copy the **unzipped** sdcard image to a microSD card either with the method described in the 'i.MX Yocto Project User's Guide' or on a Windows PC with e.g. the Win32DiskImager tool.

Note: The embedded linux system prepared has a user `root` that does not require a password. Please define a password at your earliest convenience.

Create and install SDK and Root file system on Host

To populate SDK, run:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4
MACHINE=imx6ulevk source setup-environment build-fb-6ul
bitbake -c populate_sdk core-image-full-cmdline
```

To install the SDK in the default location `/opt/fsl-imx-fb/5.4.70-2.3.4`:

```
cd ~/projects/imx-yocto-bsp-5-4-70-2-3-4/build-fb-6ul/tmp/deploy/sdk/
./fsl-imx-fb-glibc-x86_64-core-image-full-cmdline-cortexa7hf-neon-toolchain-5.4.70-2.
↪3.4.sh
```

You have now installed a set of cross-compilation tools for the `MCIMX6UL-EVK` board on the Linux Host PC.

Alternative approach to create SD card: use Yocto recipe for Plug&Trust package

The Plug&Trust MW package also includes a recipe.

- Download the Plug&Trust MW from www.nxp.com/se050 and ensure the package version (e.g. 04.00.00) is appended to the file name. (For example: SE050-PLUG-TRUST-MW-v04.00.00.zip)
- Put the se05x recipe (se05x_4.0.0.bb), the source code package (SE050-PLUG-TRUST-MW-v04.00.00.zip) and (if applicable) patches into the existing `.../sources/meta-custom/recipes directory` of the Yocto development PC (recipe and patches are available in `simw-top/scripts/yocto/v04.00.00`)

The resulting imx-yocto-bsp-5-4-70-2-3-4/sources/meta-custom directory on the Yocto development PC should look like:

```
+-- conf
|   +-- layer.conf
+-- README
+-- recipes
    +-- func-timeout
    |   +-- func-timeout_4.3.3.bb
    +-- se05x
        +-- files
        |   +-- SE050-PLUG-TRUST-MW-v04.00.00.zip
        +-- se05x_4.0.0.bb
```

To add the Plug&Trust MW to the image to be created add the following line at the end of the `build-wayland-imx8mqevk/conf/local.conf` file:

```
IMAGE_INSTALL_append += " se05x"
```

11.5.3 Freedom K64F

See Section 4.2 — *Import MCUXPresso projects from SDK* and Section 4.3 — *Freedom K64F Build (CMake - Advanced)*

11.5.4 i.MX RT 1060

See Section 4.3.2 *Importing the Project*.

MIMXRT1060 Boot Mode and Boot Device Settings

SW7-1	SW7-2	SW7-3	SW7-4	Boot Device
OFF	ON	ON	OFF	Hyper flash
OFF	OFF	ON	OFF	QSPI flash
ON	OFF	ON	OFF	SD card

Note: Default/Current Settings

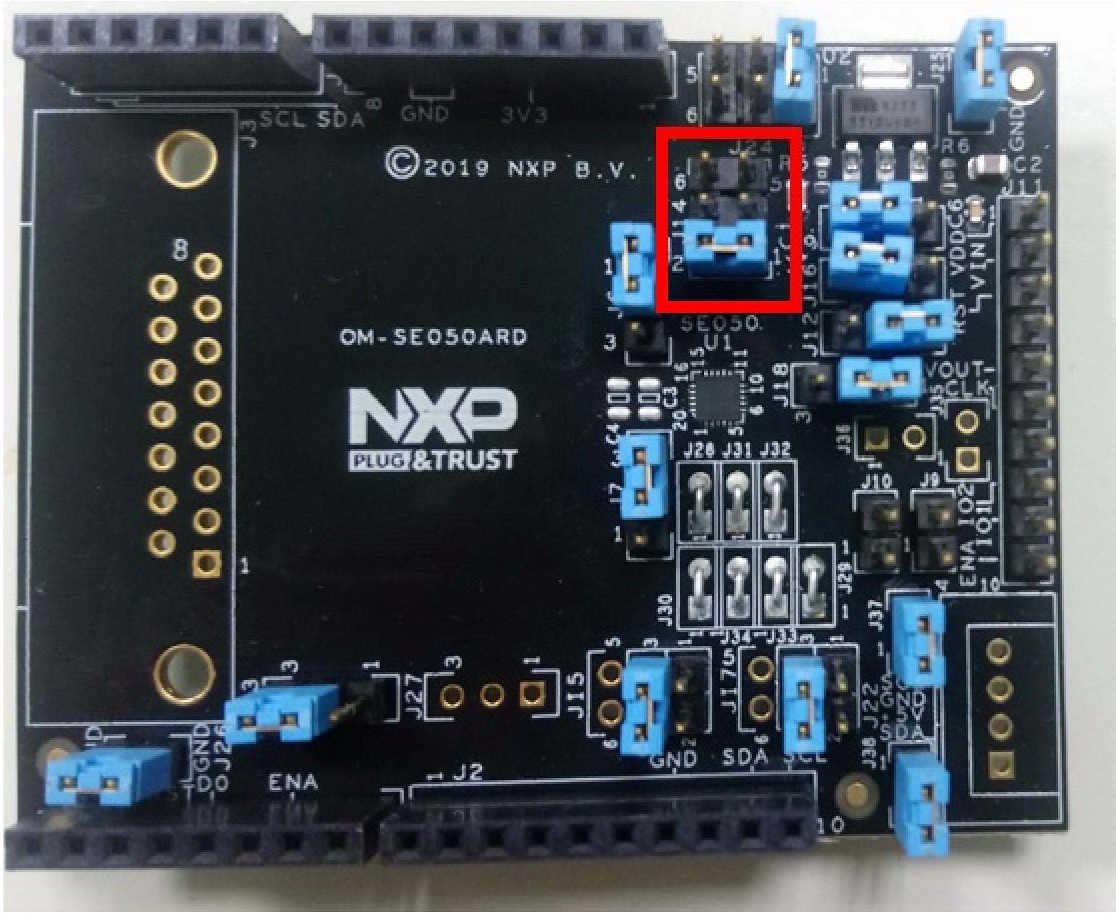
Boot Device - QSPI flash Flash driver - MIMXRT1060_SFDP_QSPI.cfx

11.5.5 LPC55S69

See Section 4.3.2 *Importing the Project*.

Connecting SE050 Arduino shield to LPC55S

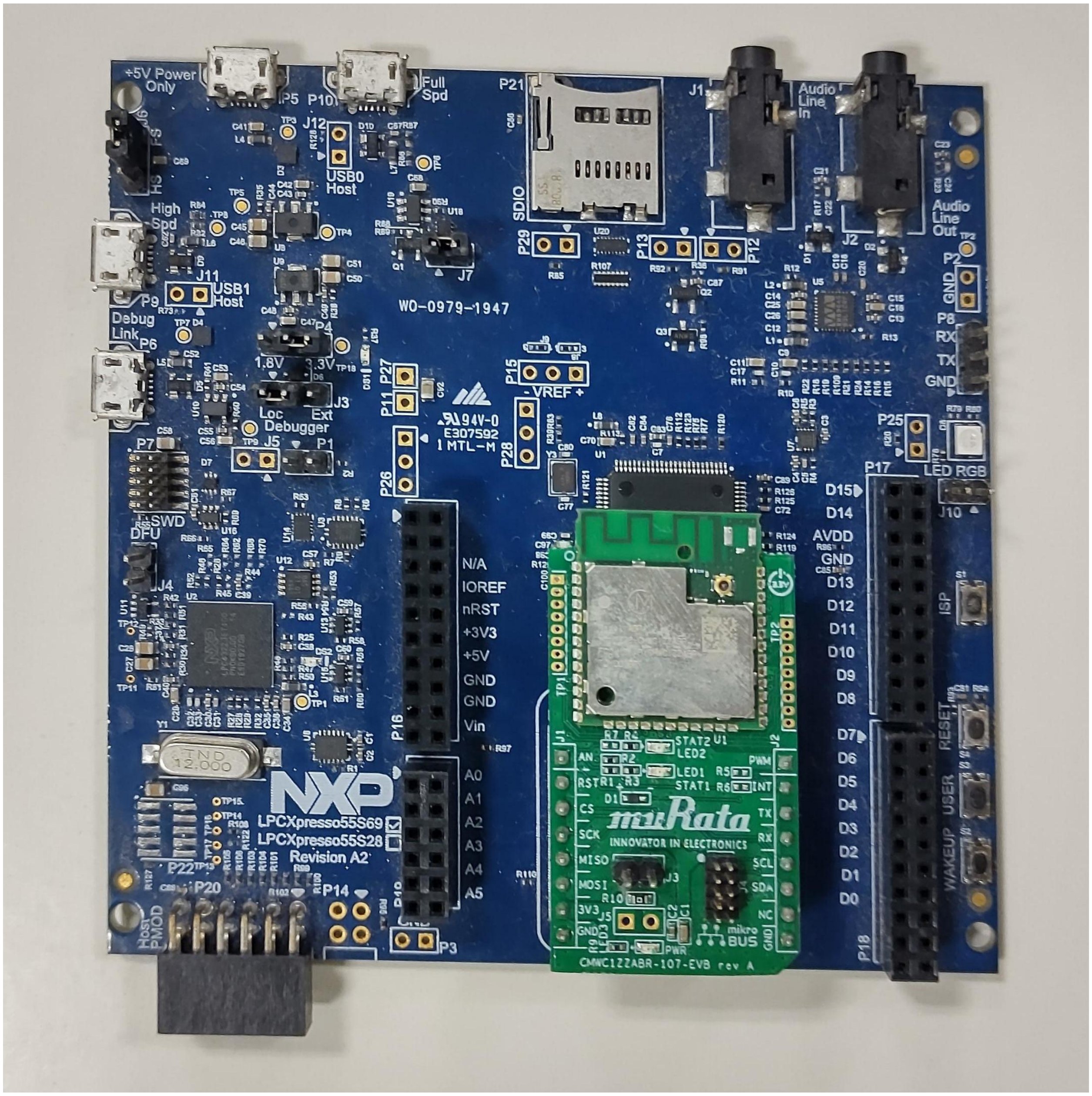
Connect SE050 to LPC55S Arduino stackable headers and change jumper J14 as:



This connects SE_VDD directly to 3V3 and bypasses enable signal. .. This is required because enable pin on LPC55S coincides with Silex-2401 SPI pins .. so we cannot use SE_EN signal to drive SE_VDD.

Connecting WiFi shield to LPC55S

Connect the muRata CMWC1ZZABR-107-EVB WiFi shield to LPC55S mikroBUS as:



Note: Maximum of 4 connections are supported at a time by the shield. Further connection attempts will result in failure.

Memory regions

Secure Zone

Total code size available for secure applications is `0x3FE00` bytes.

Memory area	Origin	Size
m_interrupts	0x10000000	LENGTH = 0x00000200
m_text	0x10000200	LENGTH = 0x0003FC00
m_veneer_table	0x1003FE00	LENGTH = 0x00000200
m_core1_image	0x1007A000	LENGTH = 0x0001E000
m_data	0x30000000	LENGTH = 0x00018000
rpmsg_sh_mem	0x30033000	LENGTH = 0
m_usb_sram	0x50100000	LENGTH = 0x00004000

Non-secure Zone

Total code size available for non-secure applications is `0x3A000` bytes.

Memory area	Origin	Size
m_interrupts	0x00040000	LENGTH = 0x00000200
m_text	0x00040200	LENGTH = 0x00039E00
m_core1_image	0x0007A000	LENGTH = 0x0001E000
m_data	0x20018000	LENGTH = 0x0001A800
rpmsg_sh_mem	0x20033000	LENGTH = 0
m_usb_sram	0x40100000	LENGTH = 0x00004000

Note: While modifying Secure/Non-secure memory regions, be sure that code size is 32kB aligned.

11.5.6 Android: Hikey960

Supported Features

Generate / Import:

- **ECC:**
  - 224-bit
  - 256-bit
  - 384-bit
  - 521-bit
- **RSA:**
  - 1024-bit
  - 2048-bit
  - 3072-bit
  - 4096-bit
- **AES:**
  - 128-bit
  - 192-bit

    - 256-bit
  - **HMAC**
    - 64-bit to 512-bit

Export:

- **ECC:**
  - 224-bit
  - 256-bit
  - 384-bit
  - 521-bit
- **RSA:**
  - 1024-bit
  - 2048-bit
  - 3072-bit
  - 4096-bit

RNG:

- Get Random number

Sign / Verify:

- **Sign / Verify with ECC**
  - **Supported digests:**
    - DIGEST:SHA1
    - DIGEST:SHA224
    - DIGEST:SHA256
    - DIGEST:SHA384
    - DIGEST:SHA512
- **Sign / Verify with RSA**
  - **Supported paddings:**
    - PADDING:NONE
    - PADDING:PKCS1_V1.5 (SHA1, SHA-224, SHA-256, SHA-384, SHA-512)
    - PADDING:PSS (SHA1, SHA-224, SHA-256, SHA-384, SHA-512)
- **Sign / Verify with HMAC**
  - **Supported digests:**
    - DIGEST:SHA1
    - DIGEST:SHA256
    - DIGEST:SHA384
    - DIGEST:SHA512

Encryption / Decryption:

- **Encrypt / Decrypt with RSA**
    - **Supported paddings:**
        - PADDING:NONE
        - PADDING:PKCS1_V1.5
        - PADDING:OAEP (SHA1)
- **Encrypt / Decrypt with AES**
    - **Supported block modes:**
        - ECB (PADDING:NONE)
        - CBC (PADDING:NONE)
        - CTR (PADDING:NONE)

Delete:

- Single key
- All keys

Attestation:

- Key attestation

AOSP build Environment Setup

AOSP build Environment for Hikey960

To setup Android build environment for Hikey960 board please follow steps below:

1) The build setup file structure should be as below:

```
<ROOT-DIR>
|
|------ android-root/
|
|------ simw-top/
```

2) Downloading and building AOSP source code (refer https://source.android.com/setup/build/devices).

   In the steps below, `android-root` means `$ROOT_DIR/android-root/`.

   For simplicity of scripts, it is assumed that `ROOT_DIR` variable is set like as below:

```
ROOT_DIR=/opt/_ddm/aospbld
```

3) Setup REPO Tool:

```
mkdir ~/bin
PATH=~/bin:$PATH
curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo
chmod a+x ~/bin/repo
```

4) Download source code using REPO tool:

```
ROOT_DIR=/opt/_ddm/aospbld # For example

mkdir -p ${ROOT_DIR}/android-root
cd ${ROOT_DIR}/android-root

repo init -u https://android.googlesource.com/platform/manifest -b android-p-
↪preview-2
repo sync -j$(nproc)
```

All scripts from here on assume `ROOT_DIR` is set.

5) Apply patches from `android.googlesource.com`:

```
cd ${ROOT_DIR}/android-root/prebuilts/tools
git fetch https://android.googlesource.com/platform/prebuilts/tools refs/changes/
↪02/682002/1 && git cherry-pick     FETCH_HEAD

cd ${ROOT_DIR}/android-root/external/e2fsprogs/
git fetch https://android.googlesource.com/platform/external/e2fsprogs refs/
↪changes/05/683305/1 && git  cherry-pick FETCH_HEAD

cd ${ROOT_DIR}/android-root/external/f2fs-tools
git fetch https://android.googlesource.com/platform/external/f2fs-tools refs/
↪changes/06/683306/1 && git     cherry-pick FETCH_HEAD
```

6) Apply patches from host library.

   These patches are for Android Keymaster 3.0 Board init

   Scripts to apply the patches:

```
cp ${ROOT_DIR}/simw-top/akm/src/Board_init/keymaster_sepolicy.patch ${ROOT_DIR}/
↪android-root/system/sepolicy/
cd ${ROOT_DIR}/android-root/system/sepolicy/
patch -p1 < keymaster_sepolicy.patch

cp ${ROOT_DIR}/simw-top/akm/src/Board_init/init_rc_file.patch ${ROOT_DIR}/android-
↪root/system/core/
cd ${ROOT_DIR}/android-root/system/core/
patch -p1 < init_rc_file.patch
```

   - `init_rc_file.patch` is to update system ownership of I2C module and to create `/data/vendor/SE05x` secure directory.
   - `keymaster_sepolicy.patch` is to update SE050 Keymaster HAL policy for accessing I2C device for communication with SE050 and `/data/vendor/SE05x` secure directory for storing Platform SCP03 keys.

7) Follow below instructions to build source code for hikey960:

```
cd ${ROOT_DIR}/android-root
export ANDROID_ROOT=$(pwd)
source build/envsetup.sh
lunch hikey960-userdebug
make -j $(nproc)
```

Note: Based on CPU core, build will take 1-4 hrs.

8) Installing images.

   Follow https://source.android.com/setup/build/devices#960fastboot

9) Flashing images. Follow https://source.android.com/setup/build/devices#960images

   Note: "fastboot" and "adb" are required for flashing images.

10) If modifications are required to hikey kernel (e.g. add/remove device driver), please refer to https://source.android.com/setup/build/devices#960kernel for bulding hikey kernel and follow the instruction given on link to create new bootimage image.

AOSP build environment for iMX8M (coming soon)

To setup Android build environment for iMX8M board please follow below steps

1. The build setup file structure should be like (your${ROOT_DIR} dir):

```
<ROOT-DIR>
|
|------ android-root/
|
|------ simw-top/
```

1) Downloading and building AOSP source code (refer section 3.2.3 : Build your own Android BSP Image from https://www.nxp.com/support/developer-resources/run-time-software/i.mx-developer-resources/evaluation-kit-for-the-i.mx-8m-applications-processor:MCIMX8M-EVK?tab=In-Depth_Tab). In the steps below, `android-root` means `$ROOT_DIR/android-root/`.

2) Setup REPO Tool:

```
mkdir -p ${ROOT_DIR}/android-root
cd ${ROOT_DIR}/android-root

mkdir ~/bin
PATH=~/bin:$PATH
curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo
chmod a+x ~/bin/repo
```

3) Download source code using REPO tool

   Get the Android source code from Google repo using the manifest and script provided inside the imx-o8.1.0_1.3.0_8m.tar.gz (Download package from https://www.nxp.com/support/developer-resources/ run-time-software/i.mx-developer-resources/evaluation-kit-for-the-i.mx-8m-applications -processor:MCIMX8M-EVK?tab=Design_Tools_Tab).

```
source ~/imx-o8.0.0_1.3.0_8mq-prc/imx_android_setup.sh

# By default, the imx_android_setup.sh script will create the source code build␣
↪environment
in the folder ~/android_build

# ${MY_ANDROID} will be refered as the i.MX Android source code root directory in␣
↪all i.MX
Andorid release documentation.

export MY_ANDROID=~/android_build
```

4) Building Android images:

```
cd ${MY_ANDROID}
export ANDROID_ROOT=$(pwd)
source build/envsetup.sh
lunch evk_8mq-userdebug
make -j$(nproc) 2>&1 | tee build-log.txt
```

Note: Based on CPU core, build will take 1-4 hrs.

5) Flashing newly generate images.

   a) The board images can be flashed to the target board by using the MFGTool. The release package includes MFGTool for i.MX 8MQuad EVK in `android_O8.0.0_1.3.0_8M-PRC_tools.tar.gz`. The MFGTool is `mfgtools-mx8mq-beta.zip`.

   b) Unzip the `mfgtools-mx8mq-beta.zip` file to a selected location. The directory is named MFGTool-Dir.

#) Copy following files from `$ROOT_DIR/android-root/out/target/product/evk_8mq` to your `MFGTool-Dir/Profiles/Linux/OS Firmware/files/ android/evk directory.`

```
u-boot-imx8mq.imx
partition-table.img
boot-imx8mq.img
vbmeta-imx8mq.img
system.img
vendor.img.
```

SE050 based Android Keymaster

CMAKE based build system

1. Download Android NDK from https://developer.android.com/ndk/downloads/ and store it in `/usr/local/` eg. `/usr/local/android-ndk-r18b-linux-x86_64`

```
cd /usr/local/
wget http://dl.google.com/android/repository/android-ndk-r18b-linux-x86_64.zip
unzip -d android-ndk-r18b-linux-x86_64 android-ndk-r18b-linux-x86_64.zip
```

2. Once you are able to bring-up Android build environment for `hikey960` follow below steps to build SE050 based android keymaster:

```
cd ${ROOT_DIR}/android-root
export ANDROID_ROOT=$(pwd)
cd ${ROOT_DIR}/simw-top/scripts/android/cmake_based
source board_config.sh hikey960
./setup_script.sh
```

After successful execution you will be able to locate `<simw-top_build>` directory parallel to `simw-top` directory and `simw-akm` directory in `$ROOT_DIR/android-root/system/keymaster`

Note: If the patches are already applied, then instead of calling setup_script.sh, call build_script.sh

3. A batch script `keymaster_flash.bat` will be copied to `$ROOT_DIR/android-root/out/target/product/<BOARD_NAME>`. Execute the batch script to push all the necessary files onto the target board.

AOSP based build system

1. Setup `simw-top` inside `$ROOT_DIR/android-root/vendor/nxp`. If `vendor/nxp` does not exist inside `$ROOT_DIR/android-root` then create the same.
2. Follow below steps to build SE050 based android keymaster.:

```
cd ${ROOT_DIR}/android-root
cp vendor/nxp/simw-top/akm/src/interface_keymaster/patch/aosp/interface_
↪keymaster3.0.patch hardware/interfaces/
cd hardware/interfaces/
patch -p1 < interface_keymaster3.0.patch
cd ${ROOT_DIR}/android-root/vendor/nxp/simw-top
mm -j$(nproc)
cd ${ROOT_DIR}/android-root/hardware/interfaces/keymaster/3.0/default
mm -j$(nproc)
```

3. AKM supports Various Auth Mechanism ,below are the list of supported Auth types:

```
None
PlatfSCP03
UserID
AESKey
ECKey
UserID_PlatfSCP03
AESKey_PlatfSCP03
ECKey_PlatfSCP03
```

4. By default SE05X Authentication is through `None`.For any other Auth type follow below steps:

```
cd ${ROOT_DIR}/android-root/vendor/nxp/simw-top
mm SE05X_Auth=(Auth Type) -j$(nproc)
eg. mm SE05X_Auth=PlatfSCP03 -j$(nproc)
cd ${ROOT_DIR}/android-root/hardware/interfaces/keymaster/3.0/default
mm -j$(nproc)
```

5. After successful build copy `keymaster_flash.bat` located at `$ROOT_DIR/android-root/vendor/nxp/simw-top/scripts/android/aosp_based` to `$ROOT_DIR/android-root/out/target/product/<BOARD_NAME>`. Execute the batch script to push all the necessary files onto the target board.
6. Other way to build SE050 based android keymaster is as follows:

```
cd ${ROOT_DIR}/android-root
export ANDROID_ROOT=$(pwd)
cd ${ANDROID_ROOT}/vendor/nxp/simw-top/scripts/android/aosp_based
source board_config.sh hikey960
./setup_script.sh
```

7. A batch script `keymaster_flash.bat` will be copied to `$ROOT_DIR/android-root/out/target/product/<BOARD_NAME>`. Execute the batch script to push all the necessary files onto the target board.

Extract Secure Element Information

Refer to *SE Platform Information on Android platform*.

Rotate Platform SCP03 Keys

Project `se05xRotatePlatfSCP03` is available to update Platform SCP03 keys on the SE. Build the project with build configuration `SE05X_Auth=PlatfSCP03`. For details about the tool, refer to *SE05X Rotate PlatformSCP Keys Demo*.

After building the project, push the built binary on the android device using `adb` tool and run it from the command line.

How to use own Platform SCP03 Keys

Refer to Section 11.10 *Using own Platform SCP03 Keys* for details on how to use your own Platform SCP03 keys.

Note: Be sure to apply `keymaster_sepolicy.patch` to allow Platform SCP03 keys access to keymaster service.

Retrieve Existing Certificates

Refer to *Get Certificate from the SE*.

Key Attestation

Key attestation support is available for RSA and ECC keys. The attestation keys and certificates need to be pre-injected at the following keyIDs:

```
#define ATTESTATION_KEY_RSA_KEYID 0x00000001
#define ATTESTATION_KEY_ECC_KEYID 0x00000004
#define ATTESTATION_CERTIFICATE_RSA_KEYID 0x00000011
#define ATTESTATION_CERTIFICATE_ECC_KEYID 0x00000014
```

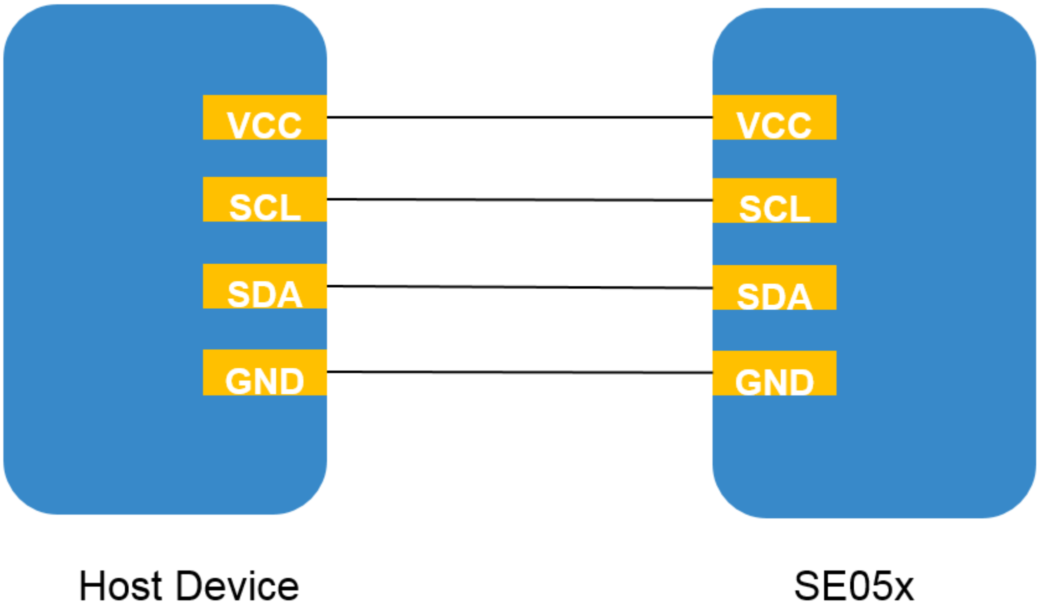
For details on how to inject certificates into SE, refer Section 5.7.20 *Inject Certificate into SE*.

How To Enable Logging

By default, information logs, error logs and warning logs are enabled but debug logs are disabled. To enable debug logs define `NX_LOG_ENABLE_DEFAULT_DEBUG` as 1 in `$ROOT_DIR/simw-top/hostlib/hostLib/libCommon/infra/nxLog_DefaultConfig.h`

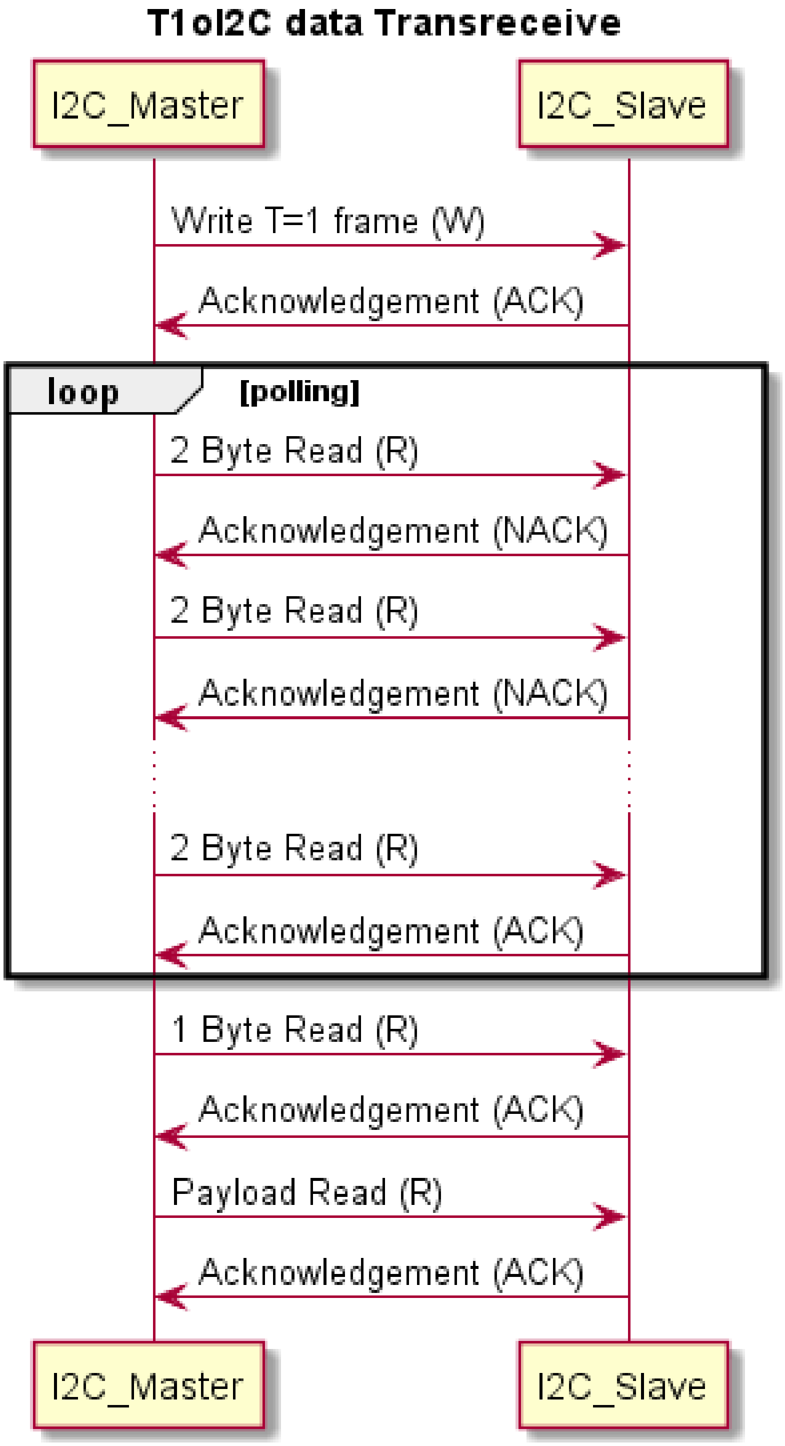
I2C connections with SE05x

1. Below Diagram shows the wiring connection between Host Device and SE05x



I2C data transceive operation

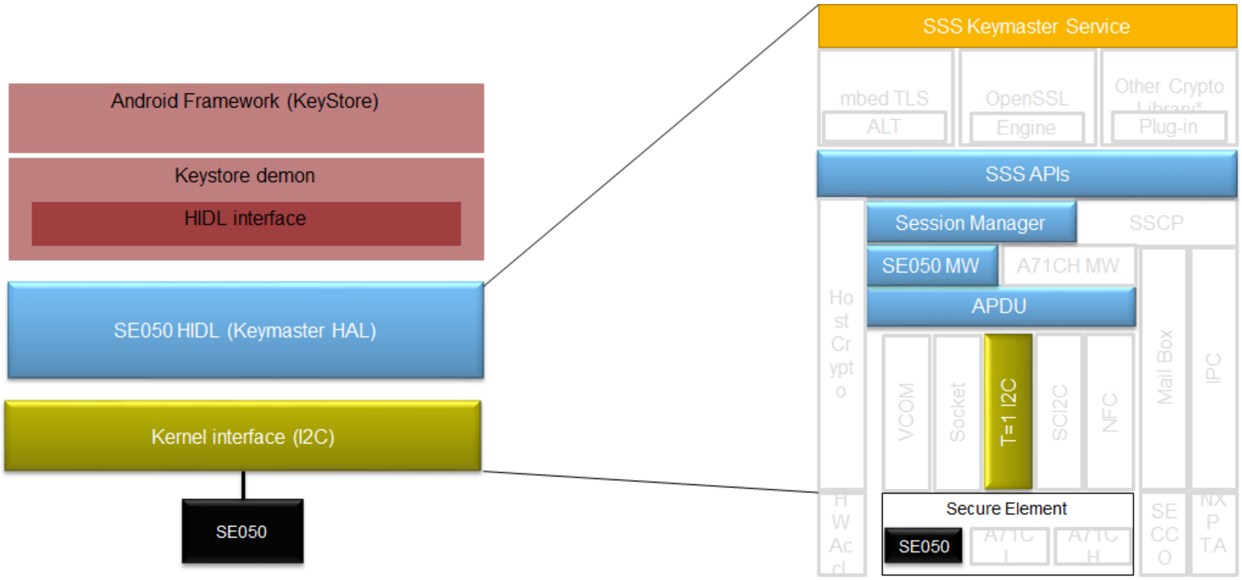
1. The Host Device acts as an I2C_master while SE05x shall be the I2C_slave.
2. HD transmits requested frame from applicaton layer to SE over I2C Bus. SE sends acknowledgement (ACK/NACK) for the received frame.
3. SE processes the recieved frame and prepares the response accordingly. HD polls for Read till the time Response is prepared and sent over I2C bus.
4. Following Diagram demonstrate the same.



Stack with SE050

We use Android Keymaster with SE050 over T=1 I2C. In this setup, we use physical T=1 over I2C Connection to the Applet.

The Architecture looks like this:



Trust Provisioned keys

The trust provisioned SE contains ECC-256 and RSA-2048 keys. These keys are provisioned at specific keyIDs. In order to use these keys, we need to pass a magic number along with the corresponding keyID of the key to the keymaster `import_key` API. Only when the `import_key` parses the key and finds the magic as a part of the key, it returns the key blob of the trust provisioned key.

Using TP RSA key

To use trust provisioned RSA key, pass the key in the following format:

```
modulus:
    a5:a6:b5:b6:a5:a6:b5:b6:xx:xx:xx:xx:xx:xx:xx:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
publicExponent: 65537 (0x10001)
privateExponent:
    A5:23:00:67:02:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
prime1:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
prime2:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
exponent1:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
exponent2:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
coefficient:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
```

Note here that the key modulus starts with the magic `A5:A6:B5:B6:A5:A6:B5:B6` and the privateExponent starts with `A5` followed by the 32-bit keyID (here, 0x23006702) of the trust provisioned RSA keypair. When an RSA key with modulus starting with the magic and privateExponent starting with `A5` is passed to `import_key`, the RSA key stored at the corresponding keyID (0x23006702) is returned. An example of java code to import RSA keypair in this format is:

```
PrivateKey ImportTPKeyRSA() throws NoSuchAlgorithmException,
                InvalidKeySpecException
{
        PrivateKey privKey;
        KeyFactory KeyFac;
        BigInteger Mod, PrivExp, PubExp, PrimeP, PrimeQ, PrimeExpP, PrimeExpQ,␣
↪CrtCoef;
        RSAPrivateCrtKeySpec spec;
        try {
                KeyFac = KeyFactory.getInstance("RSA");
        } catch (NoSuchAlgorithmException e) {
                throw e;
        }
        Random rnd = new Random();
        StringBuffer temp = new StringBuffer(112);
        for(int i=0 ; i<112 ; i++)
        {
                int val = rnd.nextInt(16);
                temp.append(Integer.toString(val, 16));
        }
        StringBuffer buf = new StringBuffer(128);
        String mag = "a5a6b5b6a5a6b5b6";
        buf.append(mag);
        buf.append(temp);
        String mod = buf.toString();

        Mod = new BigInteger(mod, 16);
        PrivExp = new BigInteger("A523006702", 16);        //KeyID in hex at which␣
↪Trust provisioned key is stored
        PubExp = new BigInteger("65537");
        PrimeP = new BigInteger("1");
        PrimeQ = new BigInteger("1");
        PrimeExpP = new BigInteger("1");
        PrimeExpQ = new BigInteger("1");
        CrtCoef = new BigInteger("1");

        // Create a RSA private key spec using components which have the magic and␣
↪keyID
        spec = new RSAPrivateCrtKeySpec(Mod, PubExp, PrivExp, PrimeP, PrimeQ,␣
↪PrimeExpP, PrimeExpQ, CrtCoef);

        try {
                // Generate a dummy keypair using key factory which will be in the␣
↪desired format to export trust provisioned keypair
                privKey = KeyFac.generatePrivate(spec);
        } catch (InvalidKeySpecException e) {
                throw e;
        }

        return privKey;
}


void SetTPKeyRSA(String Label) throws NoSuchAlgorithmException,␣
↪InvalidKeySpecException, KeyStoreException,
                        CertificateException
{
```

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```
        PrivateKey privKey;
        X509Certificate cCert;
        // Dummy RSA certificate to create a keystore entry
        final String cDummyCert =␣
↪"-----BEGIN CERTIFICATE-----\nMIIB9zCCAWCgAwIBAgIEITKMnTANBgkqhkiG9w0BAQsFADA3MRgwFgYDVQQDEw9JbnRl
↪

        try
        {
                privKey = ImportTPKeyRSA();
        }
        catch (Exception e)
        {
                throw e;
        }

        Certificate[] aUseCert;
        aUseCert = new X509Certificate[1];
        CertificateFactory cCertFac;
        InputStream in = new ByteArrayInputStream(cDummyCert.getBytes());
        try {
                cCertFac = CertificateFactory.getInstance("X.509");
        } catch (CertificateException e) {
                throw e;
        }
        aUseCert[0] = (X509Certificate) cCertFac.generateCertificate(in);

        try
        {
                // Store the keypair in keystore with alias=Label and dummy␣
↪certificate chain = aUseCert
                m_cKeyStore.setKeyEntry(Label,(Key) privKey,null ,aUseCert);
        }
        catch (KeyStoreException e)
        {
                throw e;
        }
        return;
}
```

Using TP EC key

To use trust provisioned EC key, pass the key in the following format:

```
priv:
    a5:a6:b5:b6:a5:a6:b5:b6:c3:02:00:01:xx:xx:xx:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
pub:
    xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:xx:....
```

Note here that the private component of the EC keypair contains the magic `A5:A6:B5:B6:A5:A6:B5:B6` followed by the 32-bit keyID (here, 0xC3020001) of the trust provisioned EC keypair. When an EC key with private component starting with the magic is passed to `import_key`, the EC keypair stored at the corresponding keyID (0xC3020001) is returned. An example of java code to import EC keypair in this format is:

```
ECPrivateKey ImportTPKeyECC() throws NoSuchAlgorithmException,
                InvalidKeySpecException,
                InvalidParameterSpecException,
                InvalidAlgorithmParameterException, NoSuchProviderException
{
        ECPrivateKey privKey;
        KeyFactory KeyFac;
        BigInteger PrivS;
        ECParameterSpec ECSpec;
        ECPrivateKeySpec PrivSpec;
        Random rnd = new Random();

        StringBuffer temp = new StringBuffer(40);
        for(int i=0 ; i<40 ; i++)
        {
                int val = rnd.nextInt(16);
                temp.append(Integer.toString(val, 16));
        }

        StringBuffer buf = new StringBuffer(64);
        String mag = "a5a6b5b6a5a6b5b6";
        String keyobject = "c3020001";
        buf.append(mag);
        buf.append(keyobject);
        buf.append(temp);
        String magic = buf.toString();
        PrivS = new BigInteger(magic, 16);
        String cECCCurveName = "secp256r1";
        AlgorithmParameters algSpec = AlgorithmParameters.getInstance("EC");

        try {
                algSpec.init(new ECGenParameterSpec(cECCCurveName));
        } catch (InvalidParameterSpecException e1) {
                e1.printStackTrace();
        }

        ECSpec = algSpec.getParameterSpec(ECParameterSpec.class);
        // Create PrivateKey spec with parameters for curve secp256r1 and private key␣
↪containing the magic and the keyID
        PrivSpec = new ECPrivateKeySpec(PrivS, ECSpec);

        try {
                KeyFac = KeyFactory.getInstance("EC");
        } catch (NoSuchAlgorithmException e) {
                throw e;
        }

        try {
                // Generate a dummy keypair using key factory which will be in the␣
↪desired format to export trust provisioned keypair
                privKey = (ECPrivateKey) KeyFac.generatePrivate(PrivSpec);
        } catch (InvalidKeySpecException e) {
                throw e;
        }

        return privKey;
}
```

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```
void SetTPKeyEC(String Label) throws NoSuchAlgorithmException,␣
↪InvalidKeySpecException, KeyStoreException,
                CertificateException, GeneralSecurityException {
        ECPrivateKey privKey;
        X509Certificate cCert;
        final String cDummyCert = "-----BEGIN CERTIFICATE-----\n" +
                        "MIIBeTCCASCgAwIBAgIJAKtU6mCCLJeyMAoGCCqGSM49BAMCMBExDzANBgNVBAMMBmRlbW9DQTA
↪

        privKey = ImportTPKeyECC();

        Certificate[] aUseCert;
        aUseCert = new X509Certificate[1];
        CertificateFactory cCertFac;
        InputStream in = new ByteArrayInputStream(cDummyCert.getBytes());

        try {
                cCertFac = CertificateFactory.getInstance("X.509");
        } catch (CertificateException e) {
                throw e;
        }
        aUseCert[0] = (X509Certificate) cCertFac.generateCertificate(in);

        try
        {
                // Store the keypair in keystore with alias=Label and dummy␣
↪certificate chain = aUseCert
                m_cKeyStore.setKeyEntry(Label,(Key) privKey,null ,aUseCert);
        }
        catch (KeyStoreException e)
        {
                throw e;
        }

        return;
}
```

11.5.7 MIMXRT1170

See Section 4.3.2 *Importing the Project*.

MIMXRT1170 Boot Mode and Boot Device Settings

Configure on-board switches for QSPI boot mode:

Boot source	SW1				SW2									
QSPI Flash	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Note: Default/Current Settings

Boot Device - QSPI flash

Flash driver - MIMXRT1170_SFDP_QSPI.cfx

11.6 How to get SE Platform Information and UID

Follow any one of the following methods to get the SE platform information.

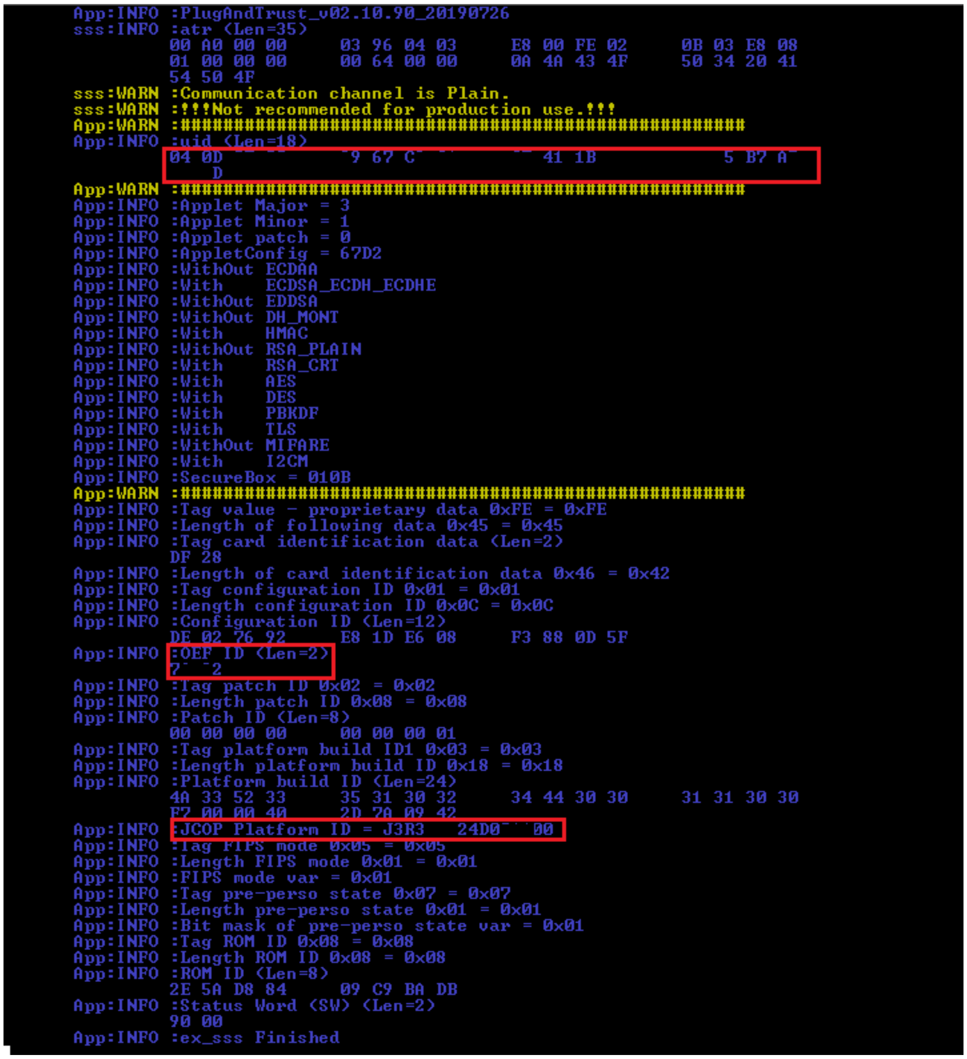
11.6.1 Using TeraTerm and pre-built binary

A pre-built binary for `se05x_GetInfo` is available in `binaries` directory for FRDM-K64F and iMX-RT1060.

You would need to install a serial terminal application, like TeraTerm.

- Install TeraTerm on your system. To setup TeraTerm, refer
- Flash the pre-built binary on your hardware.
- View the logs on TeraTerm.

You would be able to see a log like this:



```
App:INFO :PlugAndTrust_v02.10.90_20190726
sss:INFO :atr (Len=35)
         00 A0 00 00     03 96 04 03     E8 00 FE 02     0B 03 E8 08
         01 00 00 00     00 64 00 00     0A 4A 43 4F     50 34 20 41
         54 50 4F
sss:WARN :Communication channel is Plain.
sss:WARN :!!!Not recommended for production use.!!!
App:WARN :#####################################################
App:INFO :uid (Len=18)
         04 0D            9 67 C                 41 1B                5 B7 A
             D
App:WARN :#####################################################
App:INFO :Applet Major = 3
App:INFO :Applet Minor = 1
App:INFO :Applet patch = 0
App:INFO :AppletConfig = 67D2
App:INFO :WithOut ECDAA
App:INFO :With    ECDSA_ECDH_ECDHE
App:INFO :WithOut EDDSA
App:INFO :WithOut DH_MONT
App:INFO :With    HMAC
App:INFO :WithOut RSA_PLAIN
App:INFO :With    RSA_CRT
App:INFO :With    AES
App:INFO :With    DES
App:INFO :With    PBKDF
App:INFO :With    TLS
App:INFO :WithOut MIFARE
App:INFO :With    I2CM
App:INFO :SecureBox = 010B
App:WARN :#####################################################
App:INFO :Tag value - proprietary data 0xFE = 0xFE
App:INFO :Length of following data 0x45 = 0x45
App:INFO :Tag card identification data (Len=2)
         DF 28
App:INFO :Length of card identification data 0x46 = 0x42
App:INFO :Tag configuration ID 0x01 = 0x01
App:INFO :Length configuration ID 0x0C = 0x0C
App:INFO :Configuration ID (Len=12)
         DE 02 76 92     E8 1D E6 08     F3 88 0D 5F
App:INFO :OEF ID (Len=2)
         7   2
App:INFO :Tag patch ID 0x02 = 0x02
App:INFO :Length patch ID 0x08 = 0x08
App:INFO :Patch ID (Len=8)
         00 00 00 00     00 00 00 01
App:INFO :Tag platform build ID1 0x03 = 0x03
App:INFO :Length platform build ID 0x18 = 0x18
App:INFO :Platform build ID (Len=24)
         4A 33 52 33     35 31 30 32     34 44 30 30     31 31 30 30
         F7 00 00 40     2D 7A 09 42
App:INFO :JCOP Platform ID = J3R3   24D0   00
App:INFO :Tag FIPS mode 0x05 = 0x05
App:INFO :Length FIPS mode 0x01 = 0x01
App:INFO :FIPS mode var = 0x01
App:INFO :Tag pre-perso state 0x07 = 0x07
App:INFO :Length pre-perso state 0x01 = 0x01
App:INFO :Bit mask of pre-perso state var = 0x01
App:INFO :Tag ROM ID 0x08 = 0x08
App:INFO :Length ROM ID 0x08 = 0x08
App:INFO :ROM ID (Len=8)
         2E 5A D8 84     09 C9 BA DB
App:INFO :Status Word (SW) (Len=2)
         90 00
App:INFO :ex_sss Finished
```

The highlighted log is the SE UID, OEF ID and JCOP Platform ID.

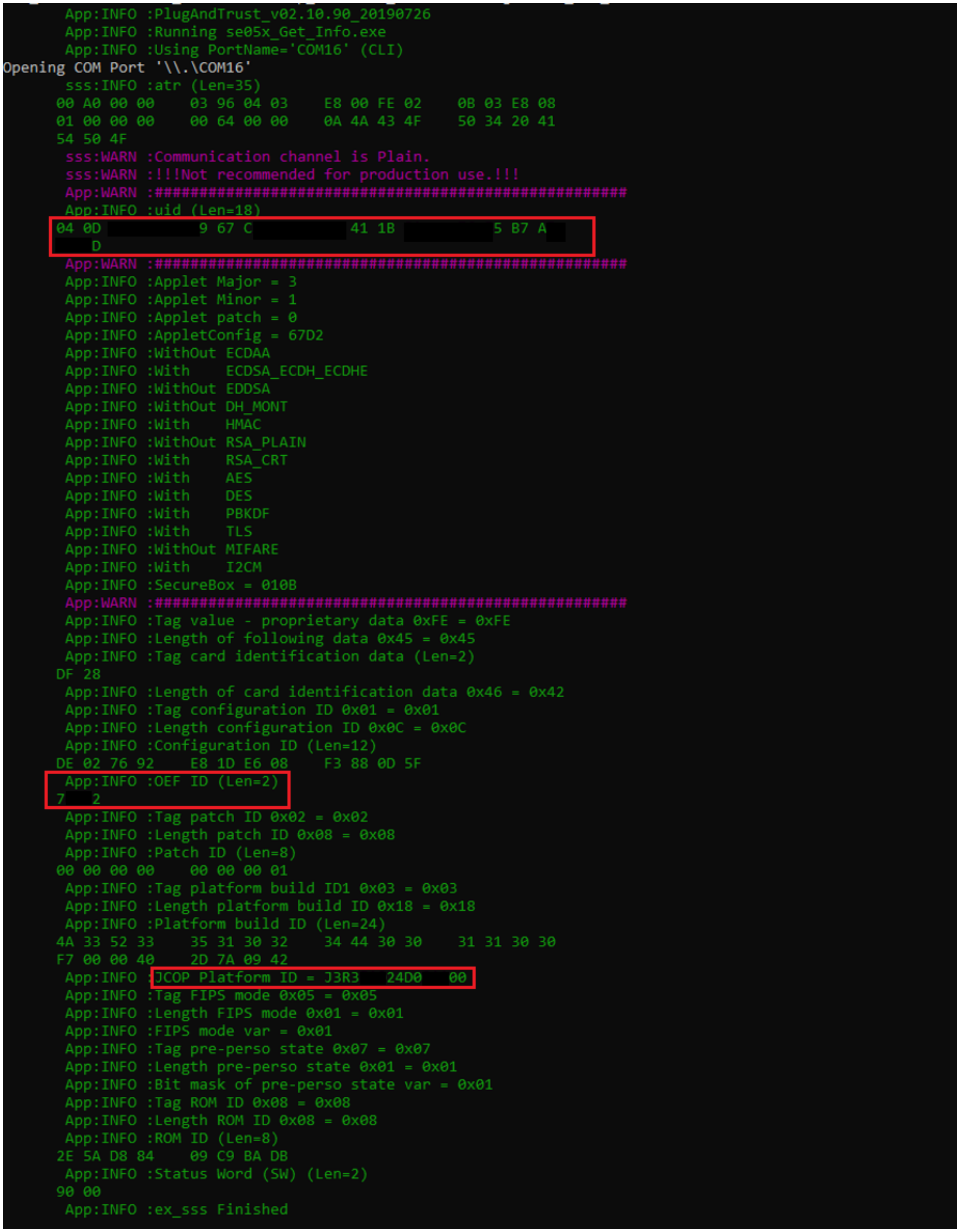
11.6.2 Using VCOM and binary

- Flash VCOM binary present in `binaries` directory accorfing to your board.
- Check VCOM Port number in device manager.
- **Build project `se05x_GetInfo` with the following configuration:**
    - `SMCOM`: `VCOM`
    - `Host`: `PCWindows`
- Run the built binary as:

```
se05x_GetInfo.exe COMxx
```

Where *COMxx* is the VCOM port number obtained from step 2.

You would be able to see a log like this:



```
       App:INFO :PlugAndTrust_v02.10.90_20190726
       App:INFO :Running se05x_Get_Info.exe
       App:INFO :Using PortName='COM16' (CLI)
Opening COM Port '\\.\COM16'
       sss:INFO :atr (Len=35)
      00 A0 00 00    03 96 04 03    E8 00 FE 02    0B 03 E8 08
      01 00 00 00    00 64 00 00    0A 4A 43 4F    50 34 20 41
      54 50 4F
       sss:WARN :Communication channel is Plain.
       sss:WARN :!!!Not recommended for production use.!!!
       App:WARN :#####################################################
       App:INFO :uid (Len=18)
      04 0D [redacted]9 67 C[redacted] 41 1B [redacted]5 B7 A[redacted]
      [redacted]D
       App:WARN :#####################################################
       App:INFO :Applet Major = 3
       App:INFO :Applet Minor = 1
       App:INFO :Applet patch = 0
       App:INFO :AppletConfig = 67D2
       App:INFO :WithOut ECDAA
       App:INFO :With    ECDSA_ECDH_ECDHE
       App:INFO :WithOut EDDSA
       App:INFO :WithOut DH_MONT
       App:INFO :With    HMAC
       App:INFO :WithOut RSA_PLAIN
       App:INFO :With    RSA_CRT
       App:INFO :With    AES
       App:INFO :With    DES
       App:INFO :With    PBKDF
       App:INFO :With    TLS
       App:INFO :WithOut MIFARE
       App:INFO :With    I2CM
       App:INFO :SecureBox = 010B
       App:WARN :#####################################################
       App:INFO :Tag value - proprietary data 0xFE = 0xFE
       App:INFO :Length of following data 0x45 = 0x45
       App:INFO :Tag card identification data (Len=2)
      DF 28
       App:INFO :Length of card identification data 0x46 = 0x42
       App:INFO :Tag configuration ID 0x01 = 0x01
       App:INFO :Length configuration ID 0x0C = 0x0C
       App:INFO :Configuration ID (Len=12)
      DE 02 76 92    E8 1D E6 08    F3 88 0D 5F
       App:INFO :OEF ID (Len=2)
      7[redacted]2
       App:INFO :Tag patch ID 0x02 = 0x02
       App:INFO :Length patch ID 0x08 = 0x08
       App:INFO :Patch ID (Len=8)
      00 00 00 00    00 00 00 01
       App:INFO :Tag platform build ID1 0x03 = 0x03
       App:INFO :Length platform build ID 0x18 = 0x18
       App:INFO :Platform build ID (Len=24)
      4A 33 52 33    35 31 30 32    34 44 30 30    31 31 30 30
      F7 00 00 40    2D 7A 09 42
       App:INFO :JCOP Platform ID = J3R3[redacted]24D0[redacted]00
       App:INFO :Tag FIPS mode 0x05 = 0x05
       App:INFO :Length FIPS mode 0x01 = 0x01
       App:INFO :FIPS mode var = 0x01
       App:INFO :Tag pre-perso state 0x07 = 0x07
       App:INFO :Length pre-perso state 0x01 = 0x01
       App:INFO :Bit mask of pre-perso state var = 0x01
       App:INFO :Tag ROM ID 0x08 = 0x08
       App:INFO :Length ROM ID 0x08 = 0x08
       App:INFO :ROM ID (Len=8)
      2E 5A D8 84    09 C9 BA DB
       App:INFO :Status Word (SW) (Len=2)
      90 00
       App:INFO :ex_sss Finished
```

The highlighted log is the SE UID, OEF ID and JCOP Platform ID.

11.6.3 Using ssscli Tool

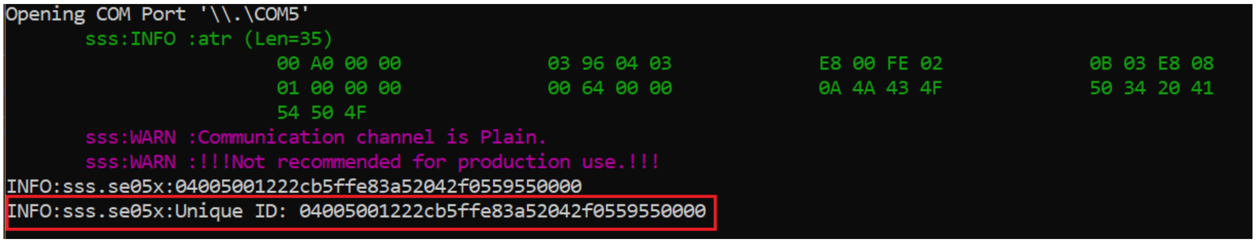
- Flash VCOM binary present in `binaries` directory accorfing to your board.

- Check VCOM Port number in device manager.
- Run the following commands in `binaries/PCWindows/ssscli` directory:

```
ssscli.exe connect se050 vcom COMxx
ssscli.exe se05x uid
ssscli.exe disconnect
```

Where *COMxx* is the VCOM Port number obtained in step 2.

You would be able to see a log like this:



```
Opening COM Port '\\.\COM5'
        sss:INFO :atr (Len=35)
                    00 A0 00 00             03 96 04 03             E8 00 FE 02             0B 03 E8 08
                    01 00 00 00             00 64 00 00             0A 4A 43 4F             50 34 20 41
                    54 50 4F
        sss:WARN :Communication channel is Plain.
        sss:WARN :!!!Not recommended for production use.!!!
INFO:sss.se05x:04005001222cb5ffe83a52042f0559550000
INFO:sss.se05x:Unique ID: 04005001222cb5ffe83a52042f0559550000
```

The highlighted log is the SE UID

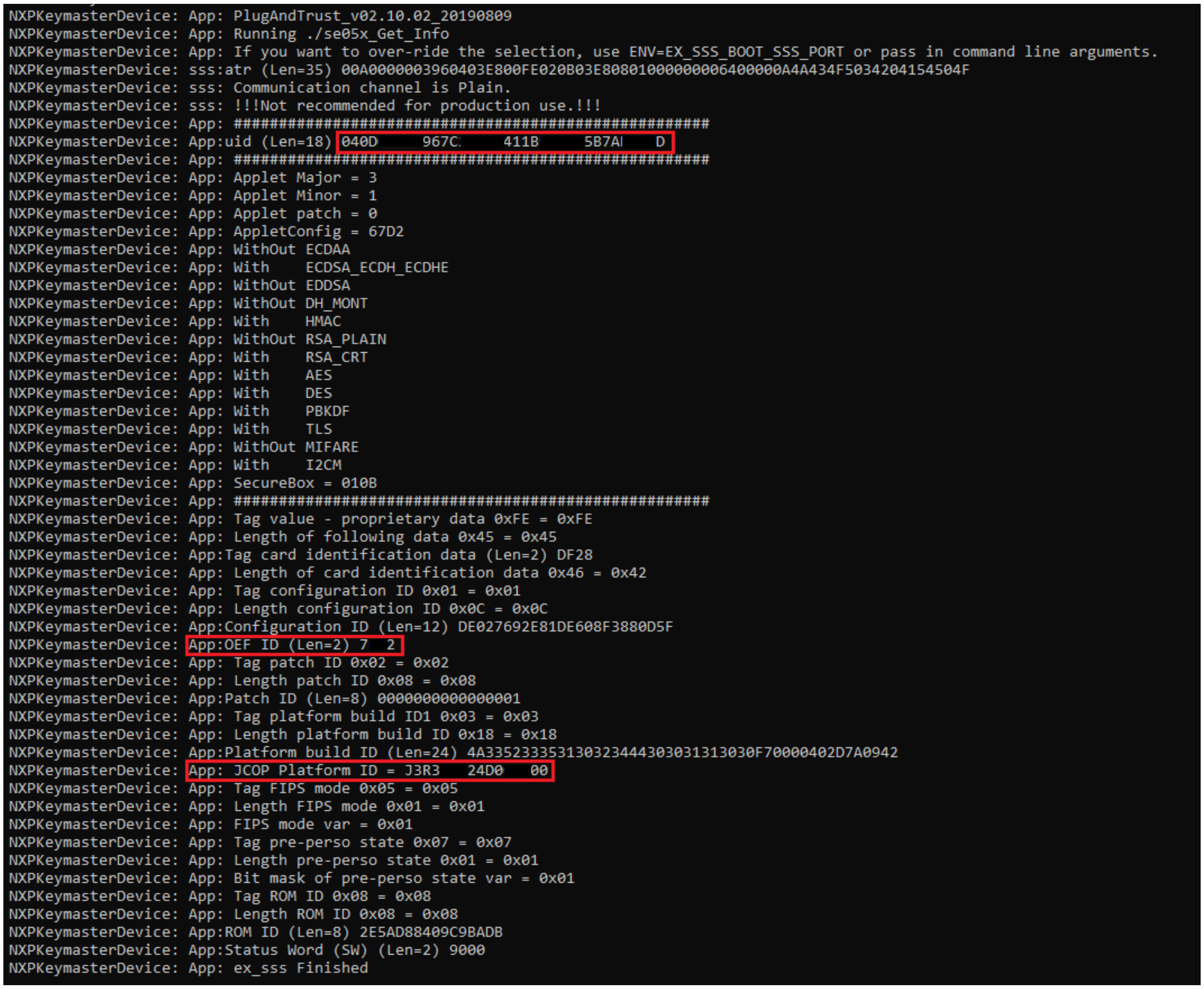
11.6.4 SE Platform Information on Android platform

1. SE will have preconfigured information with which one can verify the functionalities it supports.
2. Follow the steps in *AOSP build Environment Setup* as a pre-requisite.
3. After successful compilation of Android keymaster, `se05xGetInfo.bin` will get generated in `$ROOT_DIR/android-root/out/target/product/<BOARD_NAME>/testcases/se05xGetInfo/arm` and `$ROOT_DIR/android-root/out/target/product/<BOARD_NAME>/testcases/se05xGetInfo/arm64` directories.
4. To get the platform information on Android, follow below steps:

```
adb root && adb wait-for-device && adb remount
adb push testcases/se05xGetInfo/arm/se05xGetInfo   /system/vendor/bin/se05xGetInfo
adb reboot
adb root && adb wait-for-device && adb remount
adb shell
cd system/vendor/bin
./se05xGetInfo
```

5. In `adb logcat | grep "NXPKeymasterDevice"` respected information will be shown.

An example log of SE platform information is given below.



```
NXPKeymasterDevice: App: PlugAndTrust_v02.10.02_20190809
NXPKeymasterDevice: App: Running ./se05x_Get_Info
NXPKeymasterDevice: App: If you want to over-ride the selection, use ENV=EX_SSS_BOOT_SSS_PORT or pass in command line arguments.
NXPKeymasterDevice: sss:atr (Len=35) 00A0000003960403E800FE020B03E80801000000006400000A4A434F5034204154504F
NXPKeymasterDevice: sss: Communication channel is Plain.
NXPKeymasterDevice: sss: !!!Not recommended for production use.!!!
NXPKeymasterDevice: App: #####################################################
NXPKeymasterDevice: App:uid (Len=18) 040D[redacted]967C[redacted]411B[redacted]5B7A[redacted]D
NXPKeymasterDevice: App: #####################################################
NXPKeymasterDevice: App: Applet Major = 3
NXPKeymasterDevice: App: Applet Minor = 1
NXPKeymasterDevice: App: Applet patch = 0
NXPKeymasterDevice: App: AppletConfig = 67D2
NXPKeymasterDevice: App: WithOut ECDAA
NXPKeymasterDevice: App: With    ECDSA_ECDH_ECDHE
NXPKeymasterDevice: App: WithOut EDDSA
NXPKeymasterDevice: App: WithOut DH_MONT
NXPKeymasterDevice: App: With    HMAC
NXPKeymasterDevice: App: WithOut RSA_PLAIN
NXPKeymasterDevice: App: With    RSA_CRT
NXPKeymasterDevice: App: With    AES
NXPKeymasterDevice: App: With    DES
NXPKeymasterDevice: App: With    PBKDF
NXPKeymasterDevice: App: With    TLS
NXPKeymasterDevice: App: WithOut MIFARE
NXPKeymasterDevice: App: With    I2CM
NXPKeymasterDevice: App: SecureBox = 010B
NXPKeymasterDevice: App: #####################################################
NXPKeymasterDevice: App: Tag value - proprietary data 0xFE = 0xFE
NXPKeymasterDevice: App: Length of following data 0x45 = 0x45
NXPKeymasterDevice: App:Tag card identification data (Len=2) DF28
NXPKeymasterDevice: App: Length of card identification data 0x46 = 0x42
NXPKeymasterDevice: App: Tag configuration ID 0x01 = 0x01
NXPKeymasterDevice: App: Length configuration ID 0x0C = 0x0C
NXPKeymasterDevice: App:Configuration ID (Len=12) DE027692E81DE608F3880D5F
NXPKeymasterDevice: App:OEF ID (Len=2) 7[redacted]2
NXPKeymasterDevice: App: Tag patch ID 0x02 = 0x02
NXPKeymasterDevice: App: Length patch ID 0x08 = 0x08
NXPKeymasterDevice: App:Patch ID (Len=8) 0000000000000001
NXPKeymasterDevice: App: Tag platform build ID1 0x03 = 0x03
NXPKeymasterDevice: App: Length platform build ID 0x18 = 0x18
NXPKeymasterDevice: App:Platform build ID (Len=24) 4A335233353130323444303031313030F70000402D7A0942
NXPKeymasterDevice: App: JCOP Platform ID = J3R3[redacted]24D0[redacted]00
NXPKeymasterDevice: App: Tag FIPS mode 0x05 = 0x05
NXPKeymasterDevice: App: Length FIPS mode 0x01 = 0x01
NXPKeymasterDevice: App: FIPS mode var = 0x01
NXPKeymasterDevice: App: Tag pre-perso state 0x07 = 0x07
NXPKeymasterDevice: App: Length pre-perso state 0x01 = 0x01
NXPKeymasterDevice: App: Bit mask of pre-perso state var = 0x01
NXPKeymasterDevice: App: Tag ROM ID 0x08 = 0x08
NXPKeymasterDevice: App: Length ROM ID 0x08 = 0x08
NXPKeymasterDevice: App:ROM ID (Len=8) 2E5AD88409C9BADB
NXPKeymasterDevice: App:Status Word (SW) (Len=2) 9000
NXPKeymasterDevice: App: ex_sss Finished
```

The highlighted log is the SE UID, OEF ID and JCOP Platform ID.

11.7 Version Information

Item	Version Number
Release Version	`v04.02.00_20220630`
Middleware	`v04.02.00_20220630`
SSS APIs	`v04.02.00_20220630`
Demos and Use Cases	`v02.22.00_20220630`
JCOP	Platform ID J3R351021E950400
SE050 Applet	03.01
A71CH Applet	`1.3`

11.8 Certificate Chains

11.8.1 SE050 Certificate Chains

Certificate Chains : ROOT

The directory `demos/Certificate_Chains/ROOT` contains RootCA and Intermediate Certificates used in various configurations of SE050. More information on these certificates can be found in the application note on SE050 configurations: AN12436

ECC

This directory contains the ECC chain of trust for cloud on-boarding.

ROOT CA

The file `IOT_NXP-01-CERT_IOT_CA_KEY-IoTRootCAvE305-01-20190320162439-EC_SEC_P384R1-4B7E5A.crt` contains ROOT CA.

```
-----BEGIN CERTIFICATE-----
MIIB1jCCAVmgAwIBAgIBATAMBggqhkjOPQQDAwUAMEExFzAVBgNVBAsMDlBsdWcg
YW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2RTMw
NTAeFw0xOTAzMjAxNTI2MDRaFw0zNzAzMjAxNTI2MDRaMEExFzAVBgNVBAsMDlBs
dWcgYW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2
RTMwNTB2MBAGByqGSM49AgEGBSuBBAAiA2IABNRrkWrw7iwM3oTw1Ay8I1yzOF+g
OTNFzqfn/93N1xcK8kNEA8wNuuVjzsDXKHx7O1jrGZfy7YLjKYTwZR5wURXrE7lp
PIwwdWE3OokTmhiMiFXnzSgSHCgtb+VF6nv76aMjMCEwDwYDVR0TAQH/BAUwAwEB
/zAOBgNVHQ8BAf8EBAMCAQYwDAYIKoZIzj0EAwMFAANpADBmAjEA7cCFz6PcBHKi
HRtbE3qi0Lj9iqxe8/2w8XrLclAYhpMzZOQC05j3ZmgJ22B1bLk3AjEAhVnhuawO
Zh1Jqwf7zySh/rNJezFhGTyHAjQ9tTfY9eZAdc25feEN4j/Ad+7TF1Rg
-----END CERTIFICATE-----
```

Intermediate CA

The file `IOT_NXP-01-CERT_IOT_4LAYER_CA_KEY-IoTInt4LAYERCAvE205-01-20190320164314-EC_SEC_P256R1` `crt` contains the Intermediate CA.

```
-----BEGIN CERTIFICATE-----
MIIByjCCAU6gAwIBAgIBBDAMBggqhkjOPQQDAgUAMEExFzAVBgNVBAsMDlBsdWcg
YW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2RTMw
NTAeFw0xOTAzMjAxNTQyNTRaFw0zNDAzMjAxNTQyNTRaMFAxFzAVBgNVBAsMDlBs
dWcgYW5kIFRydXN0MQwwCgYDVQQKDANOWFAxJzAlBgNVBAMMHk5YUCBJbnRlcm1l
ZGlhdGUtNExheWVyQ0F2RTIwNTBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABO+d
HK3Oa4FnkKN9/1JQpR2KarpxmwNRaEG6Zb+kzTwnXRw4Cvknd8IAcjXHqb93VfX5
```

(continues on next page)

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```
rO+4MjX/gzqYagJByWejJjAkMBIGA1UdEwEB/wQIMAYBAf8CAQEwDgYDVR0PAQH/
BAQDAgEGMAwGCCqGSM49BAMCBQADaAAwZQIxAPvXuvlW+zkSBbz0NyyzpgFP1rCj
IZOHpfZhaERw/DEj+4aAESa5vgtiR3CspIP5pAIwRsD1Z9fdBnPSlaVMmNAXjAlZ
FPhbV7A0OXydSYhI8M5uTENrdqzvsYYr2jfqIEcp
-----END CERTIFICATE-----
```

RSA

This directory contains the RSA chain of trust for cloud on-boarding.

ROOT CA

The file `IOT_NXP-01-CERT_IOT_CA_KEY-IoTRootCAvR406-01-20190425163255-RSA4096-BAB872.crt` contains the ROOT CA.

```
-----BEGIN CERTIFICATE-----
MIIFIDCCAwigAwIBAgIBATANBgkqhkiG9w0BAQwFADBBMRcwFQYDVQQLDA5QbHVn
IGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENBdlI0
MDYwHhcNMTkwNDI1MTQzMzAzWhcNMzcwNDI1MTQzMzAzWjBBMRcwFQYDVQQLDA5Q
bHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENB
dlI0MDYwggIiMA0GCSqGSIb3DQEBAQUAA4ICDwAwggIKAoICAQCwRBRveWxzoVln
bFOWxhjFmX6hqPBB5o7pOVVGqvvdkSvcdZh7+hozTPzI7d5eCJWtiIYZ4xUXxiP8
MttIsssT4yrZjpSy2qTWbn5T/lB7a2e/A5JTGUcX05/uFATfZTs2pcoUydB68PnB
LVsS8i1atpxN4Tiy5NPchWM2mL7YwoKJxCNgZFs5WYxvm4OSOhMy7rAF010ujy1k
6L/XydcSv48G6ZlpCYH8Tn5cV7UEuNWpgq+0Wgpz6xz/ZHyfTxKhuBtj4eh3GyDv
Fmt1L1hJT/k17+Q19rW3U7OBV5w8ehuLoRNsNzG2zc9rFHlK9pVX9DRZQKI5XNoh
1he7oSxJFkjsLn27w0fOHraOaefrYuOrbKDA/X+cJzyKOvxWNhVyFRryn2iO58Wa
HuBqja7fnubexMP1Mr2b/hZVllSPmFVDk+Bl7VXpvC/tYXEqlSK1Tj/1gZ5tpmpm
SBBqcHsp0YQEkNLAnG+K9sFOKamf1Yt0IO/iyoYPUQ5IV644pOiztO2myFrT04+K
Pwi+XwoRBVSK/WrI5vy16HzAJqPP1Nb6QKdOe1Q+NwNMyUySFzHavd3L4XaiNP4Z
iPgjSG/me8ozcPTFR29eibPl7p9YlhocmU4g2UURStVL0cpdOrc36BEv6DQ6RN4H
7N9VM9AIP+lO47argR+ciYzkY+Xd+wIDAQABoyMwITAPBgNVHRMBAf8EBTADAQH/
MA4GA1UdDwEB/wQEAwIBBjANBgkqhkiG9w0BAQwFAAOCAgEAQsNB0/011ELP5rHN
rk9+sTh+Mr6Ye7geTYT1QRCCpLuyUuyc3O5ldSOKP3RorsNYD/aCJGhHDvh0ofyj
ykx5lre2+b2foSVg+ZjQQf3qju+7bqh3tW1dD2bI49+yRoCIplJZQ8V91ReH+33k
TzYNv/tvzYxnF8AF7wJ93zyafXJvIQ6AUnVoDdgtN203M853jxavjZHSVjTQXaR0
LwYCcNiE+bE2Z4owjerG3QAVG/ju8Xz+bhOFRy/+M1iblF8KGZRzSA0E0ijMhhfZ
ZIP6eXjWWaoL+9iqD8F8/IXxW2zH37IzOTB6s2xcSFvjGbzVJ7CHy8/c4OQEoZpi
gujcPF5axOpI2RSnUPX+YFyu3od5URS3ybo9aT7b1CLURkjbhcGHCo04NL3h6Zg1
G2ktasOCL3moypWY0EYNwrHKyccVY3VVR1H89P03qQf5uUAADFcrpZ8lB7yPylmt
4qcZfbACzUt3O0UzUI1VDyHL6NcTw/1Da26aGKZMseHan6xESDpiHMC5efv4Xd7U
k+bVedNwTKooDZn1K5WKTiZ3nUcSRAhdmiaQrAb6lKYEcDxRK5VPtr/MU6cL2PKZ
m9oZ0hnfB5EbYJH4tWAite7j5kMrtOltT+woeWP/dSmDg31ZCBmc3Sx0NaUl2jQZ
2vnNPomcaE8BkvyrhEPkSw/VXTw=
-----END CERTIFICATE-----
```

Intermediate CA

The file `IOT_NXP-01-CERT_IOT_4LAYER_CA_KEY-IoTInt4LayerCAvR406-01-20190425163534-RSA4096-540F1` `crt` contains the intermediate CA.

```
-----BEGIN CERTIFICATE-----
MIIFMjCCAxqgAwIBAgIBAjANBgkqhkiG9w0BAQwFADBBMRcwFQYDVQQLDA5QbHVn
IGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENBdlI0
MDYwHhcNMTkwNDI1MTQzNTA5WhcNMzQwNDI1MTQzNTA5WjBQMRcwFQYDVQQLDA5Q
bHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAgSW50ZXJt
ZWRpYXRlLTRMYXllckNBdlI0MDYwggIiMA0GCSqGSIb3DQEBAQUAA4ICDwAwggIK
AoICAQCyji2V12sVG7PQNJ8uzYSVA+cSCDvP/pCqvcA8ulaVuTfjLQVkRejPeRUO
549JKWvE/3l8mW1mUApFcKOq1ud6/W9iFgKHDvPwKkOHlmiIdHiOEHCu2Qr7EnKH
jMD5M/dhqwZdRxlojiMnEw7pt4x2gdndZQQFO5eHIBb/SIgeeUVreYnjRTfTRqqV
oZfYPV09IYx4Lm1lFcCgODpn55TSIYvE8fGqGTM+J3+Q0g47N6Uve3SGdjL7aese
wGb6EPqGUqaSGLOgKy/L0KlgnVZXOeidFJjOe5QsKUQgWbCExcLObR2a3XZbIwXq
dq+ED1ovhrRDHH5VDRgK4+7WCFy6wQD9PPIy8WioXsCV2XCSixAM6XhWUYkLignp
30Yy5tzKhbCpyxe84ZM3sZG/PAojVAbwpVpjm/px3N8jdQ/hE1eVgaoyTX0Pn9We
tXRQkUEBluOm3Czaw1YN1E5LWpP8hYhWTMPVnfxlZ/R3rdswiWaA2+knWJCXkdsk
Kle8h4xNB0e0ZAzulEXh9JROsOqZUuh0+sGwPsw13p4KqauBzSG77tos1e4xp9AI
9P7JcnRsEeNjgTvbjBxISlQdHW3FCnud7hM/OoTbGojwB3CHPIoIJmWCW7ci6beD
DUwOo2CfjZ+FlQErar2XarQrPLdSFTd+lJJqUy+tiNoWPJafYQIDAQABoyYwJDAS
BgNVHRMBAf8ECDAGAQH/AgEBMA4GA1UdDwEB/wQEAwIBBjANBgkqhkiG9w0BAQwF
AAOCAgEAW0JtZaJCEbm4+DmYa32WNvqjjxgdmRHjkJtfv+wkt0Kz71MHG0qSQBHH
UkVOkBFm/wjF+lH+/7X9ZdiFsO3b9P2JXHg1PXgU9NvtuYZBAsiy0VRxVSukp+JH
7biOFNx5nwerYv9C1JG2VRPr+JzDUP1/QV9XCFtQVnpyfm/pETLghOwaNq4Yjzg+
MxLw4sWsJL5DZrG2/jViHhogoCnXz1rFVWFI1BBvEbKnthYUxqL+Xc4vWCYLvMHc
LbZMGef05HrcPWtAS13y8qpat5MGRXDjgFqGUyoaPoxRya4dOexjw369aV/YAIsx
wgtAiWrvL4UPOUGopCMac4GEbpPA60XHmSVXyR+CCKyLwLD7rRR8Vpk5cUM2jvxI
5NMP17Wa+QD4jp8sWsSebI83+qL/0TdWgRbD/FW2igrR0ird8wgQcIhtCrJCdYMT
MjRtJc4m/iJ+OH2KaryxQi8oEkB3onsIZXvSNgXvTp4SkLw9pPheEwSKVvbo1DoF
QB4ek6ynjWGgoaHl5tx2i+tRH+mEP7+Ccw32HdX+xo8BYvMaBXJI8M5rem7k4PsQ
tLNjn9CN0FPT8j2ksk8jMi4s/c9EHY5NYNgjTG6MQ3eSS1QaoVYPi4NCDe2KWP2k
ooGZMUlICfXbP86zQz5xBJvd/+Rmdn+mvLoabzmFVPS9E1yH6fE=
-----END CERTIFICATE-----
```

Note: The certificates shown here were last Updated on June 18, 2019 in this page/document.

Certificate Chains : DEV Kit

Certificates for the DEV Kit / Ease Of Use Configuration.

- *Certificate Chain for SE050*
  - *Intermediate CA : ECC*
  - *Intermediate CA : RSA*

Certificate Chain for SE050

The directory `demos/Certificate_Chains/0004_A1F4` contains Intermediate Certificates used in Dev Kit configurations. It is signed by *Certificate Chains : ROOT*. More information on these certificates can be found in the application note on SE050 configurations: AN12436

Intermediate CA : ECC

The file `CloudConn-Intermediate-ECC_OEF_A1F4.crt` is certificate used for Dev Kit configuration.

```
-----BEGIN CERTIFICATE-----
MIIBujCCAWGgAwIBAgIKBABQAQAEofQAADAKBggqhkjOPQQDAjBQMRcwFQYDVQQL
DA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAgSW50
ZXJtZWRpYXRlLTRMYXllckNBdkUyMDUwHhcNMTkwNjE4MDAwMDAwWhcNMzQwNjE0
MDAwMDAwWjBdMRcwFQYDVQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQ
MTQwMgYDVQQDDCtDbG91ZENvbm4tSW50ZXJtZWRpYXRlLTA0MDA1MDAxMDAwNEEx
RjQtRUNDMFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAENi7KN2Z6tbFuhjRrqgHb
xzUWSCUrdPmFP8xpsIOEHM8WJPvj8D+MCeu6Y2WU/ILhxp1Y3TJ2hGZtV4foO3pq
NqMWMBQwEgYDVR0TAQH/BAgwBgEB/wIBADAKBggqhkjOPQQDAgNHADBEAiB0waPl
4dcbmqbLUfQRscoPVzSeqT2dfdwg0W0g/FlaPgIgS2ppnaRASzc5rCOeVk5AeMb2
j7IKeHDyeMRP0wlaptU=
-----END CERTIFICATE-----
```

Intermediate CA : RSA

The file `CloudConn-Intermediate-RSA_OEF_A1F4.crt` is certificate used for Dev Kit configuration.

```
-----BEGIN CERTIFICATE-----
MIIFRzCCAy+gAwIBAgIKBABQAQAEofQAADANBgkqhkiG9w0BAQsFADBQMRcwFQYD
VQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAg
SW50ZXJtZWRpYXRlLTRMYXllckNBdlI0MDYwHhcNMTkwNjE4MDAwMDAwWhcNMzQw
NjE0MDAwMDAwWjBdMRcwFQYDVQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwD
TlhQMTQwMgYDVQQDDCtDbG91ZENvbm4tSW50ZXJtZWRpYXRlLTA0MDA1MDAxMDAw
NEExRjQtUlNBMIICIjANBgkqhkiG9w0BAQEFAAOCAg8AMIICCgKCAgEAzkNa+y5n
9CQK9Aw4F1Lrml7chE3CBFgnp49OSNII0mI2G/YmhI2zotydqIpl7Wk+gJd1wpQM
rKuh2RmLihoIyLmuuOVxKbnlTw35tshiIj48IinJ7G6n4x7SmU2kHjPqsjdF4ncp
VK6IcXoNQ+zteN8/q5Pcbmozo+UriUhLGdu6By/Z3+BseTsNYJhouIzN8CwZ1h+r
LRgjpiodrwHE0jVbe74Fqjcb7TEqACHZNEaCHlfnSs4BaiiMOSMGGGhGrPMHxb0z
VHESsJGZ3aa7xzFakoP6hNz6m82q14WYMMM/2fbuOh2mIgrEexz22zTGsG1a3+wt
uy46QVCivEMwsMDYzOjocO1CbAsRUfT9pbzdKVXt5qAPpIQLxOzSkgDuOw5N/jdN
Kmt/sa7gh8uRqnQVvzjKsmDg0TqolPuTrt2tS37lMw1yKToAeo09w/HkMb6CF7GB
EgTTnob1MGUpJRdk9MM/PMil5tsXT30GlMVcXoRDk6y9nBsxLAPzBC3SQajmk6T1
KWPgBlrjNIFmkosCKQPPznlcdygpbCKHeRt29X+TsQq12tDTHMUTdG5NWJ/6gPEk
2url2J2iEF9LaAu3dM5aKfLauoyvKeN1Z6FUBVQz9PgLRrcCR52eiUn6AOR9gZZN
Lozp/uQQU+CBMw0daEBI7+xethA9F426CCMCAwEAAaMWMBQwEgYDVR0TAQH/BAgw
BgEB/wIBADANBgkqhkiG9w0BAQsFAAOCAgEAJLw+RCn/qhLVPni7NwkTfi69bnrF
jE6nhhgveleZ71xUPu3Jdd+swgfdZmKDnUfrr4mQJ2l/rj2Z4yx7WA7Cy3IjG52d
9A9/jrqUN8T9AmqdME9e4rwTmjzCtKx91yFex+jcisJphcc6zkoDmp/XaumXi9GW
M+J0laY+hj6nw9BWbd/wGDxe2mzBjdWNtP8jb3CKuqJQexWB5pjNUnexdJSDFVXs
Hf0NYtolzK7dh+/GMUfdTCX/8g3hN2Won1DD6/fTXdgCSXExaBz0EhsethdFb3y6
vR+MvngMoZhbyGH5VzQ2sESo9vGzfPSiM8mHvjaV++hDduVEpdoxSE/C8TdNpUZ7
Lh6E1JYcUbDE2VV93/dYaiM5Cag/SuKG/8phZ3g9eXT9oPmOEtKXg9bdMJoNwJ0N
LiAW3eFdBBmDGB/6D5vSOD3YkPhtBUIC+/9vBL0KNx9V9/4xWZAnmTtjLfYLoyst
IE5Qnr0TpqZ123+Tvj9X7ulNUuu7MMHtiAs2SKM9iWMXAd/UW6Vq5x7SKjQ7b6FQ
vCn/CAZn9uV4ixwDzbIoQV+4ps9QuyqVGJbtqEctxYo896ulTeJAFyiPnfeF1WdM
gPmab4mVjTyikESCtSkM2nNYVkQQ5ANHfEQ8XVoRsdJmp3rMl6MD1n1zjfSyEHrQ
lXL23wm/K2UEOfw=
-----END CERTIFICATE-----
```

Note: The certificates shown here were last Updated on June 18, 2019 in this page/document. These certificate chains are only for Dev Kit configuration (OEF A1F4).

11.8.2 SE051 Certificate Chains

Certificate Chains : ROOT

The directory `demos/Certificate_Chains/ROOT` contains RootCA and Intermediate Certificates used in various configurations of SE051. More information on these certificates can be found in the application note on SE051 configurations: AN12973

ECC

This directory contains the ECC chain of trust for cloud on-boarding.

ROOT CA

The file `RootCAvE305.crt` contains ROOT CA.

```
-----BEGIN CERTIFICATE-----
MIIB1jCCAVmgAwIBAgIBATAMBggqhkjOPQQDAwUAMEExFzAVBgNVBAsMDlBsdWcg
YW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2RTMw
NTAeFw0xOTAzMjAxNTI2MDRaFw0zNzAzMjAxNTI2MDRaMEExFzAVBgNVBAsMDlBs
dWcgYW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2
RTMwNTB2MBAGByqGSM49AgEGBSuBBAAiA2IABNRrkWrw7iwM3oTw1Ay8I1yzOF+g
OTNFzqfn/93N1xcK8kNEA8wNuuVjzsDXKHx7O1jrGZfy7YLjKYTwZR5wURXrE7lp
PIwwdWE3OokTmhiMiFXnzSgSHCgtb+VF6nv76aMjMCEwDwYDVR0TAQH/BAUwAwEB
/zAOBgNVHQ8BAf8EBAMCAQYwDAYIKoZIzj0EAwMFAANpADBmAjEA7cCFz6PcBHKi
HRtbE3qi0Lj9iqxe8/2w8XrLclAYhpMzZOQC05j3ZmgJ22B1bLk3AjEAhVnhuawO
Zh1Jqwf7zySh/rNJezFhGTyHAjQ9tTfY9eZAdc25feEN4j/Ad+7TF1Rg
-----END CERTIFICATE-----
```

Intermediate CA

The file `Intermediate-4LayerCAvE205.crt` contains the Intermediate CA.

```
-----BEGIN CERTIFICATE-----
MIIByjCCAU6gAwIBAgIBBDAMBggqhkjOPQQDAgUAMEExFzAVBgNVBAsMDlBsdWcg
YW5kIFRydXN0MQwwCgYDVQQKDANOWFAxGDAWBgNVBAMMD05YUCBSb290Q0F2RTMw
```

(continues on next page)

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```
NTAeFw0xOTAzMjAxNTQyNTRaFw0zNDAzMjAxNTQyNTRaMFAxFzAVBgNVBAsMDlBs
dWcgYW5kIFRydXN0MQwwCgYDVQQKDANOWFAxJzAlBgNVBAMMHk5YUCBJbnRlcm1l
ZGlhdGUtNExheWVyQ0F2RTIwNTBZMBMGByqGSM49AgEGCCqGSM49AwEHA0IABO+d
HK3Oa4FnkKN9/1JQpR2KarpxmwNRaEG6Zb+kzTwnXRw4Cvknd8IAcjXHqb93VfX5
rO+4MjX/gzqYagJByWejJjAkMBIGA1UdEwEB/wQIMAYBAf8CAQEwDgYDVR0PAQH/
BAQDAgEGMAwGCCqGSM49BAMCBQADaAAwZQIxAPvXuvlW+zkSBbz0NyyzpgFP1rCj
IZOHpfZhaERw/DEj+4aAESa5vgtiR3CspIP5pAIwRsD1Z9fdBnPSlaVMmNAXjAlZ
FPhbV7A0OXydSYhI8M5uTENrdqzvsYYr2jfqIEcp
-----END CERTIFICATE-----
```

RSA

This directory contains the RSA chain of trust for cloud on-boarding.

ROOT CA

The file `RootCAvR406.crt` contains the ROOT CA.

```
-----BEGIN CERTIFICATE-----
MIIFIDCCAwigAwIBAgIBATANBgkqhkiG9w0BAQwFADBBMRcwFQYDVQQLDA5QbHVn
IGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENBdlI0
MDYwHhcNMTkwNDI1MTQzMzAzWhcNMzcwNDI1MTQzMzAzWjBBMRcwFQYDVQQLDA5Q
bHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENB
dlI0MDYwggIiMA0GCSqGSIb3DQEBAQUAA4ICDwAwggIKAoICAQCwRBRveWxzoVln
bFOWxhjFmX6hqPBB5o7pOVVGqvvdkSvcdZh7+hozTPzI7d5eCJWtiIYZ4xUXxiP8
MttIsssT4yrZjpSy2qTWbn5T/lB7a2e/A5JTGUcX05/uFATfZTs2pcoUydB68PnB
LVsS8i1atpxN4Tiy5NPchWM2mL7YwoKJxCNgZFs5WYxvm4OSOhMy7rAF010ujy1k
6L/XydcSv48G6ZlpCYH8Tn5cV7UEuNWpgq+0Wgpz6xz/ZHyfTxKhuBtj4eh3GyDv
Fmt1L1hJT/k17+Q19rW3U7OBV5w8ehuLoRNsNzG2zc9rFHlK9pVX9DRZQKI5XNoh
1he7oSxJFkjsLn27w0fOHraOaefrYuOrbKDA/X+cJzyKOvxWNhVyFRryn2iO58Wa
HuBqja7fnubexMP1Mr2b/hZVllSPmFVDk+Bl7VXpvC/tYXEqlSK1Tj/1gZ5tpmpm
SBBqcHsp0YQEkNLAnG+K9sFOKamf1Yt0IO/iyoYPUQ5IV644pOiztO2myFrT04+K
Pwi+XwoRBVSK/WrI5vy16HzAJqPP1Nb6QKdOe1Q+NwNMyUySFzHavd3L4XaiNP4Z
iPgjSG/me8ozcPTFR29eibPl7p9YlhocmU4g2UURStVL0cpdOrc36BEv6DQ6RN4H
7N9VM9AIP+lO47argR+ciYzkY+Xd+wIDAQABoyMwITAPBgNVHRMBAf8EBTADAQH/
MA4GA1UdDwEB/wQEAwIBBjANBgkqhkiG9w0BAQwFAAOCAgEAQsNB0/011ELP5rHN
rk9+sTh+Mr6Ye7geTYT1QRCCpLuyUuyc3O5ldSOKP3RorsNYD/aCJGhHDvh0ofyj
ykx5lre2+b2foSVg+ZjQQf3qju+7bqh3tW1dD2bI49+yRoCIplJZQ8V91ReH+33k
TzYNv/tvzYxnF8AF7wJ93zyafXJvIQ6AUnVoDdgtN203M853jxavjZHSVjTQXaR0
LwYCcNiE+bE2Z4owjerG3QAVG/ju8Xz+bhOFRy/+M1iblF8KGZRzSA0E0ijMhhfZ
ZIP6eXjWWaoL+9iqD8F8/IXxW2zH37IzOTB6s2xcSFvjGbzVJ7CHy8/c4OQEoZpi
gujcPF5axOpI2RSnUPX+YFyu3od5URS3ybo9aT7b1CLURkjbhcGHCo04NL3h6Zg1
G2ktasOCL3moypWY0EYNwrHKyccVY3VVR1H89P03qQf5uUAADFcrpZ81B7yPylmt
4qcZfbACzUt3O0UzUI1VDyHL6NcTw/1Da26aGKZMseHan6xESDpiHMC5efv4Xd7U
k+bVedNwTKooDZn1K5WKTiZ3nUcSRAhdmiaQrAb6lKYEcDxRK5VPtr/MU6cL2PKZ
m9oZ0hnfB5EbYJH4tWAite7j5kMrtOltT+woeWP/dSmDg31ZCBmc3Sx0NaUl2jQZ
2vnNPomcaE8BkvyrhEPkSw/VXTw=
-----END CERTIFICATE-----
```

Intermediate CA

The file `Intermediate-4LayerCAvR406.crt` contains the intermediate CA.

```
-----BEGIN CERTIFICATE-----
MIIFMjCCAxqgAwIBAgIBAjANBgkqhkiG9w0BAQwFADBBMRcwFQYDVQQLDA5QbHVn
IGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMRgwFgYDVQQDDA9OWFAgUm9vdENBdlI0
MDYwHhcNMTkwNDI1MTQzNTA5WhcNMzQwNDI1MTQzNTA5WjBQMRcwFQYDVQQLDA5Q
bHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAgSW50ZXJt
ZWRpYXRlLTRMYXllckNBdlI0MDYwggIiMA0GCSqGSIb3DQEBAQUAA4ICDwAwggIK
AoICAQCyji2V12sVG7PQNJ8uzYSVA+cSCDvP/pCqvcA8ulaVuTfjLQVkRejPeRUO
549JKWvE/3l8mW1mUApFcKOq1ud6/W9iFgKHDvPwKkOHlmiIdHiOEHCu2Qr7EnKH
jMD5M/dhqwZdRxlojiMnEw7pt4x2gdndZQQFO5eHIBb/SIgeeUVreYnjRTfTRqqV
oZfYPV09IYx4Lm1lFcCgODpn55TSIYvE8fGqGTM+J3+Q0g47N6Uve3SGdjL7aese
wGb6EPqGUqaSGLOgKy/L0KlgnVZXOeidFJjOe5QsKUQgWbCExcLObR2a3XZbIwXq
dq+ED1ovhrRDHH5VDRgK4+7WCFy6wQD9PPIy8WioXsCV2XCSixAM6XhWUYkLignp
30Yy5tzKhbCpyxe84ZM3sZG/PAojVAbwpVpjm/px3N8jdQ/hE1eVgaoyTX0Pn9We
tXRQkUEBluOm3Czaw1YN1E5LWpP8hYhWTMPVnfxlZ/R3rdswiWaA2+knWJCXkdsk
Kle8h4xNB0e0ZAzulEXh9JROsOqZUuh0+sGwPsw13p4KqauBzSG77tos1e4xp9AI
9P7JcnRsEeNjgTvbjBxISlQdHW3FCnud7hM/OoTbGojwB3CHPIoIJmWCW7ci6beD
DUwOo2CfjZ+FlQErar2XarQrPLdSFTd+lJJqUy+tiNoWPJafYQIDAQABoyYwJDAS
BgNVHRMBAf8ECDAGAQH/AgEBMA4GA1UdDwEB/wQEAwIBBjANBgkqhkiG9w0BAQwF
AAOCAgEAW0JtZaJCEbm4+DmYa32WNvqjjxgdmRHjkJtfv+wkt0Kz71MHG0qSQBHH
UkVOkBFm/wjF+lH+/7X9ZdiFsO3b9P2JXHg1PXgU9NvtuYZBAsiy0VRxVSukp+JH
7biOFNx5nwerYv9C1JG2VRPr+JzDUP1/QV9XCFtQVnpyfm/pETLghOwaNq4Yjzg+
MxLw4sWsJL5DZrG2/jViHhogoCnXz1rFVWFI1BBvEbKnthYUxqL+Xc4vWCYLvMHc
LbZMGef05HrcPWtAS13y8qpat5MGRXDjgFqGUyoaPoxRya4dOexjw369aV/YAIsx
wgtAiWrvL4UPOUGopCMac4GEbpPA60XHmSVXyR+CCKyLwLD7rRR8Vpk5cUM2jvxI
5NMP17Wa+QD4jp8sWsSebI83+qL/0TdWgRbD/FW2igrR0ird8wgQcIhtCrJCdYMT
MjRtJc4m/iJ+OH2KaryxQi8oEkB3onsIZXvSNgXvTp4SkLw9pPheEwSKVvbo1DoF
QB4ek6ynjWGgoaHl5tx2i+tRH+mEP7+Ccw32HdX+xo8BYvMaBXJI8M5rem7k4PsQ
tLNjn9CN0FPT8j2ksk8jMi4s/c9EHY5NYNgjTG6MQ3eSS1QaoVYPi4NCDe2KWP2k
ooGZMUlICfXbP86zQz5xBJvd/+Rmdn+mvLoabzmFVPS9E1yH6fE=
-----END CERTIFICATE-----
```

Note: The certificates shown here were last Updated on October 16, 2020 in this page/document.

Certificate Chains : DEV Kit

Certificates for the DEV Kit / Ease Of Use Configuration.

Certificate Chain for SE051

The directory `demos/Certificate_Chains/SE051/0001_A201` contains Intermediate Certificates used in Dev Kit configurations. It is signed by *Certificate Chains : ROOT*. More information on these certificates can be found in the application note on SE050 configurations: AN12973

Intermediate CA : ECC

The file `CloudConn-Intermediate-ECC_OEF_A201.crt` is certificate used for Dev Kit configuration.

```
-----BEGIN CERTIFICATE-----
MIIBujCCAWGgAwIBAgIKBABQAQABogEAADAKBggqhkjOPQQDAjBQMRcwFQYDVQQL
DA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAgSW50
ZXJtZWRpYXRlLTRMYXllckNBdkUyMDUwHhcNMTkwNTE1MDAwMDAwWhcNMzQwNTEx
MDAwMDAwWjBdMRcwFQYDVQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQ
MTQwMgYDVQQDDCtDbG91ZENvbm4tSW50ZXJtZWRpYXRlLTA0MDA1MDAxMDAwMUEy
MDEtRUNDMFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAEeEU5NJJXLvoO0NY8kquO
VZluA+pQBPMxONWqVqxob/wXXjwxfcG7Jxla4yACIyyAR8Um6yhkDcK4T7gtf28r
HKMWMBQwEgYDVR0TAQH/BAgwBgEB/wIBADAKBggqhkjOPQQDAgNHADBEAiAXmSyR
388EKFo40juspNEHhhLbFvlsa5hpEJTxii/xGQIgL9mWlD18LvnA9qutAmBE7UnA
2tC5GoX30IwBQENAWTo=
-----END CERTIFICATE-----
```

Intermediate CA : RSA

The file `CloudConn-Intermediate-RSA_OEF_A201.crt` is certificate used for Dev Kit configuration.

```
-----BEGIN CERTIFICATE-----
MIIFRzCCAy+gAwIBAgIKBABQAQABogEAADANBgkqhkiG9w0BAQsFADBQMRcwFQYD
VQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwDTlhQMScwJQYDVQQDDB5OWFAg
SW50ZXJtZWRpYXRlLTRMYXllckNBdlI0MDYwHhcNMTkwNTE1MDAwMDAwWhcNMzQw
NTExMDAwMDAwWjBdMRcwFQYDVQQLDA5QbHVnIGFuZCBUcnVzdDEMMAoGA1UECgwD
TlhQMTQwMgYDVQQDDCtDbG91ZENvbm4tSW50ZXJtZWRpYXRlLTA0MDA1MDAxMDAw
MUEyMDEtUlNBMIICIjANBgkqhkiG9w0BAQEFAAOCAg8AMIICCgKCAgEA0guMQQvD
pdzjTU/zB4S4BWwhIKoyZVhCyEA9eaHnWgaWmUwGPnM8P5M0FiVPBTaW/Xq8kJGe
K7cAPy2VKrNCFVgO0qczL7iHCnmgmaHM0IGim5lKoP0pRcJy2O6PW+uRVozUkYEK
jZHLnsPdVHsP5+YGmU5WWYu4jnNkzFpJtR3fBJyazav0/lr0kLvSg6faH3nrqRGJ
thsCBlszKPQ/Ogi/Ew6P3J7pfoBTXngon3uz2hPgfvnkau7zqCEue8OG2+CyfKKB
N8aiEce3FM4KHSi4wnE93gYzq+Uf7PBi7pSQXV4uuop54rLZRZ2AeB4yViEn9Icf
ZRBrqKtg+b3fRnK4dSqbMjHb3OwCgRGWHMn/+WdUjZi9hdCXhflyQIVB6Pa8RTxn
kwMrYqWX+KQyhVKY1dazV5mxqwxE3pArroObq3tCLMLEpaVjG/zSXD/sBHqKDyuG
qgysmxqCdiCgFBvaOYdT3OccGHFXmltzXWvgfCGxvw2neMTfacYtGbMhlOh4O9jX
91i2CGB5ZNNHBdcH1hpbygWiyp6OqyMmEO2yBH1Age/kBgBWMppA8W3cC+xP+VwR
94RiN+uiuRBr21iUg4PSizNLrZLW8c90HcSt9p0pwvvBxt67inu/Yh52AUz2/m61
2uhzgRDpR6TvhYhFg2RnmqiSQPtvYUkErlcCAwEAAaMWMBQwEgYDVR0TAQH/BAgw
BgEB/wIBADANBgkqhkiG9w0BAQsFAAOCAgEAYvgJL4TAU7sWnydjlj20FHMdCG/8
z2sohJykn8W+nayxeCtdtil+kMxTDPGzER2rCmHfWPrLg95rDYIwWscDnuPSg2za
W8RzwyEwjv27AYZpFB57pPGw25RT2OcMPTIpZ01F3aeKEguy3SWSU/Zs6Hgj/8IS
6iJfr0VnB/znthzfd0ECZknx6bZrbyL09Ls0y/7ygxytYzDrC30vSVaaP/NWZFCp
qmHlpaGtSYr1LtPFYHS7YfLmmYfgHk5bBpzYKCR1Gov8j3b35xvj/NSETWnnojfA
xg4PwdAzKBTn8TLjIkklwcvkdwHYFUUivqcavN4f4YgYKJ48MWwKvMQBF1X73Q1C
E6dXS1TqwULX0staIS4yl9clgVLkdCxlRObKPq222IfG1OzQaBXt5iIFWA4d4PZS
dneKwDYrH9k/lUqlWMO/q87m8Tcuvo85kML8sshPWgzs2OoA30bEaOXg1D1WNhnO
t+NzdjbXc9MQPzr0r6Gk7BxL5W4wGArujMkljk781KpeTh5R4IFENI31OloPShOa
0QnL3DJbpdVMUu2LuE8FsV3k+UdHuboeego1hpP59zpN6goUoBMfGhMdI2wbi6wv
hKFpiDiBq+bu1WIBOA2DD5kUlTid7yqTp5NtI2TYvXzb5NSehqsCaHopz4Q/+j0w
tJ8ao7HfcVhb7Yc=
-----END CERTIFICATE-----
```

Note: The certificates shown here were last Updated on October 16, 2020 in this page/document. These certificate chains are only for Dev Kit configuration (OEF A201).

11.9 JRCP_v1 Server

This section explains how the JRCP_v1 server enables a client process (remote or local) to establish a communication session with a Secure Element.

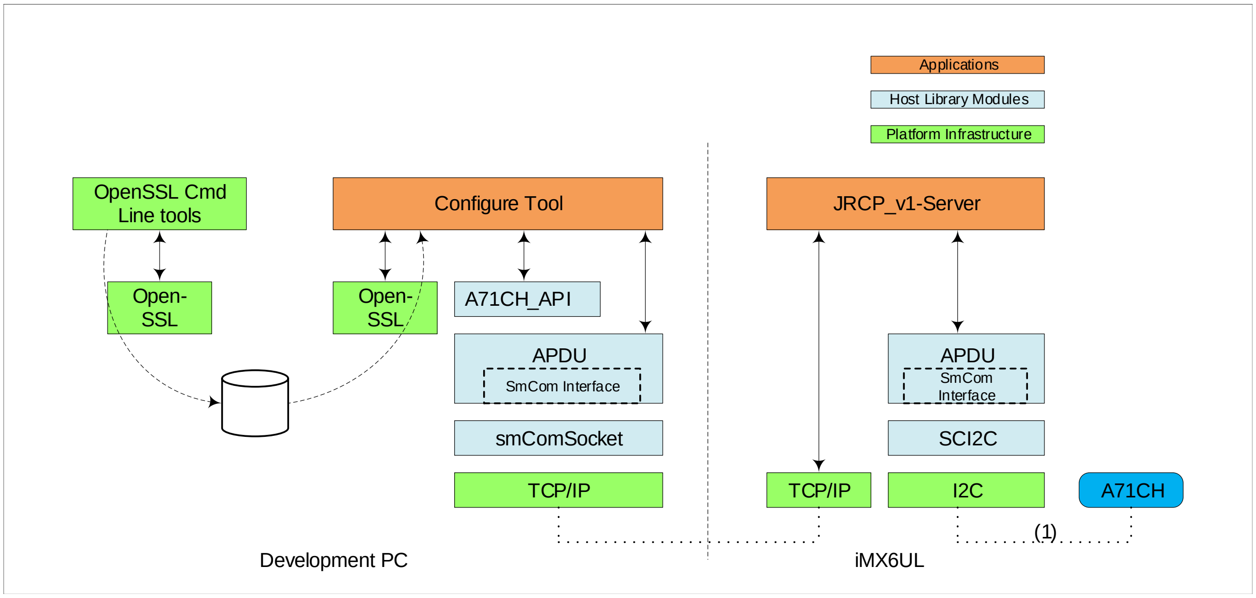
Note: The JRCP_v1 server was previously known as RJCT server.

11.9.1 Introduction

The JRCP_v1 server is a standalone process that can establish a communication session with a Secure Element on behalf of a client process. Only one client process (at a time) can have a communication session via the JRCP_v1 server with the Secure Element.

The JRCP_v1 server listens for incoming connection requests from client processes on TCP/IP port 8050. The client application must be compiled for the JRCP_V1 smCom protocol layer.

The following figure illustrates a client application (in the example the Configure Tool) connecting to the JRCP_v1 server,



The tool is provided in source code (`.../hostlib/rjct`). It can be built to connect to the Secure Element with e.g. the SCI2C or the T=1oI2C protocol.

11.9.2 Using the JRCP_v1 server

The JRCP_v1 server application that is bundled with the Host SW is a command line application. In the following example the server is started from a shell on the embedded platform

```
root@imx6ulevk:~# ./jrcpv1_server
RemoteJCShell Terminal Server (supporting SCI2C) Rev 0.92
A71 (I2C_CLK_MAX = 400 kHz) - Effective Master Clock depends on Host Platform.
*****************************************************************************
Establish a connection via JCShell:
    /term Remote|<ip-address>:<port>
     e.g.
     /term Remote|192.168.1.27:8050

Server: waiting for connections...
```

For a client to connect to the server it needs to know the IP address of the server. In the following example the Configure Tool - built with the JRCP_V1 SMCOM layer - runs on a Linux PC and connects to the JRCP_v1 server running on the embedded platform (with IP address 192.168.1.100).

```
user@dell-linux:~/$ ./A71CHConfigTool 192.168.2.81:8050 interactive
a71chConfig (Rev 1.20) .. connect to A71CH. Chunksize at link layer = 256.
PlugAndTrust_HostLib_v02.12.00_20191210
Applet Version    : 0x131X
SecureBox Version: 0x0X

==========SELECT-DONE=========
HostLib Version            : 0x020C
Applet-Rev:SecureBox-Rev   : 0x0131:0x0000
>>> info device
A71CH in Debug Mode Version (SCP03 is not set up)
selectResponse:   0x0131
transportLockState: 0x03 (Transport Lock NOT YET set)
injectLockState:    0x02 (Unlocked)
gpStorageSize:      4096
uid (LEN=18):
47:90:70:02:47:91:12:10:80:04:00:88:04:98:90:53:48:12
certUid (LEN=10):
70:02:80:04:00:88:04:98:90:53
```

11.10 Using own Platform SCP03 Keys

The Plug & Trust MW can use PlatformSCP03 keys from file system. The key files for different platforms are defined as:

For Android

```
#define EX_SSS_SCP03_FILE_DIR "/data/vendor/SE05x/"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

For Linux

```
#define EX_SSS_SCP03_FILE_DIR "/tmp/SE05X/"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

For Windows

```
#define EX_SSS_SCP03_FILE_DIR "C:\\nxp\\SE05X\\"
#define EX_SSS_SCP03_FILE_PATH EX_SSS_SCP03_FILE_DIR "plain_scp.txt"
```

You need to create a file at this location to allow the MW to pick up the file automatically. Another option is to set the environment variable `EX_SSS_BOOT_SCP03_PATH` to the complete file path.

The MW will first look for the file at the above path, if it is not able to find the file, it will try to use the environment variable, and lastly, it will fall back to pre-compiled keys.

Note: For Android systems, it is important to update sepolicy to allow access to Platform SCP03 keys directory. Refer to AOSP setup Section 11.5.6 *AOSP build Environment for Hikey960* for details on required system patches.

It is advisable to create a file at this location to allow MW to use those keys instead of pre-compiled keys as the user can also rotate the keys in which case if the MW was using pre-compiled keys, all further operations will fail.

An example of file format is:

```
# This is a comment, empty lines and comment lines allowed.
ENC 35C256458958A34F6136155F8209D6CD # Trailing comment
MAC AF177D5DBDF7C0D5C10A05B9F1607F78 # Optional trailing comment
DEK A1BC8438BF77935B361A4425FE79FA29 # Optional trailing comment
```

Replace the `ENC`, `MAC` and `DEK` keys with your own keys.

For information on rotating Platform SCP03 keys, refer to Section 5.7.6 *SE05X Rotate PlatformSCP Keys Demo*

11.11 Write APDU to buffer

See Section 5.7.19 *Write APDU to buffer*.

11.12 SE05x MW Types and APIs

11.12.1 SE05x Types

group **`se05x_types`**

SE05x Types.

Defines

`DO_LOG_A` (TAG, DESCRIPTION, ARRAY, ARRAY_LEN)

`DO_LOG_V` (TAG, DESCRIPTION, VALUE)

`kSE05x_INS_I2CM_Attestation`

When we want to read I2CM Data with attestation

kSE05x_INS_READ_With_Attestation
When we want to read with attestation

SE050_INS_MASK_INS_CHAR
3 MSBit for instruction characteristics.

SE050_INS_MASK_INSTRUCTION
5 LSBit for instruction

SE050_MAX_APDU_PAYLOAD_LENGTH
the maximum APDU payload length will be smaller, depending on which protocol applies, etc.

SE050_MAX_I2CM_COMMAND_LENGTH
How many bytes can be used for buffer for I2C Master interface

SE050_MAX_NUMBER_OF_SESSIONS
Maximum number of session supported by SE050

SE050_OBJECT_IDENTIFIER_SIZE
Maximum number of session supported by SE050

SE05x_CryptoObjectID_t
Crypto object identifiers

SE05x_KeyID_KEK_NONE
Case when there is no KEK

SE05x_KeyID_MFDF_NONE
[Optional: if the authentication key is the same as the key to be replaced, this TAG should not be present].

SE05x_MaxAttemps_NA
Identify in code that this is not an AUTH object and hence not applicable

SE05x_MaxAttemps_UNLIMITED
Fall back to applet default

TLVSET_AttestationAlgo

TLVSET_CipherMode

TLVSET_CryptoContext

TLVSET_CryptoModeSubType (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_CryptoObjectID

TLVSET_DigestMode

TLVSET_ECCurve (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_ECCurveParam

TLVSET_ECDAASignatureAlgo

TLVSET_ECSignatureAlgo

TLVSET_EDSignatureAlgo

TLVSET_KeyID (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_MacOperation

TLVSET_MaxAttemps (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_MemoryType

TLVSET_PlatformSCPRequest

TLVSET_RSAEncryptionAlgo

TLVSET_RSAKeyComponent

TLVSET_RSAPubKeyComp

TLVSET_RSASignatureAlgo

TLVSET_Se05xPolicy (DESCRIPTION, PBUF, PBUFLEN, TAG, POLICY)

TLVSET_Se05xSession (DESCRIPTION, PBUF, PBUFLEN, TAG, SESSIONID)

TLVSET_U16 (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_U16Optional (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_U32 (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_U64_SIZE (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE, SIZE)

TLVSET_U8 (DESCRIPTION, PBUF, PBUFLEN, TAG, VALUE)

TLVSET_u8buf (DESCRIPTION, PBUF, PBUFLEN, TAG, CMD, CMDLEN)

TLVSET_u8buf_I2CM (DESCRIPTION, PBUF, PBUFLEN, TAG, CMD, CMDLEN)

TLVSET_u8bufOptional (DESCRIPTION, PBUF, PBUFLEN, TAG, CMD, CMDLEN)

TLVSET_u8bufOptional_ByteShift (DESCRIPTION, PBUF, PBUFLEN, TAG, CMD, CMDLEN)

TLVSET_Variant

Typedefs

typedef *Se05x_AppletFeatures_t* ***pSe05xAppletFeatures_t**

typedef *Se05xPolicy_t* ***pSe05xPolicy_t**

typedef Se05xSession_t ***pSe05xSession_t**

typedef uint32_t **SE05x_KeyID_t**
SE05X's key IDs

typedef SE05x_MACAlgo_t **SE05x_MacOperation_t**
HMAC/CMAC Algorithms

typedef uint16_t **SE05x_MaxAttemps_t**
SE05X key's max attempts

typedef SE05x_SecObjTyp_t **SE05x_SecureObjectType_t**
Type of Object

typedef SE05x_AppletConfig_t **SE05x_Variant_t**
Features which are available / enabled in the Applet

Enums

enum SE05x_AeadAlgo_t
AEAD Algorithms

Values:

kSE05x_AeadAlgo_NA = 0
Invalid

kSE05x_AeadGCMAlgo = 0xB0

kSE05x_AeadGCM_IVAlgo = 0xF3

kSE05x_AeadCCMAlgo = 0xF4

enum SE05x_AppletConfig_t
Features which are available / enabled in the Applet

Values:

kSE05x_AppletConfig_NA = 0
Invalid

kSE05x_AppletConfig_ECDAA = 0x0001
Use of curve TPM_ECC_BN_P256

kSE05x_AppletConfig_ECDSA_ECDH_ECDHE = 0x0002
EC DSA and DH support

kSE05x_AppletConfig_EDDSA = 0x0004
Use of curve RESERVED_ID_ECC_ED_25519

Use of curve RESERVED_ID_ECC_MONT_DH_25519

kSE05x_AppletConfig_HMAC = 0x0010
Writing HMACKey objects

kSE05x_AppletConfig_RSA_PLAIN = 0x0020
Writing RSAKey objects

kSE05x_AppletConfig_RSA_CRT = 0x0040
Writing RSAKey objects

Writing AESKey objects

kSE05x_AppletConfig_DES = 0x0100
Writing DESKey objects

kSE05x_AppletConfig_PBKDF = 0x0200
PBKDF2

kSE05x_AppletConfig_TLS = 0x0400
TLS Handshake support commands (see 4.16) in APDU Spec

Mifare DESFire support (see 4.15) in APDU Spec

kSE05x_AppletConfig_RFU1 = 0x1000
RFU1

kSE05x_AppletConfig_I2CM = 0x2000
I2C Master support (see 4.17) in APDU Spec

kSE05x_AppletConfig_RFU2 = 0x4000
RFU2

enum SE05x_AppletResID_t
Reserved idendntifiers of the Applet

Values:

kSE05x_AppletResID_NA = 0
Invalid

kSE05x_AppletResID_TRANSPORT = 0x7FFF0200
An authentication object which allows the user to switch LockState of the applet. The LockState defines whether the applet is transport locked or not.

kSE05x_AppletResID_KP_ECKEY_USER = 0x7FFF0201
A device unique NIST P-256 key pair which contains SK.SE.ECKA and PK.SE.ECKA in ECKey session context.

kSE05x_AppletResID_KP_ECKEY_IMPORT = 0x7FFF0202
A device unique NIST P-256 key pair which contains SK.SE.ECKA and PK.SE.ECKA in ECKey session context; A constant card challenge (all zeroes) is applicable.

kSE05x_AppletResID_FEATURE = 0x7FFF0204
An authentication object which allows the user to change the applet variant.

kSE05x_AppletResID_FACTORY_RESET = 0x7FFF0205
An authentication object which allows the user to delete all objects, except trust provisioned by NXP objects.

kSE05x_AppletResID_UNIQUE_ID = 0x7FFF0206
A BinaryFile Secure Object which holds the device unique ID. This file cannot be overwritten or deleted.

kSE05x_AppletResID_PLATFORM_SCP = 0x7FFF0207
An authentication object which allows the user to change the platform SCP requirements, i.e. make platform SCP mandatory or not, using SetPlatformSCPRequest. Mandatory means full security, i.e. command & response MAC and encryption. Only SCP03 will be sufficient.

An authentication object which grants access to the I2C master feature. If the credential is not present, access to I2C master is allowed in general. Otherwise, a session using this credential shall be established and I2CM commands shall be sent within this session.

kSE05x_AppletResID_RESTRICT = 0x7FFF020A
An authentication object which grants access to the SetLockState command

kSE05x_AppletResID_SPAKE2P_M_P256_UNCOMPRESSED = 0x7FFF0210
SPAKE2P_M_P256_UNCOMPRESSED KEY

kSE05x_AppletResID_SPAKE2P_N_P256_UNCOMPRESSED = 0x7FFF0211
SPAKE2P_N_P256_UNCOMPRESSED KEY

kSE05x_AppletResID_SPAKE2P_M_P384_UNCOMPRESSED = 0x7FFF0212
SPAKE2P_M_P384_UNCOMPRESSED KEY

kSE05x_AppletResID_SPAKE2P_N_P384_UNCOMPRESSED = 0x7FFF0213
SPAKE2P_N_P384_UNCOMPRESSED KEY

kSE05x_AppletResID_SPAKE2P_M_P521_UNCOMPRESSED = 0x7FFF0214
SPAKE2P_M_P521_UNCOMPRESSED KEY

kSE05x_AppletResID_SPAKE2P_N_P521_UNCOMPRESSED = 0x7FFF0215
SPAKE2P_N_P521_UNCOMPRESSED KEY

enum SE05x_AttestationAlgo_t
Attestation

Values:

kSE05x_AttestationAlgo_NA = 0

kSE05x_AttestationAlgo_EC_PLAIN = kSE05x_ECSignatureAlgo_PLAIN

kSE05x_AttestationAlgo_EC_SHA = *kSE05x_ECSignatureAlgo_SHA*

kSE05x_AttestationAlgo_EC_SHA_224 = *kSE05x_ECSignatureAlgo_SHA_224*

kSE05x_AttestationAlgo_EC_SHA_256 = *kSE05x_ECSignatureAlgo_SHA_256*

kSE05x_AttestationAlgo_EC_SHA_384 = *kSE05x_ECSignatureAlgo_SHA_384*

kSE05x_AttestationAlgo_EC_SHA_512 = *kSE05x_ECSignatureAlgo_SHA_512*

kSE05x_AttestationAlgo_ED25519PURE_SHA_512 = *kSE05x_EDSignatureAlgo_ED25519PURE_SHA_512*

kSE05x_AttestationAlgo_ECDAA = *kSE05x_ECDAASignatureAlgo_ECDAA*

kSE05x_AttestationAlgo_RSA_SHA1_PKCS1_PSS = *kSE05x_RSASignatureAlgo_SHA1_PKCS1_PSS*

kSE05x_AttestationAlgo_RSA_SHA224_PKCS1_PSS = *kSE05x_RSASignatureAlgo_SHA224_PKCS1_PSS*

kSE05x_AttestationAlgo_RSA_SHA256_PKCS1_PSS = *kSE05x_RSASignatureAlgo_SHA256_PKCS1_PSS*

kSE05x_AttestationAlgo_RSA_SHA384_PKCS1_PSS = *kSE05x_RSASignatureAlgo_SHA384_PKCS1_PSS*

kSE05x_AttestationAlgo_RSA_SHA512_PKCS1_PSS = *kSE05x_RSASignatureAlgo_SHA512_PKCS1_PSS*

kSE05x_AttestationAlgo_RSA_SHA_224_PKCS1 = *kSE05x_RSASignatureAlgo_SHA_224_PKCS1*

kSE05x_AttestationAlgo_RSA_SHA_256_PKCS1 = kSE05x_RSASignatureAlgo_SHA_256_PKCS1

kSE05x_AttestationAlgo_RSA_SHA_384_PKCS1 = kSE05x_RSASignatureAlgo_SHA_384_PKCS1

kSE05x_AttestationAlgo_RSA_SHA_512_PKCS1 = *kSE05x_RSASignatureAlgo_SHA_512_PKCS1*

enum SE05x_AttestationType_t

In case the read is attested

Values:

kSE05x_AttestationType_None = 0

kSE05x_AttestationType_AUTH = *kSE05x_INS_AUTH_OBJECT*

enum SE05x_Cipher_Oper_OneShot_t

One Shot operations helper

Values:

kSE05x_Cipher_Oper_OneShot_NA = 0

kSE05x_Cipher_Oper_OneShot_Encrypt = *kSE05x_P2_ENCRYPT_ONESHOT*

kSE05x_Cipher_Oper_OneShot_Decrypt = kSE05x_P2_DECRYPT_ONESHOT

enum SE05x_Cipher_Oper_t

Cipher Operation.

Encrypt or decrypt

Values:

kSE05x_Cipher_Oper_NA = 0

kSE05x_Cipher_Oper_Encrypt = *kSE05x_P2_ENCRYPT*

kSE05x_Cipher_Oper_Decrypt = *kSE05x_P2_DECRYPT*

enum SE05x_CipherMode_t
Symmetric cipher modes

Values:

kSE05x_CipherMode_NA = 0
Invalid

kSE05x_CipherMode_DES_CBC_NOPAD = 0x01
Typically using DESKey identifiers

kSE05x_CipherMode_DES_CBC_ISO9797_M1 = 0x02
Typically using DESKey identifiers

kSE05x_CipherMode_DES_CBC_ISO9797_M2 = 0x03
Typically using DESKey identifiers

kSE05x_CipherMode_DES_CBC_PKCS5 = 0x04
NOT SUPPORTED

kSE05x_CipherMode_DES_ECB_NOPAD = 0x05
Typically using DESKey identifiers

kSE05x_CipherMode_DES_ECB_ISO9797_M1 = 0x06
NOT SUPPORTED

kSE05x_CipherMode_DES_ECB_ISO9797_M2 = 0x07
NOT SUPPORTED

NOT SUPPORTED

kSE05x_CipherMode_AES_ECB_NOPAD = 0x0E
Typically using AESKey identifiers

kSE05x_CipherMode_AES_CBC_NOPAD = 0x0D
Typically using AESKey identifiers

kSE05x_CipherMode_AES_CBC_ISO9797_M1 = 0x16
Typically using AESKey identifiers

kSE05x_CipherMode_AES_CBC_ISO9797_M2 = 0x17
Typically using AESKey identifiers

NOT SUPPORTED

kSE05x_CipherMode_AES_GCM = 0xB0
Typically using AEAD GCM mode

kSE05x_CipherMode_AES_CTR = 0xF0
Typically using AESKey identifiers

kSE05x_CipherMode_AES_CTR_INT_IV = 0xF1
Typically using AESKey CTR mode with internal IV Gen Only used by MW. Change to kSE05x_CipherMode_AES_CTR when sending to SE

kSE05x_CipherMode_AES_GCM_INT_IV = 0xF3
Typically using AEAD GCM with internal IV Gen

kSE05x_CipherMode_AES_CCM = 0xF4
Typically using AEAD CCM mode

kSE05x_CipherMode_AES_CCM_INT_IV = 0xF5
Typically using AEAD CCM with internal IV Gen

enum SE05x_CryptoContext_t
Cryptographic context for operation

Values:

kSE05x_CryptoContext_NA = 0
Invalid

kSE05x_CryptoContext_DIGEST = 0x01
For DigestInit/DigestUpdate/DigestFinal

kSE05x_CryptoContext_CIPHER = 0x02
For CipherInit/CipherUpdate/CipherFinal

kSE05x_CryptoContext_SIGNATURE = 0x03
For MACInit/MACUpdate/MACFinal

kSE05x_CryptoContext_AEAD = 0x04
For AEADInit/AEADUpdate/AEADFinal

kSE05x_CryptoContext_PAKE = 0x05
For PAKE

enum SE05x_CryptoObject_t
Crypto object identifiers

Values:

kSE05x_CryptoObject_NA = 0
Invalid

kSE05x_CryptoObject_DIGEST_SHA

kSE05x_CryptoObject_DIGEST_SHA224

kSE05x_CryptoObject_DIGEST_SHA256

kSE05x_CryptoObject_DIGEST_SHA384

kSE05x_CryptoObject_DIGEST_SHA512

kSE05x_CryptoObject_DES_CBC_NOPAD

kSE05x_CryptoObject_DES_CBC_ISO9797_M1

kSE05x_CryptoObject_DES_CBC_ISO9797_M2

kSE05x_CryptoObject_DES_CBC_PKCS5

kSE05x_CryptoObject_DES_ECB_NOPAD

kSE05x_CryptoObject_DES_ECB_ISO9797_M1

kSE05x_CryptoObject_DES_ECB_ISO9797_M2

kSE05x_CryptoObject_DES_ECB_PKCS5

kSE05x_CryptoObject_AES_ECB_NOPAD

kSE05x_CryptoObject_AES_CBC_NOPAD

kSE05x_CryptoObject_AES_CBC_ISO9797_M1

kSE05x_CryptoObject_AES_CBC_ISO9797_M2

kSE05x_CryptoObject_AES_CBC_PKCS5

kSE05x_CryptoObject_AES_CTR

kSE05x_CryptoObject_AES_CTR_INT_IV

kSE05x_CryptoObject_HMAC_SHA1

kSE05x_CryptoObject_HMAC_SHA256

kSE05x_CryptoObject_HMAC_SHA384

kSE05x_CryptoObject_HMAC_SHA512

kSE05x_CryptoObject_CMAC_128

kSE05x_CryptoObject_AES_GCM

kSE05x_CryptoObject_AES_GCM_INT_IV

kSE05x_CryptoObject_AES_CCM

kSE05x_CryptoObject_AES_CCM_INT_IV

kSE05x_CryptoObject_PAKE_TYPE_A

kSE05x_CryptoObject_PAKE_TYPE_B

kSE05x_CryptoObject_End

enum SE05x_DigestMode_t

Hashing/Digest algorithms

Values:

kSE05x_DigestMode_NA = 0

Invalid

kSE05x_DigestMode_NO_HASH = 0x00

kSE05x_DigestMode_SHA = 0x01

kSE05x_DigestMode_SHA224 = 0x07

Not supported

kSE05x_DigestMode_SHA256 = 0x04

kSE05x_DigestMode_SHA384 = 0x05

kSE05x_DigestMode_SHA512 = 0x06

enum SE05x_ECCurve_t

ECC Curve Identifiers

Values:

kSE05x_ECCurve_NA = 0x00

Invalid

kSE05x_ECCurve_NIST_P192 = 0x01

kSE05x_ECCurve_NIST_P224 = 0x02

kSE05x_ECCurve_NIST_P256 = 0x03

kSE05x_ECCurve_NIST_P384 = 0x04

kSE05x_ECCurve_NIST_P521 = 0x05

kSE05x_ECCurve_Brainpool160 = 0x06

kSE05x_ECCurve_Brainpool192 = 0x07

kSE05x_ECCurve_Brainpool320 = 0x0A

kSE05x_ECCurve_Brainpool384 = 0x0B

kSE05x_ECCurve_Brainpool512 = 0x0C

kSE05x_ECCurve_Secp160k1 = 0x0D

kSE05x_ECCurve_Secp192k1 = 0x0E

kSE05x_ECCurve_Secp224k1 = 0x0F

kSE05x_ECCurve_Secp256k1 = 0x10

kSE05x_ECCurve_TPM_ECC_BN_P256 = 0x11

kSE05x_ECCurve_ECC_ED_25519 = 0x40
Not Weierstrass

kSE05x_ECCurve_ECC_MONT_DH_25519 = 0x41

kSE05x_ECCurve_ECC_MONT_DH_448 = 0x43
Not Weierstrass

enum SE05x_ECCurveParam_t
Parameters while setting the curve

Values:

kSE05x_ECCurveParam_NA = 0
Invalid

kSE05x_ECCurveParam_PARAM_A = 0x01

kSE05x_ECCurveParam_PARAM_B = 0x02

kSE05x_ECCurveParam_PARAM_G = 0x04

kSE05x_ECCurveParam_PARAM_PRIME = 0x10

enum SE05x_ECDAASignatureAlgo_t
Different signature algorithms for ECDAA

Values:

kSE05x_ECDAASignatureAlgo_NA = 0
Invalid

kSE05x_ECDAASignatureAlgo_ECDAA = 0xF4
Message input must be pre-hashed (using SHA256)

enum SE05x_ECDHAlgo_t
Different ECDH algorithms

Values:

kSE05x_ECDHAlgo_NA = 0
Invalid

kSE05x_ECDHAlgo_EC_SVDP_DH = 0x01
Generates the SHA1 of the X coordinate.

kSE05x_ECDHAlgo_EC_SVDP_DH_PLAIN = 0x03
Generates the X coordinate.

enum SE05x_ECPMAlgo_t
ECPMAlgo

Values:

kSE05x_ECPMAlgo_PACE_GM = 0x05

kSE05x_ECPMAlgo_SVDP_DH_PLAIN_XY = 0x06

enum SE05x_ECSignatureAlgo_t
Different signature algorithms for EC

Values:

kSE05x_ECSignatureAlgo_NA = 0
Invalid

NOT SUPPORTED

kSE05x_ECSignatureAlgo_SHA = 0x11

kSE05x_ECSignatureAlgo_SHA_224 = 0x25

kSE05x_ECSignatureAlgo_SHA_256 = 0x21

kSE05x_ECSignatureAlgo_SHA_384 = 0x22

kSE05x_ECSignatureAlgo_SHA_512 = 0x26

enum SE05x_EDSignatureAlgo_t
Different signature algorithms for ED

Values:

kSE05x_EDSignatureAlgo_NA = 0
Invalid

kSE05x_EDSignatureAlgo_ED25519PURE_SHA_512 = 0xA3
Message input must be plain Data. Pure EDDSA algorithm

enum SE05x_HealthCheckMode_t
Health check

Values:

kSE05x_HealthCheckMode_NA = 0
Invalid

Performs all on-demand self-tests. Can only be done when the module is in FIPS mode. When the test fails, the chip goes into TERMINATED state.

kSE05x_HealthCheckMode_CODE_SIGNATURE = 0xFE01
Performs ROM integrity checks. When the test fails, the chip triggers the attack counter and the chip will reset.

kSE05x_HealthCheckMode_DYNAMIC_FLASH_INTEGRITY = 0xFD02
Performs flash integrity tests. When the test fails, the chip triggers the attack counter and the chip will reset.

kSE05x_HealthCheckMode_SHIELDING = 0xFC03

Performs tests on the active shield protection of the hardware. When the test fails, the chip triggers the attack counter and the chip will reset.

kSE05x_HealthCheckMode_SENSOR = 0xFB04

Performs self-tests on hardware sensors and reports the status.

kSE05x_HealthCheckMode_SFR_CHECK = 0xFA05

Performs self-tests on the hardware registers. When the test fails, the chip triggers the attack counter and the chip will reset.

enum SE05x_HkdfMode_t

HKDF Mode

Values:

kSE05x_HkdfMode_NA = 0x00

Invalid

kSE05x_HkdfMode_ExtractExpand = 0x01

kSE05x_HkdfMode_ExpandOnly = 0x02

enum SE05x_INS_t

Values for INS in ISO7816 APDU

Values:

kSE05x_INS_NA = 0

Invalid

kSE05x_INS_MASK_INS_CHAR = 0xE0

3 MSBit for instruction characteristics.

kSE05x_INS_MASK_INSTRUCTION = 0x1F

5 LSBit for instruction

Mask for transient object creation, can only be combined with INS_WRITE.

kSE05x_INS_AUTH_OBJECT = 0x40

Mask for authentication object creation, can only be combined with INS_WRITE

kSE05x_INS_ATTEST = 0x20

Mask for getting attestation data.

kSE05x_INS_WRITE = 0x01

Write or create a persistent object.

kSE05x_INS_READ = 0x02

Read the object

kSE05x_INS_CRYPTO = 0x03

Perform Security Operation

kSE05x_INS_MGMT = 0x04

General operation

kSE05x_INS_PROCESS = 0x05

Process session command

enum SE05x_KeyPart_t

Part of the asymmetric key

Values:

kSE05x_KeyPart_NA = *kSE05x_P1_DEFAULT*

kSE05x_KeyPart_Pair = *kSE05x_P1_KEY_PAIR*
Key pair (private key + public key)

kSE05x_KeyPart_Private = *kSE05x_P1_PRIVATE*
Private key

kSE05x_KeyPart_Public = *kSE05x_P1_PUBLIC*
Public key

enum SE05x_LockIndicator_t
Transient / Persistent lock

Values:

kSE05x_LockIndicator_NA = 0
Invalid

kSE05x_LockIndicator_TRANSIENT_LOCK = 0x01

kSE05x_LockIndicator_PERSISTENT_LOCK = 0x02

enum SE05x_LockState_t
Lock the sample (until unlocked)

Values:

kSE05x_LockState_NA = 0
Invalid

kSE05x_LockState_LOCKED = 0x01

enum SE05x_Mac_Oper_t
MAC operations

Values:

kSE05x_Mac_Oper_NA = 0

kSE05x_Mac_Oper_Generate = *kSE05x_P2_GENERATE*

kSE05x_Mac_Oper_Validate = *kSE05x_P2_VALIDATE*

enum SE05x_MACAlgo_t
HMAC/CMAC Algorithms

Values:

kSE05x_MACAlgo_NA = 0
Invalid

kSE05x_MACAlgo_HMAC_SHA384 = 0x1A

kSE05x_MACAlgo_HMAC_SHA512 = 0x1B

kSE05x_MACAlgo_CMAC_128 = 0x31

kSE05x_MACAlgo_DES_CMAC8 = 0x7A

enum SE05x_MemoryType_t
Data for available memory

Values:

kSE05x_MemoryType_NA = 0
Invalid

kSE05x_MemoryType_PERSISTENT = 0x01
Persistent memory

kSE05x_MemoryType_TRANSIENT_RESET = 0x02
Transient memory, clear on reset

kSE05x_MemoryType_TRANSIENT_DESELECT = 0x03
Transient memory, clear on deselect

enum SE05x_MoreIndicator_t
When there are more entries yet to be fetched from few of the APIs

Values:

kSE05x_MoreIndicator_NA = 0
Invalid

kSE05x_MoreIndicator_NO_MORE = 0x01
No more data available

kSE05x_MoreIndicator_MORE = 0x02
More data available

enum SE05x_Origin_t
Where was this object originated

Values:

kSE05x_Origin_NA = 0
Invalid

kSE05x_Origin_EXTERNAL = 0x01
Generated outside the module.

kSE05x_Origin_INTERNAL = 0x02
Generated inside the module.

kSE05x_Origin_PROVISIONED = 0x03
Trust provisioned by NXP

enum SE05x_P1_t
Values for P1 in ISO7816 APDU

Values:

kSE05x_P1_NA = 0
Invalid

Highest bit not used

kSE05x_P1_MASK_KEY_TYPE = 0x60
2 MSBit for key type

kSE05x_P1_MASK_CRED_TYPE = 0x1F
5 LSBit for credential type

kSE05x_P1_KEY_PAIR = 0x60
Key pair (private key + public key)

kSE05x_P1_PRIVATE = 0x40
Private key

kSE05x_P1_PUBLIC = 0x20
Public key

kSE05x_P1_DEFAULT = 0x00

kSE05x_P1_EC = 0x01

kSE05x_P1_RSA = 0x02

kSE05x_P1_AES = 0x03

kSE05x_P1_DES = 0x04

kSE05x_P1_HMAC = 0x05

kSE05x_P1_BINARY = 0x06

kSE05x_P1_UserID = 0x07

kSE05x_P1_CURVE = 0x0B

kSE05x_P1_SIGNATURE = 0x0C

kSE05x_P1_MAC = 0x0D

kSE05x_P1_CIPHER = 0x0E

kSE05x_P1_TLS = 0x0F

kSE05x_P1_CRYPTO_OBJ = 0x10

kSE05x_P1_AEAD = 0x11
Applet >= 4.4

kSE05x_P1_AEAD_SP800_38D = 0x12
Applet >= 4.4

kSE05x_P1_PAKE = 0x12

enum SE05x_P2_t
Values for P2 in ISO7816 APDU

Values:

kSE05x_P2_DEFAULT = 0x00
Invalid

kSE05x_P2_GENERATE = 0x03

kSE05x_P2_CREATE = 0x04

kSE05x_P2_SIZE = 0x07

kSE05x_P2_VERIFY = 0x0A

kSE05x_P2_INIT = 0x0B

kSE05x_P2_UPDATE = 0x0C

kSE05x_P2_FINAL = 0x0D

kSE05x_P2_ONESHOT = 0x0E

kSE05x_P2_DH = 0x0F

kSE05x_P2_DIVERSIFY = 0x10

kSE05x_P2_AUTH_FIRST_PART2 = 0x12

kSE05x_P2_AUTH_NONFIRST_PART2 = 0x13

kSE05x_P2_DUMP_KEY = 0x14

kSE05x_P2_CHANGE_KEY_PART1 = 0x15

kSE05x_P2_CHANGE_KEY_PART2 = 0x16

kSE05x_P2_KILL_AUTH = 0x17

kSE05x_P2_SESSION_CREATE = 0x1B

kSE05x_P2_SESSION_CLOSE = 0x1C

kSE05x_P2_SESSION_REFRESH = 0x1E

kSE05x_P2_SESSION_POLICY = 0x1F

kSE05x_P2_VERSION = 0x20

kSE05x_P2_VERSION_EXT = 0x21

kSE05x_P2_MEMORY = 0x22

kSE05x_P2_LIST = 0x25

kSE05x_P2_TYPE = 0x26

kSE05x_P2_EXIST = 0x27

kSE05x_P2_DELETE_ALL = 0x2A

kSE05x_P2_SESSION_UserID = 0x2C

kSE05x_P2_HKDF = 0x2D

kSE05x_P2_PBKDF = 0x2E

kSE05x_P2_HKDF_EXPAND_ONLY = 0x2F

kSE05x_P2_I2CM = 0x30

kSE05x_P2_I2CM_ATTESTED = 0x31

kSE05x_P2_MAC = 0x32

kSE05x_P2_UNLOCK_CHALLENGE = 0x33

kSE05x_P2_CURVE_LIST = 0x34

kSE05x_P2_SIGN_ECDAA = 0x35

kSE05x_P2_ID = 0x36

kSE05x_P2_ENCRYPT_ONESHOT = 0x37

kSE05x_P2_ATTEST = 0x3A

kSE05x_P2_ATTRIBUTES = 0x3B

kSE05x_P2_CPLC = 0x3C

kSE05x_P2_TIME = 0x3D

kSE05x_P2_TRANSPORT = 0x3E

kSE05x_P2_VARIANT = 0x3F

kSE05x_P2_PARAM = 0x40

kSE05x_P2_DELETE_CURVE = 0x41

kSE05x_P2_ENCRYPT = 0x42

kSE05x_P2_DECRYPT = 0x43

kSE05x_P2_VALIDATE = 0x44

kSE05x_P2_GENERATE_ONESHOT = 0x45

kSE05x_P2_VALIDATE_ONESHOT = 0x46

kSE05x_P2_CRYPTO_LIST = 0x47

kSE05x_P2_TLS_PMS = 0x4A

kSE05x_P2_TLS_PRF_CLI_HELLO = 0x4B

kSE05x_P2_TLS_PRF_SRV_HELLO = 0x4C

kSE05x_P2_TLS_PRF_CLI_RND = 0x4D

kSE05x_P2_TLS_PRF_SRV_RND = 0x4E

kSE05x_P2_TLS_PRF_BOTH = 0x5A

kSE05x_P2_RAW = 0x4F

kSE05x_P2_IMPORT_EXT = 0x51

kSE05x_P2_SCP = 0x52

kSE05x_P2_AUTH_FIRST_PART1 = 0x53

kSE05x_P2_AUTH_NONFIRST_PART1 = 0x54

kSE05x_P2_CM_COMMAND = 0x55

kSE05x_P2_MODE_OF_OPERATION = 0x56

kSE05x_P2_RESTRICT = 0x57

kSE05x_P2_READ_STATE = 0x5B

enum SE05x_PAKEMode_t

PAKE Mode

Values:

kSE05x_SPAKE2PLUS_NA = 0
Invalid

kSE05x_SPAKE2PLUS_P256_SHA256_HKDF_HMAC = 0x01

kSE05x_SPAKE2PLUS_P256_SHA512_HKDF_HMAC = 0x02

kSE05x_SPAKE2PLUS_P384_SHA256_HKDF_HMAC = 0x03

kSE05x_SPAKE2PLUS_P384_SHA512_HKDF_HMAC = 0x04

kSE05x_SPAKE2PLUS_P521_SHA512_HKDF_HMAC = 0x05

enum SE05x_PAKEState_t
PAKE State

Values:

kSE05x_PAKE_STATE_SETUP = 0

kSE05x_PAKE_STATE_KEY_SHARE_GENERATED = 0xA5

kSE05x_PAKE_STATE_SESSION_KEYS_GENERATED = 0x5A

enum SE05x_PlatformSCPRequest_t
Mandate platform SCP or not

Values:

kSE05x_PlatformSCPRequest_NA = 0
Invalid

kSE05x_PlatformSCPRequest_REQUIRED = 0x01
Platform SCP is required (full enc & MAC)

kSE05x_PlatformSCPRequest_NOT_REQUIRED = 0x02
No platform SCP required.

enum SE05x_RestrictMode_t
Applet >= 4.4

See Se05x_API_DisableObjCreation

Values:

kSE05x_RestrictMode_NA = 0

kSE05x_RestrictMode_RESTRICT_NEW = 0x01

kSE05x_RestrictMode_RESTRICT_ALL = 0x02

enum SE05x_Result_t
Result of operations

Values:

kSE05x_Result_NA = 0
Invalid

kSE05x_Result_SUCCESS = 0x01

kSE05x_Result_FAILURE = 0x02

enum SE05x_RSABitLength_t
Size of RSA Key Objects

Values:

kSE05x_RSABitLength_NA = 0
Invalid

kSE05x_RSABitLength_512 = 512

kSE05x_RSABitLength_1024 = 1024

kSE05x_RSABitLength_1152 = 1152

kSE05x_RSABitLength_2048 = 2048

kSE05x_RSABitLength_3072 = 3072

kSE05x_RSABitLength_4096 = 4096

enum SE05x_RSAEncryptionAlgo_t
Different encryption/decryption algorithms for RSA

Values:

kSE05x_RSAEncryptionAlgo_NA = 0
Invalid

kSE05x_RSAEncryptionAlgo_NO_PAD = 0x0C
Plain RSA, padding required on host.

kSE05x_RSAEncryptionAlgo_PKCS1 = 0x0A
RFC8017: RSAES-PKCS1-v1_5

kSE05x_RSAEncryptionAlgo_PKCS1_OAEP = 0x0F
RFC8017: RSAES-OAEP

enum SE05x_RSAKeyComponent_t
Part of the RSA Key Objects

Values:

kSE05x_RSAKeyComponent_NA = 0xFF
Invalid

kSE05x_RSAKeyComponent_MOD = 0x00
Modulus

kSE05x_RSAKeyComponent_PUB_EXP = 0x01
Public key exponent

kSE05x_RSAKeyComponent_PRIV_EXP = 0x02
Private key exponent

kSE05x_RSAKeyComponent_P = 0x03
CRT component p

kSE05x_RSAKeyComponent_Q = 0x04
CRT component q

kSE05x_RSAKeyComponent_DP = 0x05
CRT component dp

kSE05x_RSAKeyComponent_DQ = 0x06
CRT component dq

kSE05x_RSAKeyComponent_INVQ = 0x07
CRT component q_inv

enum SE05x_RSAKeyFormat_t
RSA Key format

Values:

kSE05x_RSAKeyFormat_CRT = *kSE05x_P2_DEFAULT*

kSE05x_RSAKeyFormat_RAW = *kSE05x_P2_RAW*

enum SE05x_RSAPubKeyComp_t
Public part of RSA Keys

Values:

kSE05x_RSAPubKeyComp_NA = 0

kSE05x_RSAPubKeyComp_MOD = *kSE05x_RSAKeyComponent_MOD*

kSE05x_RSAPubKeyComp_PUB_EXP = *kSE05x_RSAKeyComponent_PUB_EXP*

enum SE05x_RSASignAlgo_t
Algorithms for RSA Signature

Values:

kSE05x_RSASignAlgo_NA = 0
Invalid

kSE05x_RSASignAlgo_SHA1_PKCS1_PSS = 0x15
RFC8017: RSASSA-PSS

kSE05x_RSASignAlgo_SHA224_PKCS1_PSS = 0x2B
RFC8017: RSASSA-PSS

kSE05x_RSASignAlgo_SHA256_PKCS1_PSS = 0x2C
RFC8017: RSASSA-PSS

kSE05x_RSASignAlgo_SHA384_PKCS1_PSS = 0x2D
RFC8017: RSASSA-PSS

kSE05x_RSASignAlgo_SHA512_PKCS1_PSS = 0x2E
RFC8017: RSASSA-PSS

kSE05x_RSASignAlgo_SHA_224_PKCS1 = 0x27
RFC8017: RSASSA-PKCS1-v1_5

RFC8017: RSASSA-PKCS1-v1_5

RFC8017: RSASSA-PKCS1-v1_5

kSE05x_RSASignAlgo_SHA_512_PKCS1 = 0x2A
RFC8017: RSASSA-PKCS1-v1_5

enum SE05x_RSASignatureAlgo_t
Different signature algorithms for RSA

Values:

kSE05x_RSASignatureAlgo_NA = 0
Invalid

kSE05x_RSASignatureAlgo_SHA1_PKCS1_PSS = 0x15
RFC8017: RSASSA-PSS

kSE05x_RSASignatureAlgo_SHA224_PKCS1_PSS = 0x2B
RFC8017: RSASSA-PSS

kSE05x_RSASignatureAlgo_SHA256_PKCS1_PSS = 0x2C
RFC8017: RSASSA-PSS

kSE05x_RSASignatureAlgo_SHA384_PKCS1_PSS = 0x2D
RFC8017: RSASSA-PSS

kSE05x_RSASignatureAlgo_SHA512_PKCS1_PSS = 0x2E
RFC8017: RSASSA-PSS

kSE05x_RSASignatureAlgo_SHA1_PKCS1 = 0x0A
RFC8017: RSASSA-PKCS1-v1_5

kSE05x_RSASignatureAlgo_SHA_224_PKCS1 = 0x27
RFC8017: RSASSA-PKCS1-v1_5

RFC8017: RSASSA-PKCS1-v1_5

RFC8017: RSASSA-PKCS1-v1_5

kSE05x_RSASignatureAlgo_SHA_512_PKCS1 = 0x2A
RFC8017: RSASSA-PKCS1-v1_5

enum SE05x_SecObjTyp_t
Type of Object

Values:

kSE05x_SecObjTyp_NA = 0x00

kSE05x_SecObjTyp_EC_KEY_PAIR = 0x01

kSE05x_SecObjTyp_EC_PRIV_KEY = 0x02

kSE05x_SecObjTyp_EC_PUB_KEY = 0x03

kSE05x_SecObjTyp_RSA_KEY_PAIR = 0x04

kSE05x_SecObjTyp_RSA_KEY_PAIR_CRT = 0x05

kSE05x_SecObjTyp_RSA_PRIV_KEY = 0x06

kSE05x_SecObjTyp_RSA_PRIV_KEY_CRT = 0x07

kSE05x_SecObjTyp_DES_KEY = 0x0A

kSE05x_SecObjTyp_BINARY_FILE = 0x0B

kSE05x_SecObjTyp_UserID = 0x0C

kSE05x_SecObjTyp_COUNTER = 0x0D

kSE05x_SecObjTyp_PCR = 0x0F

kSE05x_SecObjTyp_CURVE = 0x10

kSE05x_SecObjTyp_HMAC_KEY = 0x11

enum SE05x_SetIndicator_t
Whether object attribute is set

Values:

kSE05x_SetIndicator_NA = 0
Invalid

kSE05x_SetIndicator_NOT_SET = 0x01

kSE05x_SetIndicator_SET = 0x02

enum SE05x_SPAKE2PlusDeviceType_t
SPAKE device type

Values:

kSE05x_SPAKE2PLUS_DEVICE_TYPE_UNKNOWN = 0
Invalid

SE05x_SPAKE2PLUS_DEVICE_TYPE_A = 1
Spake device commionsioner

SE05x_SPAKE2PLUS_DEVICE_TYPE_B = 2
Spake device Node/accessory

enum SE05x_SW12_t
Mapping of 2 byte return code

Values:

kSE05x_SW12_NA = 0
Invalid

No Error

Conditions not satisfied

Security status not satisfied.

Wrong data provided.

Data invalid - policy set invalid for the given object

Command not allowed - access denied based on object policy

enum SE05x_SymmKeyType_t
Symmetric keys

Values:

kSE05x_SymmKeyType_NA = 0

kSE05x_SymmKeyType_AES = *kSE05x_P1_AES*

kSE05x_SymmKeyType_DES = *kSE05x_P1_DES*

kSE05x_SymmKeyType_HMAC = *kSE05x_P1_HMAC*

kSE05x_SymmKeyType_CMAC = *kSE05x_P1_AES*

enum SE05x_TAG_t
Different TAG Values to talk to SE05X IoT Applet

Values:

kSE05x_TAG_NA = 0
Invalid

kSE05x_TAG_SESSION_ID = 0x10

kSE05x_TAG_POLICY = 0x11

kSE05x_TAG_MAX_ATTEMPTS = 0x12

kSE05x_TAG_IMPORT_AUTH_DATA = 0x13

kSE05x_TAG_IMPORT_AUTH_KEY_ID = 0x14

kSE05x_TAG_POLICY_CHECK = 0x15

kSE05x_TAG_1 = 0x41

kSE05x_TAG_2 = 0x42

kSE05x_TAG_3 = 0x43

kSE05x_TAG_4 = 0x44

kSE05x_TAG_5 = 0x45

kSE05x_TAG_6 = 0x46

kSE05x_TAG_7 = 0x47

kSE05x_TAG_10 = 0x4A

kSE05x_TAG_11 = 0x4B

kSE05x_GP_TAG_CONTRL_REF_PARM = 0xA6

kSE05x_GP_TAG_AID = 0x4F

enum SE05x_TLSPerformPRFType_t

TLS Perform PRF

Values:

kSE05x_TLS_PRF_NA = 0

kSE05x_TLS_PRF_CLI_HELLO = *kSE05x_P2_TLS_PRF_CLI_HELLO*

kSE05x_TLS_PRF_SRV_HELLO = *kSE05x_P2_TLS_PRF_SRV_HELLO*

kSE05x_TLS_PRF_CLI_RND = *kSE05x_P2_TLS_PRF_CLI_RND*

kSE05x_TLS_PRF_SRV_RND = *kSE05x_P2_TLS_PRF_SRV_RND*

kSE05x_TLS_PRF_BOTH = *kSE05x_P2_TLS_PRF_BOTH*

enum SE05x_TransientIndicator_t

Whether object is transient or persistent

Values:

kSE05x_TransientIndicator_NA = 0
Invalid

kSE05x_TransientIndicator_PERSISTENT = 0x01

kSE05x_TransientIndicator_TRANSIENT = 0x02

enum SE05x_TransientType_t
Whether key is transient of persistent

Values:

kSE05x_TransientType_Persistent = 0

kSE05x_TransientType_Transient = kSE05x_INS_TRANSIENT

Functions

smStatus_t **DoAPDUTx_s_Case3** (Se05xSession_t **pSessionCtx*, **const** tlvHeader_t **hdr*, uint8_t **cmdBuf*, size_t *cmdBufLen*)

smStatus_t **DoAPDUTxRx** (Se05xSession_t **pSessionCtx*, uint8_t **cmdBuf*, size_t *cmdBufLen*, uint8_t **rspBuf*, size_t **pRspBufLen*)

smStatus_t **DoAPDUTxRx_s_Case2** (Se05xSession_t **pSessionCtx*, **const** tlvHeader_t **hdr*, uint8_t **cmdBuf*, size_t *cmdBufLen*, uint8_t **rspBuf*, size_t **pRspBufLen*)

smStatus_t **DoAPDUTxRx_s_Case4** (Se05xSession_t **pSessionCtx*, **const** tlvHeader_t **hdr*, uint8_t **cmdBuf*, size_t *cmdBufLen*, uint8_t **rspBuf*, size_t **pRspBufLen*)

smStatus_t **DoAPDUTxRx_s_Case4_ext** (Se05xSession_t **pSessionCtx*, **const** tlvHeader_t **hdr*, uint8_t **cmdBuf*, size_t *cmdBufLen*, uint8_t **rspBuf*, size_t **pRspBufLen*)

smStatus_t **Se05x_API_I2CM_Send** (*pSe05xSession_t sessionId*, **const** uint8_t **buffer*, size_t *bufferLen*, uint8_t **result*, size_t **presultLen*)

smStatus_t **se05x_DeCrypt** (**struct** *Se05xSession* **pSessionCtx*, size_t *cmd_cmacLen*, uint8_t **rsp*, size_t **rspLength*, uint8_t *hasle*)

smStatus_t **se05x_Transform** (**struct** *Se05xSession* **pSession*, **const** tlvHeader_t **hdr*, uint8_t **cmdApduBuf*, **const** size_t *cmdApduBufLen*, tlvHeader_t **out_hdr*, uint8_t **txBuf*, size_t **ptxBufLen*, uint8_t *hasle*)

smStatus_t **se05x_Transform_scp** (**struct** *Se05xSession* **pSession*, **const** tlvHeader_t **hdr*, uint8_t **cmdApduBuf*, **const** size_t *cmdApduBufLen*, tlvHeader_t **outhdr*, uint8_t **txBuf*, size_t **ptxBufLen*, uint8_t *hasle*)

int **tlvGet_Result** (uint8_t **buf*, size_t **pBufIndex*, size_t *bufLen*, SE05x_TAG_t *tag*, SE05x_Result_t **presult*)

int **tlvGet_Se05xSession** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, *pSe05xSession_t* **pSessionId*)

int **tlvGet_SecureObjectType** (uint8_t **buf*, size_t **pBufIndex*, size_t *bufLen*, SE05x_TAG_t *tag*, SE05x_SecObjTyp_t **pType*)

int **tlvGet_TimeStamp** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, *SE05x_TimeStamp_t* **pTs*)

int **tlvGet_U16** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, uint16_t **pRsp*) int **tlvGet_U32** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, uint32_t **pRsp*)

int **tlvGet_U8** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, uint8_t **pRsp*)

int **tlvGet_u8buf** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*, uint8_t **rsp*, size_t **pRspLen*)

int **tlvGet_ValueIndex** (uint8_t **buf*, size_t **pBufIndex*, **const** size_t *bufLen*, SE05x_TAG_t *tag*)

int **tlvSet_ECCurve** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, SE05x_ECCurve_t *value*)

int **tlvSet_KeyID** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint32_t *keyID*)

int **tlvSet_MaxAttemps** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint16_t *maxAttemps*)

int **tlvSet_Se05xPolicy** (**const** char **description*, uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, *Se05xPolicy_t *policy*)

int **tlvSet_U16** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint16_t *value*)

int **tlvSet_U16Optional** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint16_t *value*)

int **tlvSet_U32** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint32_t *value*)

int **tlvSet_U64_size** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint64_t *value*, uint16_t *size*)

int **tlvSet_U8** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, uint8_t *value*)

int **tlvSet_u8buf** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, **const** uint8_t **cmd*, size_t *cmdLen*)

int **tlvSet_u8buf_features** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, *pSe05xAppletFeatures_t appletVariant*)

int **tlvSet_u8buf_I2CM** (uint8_t ***buf*, size_t **bufLen*, SE05x_I2CM_TAG_t *tag*, **const** uint8_t **cmd*, size_t *cmdLen*)

int **tlvSet_u8bufOptional** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, **const** uint8_t **cmd*, size_t *cmdLen*)

int **tlvSet_u8bufOptional_ByteShift** (uint8_t ***buf*, size_t **bufLen*, SE05x_TAG_t *tag*, **const** uint8_t **cmd*, size_t *cmdLen*)

Variables

uint32_t **auth_id**

SE_AuthType_t **authType**

void ***conn_ctx**
Connection data context

uint8_t ***dataToMac**

size_t **dataToMacLen**

SE05x_ExtendedFeatures_t ***extended_features**

uint8_t **features**[30]

smStatus_t (***fp_DeCrypt**) (**struct** *Se05xSession* *pSession, size_t prevCmdBufLen, uint8_t *pInRxBuf, size_t *pInRxBufLen, uint8_t hasle) smStatus_t (***fp_RawTXn**)(void *conn_ctx, **struct** *_sss_se05x_tunnel_context* *pChannelCtx, SE_AuthType_t currAuth, **const** tlvHeader_t *hdr, uint8_t *cmdBuf, size_t cmdBufLen, uint8_t *rsp, size_t *rspLen, uint8_t hasle)

smStatus_t (***fp_Transform**)(**struct** *Se05xSession* *pSession, **const** tlvHeader_t *inHdr, uint8_t *inCmdBuf, size_t inCmdBufLen, tlvHeader_t *outHdr, uint8_t *pTxBuf, size_t *pTxBufLen, uint8_t hasle)

API called by fp_TXn. Helps handle UserID/Applet/ECKey to transform buffer.

But this API never sends any data out over any communication link.

smStatus_t (***fp_TXn**)(**struct** *Se05xSession* *pSession, **const** tlvHeader_t *hdr, uint8_t *cmdBuf, size_t cmdBufLen, uint8_t *rsp, size_t *rspLen, uint8_t hasle)

Meta Funciton

Internall first calls fp_Transform Then calls fp_RawTXn Then calls fp_DeCrypt

uint8_t **hasSession**

struct *_sss_se05x_tunnel_context* ***pChannelCtx**

NXSCP03_DynCtx_t ***pdynScp03Ctx**

uint8_t ***se05xCmd**

const tlvHeader_t ***se05xCmd_hdr**

size_t **se05xCmdLC**

size_t **se05xCmdLCW**

size_t **se05xCmdLen**

uint8_t ***se05xTxBuf**

size_t **se05xTxBufLen**

uint8_t **ts**[12]

uint8_t ***value**

uint8_t **value**[8]

size_t **value_len**

SE05x_Variant_t **variant**

size_t **ws_LC**

size_t **ws_LCW**

uint8_t ***wsSe05x_cmd**

size_t **wsSe05x_cmdLen**

uint8_t ***wsSe05x_tag1Cmd**

size_t **wsSe05x_tag1CmdLen**

size_t **wsSe05x_tag1Len**

size_t **wsSe05x_tag1W**

struct Se05x_AppletFeatures_t

Public Members

SE05x_ExtendedFeatures_t ***extended_features**

SE05x_Variant_t **variant**

union SE05x_CryptoModeSubType_t

#include <se05x_enums.h> Cyrpto module subtype

Public Members

SE05x_AeadAlgo_t **aead**

In case it's aead

SE05x_CipherMode_t **cipher**

In case it's cipher

SE05x_DigestMode_t **digest**

In case it's digest

SE05x_MACAlgo_t **mac**

In case it's mac

SE05x_PAKEMode_t **pakeMode**

In case it's pake

uint8_t **union_8bit**

Accessing 8 bit value for APDUs

struct SE05x_ExtendedFeatures_t

Public Members

uint8_t **features**[30]

struct SE05x_TimeStamp_t

Public Members

uint8_t **ts**[12]

struct Se05xApdu_t

Public Members

uint8_t ***dataToMac**

size_t **dataToMacLen**

uint8_t ***se05xCmd**

const tlvHeader_t ***se05xCmd_hdr**

size_t **se05xCmdLC**

size_t **se05xCmdLCW**

size_t **se05xCmdLen**

uint8_t ***se05xTxBuf**

size_t **se05xTxBufLen**

size_t **ws_LC**

size_t **ws_LCW**

uint8_t ***wsSe05x_cmd**

size_t **wsSe05x_cmdLen**

uint8_t ***wsSe05x_tag1Cmd**

size_t **wsSe05x_tag1CmdLen**

size_t **wsSe05x_tag1Len**

size_t **wsSe05x_tag1W**

struct Se05xPolicy_t

Public Members

uint8_t ***value**

size_t **value_len**

struct Se05xSession

Public Members

uint32_t **auth_id**

SE_AuthType_t **authType**

void ***conn_ctx**
Connection data context

smStatus_t (***fp_DeCrypt**)(**struct** *Se05xSession* *pSession, size_t prevCmdBufLen, uint8_t *pInRxBuf, size_t *pInRxBufLen, uint8_t hasle)

smStatus_t (***fp_RawTXn**)(void *conn_ctx, **struct** *_sss_se05x_tunnel_context* *pChannelCtx, SE_AuthType_t currAuth, **const** tlvHeader_t *hdr, uint8_t *cmdBuf, size_t cmdBufLen, uint8_t *rsp, size_t *rspLen, uint8_t hasle)

smStatus_t (***fp_Transform**)(**struct** *Se05xSession* *pSession, **const** tlvHeader_t *inHdr, uint8_t *inCmdBuf, size_t inCmdBufLen, tlvHeader_t *outHdr, uint8_t *pTxBuf, size_t *pTxBufLen, uint8_t hasle)
API called by fp_TXn. Helps handle UserID/Applet/ECKey to transform buffer.

But this API never sends any data out over any communication link.

smStatus_t (***fp_TXn**)(**struct** *Se05xSession* *pSession, **const** tlvHeader_t *hdr, uint8_t *cmdBuf, size_t cmdBufLen, uint8_t *rsp, size_t *rspLen, uint8_t hasle)
Meta Funciton

Internall first calls fp_Transform Then calls fp_RawTXn Then calls fp_DeCrypt

uint8_t **hasSession**

struct *_sss_se05x_tunnel_context* ***pChannelCtx**

NXSCP03_DynCtx_t ***pdynScp03Ctx**

uint8_t **value**[8]

11.12.2 SE05x APIs

group **`se05x_apis`**

SE05x APIs.

Defines

`ENABLE_DEPRECATED_API_WritePCR`

`Se05x_API_ECGenSharedSecret`

Wrapper for Se05x_API_ECDHGenerateSharedSecret

`Se05x_API_SHAOneShot`

Wrapper for Se05x_API_DigestOneShot

`Se05x_API_WriteECKey_with_version`

Functions

smStatus_t **`Se05x_API_AeadCCMFinal`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, uint8_t **pOutputData*, size_t **pOutputLen*, uint8_t **pTag*, size_t **pTagLen*, **`const`** SE05x_Cipher_Oper_t *operation*)

Se05x_API_AeadCCMFinal

Finish a sequence of AES_CCM AEAD operations.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_FINAL	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
TLV[TAG_6]	Byte array containing tag to verify [Conditional] When the mode is decrypt and verify (i.e. AEADInit has been called with P2 = P2_DECRYPT).	
Le	0x00	Expected returned data.

R-APDU Body

Value	Description
TLV[TAG_1]	Output data
TLV[TAG_2]	Byte array containing tag (if P2 = P2_ENCRYPT) or byte array containing Result (if P2 = P2_DECRYPT)

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] cryptoObjectID`: The crypto object id
- `[out] pOutputData`: The output data
- `[out] pOutputLen`: The output length
- `tag`: The tag
- `tagLen`: The tag length
- `[in] operation`: The operation

smStatus_t **`Se05x_API_AeadCCMInit`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CipherMode_t *cipherMode*, SE05x_CryptoObjectID_t *cryptoObjectID*, uint8_t **pIV*, size_t *IVLen*, size_t *aadLen*, size_t *payloadLen*, size_t *tagLen*, **`const`** SE05x_Cipher_Oper_t *operation*)

Se05x_API_AeadCCMInit

Initialize an authentication encryption or decryption with associated data. The Crypto Object keeps the state of the AEAD operation until it's finalized or deleted. Once the AEADFinal function is executed successfully, the Crypto Object state returns to the state immediately after the previous AEADInit function.AEAD in CCM mode.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_ENCRYPT or P2_DECRYPT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the AESKey Secure object.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_5]	Byte array containing the initialization vector [12 bytes until 60 bytes] or a 2-byte value containing the initialization vector length, depending on the AEADMode of the Crypto Object.
	TLV[TAG_6]	Byte array containing 2-byte AAD length. [Conditional: needed if AEADMode equals AES_CCM]
	TLV[TAG_7]	Byte array containing 2-byte message length. [Conditional: needed if AEADMode equals AES_CCM]
	TLV[TAG_8]	Byte array containing 2-byte tag size. [Conditional: needed if AEADMode equals AES_CCM].
Le	•	

R-APDU Body

NA *R-APDU Trailer*

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] cryptoObjectID`: The crypto object id
- `[in] pIV`: { parameter_description }
- `[in] IVLen`: The iv length
- `[in] aadLen`: The aad length
- `[in] payloadLen`: The payloadLen length

- `[in] tagLen`: The tag length
- `[in] operation`: The operation

smStatus_t **`Se05x_API_AeadCCMLastUpdate`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **pInputData*, size_t *inputDataLen*)

Se05x_API_AeadCCMLastUpdate.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing input data [Conditional: only when TLV[TAG_4] is not present] [Optional]
Le	0x00	Expecting returned data.

R-APDU Body

NA *R-APDU Trailer*

SW	Description
SW_NO_ERROR	The command is handled successfully.

R-APDU Trailer

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] cryptoObjectID`: The crypto object id
- `[in] pInputData`: The input data
- `[in] inputDataLen`: The input data length

smStatus_t **`Se05x_API_AeadFinal`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, uint8_t **tag*, size_t **tagLen*, **`const`** SE05x_Cipher_Oper_t *operation*)

Se05x_API_AeadFinal

Finish a sequence of AEAD operations. The AEADFinal command provides the computed GMAC or indicates whether the GMAC is correct depending on the P2 parameters passed during AEADInit. The length of the GMAC is always 16 bytes when P2 equals P2_ENCRYPT. When P2 equals P2_DECRYPT, the minimum tag length to pass is 4 bytes.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_FINAL	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
TLV[TAG_6]	Byte array containing tag to verify [Conditional] When the mode is decrypt and verify (i.e. AEADInit has been called with P2 = P2_DECRYPT).	
Le	0x00	Expected returned data.

R-APDU Body

Value	Description
TLV[TAG_2]	Byte array containing tag (if P2 = P2_ENCRYPT) or byte array containing Result (if P2 = P2_DECRYPT)

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] cryptoObjectID`: The crypto object id
- `tag`: The tag
- `tagLen`: The tag length
- `[in] operation`: The operation

smStatus_t **`Se05x_API_AeadInit`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CipherMode_t *cipherMode*, SE05x_CryptoObjectID_t *cryptoObjectID*, uint8_t **pIV*, size_t *IVLen*, **`const`** SE05x_Cipher_Oper_t *operation*)

Se05x_API_AeadInit

Initialize an authentication encryption or decryption with associated data. The Crypto Object keeps the state of the AEAD operation until it's finalized or deleted. Once the AEADFinal function is executed successfully, the Crypto Object state returns to the state immediately after the previous AEADInit function.

When P1 equals P1_AEAD_INT_IV and P2 equals P1_ENCRYPT, TLV[TAG_5] must includes the length of the initialization vector. In that case, the initialization vector is generated internally and passed back in the response command. When the device is in FIPS mode (see FIPS Compliance), P1 equal to P1_AEAD will result in SW_CONDITIONS_NOT_SATISFIED.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD or P1_AEAD_INT_IV	See `SE05x_P1_t`
P2	P2_ENCRYPT or P2_DECRYPT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the AESKey Secure object.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_5]	Byte array containing the initialization vector (if P1 equals P1_AEAD or P1 equals P1_AEAD and P2 equals P2_DECRYPT) or 2-byte value containing the initialization vector length (if P1 equals P1_AEAD_INT_IV and P2 equals P2_ENCRYPT) [Optional] [Conditional: required when P1 equals P1_AEAD_INT_IV and P2 equals P2_ENCRYPT]
Le	•	

R-APDU Body

Value	Description
TLV[TAG_3]	Byte array containing the used initialization vector. It remains valid until deselect, AEADInit, AEADFinal or AEADOneShot is called. [Conditional: Only when P1 equals P1_AEAD_INT_IV and P2 equals P2_ENCRYPT]

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] cryptoObjectID`: The crypto object id
- `[in] pIV`: { parameter_description }
- `[in] IVLen`: The iv length
- `[in] operation`: The operation

smStatus_t **Se05x_API_AeadOneShot** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CipherMode_t *cipherMode*, **const** uint8_t **inputData*, size_t *inputDataLen*, **const** uint8_t **aad*, size_t *aadLen*, uint8_t **IV*, size_t *IVLen*, uint8_t **tagData*, size_t **tagDataLen*, uint8_t **outputData*, size_t **poutputDataLen*, **const** SE05x_Cipher_Oper_OneShot_t *operation*)

Se05x_API_AeadOneShot

Authenticated encryption or decryption with associated data in one shot mode.

The key object must be either an AES key or DES key.

The AEADOneShot command returns the computed GMAC (when P2 equals P2_ENCRYPT_ONESHOT) or indicates whether the GMAC is correct (when P2 equals P2_DECRYPT_ONESHOT). The length of the GMAC is always 16 bytes when P2 equals P2_ENCRYPT_ONESHOT.

When P2 equals P2_DECRYPT_ONESHOT:

- the minimum tag length to pass is 4 bytes.
- when the GMAC tag is not correct, only the result will be returned, no output data will be present.

Note: on applet v4.4.0, the maximum lengths are not yet enforced and might differ from the values listed in the C-APDU.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD or P1_AEAD_INT_IV	See `SE05x_P1_t`
P2	P2_ENCRYPT_ONESHOT or P2_DECRYPT_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the AESKey Secure object.
	TLV[TAG_2]	1-byte AEADMode
	TLV[TAG_3]	Byte array containing input data. Maximum length = 256 bytes. [Optional]
	TLV[TAG_4]	Byte array containing Additional Authenticated Data. Maximum length = 64 bytes. [Optional]
	TLV[TAG_5]	Byte array containing an initialization vector (if P1 equals P1_AEAD) or 2-byte value containing the initialization vector length (if P1 equals P1_AEAD_SP800_108). Maximum IV length = 60 bytes. [Optional] [Conditional: required when P1 equals P1_AEAD_INT_IV]
	TLV[TAG_6]	Byte array containing the GMAC tag to verify. [Conditional: when P2 equals P2_DECRYPT_ONESHOT]
Le	0x00	Expecting return data.

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing output data.
TLV[TAG_2]	Byte array containing tag (if P2 = P2_ENCRYPT_ONESHOT) or byte array containing Result (if P2 = P2_DECRYPT_ONESHOT)
TLV[TAG_3]	Byte array containing the initialization vector (if P1 = P1_AEAD_INT_IV and P2 = P2_ENCRYPT_ONESHOT).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] cipherMode`: The cipher mode
- `[in] inputData`: The input data
- `[in] inputDataLen`: The input data length
- `[in] aad`: The aad
- `[in] aadLen`: The aad length
- `[in] IV`: The iv
- `[in] IVLen`: The iv length
- `tagData`: The tag data
- `tagDataLen`: The tag data length
- `outputData`: The output data
- `poutputDataLen`: The poutput data length
- `[in] operation`: The operation

smStatus_t **`Se05x_API_AeadUpdate`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **pInputData*, size_t *inputDataLen*, uint8_t **pOutputData*, size_t **pOutputLen*)

Se05x_API_AeadUpdate.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing input data [Conditional: only when TLV[TAG_4] is not present] [Optional]
Le	0x00	Expecting returned data.

R-APDU Body

Value	Description
TLV[TAG_1]	Output data [Conditional: only when TLV[TAG_3] is passed as input]

R-APDU Trailer

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] cryptoObjectID`: The crypto object id
- `[in] pInputData`: The input data
- `[in] inputDataLen`: The input data length
- `pOutputData`: The output data
- `pOutputLen`: The output length

smStatus_t **`Se05x_API_AeadUpdate_aad`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **pAadData*, size_t *aadDataLen*)

Se05x_API_AeadUpdate_aad

Update a Crypto Object of type CC_AEAD.

The user either needs to send input data or Additional Authenticated Data (AAD), but not both at once.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_AEAD	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_4]	Byte array containing Additional Authenticated Data. [Conditional: only when TLV[TAG_3] is not present] [Optional]
Le	0x00	Expecting returned data.

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] cryptoObjectID`: The crypto object id
- `[in] pAadData`: The aad data
- `[in] aadDataLen`: The aad data length

smStatus_t **`Se05x_API_CheckObjectExists`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_Result_t **presult*)

Se05x_API_CheckObjectExists

Check if a Secure Object with a certain identifier exists or not.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_EXIST	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte existing Secure Object identifier.
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	1-byte `SE05x_Result_t`

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[out] presult`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_CipherFinal`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **outputData*, size_t **poutputDataLen*)

Se05x_API_CipherFinal

Finish a sequence of cipher operations.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_CIPHER	See `SE05x_P1_t`
P2	P2_FINAL	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
TLV[TAG_3]	Input data	
Le	0x00	Expected returned data.

R-APDU Body

Value	Description
TLV[TAG_1]	Output data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_2]
- `[in] inputData`: inputData [2:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] outputData`: [0:kSE05x_TAG_1]
- `[inout] poutputDataLen`: Length for outputData

smStatus_t **`Se05x_API_CipherInit`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CryptoObjectID_t *cryptoObjectID*, uint8_t **IV*, size_t *IVLen*, **`const`** SE05x_Cipher_Oper_t *operation*)

Se05x_API_CipherInit

Initialize a symmetric encryption or decryption. The Crypto Object keeps the state of the cipher operation until it's finalized or deleted. Once the CipherFinal function is executed successfully, the Crypto Object state returns to the state immediately after the previous CipherInit function.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_CIPHER	See `SE05x_P1_t`
P2	P2_ENCRYPT or P2_DECRYPT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_4]	Initialization Vector [Optional] [Conditional: only when the Crypto Object type equals CC_CIPHER and subtype is not including ECB]
Le	•	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] cryptoObjectID`: cryptoObjectID [2:kSE05x_TAG_2]
- `[in] IV`: IV [3:kSE05x_TAG_4]
- `[in] IVLen`: Length of IV
- `[in] operation`: See SE05x_Cipher_Oper_t

smStatus_t **`Se05x_API_CipherOneShot`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CipherMode_t *cipherMode*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **IV*, size_t *IVLen*, uint8_t **outputData*, size_t **poutputDataLen*, **`const`** SE05x_Cipher_Oper_OneShot_t *operation*)

Se05x_API_CipherOneShot.

Encrypt or decrypt data in one shot mode.

The key object must be either an AES key or DES key.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_CIPHER	See `SE05x_P1_t`
P2	P2_ENCRYPT_ONESHOT or P2_DECRYPT_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object.
	TLV[TAG_2]	1-byte CipherMode
	TLV[TAG_3]	Byte array containing input data.
	TLV[TAG_4]	Byte array containing an initialization vector. [Optional] [Conditional: only when the Crypto Object type equals CC_CIPHER and subtype is not including ECB]
Le	0x00	Expecting return data.

R-APDU Body

Value	Description
TLV[TAG_1]	Output data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] cipherMode`: The cipher mode
- `[in] inputData`: The input data
- `[in] inputDataLen`: The input data length
- `[in] IV`: Initial vector
- `[in] IVLen`: The iv length
- `outputData`: The output data
- `poutputDataLen`: The poutput data length
- `[in] operation`: The operation

smStatus_t **`Se05x_API_CipherUpdate`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **outputData*, size_t **poutputDataLen*)

Se05x_API_CipherUpdate

Update a cipher context.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_CIPHER	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_2]	2-byte Crypto Object identifier
TLV[TAG_3]	Byte array containing input data	
Le	0x00	Expecting returned data.

R-APDU Body

Value	Description
TLV[TAG_1]	Output data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_2]
- `[in] inputData`: inputData [2:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] outputData`: [0:kSE05x_TAG_1]
- `[inout] poutputDataLen`: Length for outputData

smStatus_t **`Se05x_API_CloseSession`** (*pSe05xSession_t session_ctx*)

Se05x_API_CloseSession

Closes a running session.

When a session is closed, it cannot be reopened.

All session parameters are transient.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SESSION_CLOSE	See `SE05x_P2_t`

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The session is closed successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]

smStatus_t **`Se05x_API_CreateCounter`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *size*)

Se05x_API_CreateCounter

Creates a new counter object.

Counters can only be incremented, not decremented.

When a counter reaches its maximum value (e.g., 0xFFFFFFFF for a 4-byte counter), they cannot be incremented again.

An input value (TAG_3) must always have the same length as the existing counter (if it exists); otherwise the command will return an error.

Command to Applet

Field	Value	Description
P1	P1_COUNTER	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_1]	4-byte counter identifier.
	TLV[TAG_2]	2-byte counter size (1 up to 8 bytes). [Conditional: only if object doesn't exist yet and TAG_3 is not given]
	TLV[TAG_3]	Counter value [Optional: - if object doesn't exist: must be present if TAG_2 is not given. - if object exists: if not present, increment by 1. if present, set counter to value.]

R-APDU Body

NA

R-APDU Trailer

NA

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] policy`: policy [1:kSE05x_TAG_POLICY]
- `[in] objectID`: object id [2:kSE05x_TAG_1]
- `[in] size`: size [3:kSE05x_TAG_2]

smStatus_t **`Se05x_API_CreateCryptoObject`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, SE05x_CryptoContext_t *cryptoContext*, *SE05x_CryptoModeSubType_t subtype*)

Se05x_API_CreateCryptoObject

Creates a Crypto Object on the SE05X . Once the Crypto Object is created, it is bound to the user who created the Crypto Object.

A CryptoObject is a 2-byte value consisting of a CryptoContext in MSB and one of the following in LSB:

- DigestMode in case CryptoContext = CC_DIGEST
- CipherMode in case CryptoContext = CC_CIPHER
- MACAlgo in case CryptoContext = CC_SIGNATURE
- AEADMode in case CryptoContext = CC_AEAD

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See `SE05x_INS_t`
P1	P1_CRYPTO_OBJ	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte Crypto Object identifier
	TLV[TAG_2]	1-byte `SE05x_CryptoObject_t`
	TLV[TAG_3]	1-byte Crypto Object subtype, either from `DigestModeRef`, CipherMode, MACAlgo (depending on TAG_2) or AEADMode.

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_1]
- `[in] cryptoContext`: cryptoContext [2:kSE05x_TAG_2]
- `[in] subtype`: 1-byte Crypto Object subtype, either from DigestMode, CipherMode or MACAlgo (depending on TAG_2). [3:kSE05x_TAG_3]

smStatus_t **Se05x_API_CreateECCurve** (*pSe05xSession_t session_ctx*, SE05x_ECCurve_t *curveID*)

Se05x_API_CreateECCurve

Create an EC curve listed in ECCurve.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See `SE05x_INS_t`
P1	P1_CURVE	See `SE05x_P1_t`
P2	P2_CREATE	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier (from `SE05x_ECCurve_t`).
Le		

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] curveID`: curve id [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_CreateSession`** (*pSe05xSession_t session_ctx*, uint32_t *authObjectID*, uint8_t **sessionId*, size_t **psessionIdLen*)

Se05x_API_CreateSession

Creates a session on SE05X .

Depending on the authentication object being referenced, a specific method of authentication applies. The response needs to adhere to this authentication method.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SESSION_CREATE	See `SE05x_P2_t`
Lc	#(Payload)	Payload length.
Payload	TLV[TAG_1]	4-byte authentication object identifier.
Le	0x0A	Expecting TLV with 8-byte session ID.

R-APDU Body

Value	Description
TLV[TAG_1]	8-byte session identifier.

R-APDU Trailer

SW_NO_ERROR:

- The command is handled successfully.

SW_CONDITIONS_NOT_SATISFIED:

- The authenticator does not exist
- The provided input data are incorrect.
- The session is invalid.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] authObjectID`: auth [1:kSE05x_TAG_1]
- `[out] sessionId`: [0:kSE05x_TAG_1]
- `[inout] psessionIdLen`: Length for sessionId

smStatus_t **`Se05x_API_DeleteAll`** (*pSe05xSession_t session_ctx*)

Se05x_API_DeleteAll

Delete all Secure Objects, delete all curves and Crypto Objects. Secure Objects that are trust provisioned by NXP are not deleted (i.e., all objects that have Origin set to ORIGIN_PROVISIONED, including the objects with reserved object identifiers listed in Object attributes).

This command can only be used from sessions that are authenticated using the credential with index RESERVED_ID_FACTORY_RESET.

Important : if a secure messaging session is up & running (e.g., AESKey or ECKey session) and the command is sent within this session, the response of the DeleteAll command will not be wrapped (i.e., not encrypted and no R-MAC), so this will also break down the secure channel protocol (as the session is closed by the DeleteAll command itself).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DELETE_ALL	See `SE05x_P2_t`
Lc	0x00	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]

smStatus_t **`Se05x_API_DeleteAll_Iterative`** (*pSe05xSession_t session_ctx*)

Se05x_API_DeleteAll_Iterative

Go through each object and delete it individually.

This API does not use the Applet API Se05x_API_DeleteAll. It does not delete ALL objects and purposefully skips few objects.

Instead, this API uses Se05x_API_ReadIDList and Se05x_API_ReadCryptoObjectList to first fetch list of objects to host, and **selectitvely** deletes.

For e.g. It does not kill objects from:

- The range SE05X_OBJID_SE05X_APPLET_RES_START to SE05X_OBJID_SE05X_APPLET_RES_END. This range is used by applet.
- The range EX_SSS_OBJID_DEMO_AUTH_START to EX_SSS_OBJID_DEMO_AUTH_END, which is used by middleware DEMOS for authentication.
- And others.

Kindly see the Implementation of is API Se05x_API_DeleteAll_Iterative to see the list of ranges that are skipped.

Return The status of API.

Parameters

- `[in] session_ctx`: Session Context

smStatus_t **`Se05x_API_DeleteCryptoObject`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*)

Se05x_API_DeleteCryptoObject

Deletes a Crypto Object on the SE05X .

Note: when a Crypto Object is deleted, the memory (as mentioned in) is de- allocated, but the transient memory is only freed when de-selecting the applet!

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_CRYPTO_OBJ	See `SE05x_P1_t`
P2	P2_DELETE_OBJECT	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte Crypto Object identifier

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_DeleteECCurve`** (*pSe05xSession_t session_ctx*, SE05x_ECCurve_t *curveID*)

Se05x_API_DeleteECCurve

Deletes an EC curve.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_CURVE	See `SE05x_P1_t`
P2	P2_DELETE_OBJECT	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier (from `SE05x_ECCurve_t`)

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] curveID`: curve id [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_DeleteSecureObject`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*)
Se05x_API_DeleteSecureObject

Deletes a Secure Object.

If the object origin = ORIGIN_PROVISIONED, an error will be returned and the object is not deleted.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DELETE_OBJECT	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte existing Secure Object identifier.
Le	•	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_DFAuthenticateFirstPart1`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **outputData*, size_t **poutputDataLen*)

Se05x_API_DFAuthenticateFirstPart1

MIFARE DESFire support

MIFARE DESFire EV2 Key derivation (S-mode). This is limited to AES128 keys only.

The SE05X can be used by a card reader to setup a session where the SE05X stores the master key(s) and the session keys are generated and passed to the host.

The SE05X keeps an internal state of MIFARE DESFire authentication data during authentication setup. This state is fully transient, so it is lost on deselect of the applet.

The MIFARE DESFire state is owned by 1 user at a time; i.e., the user who calls DFAuthenticateFirstPart1 owns the MIFARE DESFire context until DFAuthenticateFirstPart1 is called again or until DFKillAuthentication is called.

The SE05X can also be used to support a ChangeKey command, either supporting ChangeKey or ChangeKeyEV2. To establish a correct use case, policies need to be applied to the keys to indicate keys can be used for ChangeKey or not, etc. (to be detailed)

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_AUTH_FIRST_PART1	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte key identifier.
	TLV[TAG_2]	16-byte encrypted card challenge: E(Kx,RndB)
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	32-byte output data: E(Kx, RandA || RandB’)

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] inputData`: inputData [2:kSE05x_TAG_2]
- `[in] inputDataLen`: Length of inputData

- `[out] outputData`: [0:kSE05x_TAG_1]
- `[inout] poutputDataLen`: Length for outputData

smStatus_t **`Se05x_API_DFAuthenticateFirstPart2`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **outputData*, size_t **poutputDataLen*)

Se05x_API_DFAuthenticateFirstPart2

For First part 2, the key identifier is implicitly set to the identifier used for the First authentication. DFAuthenticateFirstPart1 needs to be called before; otherwise an error is returned.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_AUTH_FIRST_PART2	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	32 byte input: E(Kx,TI||RndA'||PDcap2||PCDcap2)
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	12-byte array returning PDcap2||PCDcap2.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_WRONG_DATA	
SW_CONDITIONS_NOT_SATISFIED	

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] inputData`: inputData [1:kSE05x_TAG_1]
- `[in] inputDataLen`: Length of inputData
- `[out] outputData`: [0:kSE05x_TAG_1]
- `[inout] poutputDataLen`: Length for outputData

smStatus_t **`Se05x_API_DFAuthenticateNonFirstPart1`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **outputData*, size_t **poutputDataLen*)

Se05x_API_DFAuthenticateNonFirstPart1

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_AUTH_NONFIRST_PART1	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte key identifier.
	TLV[TAG_2]	16-byte encrypted card challenge: E(Kx,RndB)
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	32-byte output data: E(Kx, RandA ‖ RandB')

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] inputData`: inputData [2:kSE05x_TAG_2]
- `[in] inputDataLen`: Length of inputData
- `[out] outputData`: [0:kSE05x_TAG_1]
- `[inout] poutputDataLen`: Length for outputData

smStatus_t **Se05x_API_DFAuthenticateNonFirstPart2** (*pSe05xSession_t session_ctx*, **const** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_DFAuthenticateNonFirstPart2

For NonFirst part 2, the key identifier is implicitly set to the identifier used for the NonFirst part 1 authentication. DFAuthenticateNonFirstPart1 needs to be called before; otherwise an error is returned.

If authentication fails, SW_WRONG_DATA will be returned.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_AUTH_NONFIRST_PART2	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	16-byte E(Kx, RndA')
Le	0x00	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] inputData`: inputData [1:kSE05x_TAG_1]
- `[in] inputDataLen`: Length of inputData

smStatus_t **`Se05x_API_DFChangeKeyPart1`** (*pSe05xSession_t session_ctx*, uint32_t *oldObjectID*, uint32_t *newObjectID*, uint8_t *keySetNr*, uint8_t *keyNoDESFire*, uint8_t *keyVer*, uint8_t **KeyData*, size_t **pKeyDataLen*)

Se05x_API_DFChangeKeyPart1

The DFChangeKeyPart1 command is supporting the function to change keys on the DESFire PICC. The command generates the cryptogram required to perform such operation.

The new key and, if used, the current (or old) key must be stored in the SE05X and have the POLICY_OBJ_ALLOW_DESFIRE_AUTHENTICATION associated to execute this command. This means the new PICC key must have been loaded into the SE05X prior to issuing this command.

The 1-byte key set number indicates whether DESFire ChangeKey or DESFire ChangeKeyEV2 is used. When key set equals 0xFF, ChangeKey is used.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_CHANGE_KEY_PART1	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the old key. [Optional: if the authentication key is the same as the key to be replaced, this TAG should not be present].
	TLV[TAG_2]	4-byte identifier of the new key.
	TLV[TAG_3]	1-byte key set number [Optional: default = 0xC6]
	TLV[TAG_4]	1-byte DESFire key number to be targeted.
	TLV[TAG_5]	1-byte key version
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Cryptogram holding key data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] oldObjectID`: oldObjectID [1:kSE05x_TAG_1]
- `[in] newObjectID`: newObjectID [2:kSE05x_TAG_2]
- `[in] keySetNr`: keySetNr [3:kSE05x_TAG_3]
- `[in] keyNoDESFire`: keyNoDESFire [4:kSE05x_TAG_4]
- `[in] keyVer`: keyVer [5:kSE05x_TAG_5]
- `[out] KeyData`: [0:kSE05x_TAG_1]
- `[inout] pKeyDataLen`: Length for KeyData

smStatus_t **`Se05x_API_DFChangeKeyPart2`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **MAC*, size_t *MACLen*, uint8_t **presult*)

Se05x_API_DFChangeKeyPart2

The DFChangeKeyPart2 command verifies the MAC returned by ChangeKey or ChangeKeyEV2. Note that this function only needs to be called if a MAC is returned (which is not the case if the currently authenticated key is changed on the DESFire card).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_CHANGE_KEY_PART2	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	MAC
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	1-byte `SE05x_Result_t`

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] MAC`: MAC [1:kSE05x_TAG_1]
- `[in] MACLen`: Length of MAC
- `[out] presult`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_DFDiversifyKey`** (*pSe05xSession_t session_ctx*, uint32_t *masterKeyID*, uint32_t *diversifiedKeyID*, **`const`** uint8_t **divInputData*, size_t *divInputDataLen*)

Se05x_API_DFDiversifyKey

Create a Diversified Key. Input is *divInput* 1 up to 31 bytes.

Note that users need to create the diversified key object before calling this function.

Both the master key and the diversified key need the policy POLICY_OBJ_ALLOW_DESFIRE_AUTHENTICATION to be set.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DIVERSIFY	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte master key identifier.
	TLV[TAG_2]	4-byte diversified key identifier.
	TLV[TAG_3]	Byte array containing divInput (up to 31 bytes).
Le		

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	No master key found.
	Wrong length for divInput.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] masterKeyID`: masterKeyID [1:kSE05x_TAG_1]
- `[in] diversifiedKeyID`: diversifiedKeyID [2:kSE05x_TAG_2]
- `[in] divInputData`: divInputData [3:kSE05x_TAG_3]
- `[in] divInputDataLen`: Length of divInputData

smStatus_t **`Se05x_API_DFDumpSessionKeys`** (*pSe05xSession_t session_ctx*, uint8_t **sessionData*, size_t **psessionDataLen*)

Se05x_API_DFDumpSessionKeys

Dump the Transaction Identifier and the session keys to the host.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DUMP_KEY	See `SE05x_P2_t`
Lc	#(Payload)	
Le	0x28	Expecting TLV with 38 bytes data.

R-APDU Body

Value	Description
TLV[TAG_1]	38 bytes: KeyID.SesAuthENCKey || KeyID.SesAuthMACKey || TI || Cmd-Ctr

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[out] sessionData`: 38 bytes: KeyID.SesAuthENCKey || KeyID.SesAuthMACKey || TI || Cmd-Ctr [0:kSE05x_TAG_1]
- `[inout] psessionDataLen`: Length for sessionData

smStatus_t **`Se05x_API_DFKillAuthentication`** (*pSe05xSession_t session_ctx*)

Se05x_API_DFKillAuthentication

DFKillAuthentication invalidates any authentication and clears the internal DESFire state. Keys used as input (master keys or diversified keys) are not touched.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_KILL_AUTH	See `SE05x_P2_t`
Lc	#(Payload)	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]

smStatus_t **`Se05x_API_DigestFinal`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **cmacValue*, size_t **pcmacValueLen*)

Se05x_API_DigestFinal

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_FINAL	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Data to be encrypted or decrypted.
Le	0x00	Expecting TLV with hash value.

R-APDU Body

Value	Description
TLV[TAG_1]	CMAC value

R-APDU Trailer

SW	Description
SW_NO_ERROR	The hash is created successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_2]
- `[in] inputData`: inputData [2:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] cmacValue`: [0:kSE05x_TAG_1]
- `[inout] pcmacValueLen`: Length for cmacValue

smStatus_t **`Se05x_API_DigestInit`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*)

Se05x_API_DigestInit

Open a digest operation. The state of the digest operation is kept in the Crypto Object until the Crypto Object is finalized or deleted.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_INIT	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_2]

smStatus_t **`Se05x_API_DigestOneShot`** (*pSe05xSession_t session_ctx*, uint8_t *digestMode*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **hashValue*, size_t **phashValueLen*)

Se05x_API_DigestOneShot

Performs a hash operation in one shot (without context).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	1-byte DigestMode (except DIGEST_NO_HASH)
	TLV[TAG_2]	Data to hash.
Le	0x00	TLV expecting hash value

R-APDU Body

Value	Description
TLV[TAG_1]	Hash value.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The hash is created successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] digestMode`: digestMode [1:kSE05x_TAG_1]
- `[in] inputData`: inputData [2:kSE05x_TAG_2]
- `[in] inputDataLen`: Length of inputData
- `[out] hashValue`: [0:kSE05x_TAG_1]
- `[inout] phashValueLen`: Length for hashValue

smStatus_t **`Se05x_API_DigestUpdate`** (*pSe05xSession_t session_ctx*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_DigestUpdate

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Data to be hashed.
Le		

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] cryptoObjectID`: cryptoObjectID [1:kSE05x_TAG_2]
- `[in] inputData`: inputData [2:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData

smStatus_t **`Se05x_API_DisableObjCreation`** (*pSe05xSession_t session_ctx*, SE05x_LockIndicator_t *lockIndicator*, SE05x_RestrictMode_t *restrictMode*)

Se05x_API_DisableObjCreation

Command to Applet

R-APDU Body

NA

R-APDU Trailer

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] lockIndicator`: [1:kSE05x_TAG_1]
- `[in] restrictMode`: [2:kSE05x_TAG_2]

smStatus_t **`Se05x_API_EC_CurveGetId`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_ECCurve_t **pcurveId*)

Get the Curve ID for existing Key.

This API is functionally same as Se05x_API_GetECCurveId but uses SE05x_ECCurve_t as a type instead of uint8_t.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `pcurveId`: The pcurve identifier

smStatus_t **`Se05x_API_ECDAASign`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_ECDAASignatureAlgo_t *ecdaaSignAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, **`const`** uint8_t **randomData*, size_t *randomDataLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_ECDAASign

The ECDAASign command signs external data using the indicated key pair or private key. This is performed according to ECDAA. The generated signature is:

- r = random mod n
- s = (r + T.ds) mod n where d is the private key

The ECDAASignatureAlgo indicates the applied algorithm.

This APDU command should be used with a key identifier linked to TPM_ECC_BN_P256 curve.

Note: The applet allows the random input to be 32 bytes of zeroes; the user must take care that this is not considered as valid input. Only input in the interval [1, n-1] must be considered as valid.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_SIGN	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of EC key pair or private key.
	TLV[TAG_2]	1-byte ECDAASignatureAlgo
	TLV[TAG_3]	T = 32-byte array containing hashed input data.
	TLV[TAG_4]	r = 32-byte array containing random data, must be in the interval [1, n-1] where n is the order of the curve.
Le	0x00	Expecting signature

R-APDU Body

Value	Description
TLV[TAG_1]	ECDSA Signature (r concatenated with s).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]

- `[in] ecdaaSignAlgo`: ecdaaSignAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[in] randomData`: randomData [4:kSE05x_TAG_4]
- `[in] randomDataLen`: Length of randomData
- `[out] signature`: [0:kSE05x_TAG_1]
- `[inout] psignatureLen`: Length for signature

smStatus_t **`Se05x_API_ECDHGenerateSharedSecret`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **pubKey*, size_t *pubKeyLen*, uint8_t **sharedSecret*, size_t **psharedSecretLen*)

Se05x_API_ECDHGenerateSharedSecret

The ECDHGenerateSharedSecret command generates a shared secret ECC point on the curve using an EC private key on SE05X and an external public key provided by the caller. The output shared secret is returned to the caller.

All curves from ECCurve are supported, except ECC_ED_25519.

Note that ECDHGenerateSharedSecret commands with EC keys using curve ID_ECC_MONT_DH_25519 or ID_ECC_MONT_DH_448 cause NVM write operations for each call. This is not the case for the other curves.

When CONFIG_FIPS_MODE_DISABLED is not set, this function will always return SW_CONDTIONS_NOT_SATISFIED.

The shared secret can only be received when the Secure Object containing the key pair or private key (TLV[TAG_1]) does not contain the policy POLICY_OBJ_FORBID_DERIVED_OUTPUT. If that is the case, the user must provide TLV[TAG_7} to store the shared secret in an HMACKey object. The user is responsible to assign the correct size of the HMACKey object: this must equal the size of the shared secret exactly.

On applet 4.4.0, the policy POLICY_OBJ_FORBID_DERIVED_OUTPUT is not yet verified for this function. It will always be allowed.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_EC	See `SE05x_P1_t`
P2	P2_DH	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or private key.
TLV[TAG_2]	External public key (see `ECKeyRef`).	
TLV[TAG_7]	4-byte HMACKey identifier to store output. [Optional]	
Le	0x00	Expected shared secret length.

R-APDU Body

Value	Description
TLV[TAG_1]	The returned shared secret. [Conditional: only when the input does not contain TLV[TAG_7].}

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] pubKey`: pubKey [2:kSE05x_TAG_2]
- `[in] pubKeyLen`: Length of pubKey
- `[out] sharedSecret`: [0:kSE05x_TAG_1]
- `[inout] psharedSecretLen`: Length for sharedSecret

smStatus_t **`Se05x_API_ECDHGenerateSharedSecret_InObject`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **pubKey*, size_t *pubKeyLen*, uint32_t *sharedSecretID*, uint8_t *invertEndianness*)

Se05x_API_ECDHGenerateSharedSecret_InObject

See Se05x_API_ECDHGenerateSharedSecret

smStatus_t **`Se05x_API_ECDHGenerateSharedSecret_InObject_extended`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **pubKey*, size_t *pubKeyLen*, SE05x_ECDHAlgo_t *ecdhAlgo*, uint32_t *sharedSecretID*, uint8_t *invertEndianness*)

Se05x_API_ECDHGenerateSharedSecret_InObject_extended

See Se05x_API_ECDHGenerateSharedSecret_InObject_extended. New ECDH api with support for ECDH algo input (EC_SVDP_DH and EC_SVDP_DH_PLAIN).

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: Private key or key pair identifier
- `[in] pubKey`: External EC public key

- `[in] pubKeyLen`: External EC public key length
- `[in] ecdhAlgo`: ECDH Algorithm
- `[in] sharedSecretID`: Identifier to store derived key
- `[in] invertEndianness`: Option to invert endianness of derived key

smStatus_t **`Se05x_API_ECDSASign`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_ECSignatureAlgo_t *ecSignAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_ECDSASign

The ECDSASign command signs external data using the indicated key pair or private key.

The ECSignatureAlgo indicates the ECDSA algorithm that is used, but the hashing of data always must be done on the host. E.g., if ECSignatureAlgo = SIG_ ECDSA_SHA256, the user must have applied SHA256 on the input data already.

The user must take care of providing the correct input length; i.e., the data input length (TLV[TAG_3]) must match the digest indicated in the signature algorithm (TLV[TAG_2]).

In any case, the APDU payload must be smaller than MAX_APDU_PAYLOAD_LENGTH.

This is performed according to the ECDSA algorithm as specified in [ANSI X9.62]. The signature (a sequence of two integers 'r' and 's') as returned in the response adheres to the ASN.1 DER encoded formatting rules for integers.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_SIGN	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of EC key pair or private key.
	TLV[TAG_2]	1-byte ECSignatureAlgo.
	TLV[TAG_3]	Byte array containing input data.
Le	0x00	Expecting ASN.1 signature

R-APDU Body

Value	Description
TLV[TAG_1]	ECDSA Signature in ASN.1 format.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] ecSignAlgo`: ecSignAlgo [2:kSE05x_TAG_2]

- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] signature`: [0:kSE05x_TAG_1]
- `[inout] psignatureLen`: Length for signature

smStatus_t **`Se05x_API_ECDSAVerify`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_ECSignatureAlgo_t *ecSignAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, **`const`** uint8_t **signature*, size_t *signatureLen*, SE05x_Result_t **presult*)

Se05x_API_ECDSAVerify

The ECDSAVerify command verifies whether the signature is correct for a given (hashed) data input using an EC public key or EC key pair's public key.

The ECSignatureAlgo indicates the ECDSA algorithm that is used, but the hashing of data must always be done on the host. E.g., if ECSignatureAlgo = SIG_ ECDSA_SHA256, the user must have applied SHA256 on the input data already.

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this ECDSAVerify command.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_VERIFY	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or public key.
	TLV[TAG_2]	1-byte ECSignatureAlgo.
	TLV[TAG_3]	Byte array containing ASN.1 signature
	TLV[TAG_5]	Byte array containing hashed data to compare.
Le	0x03	Expecting TLV with `SE05x_Result_t`

R-APDU Body

Value	Description
TLV[TAG_1]	Result of the signature verification (`SE05x_Result_t`).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Incorrect data

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] ecSignAlgo`: ecSignAlgo [2:kSE05x_TAG_2]

- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[in] signature`: signature [4:kSE05x_TAG_5]
- `[in] signatureLen`: Length of signature
- `[out] presult`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_ECPointMultiply_InputObj`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint32_t *pubKeyID*, uint32_t *sharedSecretID*, uint8_t **sharedSecretOuput*, size_t **psharedSecretOuputLen*, SE05x_ECPMAlgo_t *ECPMAlgo*)

smStatus_t **`Se05x_API_EdDSASign`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_EDSignatureAlgo_t *edSignAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_EdDSASign

The EdDSASign command signs external data using the indicated key pair or private key (using a Twisted Edwards curve). This is performed according to the EdDSA algorithm as specified in [RFC8032].

The input data need to be the plain data (not hashed).

The signature as returned in the response is a 64-byte array, being the concatenation of the signature r and s component (without leading zeroes for sign indication).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_SIGN	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of EC key pair or private key.
	TLV[TAG_2]	1-byte EDSignatureAlgo
	TLV[TAG_3]	Byte array containing plain input data.
Le	0x00	Expecting signature

R-APDU Body

Value	Description
TLV[TAG_1]	EdDSA Signature (r concatenated with s).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]

- `[in] edSignAlgo`: edSignAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] signature`: [0:kSE05x_TAG_1]
- `[inout] psignatureLen`: Length for signature

smStatus_t **`Se05x_API_EdDSAVerify`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_EDSignatureAlgo_t *edSignAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, **`const`** uint8_t **signature*, size_t *signatureLen*, SE05x_Result_t **presult*)

Se05x_API_EdDSAVerify

The EdDSAVerify command verifies whether the signature is correct for a given data input (hashed using SHA512) using an EC public key or EC key pair's public key. The signature needs to be given as concatenation of r and s.

The data needs to be compared with the plain message without being hashed.

Note : See chapter 7 for correct byte order as both r and s need to be byte swapped.

This is performed according to the EdDSA algorithm as specified in [RFC8032].

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this EdDSAVerify command.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_VERIFY	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or public key.
	TLV[TAG_2]	1-byte `EDSignatureAlgoRef`.
	TLV[TAG_3]	64-byte array containing the signature (concatenation of r and s).
	TLV[TAG_5]	Byte array containing plain data to compare.
Le	0x03	Expecting TLV with `SE05x_Result_t`

R-APDU Body

Value	Description
TLV[TAG_1]	Result of the signature verification (`SE05x_Result_t`).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Incorrect data

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] edSignAlgo`: edSignAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[in] signature`: signature [4:kSE05x_TAG_5]
- `[in] signatureLen`: Length of signature
- `[out] presult`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_ExchangeSessionData`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*)

Se05x_API_ExchangeSessionData

Sets session policies for the current session.

Command to Applet

Field	Value	Description
CLA	0x80 or 0x84	•
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SESSION_POLICY	See P2
Lc	#(Payload)	Payload length.
Payload	TLV[TAG_1]	Session policies
	C-MAC	If applicable
Le	0x00	•

R-APDU Body

Value	Description
R-MAC	Optional, depending on established security level

SW	Description
SW_NO_ERROR	The command is handled successfully.
SW_CONDITIONS_NOT_SATISFIED	Invalid policies

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] policy`: Check pdf [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_ExportObject`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSAKeyComponent_t *rsaKeyComp*, uint8_t **data*, size_t **pdataLen*)

Se05x_API_ExportObject

Reads a transient Secure Object from SE05X.

Secure Objects can be serialized so the Secure Object can be represented as a byte array. The byte array contains all attributes of the Secure Object, as well as the value (including the secret part!) of the object.

The purpose of the serialization is to be able to allow export and import of Secure Objects. Serialized Secure Objects can be reconstructed so they can be used as a (normal) Secure Object. Any operation like key or file management and crypto operation can only be done on a deserialized Secure Object.

Users can export transient Secure Objects to a non-trusted environment (e.g., host controller). The object must be AESKey, DESKey, RSAKey or ECCKey.

Exported credentials are always encrypted and MAC'ed.

The following steps are taken:

- The secure element holds a randomly generated persistent 256-bit AES cipher and an 128-bit AES CMAC key. Both keys do not require user interaction, they are internal to the SE05X .
- A Secure Object that is identified for export is serialized. This means the key value as well as all Secure Object attributes are stored as byte array (see Object attributes for attribute details).
- The serialized Secure Object is encrypted using AES CBC (no padding) and using the default IV.
- A CMAC is applied to the serialized Secure Object + metadata using the AES CMAC key.
- The byte array is exported.

An object may only be imported into the store if the SecureObject ID and type are the same as the exported object. Therefore, it is not possible to import if the corresponding object in the applet has been deleted.

NOTES:

- The exported object is not deleted automatically.
- The timestamp has a 100msec granularity, so it is possible to export multiple times with the same timestamp. The freshness (user input) should avoid duplicate attestation results as the user has to provide different freshness input.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_EXPORT	See `SE05x_P2_t`
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	1-byte `SE05x_RSAKeyComponent_t` (only applies to Secure Objects of type RSAKey).
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing exported Secure Object data.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The file is created or updated successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[in] rsaKeyComp`: rsaKeyComp [2:kSE05x_TAG_2]
- `[out] data`: [0:kSE05x_TAG_1]
- `[inout] pdataLen`: Length for data

smStatus_t **`Se05x_API_GetECCurveId`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint8_t **pcurveId*)

Se05x_API_GetECCurveId

Get the curve associated with an EC key.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_CURVE	See `SE05x_P1_t`
P2	P2_ID	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	1-byte curve identifier (from `SE05x_ECCurve_t`)

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[out] pcurveId`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_GetExtVersion`** (*pSe05xSession_t session_ctx*, uint8_t **pappletVersion*, size_t **appletVersionLen*)

Se05x_API_GetExtVersion

Gets the applet extended version information.

This will return 37-byte VersionInfo (including major, minor and patch version of the applet, supported applet features and secure box version).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_VERSION or P2_VERSION_EXT	See `SE05x_P2_t`
Lc	#(Payload)	
Le	0x00	Expecting TLV with 7-byte data (when P2 = P2_VERSION) or a TLV with 37 byte data (when P2= P2_VERSION_EXT).

R-APDU Body

Value	Description
TLV[TAG_1]	7-byte `VersionInfoRef` (if P2 = P2_VERSION) or 7-byte VersionInfo followed by 30 bytes extendedFeatureBits (if P2 = P2_VERSION_EXT)

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `pappletVersion`: The papplet version
- `appletVersionLen`: The applet version length

smStatus_t **`Se05x_API_GetFreeMemory`** (*pSe05xSession_t session_ctx*, SE05x_MemoryType_t *memoryType*, uint16_t **pfreeMem*)

Se05x_API_GetFreeMemory

Gets the amount of free memory. MemoryType indicates the type of memory.

The result indicates the amount of free memory. Note that behavior of the function might not be fully linear and can have a granularity of 16 bytes where the applet will typically report the "worst case" amount. For example, when allocating 2 bytes a time, the first report will show 16 bytes being allocated, which remains the same for the next 7 allocations of 2 bytes.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_MEMORY	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	`SE05x_MemTyp_t`
Le	0x04	Expecting TLV with 2-byte data.

R-APDU Body

Value	Description
TLV[TAG_1]	2 bytes indicating the amount of free memory of the requested memory type. 0x7FFF as response means at least 32768 bytes are available.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] memoryType`: The memory type
- `pfreeMem`: The pfree memory

smStatus_t **Se05x_API_GetRandom** (*pSe05xSession_t session_ctx*, uint16_t *size*, uint8_t *randomData, size_t *prandomDataLen)

Se05x_API_GetRandom

Gets random data from the SE05X .

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_RANDOM	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	2-byte requested size.
Le	0x00	Expecting random data

R-APDU Body

Value	Description
TLV[TAG_1]	Random data.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] size`: The size
- `randomData`: The random data
- `prandomDataLen`: The prandom data length

smStatus_t **`Se05x_API_GetTimestamp`**(*pSe05xSession_t session_ctx*, *SE05x_TimeStamp_t *ptimeStamp*)

Se05x_API_GetTimestamp

Gets a monotonic counter value (time stamp) from the operating system of the device (both persistent and transient part). See TimestampFunctionality for details on the timestamps.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_TIME	See `SE05x_P2_t`
Lc	#(Payload)	
Le	0x2C	Expecting TLV with timestamp.

R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing a 12-byte operating system timestamp.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `ptimeStamp`: The ptime stamp

smStatus_t **`Se05x_API_GetVersion`**(*pSe05xSession_t session_ctx*, uint8_t **pappletVersion*, size_t **appletVersionLen*)

Se05x_API_GetVersion

Gets the applet version information.

This will return 7-byte VersionInfo (including major, minor and patch version of the applet, supported applet features and secure box version).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_VERSION or P2_VERSION_EXT	See `SE05x_P2_t`
Lc	#(Payload)	
Le	0x00	Expecting TLV with 7-byte data (when P2 = P2_VERSION) or a TLV with 37 byte data (when P2= P2_VERSION_EXT).

R-APDU Body

Value	Description
TLV[TAG_1]	7-byte `VersionInfoRef` (if P2 = P2_VERSION) or 7-byte VersionInfo followed by 30 bytes extendedFeatureBits (if P2 = P2_VERSION_EXT)

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `pappletVersion`: The papplet version
- `appletVersionLen`: The applet version length

smStatus_t **`Se05x_API_HKDF`** (*pSe05xSession_t session_ctx*, uint32_t *hmacID*, SE05x_DigestMode_t *digestMode*, **`const`** uint8_t **salt*, size_t *saltLen*, **`const`** uint8_t **info*, size_t *infoLen*, uint16_t *deriveDataLen*, uint8_t **hkdfOuput*, size_t **phkdfOuputLen*)

Se05x_API_HKDF

Note that this KDF is equal to the KDF in Feedback Mode described in [NIST SP800-108] with the PRF being HMAC with SHA256 and with an 8-bit counter at the end of the iteration variable.

The full HKDF algorithm is executed, i.e. Extract-And-Expand.

The caller must provide a salt length (0 up to 64 bytes). If salt length equals 0 or salt is not provided as input, the default salt will be used.

The output of the HKDF functions can be either:

- send back to the caller => *precondition* : none of the input Secure Objects -if present- shall have a policy POLICY_OBJ_FORBID_DERIVED_OUTPUT set.
- be stored in a Secure Object => *precondition* : the Secure Object must be created upfront and the size must exactly match the expected length.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_HKDF	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte HMACKey identifier (= IKM)
TLV[TAG_2]	1-byte DigestMode (except DIGEST_NO_HASH)	
TLV[TAG_3]	Byte array (0-64 bytes) containing salt. [Optional] [Conditional: only when TLV[TAG_6] is absent.]	
TLV[TAG_4]	Info: The context and information to apply (1 to 80 bytes). [Optional]	
TLV[TAG_5]	2-byte requested length (L): 1 up to MAX_APDU_PAYLOAD_LENGTH	
TLV[TAG_6]	4-byte HMACKey identifier containing salt. [Optional] [Conditional: only when TLV[TAG_3] is absent]	
TLV[TAG_7]	4-byte HMACKey identifier to store output. [Optional]	
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	HKDF output. [Conditional: only when the input does not contain TLV[TAG-7]]

R-APDU Trailer

SW	Description
SW_NO_ERROR	The HKDF is executed successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] hmacID`: hmacID [1:kSE05x_TAG_1]
- `[in] digestMode`: digestMode [2:kSE05x_TAG_2]
- `[in] salt`: salt [3:kSE05x_TAG_3]
- `[in] saltLen`: Length of salt
- `[in] info`: info [4:kSE05x_TAG_4]
- `[in] infoLen`: Length of info
- `[in] deriveDataLen`: 2-byte requested length (L) [5:kSE05x_TAG_5]
- `[out] hkdfOuput`: [0:kSE05x_TAG_1]
- `[inout] phkdfOuputLen`: Length for hkdfOuput

smStatus_t **Se05x_API_I2CM_ExecuteCommandSet**(*pSe05xSession_t session_ctx*, **const** uint8_t **inputData*, size_t *inputDataLen*, uint32_t *attestationID*, uint8_t *attestationAlgo*, uint8_t **response*, size_t **presponseLen*, *SE05x_TimeStamp_t *ptimeStamp*, uint8_t **freshness*, size_t **pfreshnessLen*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **signature*, size_t **psignatureLen*, uint8_t **randomAttst*, size_t *randomAttstLen*)

Se05x_API_I2CM_ExecuteCommandSet

Execute one or multiple I2C commands in master mode. Execution is conditional to the presence of the authentication object identified by RESERVED_ID_I2CM_ACCESS. If the credential is not present in the eSE, access is allowed in general. Otherwise, a session shall be established before executing this command. In this case, the I2CM_ExecuteCommandSet command shall be sent within the mentioned session.

The I2C command set is constructed as a sequence of instructions described in with the following rules:

- The length should be limited to MAX_I2CM_COMMAND_LENGTH.
- The data to be read cannot exceed MAX_I2CM_COMMAND_LENGTH, including protocol overhead.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`, in addition to INS_CRYPTO, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_I2CM	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	Byte array containing I2C Command set as TLV array.
	TLV[TAG_2]	4-byte attestation object identifier. [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_3]	1-byte `SE05x_AttestationAlgo_t` [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_7]	16-byte freshness random [Optional] [Conditional: only when INS_ATTEST is set]
Le	0x00	Expecting TLV with return data.

R-APDU Body

Value	Description
TLV[TAG_1]	Read response, a bytestring containing a sequence of: * CONFIGURE (0x01), followed by 1 byte of return code (0x5A = SUCCESS). * WRITE (0x03), followed by 1 byte of return code * READ (0x04), followed by - Length: 2 bytes in big endian encoded without TLV length encoding - Read bytes * 0xFF followed by the error return code in case of a structural error of the incoming buffer (too long, for example)
TLV[TAG_3]	TLV containing 12-byte timestamp
TLV[TAG_4]	TLV containing 16-byte freshness (random)
TLV[TAG_5]	TLV containing 18-byte chip unique ID
TLV[TAG_6]	TLV containing signature over the concatenated values of TLV[TAG_1], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_5].

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] inputData`: The input data
- `[in] inputDataLen`: The input data length
- `[in] attestationID`: The attestation id
- `[in] attestationAlgo`: The attestation algorithm
- `response`: The response
- `presponseLen`: The presponse length
- `ptimeStamp`: The ptime stamp
- `freshness`: The freshness
- `pfreshnessLen`: The pfreshness length
- `chipId`: The chip identifier
- `pchipIdLen`: The pchip identifier length
- `signature`: The signature
- `psignatureLen`: The psignature length
- `randomAttst`: The random attst
- `[in] randomAttstLen`: The random attst length

smStatus_t **`Se05x_API_ImportExternalObject`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **ECKeydata*, size_t *ECKeydataLen*, **`const`** uint8_t **ECAuthKeyID*, size_t *ECAuthKeyIDLen*, **`const`** uint8_t **serializedObject*, size_t *serializedObjectLen*)

Se05x_API_ImportExternalObject

Combined with the INS_IMPORT_EXTERNAL mask, enables users to send a WriteSecureObject APDU (WriteECKey until WritePCR) protected by a secure channel.

Secure Objects can be imported into the SE05X through a secure channel which does not require the establishment of a session. This feature is also referred to single side import and can only be used to create or update objects.

The mechanism is based on ECKey session to protect the Secure Object content and is summarized in the following figure.

External import flow

The flow above can be summarized in the following steps:

1. The user obtains the SE public key for import via the to get the public key from the device's key pair. Key ID 0x02 will return the public key of the EC key pair with RESERVED_ID_EXTERNAL_IMPORT. The response is signed by the same key pair.

2. The user calls with input:
   - the applet AID (e.g.A00000039654530000000103000000000)
   - the SCPparameters
     - 1-byte SCP identifier, must equal0xAB
     - 2-byte SCP parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: .
   - key type, must be 0x88 (AES keytype)
   - key length, must be 0x10 (AES128key)
   - host public key (65-byte NIST P-256 publickey)
   - host public key curve identifier (must be 0x03 (=NIST_P256))
   - ASN.1 signature over the TLV with tags 0xA6 and0x7F49.

The applet will then calculate the master key by performing SHA256 over a byte array containing (in order):

- 4-byte counter value being0x00000001
- shared secret (ECDH calculation according [IEEE P1363] using the private keyfrom RESERVED_ID_ECKEY_SESSION and the public key provided as input to ECKeySessionInternalAuthenticate. The length depends on the curve used (e.g. 32 byte for NIST P-256 curve).
- 16-byte random generated by the SE05X.
- 2-byte SCP parameter, must equal 0x01 followed by 1-byte security level (which follows the GlobalPlatform security level definition, see: .
- 1-byte keytype
- 1-byte keylength

The master key will then be the 16 MSB's of the hash output.

Using the master key, the 3 session keys are derived by following the GlobalPlatform specification to derive session keys, e.g. derivation input:

- ENCsession key = CMAC(MK, 00000000000000000000000400008001)
- CMACsession key = CMAC(MK, 00000000000000000000000600008001)
- RMACsession key = CMAC(MK, 00000000000000000000000700008001)

The Authentication Object ID needs to be passed using TAG_IMPORT_AUTH_KEY_ID, followed by the Write APDU command (using tag TAG_1).

The Write APDU command needs to be constructed as follows:

- Encrypt the command encryption counter (starting with 0x00000000000000000000000000000001) using the S_ENC key. This becomes the IV for the encrypted APDU.
- Get the APDU command payload and pad it (ISO9797 M2 padding).
- Encrypt the payload in AES CBC mode using the S_ENC key.
- Set the Secure Messaging bit in the CLA (0x04).
- Concatenate the MAC chaining value with the full APDU.

- Then calculate the MAC on this byte array and append the 8-byte MAC value to the APDU.
- Finally increment the encryption counter for the next command.

A receipt will be generated by doing a CMAC operation on the input from tag 0xA6 and 0x7F49 using the RMAC session key,

Receipt = CMAC(RMAC session key, <input from TLV 0xA6 and TLV 0x7F49>)

There is no need to establish a session; therefore, the ImportExternalObject commands are always sent in the default session. The ImportExternalObject commands are replayable.

The P1 and P2 parameters shall be coded as per the intended operation. For example, to import an EC Key, the P1 and P2 parameters as defined in WriteECKey shall be specified.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_IMPORT_EXTERNAL	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_IMPORT_AUTH_DATA]	Authentication data
	TLV[TAG_IMPORT_AUTH_KEY_ID]	Host public key Identifier
	TLV[TAG_1]…	Wraps a complete WriteSecureObject command, protected by ECKey session secure messaging
	TLV[TAG_11]	4-byte version [Optional]

R-APDU Body

NA

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] ECKeydata`: ECKeydata [1:kSE05x_TAG_2]
- `[in] ECKeydataLen`: Length of ECKeydata
- `[in] serializedObject`: serializedObject [2:kSE05x_TAG_3]
- `[in] serializedObjectLen`: Length of serializedObject

smStatus_t **`Se05x_API_ImportObject`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSAKeyComponent_t *rsaKeyComp*, **`const`** uint8_t **serializedObject*, size_t *serializedObjectLen*)

Se05x_API_ImportObject

Writes a serialized Secure Object to the SE05X (i.e., “import”)

Command to Applet

Field	Value	Description
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_IMPORT	See `SE05x_P2_t`
Payload	TLV[TAG_1]	4-byte identifier.
	TLV[TAG_2]	1-byte `SE05x_RSAKeyComponent_t` [Conditional: only when the identifier refers to an RSAKey object]
	TLV[TAG_3]	Serialized object (encrypted).

R-APDU Body

NA

R-APDU Trailer

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[in] rsaKeyComp`: rsaKeyComp [2:kSE05x_TAG_2]
- `[in] serializedObject`: serializedObject [3:kSE05x_TAG_3]
- `[in] serializedObjectLen`: Length of serializedObject

smStatus_t **`Se05x_API_IncCounter`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*)

Se05x_API_IncCounter

See Se05x_API_CreateCounter

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_MACFinal`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** uint8_t **macValidateData*, size_t *macValidateDataLen*, uint8_t **macValue*, size_t **pmacValueLen*)

Se05x_API_MACFinal

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_MAC	See `SE05x_P1_t`
P2	P2_FINAL	See `SE05x_P2_t`
Payload	TLV[TAG_1]	Byte array containing data to be taken as input to MAC.
	TLV[TAG_2]	2-byte Crypto Object identifier
	TLV[TAG_3]	Byte array containing MAC to validate. [Conditional: only applicable the crypto object is set for validating (MACInit P2 = P2_VALIDATE)]
Le	0x00	Expecting MAC or result.

R-APDU Body

Value	Description
TLV[TAG_1]	MAC value (when MACInit had P2 = P2_GENERATE) or `SE05x_Result_t` (when MACInit had P2 = P2_VERIFY).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] inputData`: inputData [1:kSE05x_TAG_1]
- `[in] inputDataLen`: Length of inputData
- `[in] cryptoObjectID`: cryptoObjectID [2:kSE05x_TAG_2]
- `[in] macValidateData`: macValidateData [3:kSE05x_TAG_3]
- `[in] macValidateDataLen`: Length of macValidateData
- `[out] macValue`: [0:kSE05x_TAG_1]
- `[inout] pmacValueLen`: Length for macValue

smStatus_t **`Se05x_API_MACInit`**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_CryptoObjectID_t *cryptoObjectID*, **`const`** SE05x_Mac_Oper_t *mac_oper*)

Se05x_API_MACInit

Initiate a MAC operation. The state of the MAC operation is kept in the Crypto Object until it's finalized or deleted.

The 4-byte identifier of the key must refer to an AESKey, DESKey or HMACKey.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_MAC	See `SE05x_P1_t`
P2	P2_GENERATE or P2_VALIDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the MAC key.
	TLV[TAG_2]	2-byte Crypto Object identifier
Le	0x00	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] cryptoObjectID`: cryptoObjectID [2:kSE05x_TAG_2]
- `[in] mac_oper`: The Operation

smStatus_t **`Se05x_API_MACOneShot_G`**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint8_t *macOperation*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **macValue*, size_t **pmacValueLen*)

Se05x_API_MACOneShot_G

Generate. See Se05x_API_MACOneShot_V for Verfiication.

Performs a MAC operation in one shot (without keeping state).

The 4-byte identifier of the key must refer to an AESKey, DESKey or HMACKey.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_MAC	See `SE05x_P1_t`
P2	P2_GENERATE_ONESHOT or P2_VALIDATE_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key object.
	TLV[TAG_2]	1-byte `MACAlgoRef`
	TLV[TAG_3]	Byte array containing data to be taken as input to MAC.
	TLV[TAG_5]	MAC to verify (when P2=P2_VALIDATE_ONESHOT)
Le	0x00	Expecting MAC or Result.

R-APDU Body

Value	Description
TLV[TAG_1]	MAC value (P2=P2_GENERATE_ONESHOT) or `SE05x_Result_t` (when p2=P2_VALIDATE_ONESHOT).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] macOperation`: macOperation [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]

  - `[in] inputDataLen`: Length of inputData
  - `[out] macValue`: [0:kSE05x_TAG_1]
  - `[inout] pmacValueLen`: Length for macValue

smStatus_t **`Se05x_API_MACOneShot_V`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint8_t *macOperation*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, **`const`** uint8_t **MAC*, size_t *MACLen*, uint8_t **result*, size_t **presultLen*)

Se05x_API_MACOneShot_V

Validate. See Se05x_API_MACOneShot_G for Generation.

Parameters

  - `[in] session_ctx`: Session Context [0:kSE05x_pSession]
  - `[in] objectID`: objectID [1:kSE05x_TAG_1]
  - `[in] macOperation`: macOperation [2:kSE05x_TAG_2]
  - `[in] inputData`: inputData [3:kSE05x_TAG_3]
  - `[in] inputDataLen`: Length of inputData
  - `[in] MAC`: MAC to verify (when P2=P2_VALIDATE_ONESHOT) [4:kSE05x_TAG_5]
  - `[in] MACLen`: Length of MAC
  - `[out] result`: [0:kSE05x_TAG_1]
  - `[inout] presultLen`: Length for result

smStatus_t **`Se05x_API_MACUpdate`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, SE05x_CryptoObjectID_t *cryptoObjectID*)

Se05x_API_MACUpdate

Update MAC

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_MAC	See `SE05x_P1_t`
P2	P2_UPDATE	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	Byte array containing data to be taken as input to MAC.
	TLV[TAG_2]	2-byte Crypto Object identifier
Le	•	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] inputData`: inputData [1:kSE05x_TAG_1]
- `[in] inputDataLen`: Length of inputData
- `[in] cryptoObjectID`: cryptoObjectID [2:kSE05x_TAG_2]

smStatus_t **`Se05x_API_PBKDF2`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **salt*, size_t *saltLen*, uint16_t *count*, uint16_t *requestedLen*, uint8_t **derivedSessionKey*, size_t **pderivedSessionKeyLen*)

Se05x_API_HKDF_Extended

Only step 2 of the algorithm is executed, i.e. Expand only.

Using an IV as input parameter results in a FIPS compliant SP800-108 KDF in Feedback Mode where K[0] is the provided IV. This KDF is then using a 8-bit counter, AFTER_FIXED counter location.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_HKDF_EXPAND_ONLY	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte HMACKey identifier (= PRK)
TLV[TAG_2]	1-byte DigestMode (except DIGEST_NO_HASH)	
TLV[TAG_3]	Byte array (0-64 bytes) containing IV. [Optional] [Conditional: only when TLV[TAG_6] is absent.]	
TLV[TAG_4]	Info: The context and information to apply (1 to 80 bytes). [Optional]	
TLV[TAG_5]	2-byte requested length (L): 1 up to MAX_APDU_PAYLOAD_LENGTH	
TLV[TAG_6]	4-byte HMACKey identifier containing IV. [Optional] [Conditional: only when TLV[TAG_3] is absent]	
TLV[TAG_7]	4-byte HMACKey identifier to store output. [Optional]	
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	HKDF output. [Conditional: only when the input does not contain TLV[TAG-7]]

R-APDU Trailer

SW	Description
SW_NO_ERROR	The HKDF is executed successfully.

/

smStatus_t Se05x_API_HKDF_Extended(pSe05xSession_t session_ctx, uint32_t hmacID, SE05x_DigestMode_t digestMode, SE05x_HkdfMode_t hkdfMode, const uint8_t salt, size_t saltLen, uint32_t saltID, const uint8_t info, size_t infoLen, uint32_t derivedKeyID, uint16_t deriveDataLen, uint8_t hkdfOuput, size_t phkdfOuputLen);

/ * Se05x_API_PBKDF2

Password Based Key Derivation Function 2 (PBKDF2) according [RFC8018].

The password is an input to the KDF and must be stored inside the .

The output is returned to the host.

# Command to Applet

verbatim embed:rst:leading-asterisk +——-+————+———————————————-+ | Field | Value | Description | +=======+============+== | CLA | 0x80 | | +——-+————+———————————————-+ | INS | INS_CRYPTO | `SE05x_INS_t` | +——-+————+———————————————-+ | P1 | P1_DEFAULT | See `SE05x_P1_t` | +——-+————+———————————————-+ | P2 | P2_PBKDF | See `SE05x_P2_t` | +——-+————+———————————————-+ | Lc | #(Payload) | | +——-+————+———————————————-+ | | TLV[TAG_1] | 4-byte password identifier (object type must | | | | | be HMACKey) | +——-+————+———————————————-+ | | TLV[TAG_2] | Salt (0 to 64 bytes) [Optional] | +——-+————+———————————————-+ | | TLV[TAG_3] | 2-byte Iteration count: 1 up to 0x7FFF. | +——-+————+———————————————-+ | | TLV[TAG_4] | 2-byte Requested length: 1 up to 512 bytes. | +——-+————+———————————————-+ | Le | 0x00 | Expecting derived key material. | +——-+————+———————————————-+

R-APDU Body

Value	Description
TLV[TAG_1]	Derived key material (session key).

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: 4-byte password identifier (object type must be HMACKey) [1:kSE05x_TAG_1]
- `[in] salt`: salt [2:kSE05x_TAG_2]
- `[in] saltLen`: Length of salt
- `[in] count`: count [3:kSE05x_TAG_3]
- `[in] requestedLen`: requestedLen [4:kSE05x_TAG_4]
- `[out] derivedSessionKey`: [0:kSE05x_TAG_1]
- `[inout] pderivedSessionKeyLen`: Length for derivedSessionKey

smStatus_t **`Se05x_API_PBKDF2_extended`**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, **`const`** uint8_t **salt*, size_t *saltLen*, uint32_t *saltID*, uint16_t *count*, SE05x_MACAlgo_t *macAlgo*, uint16_t *requestedLen*, uint32_t *derivedSessionKeyID*, uint8_t **derivedSessionKey*, size_t **pderivedSessionKeyLen*)

Se05x_API_PBKDF2_extended

See Se05x_API_PBKDF2_extended. New PBKDF2 api with optional salt object id and optional derived Session key id. This api also supports additional mac algorithms.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: HMAC key object id
- `[in] salt`: Salt data
- `[in] saltLen`: Salt length
- `[in] saltID`: Object id with salt data
- `[in] macAlgo`: MAC Algorithm
- `[in] requestedLen`: Requested derived session key length
- `[inout] derivedSessionKeyID`: HMAC object id to store output derived session key
- `[inout] derivedSessionKey`: Buffer to store derived session key on host
- `[inout] pderivedSessionKeyLen`: DerivedSessionKey buffer length

smStatus_t **`Se05x_API_ReadCryptoObjectList`**(*pSe05xSession_t session_ctx*, uint8_t **idlist*, size_t **pidlistLen*)

Se05x_API_ReadCryptoObjectList

Get the list of allocated Crypto Objects indicating the identifier, the CryptoContext and the sub type of the CryptoContext.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_CRYPTO_OBJ	See `SE05x_P1_t`
P2	P2_LIST	See `SE05x_P2_t`
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing a list of 2-byte Crypto Object identifiers, followed by 1-byte CryptoContext and 1-byte subtype for each Crypto Object (so 4 bytes for each Crypto Object).

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[out] idlist`: If more ids are present [0:kSE05x_TAG_1]
- `[inout] pidlistLen`: Length for idlist

smStatus_t **`Se05x_API_ReadECCurveList`** (*pSe05xSession_t session_ctx*, uint8_t **curveList*, size_t **pcurveListLen*)

Se05x_API_ReadECCurveList

Get a list of (Weierstrass) EC curves that are instantiated.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_CURVE	See `SE05x_P1_t`
P2	P2_LIST	See `SE05x_P2_t`
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array listing all curve identifiers in `SE05x_ECCurve_t` (excluding UNUSED) where the curve identifier < 0x40; for each curve, a 1-byte `SetIndicatorRef` is returned.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[out] curveList`: [0:kSE05x_TAG_1]
- `[inout] pcurveListLen`: Length for curveList

smStatus_t **`Se05x_API_ReadIDList`** (*pSe05xSession_t session_ctx*, uint16_t *outputOffset*, uint8_t *filter*, uint8_t **pmore*, uint8_t **idlist*, size_t **pidlistLen*)

Se05x_API_ReadIDList

Get a list of present Secure Object identifiers.

The offset in TAG_1 is an 0-based offset in the list of object. As the user does not know how many objects would be returned, the offset needs to be based on the return values from the previous ReadIDList. If the applet only returns a part of the result, it will indicate that more identifiers are available (by setting TLV[TAG_1] in the response to 0x01). The user can then retrieve the next chunk of identifiers by calling ReadIDList with an offset that equals the amount of identifiers listed in the previous response.

Example 1: first ReadIDList command TAG_1=0, response TAG_1=0, TAG_2=complete list

Example 2: first ReadIDList command TAG_1=0, response TAG_1=1, TAG_2=first chunk (m entries) second ReadIDList command TAG_1=m, response TAG_1=1, TAG_2=second chunk (n entries) thirst ReadIDList command TAG_1=(m+n), response TAG_1=0, TAG_2=third last chunk

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_LIST	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	2-byte offset
	TLV[TAG_2]	1-byte type filter: 1 byte from `SE05x_SecObjTyp_t` or 0xFF for all types.
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	1-byte `MoreIndicatorRef`
TLV[TAG_2]	Byte array containing 4-byte identifiers.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] outputOffset`: output offset [1:kSE05x_TAG_1]
- `[in] filter`: filter [2:kSE05x_TAG_2]
- `[out] pmore`: If more ids are present [0:kSE05x_TAG_1]
- `[out] idlist`: Byte array containing 4-byte identifiers [1:kSE05x_TAG_2]
- `[inout] pidlistLen`: Length for idlist

smStatus_t **`Se05x_API_ReadObject`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, uint8_t **data*, size_t **pdataLen*)

Se05x_API_ReadObject

Reads the content of a Secure Object.

- If the object is a key pair, the command will return the key pair's public key.
- If the object is a public key, the command will return the public key.
- If the object is a private key or a symmetric key or a userID, the command will return SW_CONDITIONS_NOT_SATISFIED.
- If the object is a binary file, the file content is read, giving the offset in TLV[TAG_2] and the length to read in TLV[TAG_3]. Both TLV[TAG_2] and TLV[TAG_3] are bound together; i.e.. either both tags are present, or both are absent. If both are absent, the whole file content is returned.
- If the object is a monotonic counter, the counter value is returned.
- If the object is a PCR, the PCR value is returned.
- If TLV[TAG_4] is filled, only the modulus or public exponent of an RSA key pair or RSA public key is read. It does not apply to other Secure Object types.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`, in addition to INS_READ, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	2-byte offset [Optional: default 0] [Conditional: only when the object is a BinaryFile object]
	TLV[TAG_3]	2-byte length [Optional: default 0] [Conditional: only when the object is a BinaryFile object]
	TLV[TAG_4]	1-byte `SE05x_RSAKeyComponent_t`: either RSA_COMP_MOD or RSA_COMP_PUB_EXP. [Optional] [Conditional: only for RSA key components]
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Data read from the secure object.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The read is done successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[in] offset`: offset [2:kSE05x_TAG_2]
- `[in] length`: length [3:kSE05x_TAG_3]
- `[out] data`: [0:kSE05x_TAG_1]
- `[inout] pdataLen`: Length for data

smStatus_t **`Se05x_API_ReadObject_W_Attst`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, uint32_t *attestID*, SE05x_AttestationAlgo_t *attestAlgo*, **`const`** uint8_t **random*, size_t *randomLen*, uint8_t **data*, size_t **pdataLen*, uint8_t **attribute*, size_t **pattributeLen*, *SE05x_TimeStamp_t *ptimeStamp*, uint8_t **outrandom*, size_t **poutrandomLen*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **signature*, size_t **psignatureLen*) smStatus_t **Se05x_API_ReadObject_W_Attst_V2**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, uint32_t *attestID*, SE05x_AttestationAlgo_t *attestAlgo*, **const** uint8_t **random*, size_t *randomLen*, uint8_t **data*, size_t **pdataLen*, uint8_t **attribute*, size_t **pattributeLen*, *SE05x_TimeStamp_t* **ptimeStamp*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **pCmd*, size_t **pCmdLen*, uint8_t **pObj*, size_t **pObjLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_ReadObject_W_Attst

Read with attestation.

See Se05x_API_ReadObject

When INS_ATTEST is set in addition to INS_READ, the secure object is read with attestation. In addition to the response in TLV[TAG_1], there are additional tags:

TLV[TAG_2] will hold the object attributes (see ObjectAttributes).

TLV[TAG_3] relative timestamp when the object has been retrieved

TLV[TAG_4] will hold freshness random data

TLV[TAG_5] will hold the unique ID of the device.

TLV[TAG_6] will hold the signature over all concatenated Value fields tags of the response (TAG_1 until and including TAG_5).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`, in addition to INS_READ, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	2-byte offset [Optional: default 0] [Conditional: only when the object is a BinaryFile object]
	TLV[TAG_3]	2-byte length [Optional: default 0] [Conditional: only when the object is a BinaryFile object]
	TLV[TAG_4]	1-byte `SE05x_RSAKeyComponent_t`: either RSA_COMP_MOD or RSA_COMP_PUB_EXP. [Optional] [Conditional: only for RSA key components]
	TLV[TAG_5]	4-byte attestation object identifier. [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_6]	1-byte `SE05x_AttestationAlgo_t` [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_7]	16-byte freshness random [Optional] [Conditional: only when INS_ATTEST is set]
Le	0x00	

Value	Description
TLV[TAG_1]	Data read from the secure object.
TLV[TAG_2]	(only when INS_ATTEST is set) Byte array containing the attributes (see `ObjectAttributesRef`).
TLV[TAG_3]	(only when INS_ATTEST is set) 12-byte timestamp
TLV[TAG_4]	(only when INS_ATTEST is set) 16-byte freshness random
TLV[TAG_5]	(only when INS_ATTEST is set) 18-byte Chip unique ID
TLV[TAG_6]	(only when INS_ATTEST is set) Signature applied over the value of TLV[TAG_1], TLV[TAG_2], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_5].

R-APDU Body

Value	Description
TLV[TAG_1]	Data read from the secure object.
TLV[TAG_2]	(only when INS_ATTEST is set) Byte array containing the attributes (see `ObjectAttributesRef`).
TLV[TAG_3]	(only when INS_ATTEST is set) 12-byte timestamp
TLV[TAG_4]	(only when INS_ATTEST is set) 16-byte freshness random
TLV[TAG_5]	(only when INS_ATTEST is set) 18-byte Chip unique ID
TLV[TAG_6]	(only when INS_ATTEST is set) Signature applied over the value of TLV[TAG_1], TLV[TAG_2], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_5].

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] offset`: The offset
- `[in] length`: The length
- `[in] attestID`: The attest id
- `[in] attestAlgo`: The attest algorithm
- `[in] random`: The random
- `[in] randomLen`: The random length
- `data`: The data
- `pdataLen`: The pdata length
- `attribute`: The attribute
- `pattributeLen`: The pattribute length
- `ptimeStamp`: The ptime stamp
- `outrandom`: The outrandom
- `poutrandomLen`: The poutrandom length
- `chipId`: The chip identifier
- `pchipIdLen`: The pchip identifier length
- `signature`: The signature

- `psignatureLen`: The psignature length

smStatus_t **`Se05x_API_ReadObjectAttributes`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint8_t **data*, size_t **pdataLen*)

Se05x_API_ReadObjectAttributes

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[out] data`: [0:kSE05x_TAG_2]
- `[inout] pdataLen`: Length for data

smStatus_t **`Se05x_API_ReadObjectAttributes_W_Attst`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint32_t *attestID*, SE05x_AttestationAlgo_t *attestAlgo*, **`const`** uint8_t **random*, size_t *randomLen*, uint8_t **data*, size_t **pdataLen*, *SE05x_TimeStamp_t *ptimeStamp*, uint8_t **outrandom*, size_t **poutrandomLen*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_ReadObjectAttributes_W_Attst

Reads the attributes of a Secure Object (without the value of the Secure Object).

Each Secure Object has a number of attributes assigned to it. These attributes are listed in for Authentication Objects and in for non-Authentication Objects.

Authentication Object attributes

Attribute	Size (bytes)	Description
Object identifier	4	See `identifiersRef`
Object type	1	One of SecureObjectType
Authentication attribute	1	One of `SetIndicatorRef`
Object counter	2	Number of failed attempts for an authentication object if the Maximum Authentication Attempts has been set.
Authentication object identifier	4	”Owner” of the secure object; i.e., the identifier of the session authentication object when the object has been created.
Maximum authentication attempts	2	Maximum number of authentication attempts. 0 means unlimited.
Policy	Variable	Policy attached to the object
Origin	1	One of `OriginRef`; indicates the origin of the Secure Object, either externally set, internally generated or trust provisioned by NXP.
Version	1	The Secure Object version. Default = 0. See FIPS compliance for details about versioning of Secure Objects.

Non-Authentication Objects

Attribute	Size (bytes)	Description
Object identifier	4	See Object identifiers
Object type	1	One of SecureObjectType
Authentication attribute	1	One of `SetIndicatorRef`
Tag length	2	Set to 0x0000, except for AESKey objects: for AESKey objects, this indicates the GMAC length that applies when doing AEAD operations. If the value is set to 0 and AEAD operations are done, the GMAC length shall be 128 bit.
Authentication object identifier	4	”Owner” of the secure object; i.e., the identifier of the session authentication object when the object has been created.
RFU	2	Set to 0x0000.
Policy	Variable	Policy attached to the object
Origin	1	One of `OriginRef`; indicates the origin of the Secure Object, either externally set, internally generated or trust provisioned by NXP.
Version	1	The Secure Object version. Default = 0. See FIPS compliance for details about versioning of Secure Objects.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`, in addition to INS_READ, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_ATTRIBUTES	See `SE05x_P2_t`
Lc	#(Payload)	Payload Length.
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_5]	4-byte attestation object identifier. [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_6]	1-byte AttestationAlgo [Optional] [Conditional: only when INS_ATTEST is set]
	TLV[TAG_7]	16-byte freshness random [Optional] [Conditional: only when INS_ATTEST is set]
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_2]	Byte array containing the attributes (see Object Attributes).
TLV[TAG_3]	(only when INS_ATTEST is set) 12-byte timestamp
TLV[TAG_4]	(only when INS_ATTEST is set) 16-byte freshness random
TLV[TAG_5]	(only when INS_ATTEST is set) 18-byte Chip unique ID
TLV[TAG_6]	(only when INS_ATTEST is set) Signature applied over the value of TLV[TAG_2], TLV[TAG_2], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_5].

R-APDU Trailer

SW	Description
SW_NO_ERROR	The read is done successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] attestID`: The attest id
- `[in] attestAlgo`: The attest algorithm
- `[in] random`: The random
- `[in] randomLen`: The random length
- `data`: The data
- `pdataLen`: The pdata length
- `ptimeStamp`: The ptime stamp
- `outrandom`: The outrandom
- `poutrandomLen`: The poutrandom length
- `chipId`: The chip identifier
- `pchipIdLen`: The pchip identifier length
- `signature`: The signature
- `psignatureLen`: The psignature length

smStatus_t **`Se05x_API_ReadRSA`**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, SE05x_RSAPubKeyComp_t *rsa_key_comp*, uint8_t **data*, size_t **pdataLen*)

Se05x_API_ReadRSA

See Se05x_API_ReadObject

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[in] offset`: offset [2:kSE05x_TAG_2]
- `[in] length`: length [3:kSE05x_TAG_3]
- `[in] rsa_key_comp`: rsa_key_comp [4:kSE05x_TAG_4]
- `[out] data`: [0:kSE05x_TAG_1]
- `[inout] pdataLen`: Length for data

smStatus_t **`Se05x_API_ReadRSA_W_Attst`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, SE05x_RSAPubKeyComp_t *rsa_key_comp*, uint32_t *attestID*, SE05x_AttestationAlgo_t *attestAlgo*, **`const`** uint8_t **random*, size_t *randomLen*, uint8_t **data*, size_t **pdataLen*, uint8_t **attribute*, size_t **pattributeLen*, *SE05x_TimeStamp_t *ptimeStamp*, uint8_t **outrandom*, size_t **poutrandomLen*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_ReadRSA_W_Attst

See Se05x_API_ReadObject_W_Attst

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] offset`: The offset
- `[in] length`: The length
- `[in] rsa_key_comp`: The rsa key component
- `[in] attestID`: The attest id
- `[in] attestAlgo`: The attest algorithm
- `[in] random`: The random
- `[in] randomLen`: The random length
- `data`: The data
- `pdataLen`: The pdata length
- `attribute`: The attribute
- `pattributeLen`: The pattribute length
- `ptimeStamp`: The ptime stamp
- `outrandom`: The outrandom
- `poutrandomLen`: The poutrandom length
- `chipId`: The chip identifier
- `pchipIdLen`: The pchip identifier length
- `signature`: The signature
- `psignatureLen`: The psignature length

smStatus_t **`Se05x_API_ReadSize`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t **psize*)

Se05x_API_ReadSize

ReadSize

Get the size of a Secure Object (in bytes):

- For EC keys: the size of the curve is returned.

- For RSA keys: the key size is returned.
- For AES/DES/HMAC keys, the key size is returned.
- For binary files: the file size is returned
- For userIDs: nothing is returned (SW_CONDITIONS_NOT_SATISFIED).
- For counters: the counter length is returned.
- For PCR: the PCR length is returned.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SIZE	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte object identifier.
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing size.

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `psize`: The psize

smStatus_t **`Se05x_API_ReadState`** (*pSe05xSession_t session_ctx*, uint8_t **pstateValues*, size_t **pstateValuesLen*)

Se05x_API_ReadState

Command to Applet

R-APDU Body

NA

R-APDU Trailer

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[out] pstateValues`: [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_ReadType`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, *SE05x_SecureObjectType_t *ptype*, uint8_t **pisTransient*, **`const`** SE05x_AttestationType_t *attestation_type*)

Se05x_API_ReadType

Get the type of a Secure Object.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_READ	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_TYPE	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte object identifier.
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Type of the Secure Object: one of `SE05x_SecObjTyp_t`
TLV[TAG_2]	`TransientIndicatorRef`

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `ptype`: The ptype
- `pisTransient`: The pis transient
- `[in] attestation_type`: The attestation type

smStatus_t **`Se05x_API_RefreshSession`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*)

Se05x_API_RefreshSession

Refreshes a session on , the policy of the running session can be updated; the rest of the session state remains.

Command to Applet

Field	Value	Description
CLA	0x80	-
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SESSION_REFRESH	See `SE05x_P2_t`
Lc	#(Payload)	Payload length.
	TLV[TAG_POLICY]	Byte array containing the policy to attach to the session. [Optional]
Le	-	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] policy`: policy [1:kSE05x_TAG_POLICY]

smStatus_t **`Se05x_API_RSADecrypt`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSAEncryptionAlgo_t *rsaEncryptionAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **decryptedData*, size_t **pdecryptedDataLen*)

Se05x_API_RSADecrypt

The RSADecrypt command decrypts data.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_RSA	See `SE05x_P1_t`
P2	P2_DECRYPT_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or private key.
	TLV[TAG_2]	1-byte `SE05x_RSAEncryptionAlgo_t`
	TLV[TAG_3]	Byte array containing data to be decrypted.
Le	0x00	Expected TLV with decrypted data.

R-APDU Body

Value	Description
TLV[TAG_1]	Encrypted data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] rsaEncryptionAlgo`: rsaEncryptionAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] decryptedData`: [0:kSE05x_TAG_1]
- `[inout] pdecryptedDataLen`: Length for decryptedData

smStatus_t **`Se05x_API_RSAEncrypt`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSAEncryptionAlgo_t *rsaEncryptionAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **encryptedData*, size_t **pencryptedDataLen*)

Se05x_API_RSAEncrypt

The RSAEncrypt command encrypts data.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_RSA	See `SE05x_P1_t`
P2	P2_ENCRYPT_ONESHOT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	4-byte identifier of the key pair or public key.
	TLV[TAG_2]	1-byte `SE05x_RSAEncryptionAlgo_t`
	TLV[TAG_3]	Byte array containing data to be encrypted.
Le	0x00	Expected TLV with encrypted data.

R-APDU Body

Value	Description
TLV[TAG_1]	Encrypted data

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]

- `[in] rsaEncryptionAlgo`: rsaEncryptionAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] encryptedData`: [0:kSE05x_TAG_1]
- `[inout] pencryptedDataLen`: Length for encryptedData

smStatus_t **`Se05x_API_RSASign`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSASignatureAlgo_t *rsaSigningAlgo*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_RSASign

The RSASign command signs the input message using an RSA private key.

Name	Value	Description
RSA_SHA1_PKCS1_PSS	0x15	RFC8017: RSASSA-PSS
RSA_SHA224_PKCS1_PSS	0x2B	RFC8017: RSASSA-PSS
RSA_SHA256_PKCS1_PSS	0x2C	RFC8017: RSASSA-PSS
RSA_SHA384_PKCS1_PSS	0x2D	RFC8017: RSASSA-PSS
RSA_SHA512_PKCS1_PSS	0x2E	RFC8017: RSASSA-PSS
RSA_SHA1_PKCS1	0x0A	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_224_PKCS1	0x27	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_256_PKCS1	0x28	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_384_PKCS1	0x29	RFC8017: RSASSA-PKCS1-v1_5
RSA_SHA_512_PKCS1	0x2A	RFC8017: RSASSA-PKCS1-v1_5

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_SIGN	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte identifier of the key pair or private key.
	TLV[TAG_2]	1-byte `SE05x_RSASignAlgo_t`
	TLV[TAG_3]	Byte array containing input data.
Le	0x00	Expecting ASN.1 signature.

R-APDU Body

Value	Description
TLV[TAG_1]	RSA signature in ASN.1 format.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] rsaSigningAlgo`: rsaSigningAlgo [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[out] signature`: [0:kSE05x_TAG_1]
- `[inout] psignatureLen`: Length for signature

smStatus_t **Se05x_API_RSAVerify**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, SE05x_RSASignatureAlgo_t *rsaSigningAlgo*, **const** uint8_t **inputData*, size_t *inputDataLen*, **const** uint8_t **signature*, size_t *signatureLen*, SE05x_Result_t **presult*)

Se05x_API_RSAVerify

The RSAVerify command verifies the given signature and returns the result.

The key cannot be passed externally to the command directly. In case users want to use the command to verify signatures using different public keys or the public key value regularly changes, the user should create a transient key object to which the key value is written and then the identifier of that transient secure object can be used by this RSAVerify command.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	`SE05x_INS_t`
P1	P1_SIGNATURE	See `SE05x_P1_t`
P2	P2_VERIFY	See `SE05x_P2_t`
Lc	#(Payload)	
Payload		
	TLV[TAG_1]	4-byte identifier of the key pair or public key.
	TLV[TAG_2]	1-byte `SE05x_RSASignAlgo_t`
	TLV[TAG_3]	Byte array containing data to be verified.
	TLV[TAG_5]	Byte array containing ASN.1 signature.
Le	0x03	Expecting Result in TLV

R-APDU Body

Value	Description
TLV[TAG_1]	`SE05x_Result_t`: Verification result

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: objectID [1:kSE05x_TAG_1]
- `[in] rsaSigningAlgo`: rsaSigningAlgo [2:kSE05x_TAG_2]

- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData
- `[in] signature`: signature [4:kSE05x_TAG_5]
- `[in] signatureLen`: Length of signature
- `[out] presult`: [0:kSE05x_TAG_1]

smStatus_t **`Se05x_API_SendCardManagerCmd`** (*pSe05xSession_t session_ctx*, uint8_t **pCmdData*, size_t *cmdDataLen*, uint8_t **pOutputData*, size_t **pOutputDataLen*)

Se05x_API_SendCardManagerCmd

Sends a command to the Card Manager.

This APDU will send command to Card Manager

Command to Card Manager

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_CM_COMMAND	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	APDU to be sent to the Card Manager.
Le	0x00	Expected response length

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing the Card Manager response.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] pCmdData`: The command input data
- `[in] cmdDataLen`: The command input data length
- `[out] pOutputData`: The response data
- `[out] pOutputDataLen`: The response data length

smStatus_t **`Se05x_API_SetAppletFeatures`** (*pSe05xSession_t session_ctx*, *pSe05xAppletFeatures_t appletVariant*)

Se05x_API_SetAppletFeatures

Sets the applet features that are supported. To successfully execute this command, the session must be authenticated using the RESERVED_ID_FEATURE.

The 2-byte input value is a pre-defined AppletConfig value.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_VARIANT	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte Variant from `SE05x_AppletConfig_t`

R-APDU Body

NA

R-APDU Trailer

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] variant`: variant [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_SetCounterValue`** (*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint16_t *size*, uint64_t *value*)

Se05x_API_SetCounterValue

See Se05x_API_CreateCounter

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] objectID`: object id [1:kSE05x_TAG_1]
- `[in] size`: size [3:kSE05x_TAG_2]
- `[in] value`: value [4:kSE05x_TAG_3]

smStatus_t **`Se05x_API_SetECCurveParam`** (*pSe05xSession_t session_ctx*, SE05x_ECCurve_t *curveID*, SE05x_ECCurveParam_t *ecCurveParam*, **`const`** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_SetECCurveParam

Set a curve parameter. The curve must have been created first by CreateEcCurve.

All parameters must match the expected value for the listed curves. If the curve parameters are not correct, the curve cannot be used.

Users have to set all 5 curve parameters for the curve to be usable. Once all curve parameters are given, the secure element will check if all parameters are correct and return SW_NO_ERROR..

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_WRITE	See `SE05x_INS_t`
P1	P1_CURVE	See `SE05x_P1_t`
P2	P2_PARAM	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	1-byte curve identifier, from `SE05x_ECCurve_t`
	TLV[TAG_2]	1-byte `SE05x_ECCurveParam_t`
	TLV[TAG_3]	Bytestring containing curve parameter value.

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	Data is returned successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] curveID`: curve id [1:kSE05x_TAG_1]
- `[in] ecCurveParam`: ecCurveParam [2:kSE05x_TAG_2]
- `[in] inputData`: inputData [3:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData

smStatus_t **Se05x_API_SetLockState** (*pSe05xSession_t session_ctx*, uint8_t *lockIndicator*, uint8_t *lockState*)

Se05x_API_SetLockState

Sets the applet transport lock (locked or unlocked). There is a Persistent lock and a Transient Lock. If the Persistent lock is UNLOCKED, the device is unlocked (regardless of the Transient lock). If the Persistent lock is LOCKED, the device is only unlocked when the Transient lock is UNLOCKED and the device will be locked again after deselect of the applet.

Note that regardless of the lock state, the credential RESERVED_ID_TRANSPORT allows access to all features. For example, it is possible to write/update objects within the session opened by RESERVED_ID_TRANSPORT, even if the applet is locked.

The default TRANSIENT_LOCK state is LOCKED; there is no default PERSISTENT_LOCK state (depends on product configuration).

This command can only be used in a session that used the credential with identifier RESERVED_ID_TRANSPORT as authentication object.

PERSISTENT_LOCK	TRANSIENT_LOCK	Behavior
UNLOCKED	UNLOCKED	Unlocked until PERSISTENT_LOCK set to LOCKED.
UNLOCKED	LOCKED	Unlocked until PERSISTENT_LOCK set to LOCKED.
LOCKED	UNLOCKED	Unlocked until deselect or TRANSIENT_LOCK set to LOCKED.
LOCKED	LOCKED	Locked until PERSISTENT_LOCK set to UNLOCKED.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_TRANSPORT	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	1-byte `LockIndicatorRef`
	TLV[TAG_2]	1-byte `LockStateRef`
Le		

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] lockIndicator`: lock indicator [1:kSE05x_TAG_1]
- `[in] lockState`: lock state [2:kSE05x_TAG_2]

smStatus_t **`Se05x_API_SetPlatformSCPRequest`** (*pSe05xSession_t session_ctx*, SE05x_PlatformSCPRequest_t *platformSCPRequest*)

Se05x_API_SetPlatformSCPRequest

Sets the required state for platform SCP (required or not required). This is a persistent state.

If platform SCP is set to SCP_REQUIRED, any applet APDU command will be refused by the applet when platform SCP is not enabled. Enabled means full encryption and MAC, both on C-APDU and R-APDU. Any other level is not sufficient and will not be accepted. SCP02 will not be accepted (as there is no response MAC and encryption).

If platform SCP is set to “not required,” any applet APDU command will be accepted by the applet.

This command can only be used in a session that used the credential with identifier RESERVED_ID_PLATFORM_SCP as authentication object.

Note that the default state is SCP_NOT_REQUIRED.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SCP	See `SE05x_P2_t`
Lc	#(Payload)	
Payload	TLV[TAG_1]	1-byte `SE05x_PlatformSCPRequest_t`
Le		

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] platformSCPRequest`: platf scp req [1:kSE05x_TAG_1]

smStatus_t **`Se05x_API_TLSCalculatePreMasterSecret`** (*pSe05xSession_t session_ctx*, uint32_t *keyPairId*, uint32_t *pskId*, uint32_t *hmacKeyId*, **`const`** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_TLSCalculatePreMasterSecret

The command TLSCalculatePreMasterSecret will compute the pre-master secret for TLS according [RFC5246]. The pre-master secret will always be stored in an HMACKey object (TLV[TAG_3]). The HMACKey object must be created before; otherwise the calculation of the pre-master secret will fail.

It can use one of these algorithms: - - - -

- PSK Key Exchange algorithm as defined in [RFC4279]
- RSA_PSK Key Exchange algorithm as defined in [RFC4279]
- ECDHE_PSK Key Exchange algorithm as defined in [RFC5489]
- EC Key Exchange algorithm as defined in [RFC4492]
- RSA Key Exchange algorithm as defined in [RFC5246]

TLV[TAG_1] needs to be an (existing) HMACKey identifier containing the pre- shared Key.

Input data in TLV[TAG_4] are:

- An EC public key when TLV[TAG_2] refers to an EC key pair.
- An RSA encrypted secret when TLV[TAG_2] refers to an RSA key pair.
- Empty when TLV[TAG_2] is absent or empty.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_TLS	See `SE05x_P1_t`
P2	P2_PMS	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte PSK identifier referring to a 16, 32, 48 or 64-byte Pre Shared Key. [Optional]
	TLV[TAG_2]	4-byte key pair identifier. [Optional]
	TLV[TAG_3]	4-byte target HMACKey identifier.
	TLV[TAG_4]	Byte array containing input data.
Le	•	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] keyPairId`: keyPairId [1:kSE05x_TAG_1]
- `[in] pskId`: pskId [2:kSE05x_TAG_2]
- `[in] hmacKeyId`: hmacKeyId [3:kSE05x_TAG_3]
- `[in] inputData`: inputData [4:kSE05x_TAG_4]
- `[in] inputDataLen`: Length of inputData

smStatus_t **Se05x_API_TLSCalculateRsaPreMasterSecret** (*pSe05xSession_t session_ctx*, uint32_t *keyPairId*, uint32_t *pskId*, uint32_t *hmacKeyId*, **const** uint8_t **inputData*, size_t *inputDataLen*, **const** uint8_t **clientVersion*, size_t *clientVersionLen*)

Se05x_API_TLSCalculateRsaPreMasterSecret

Parameters

- `[in] session_ctx`: Session Context[0:kSE05x_pSession]
- `[in] keyPairId`: keyPairId[1:kSE05x_TAG_1]
- `[in] pskId`: pskId[2:kSE05x_TAG_2]

- `[in] hmacKeyId`: hmacKeyId[3:kSE05x_TAG_3]
- `[in] inputData`: inputData[4:kSE05x_TAG_4]
- `[in] inputDataLen`: Length of inputData
- `[in] clientVersion`: client version[6:kSE05x_TAG_6]
- `[in] clientVersionLen`: Length of client version

smStatus_t **`Se05x_API_TLSGenerateRandom`**(*pSe05xSession_t session_ctx*, uint8_t **randomValue*, size_t **prandomValueLen*)

Se05x_API_TLSGenerateRandom

Generates a random that is stored in the SE05X and used by TLSPerformPRF.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_TLS	See `SE05x_P1_t`
P2	P2_RANDOM	See `SE05x_P2_t`
Lc	#(Payload)	
Le	0x22	Expecting TLV with 32 bytes data.

R-APDU Body

Value	Description
TLV[TAG_1]	32-byte random value

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[out] randomValue`: [0:kSE05x_TAG_1]
- `[inout] prandomValueLen`: Length for randomValue

smStatus_t **`Se05x_API_TLSPerformPRF`**(*pSe05xSession_t session_ctx*, uint32_t *objectID*, uint8_t *digestAlgo*, **`const`** uint8_t **label*, size_t *labelLen*, **`const`** uint8_t **random*, size_t *randomLen*, uint16_t *reqLen*, uint8_t **outputData*, size_t **poutputDataLen*, **`const`** SE05x_TLSPerformPRFType_t *tlsprf*)

Se05x_API_TLSPerformPRF

The command TLSPerformPRF will compute either:

- the master secret for TLS according [RFC5246], section 8.1
- key expansion data from a master secret for TLS according [RFC5246], section 6.3

Each time before calling this function, TLSGenerateRandom must be called. Executing this function will clear the random that is stored in the SE05X .

The function can be called as client or as server and either using the pre- master secret or master secret as input, stored in an HMACKey. The input length must be either 16, 32, 48 or 64 bytes.

This results in P2 having 4 possibilities:

- P2_TLS_PRF_CLI_HELLO: pass the clientHelloRandom to calculate a master secret, the serverHelloRandom is in SE05X , generated by TLSGenerateRandom.
- P2_TLS_PRF_SRV_HELLO: pass the serverHelloRandom to calculate a master secret, the clientHelloRandom is in SE05X , generated by TLSGenerateRandom.
- P2_TLS_PRF_CLI_RANDOM: pass the clientRandom to generate key expansion data, the serverRandom is in SE05X , generated by TLSGenerateRandom.
- P2_TLS_PRF_SRV_RANDOM: pass the serverRandom to generate key expansion data, the clientRandom is in SE05X

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_CRYPTO	See `SE05x_INS_t`
P1	P1_TLS	See `SE05x_P1_t`
P2	See description above.	See `SE05x_P2_t`
Lc	#(Payload)	
	TLV[TAG_1]	4-byte HMACKey identifier.
	TLV[TAG_2]	1-byte `SE05x_DigestMode_t`, except DIGEST_NO_HASH.
	TLV[TAG_3]	Label (1 to 64 bytes)
	TLV[TAG_4]	32-byte random
	TLV[TAG_5]	2-byte requested length
Le	0x00	

R-APDU Body

Value	Description
TLV[TAG_1]	Byte array containing requested output data.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] objectID`: The object id
- `[in] digestAlgo`: The digest algorithm
- `[in] label`: The label
- `[in] labelLen`: The label length
- `[in] random`: The random

- `[in] randomLen`: The random length
- `[in] reqLen`: The request length
- `outputData`: The output data
- `poutputDataLen`: The poutput data length
- `[in] tlsprf`: The tlsprf

smStatus_t **`Se05x_API_TriggerSelfTest`** (*pSe05xSession_t session_ctx*, SE05x_HealthCheckMode_t *healthCheckMode*, uint8_t **result*)

Se05x_API_TriggerSelfTest

Trigger a system health check for the system. When calling this command, a self-test is triggered in the operating system. When the test fails, the device might not respond with a R-APDU as the chip is reset. If HealthCheckMode is set to HCM_FIPS, the test will only work if the device is running in FIPS approved mode of operation.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`. In addition to INS_CRYPTO, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SANITY	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte value from HealthCheckMode
Le	0x00	2-byte response + attested data (if INS_ATTEST is set).

R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing 1-byte Result.

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] HealthCheckMode`: The health check mode
- `result`: The result of Self Test

smStatus_t **`Se05x_API_TriggerSelfTest_W_Attst`** (*pSe05xSession_t session_ctx*, SE05x_HealthCheckMode_t *healthCheckMode*, uint32_t *attestID*, SE05x_AttestationAlgo_t *attestAlgo*, **`const`** uint8_t **random*, size_t *randomLen*, uint8_t **result*, *SE05x_TimeStamp_t *ptimeStamp*, uint8_t **outrandom*, size_t **poutrandomLen*, uint8_t **chipId*, size_t **pchipIdLen*, uint8_t **signature*, size_t **psignatureLen*)

Se05x_API_TriggerSelfTest_W_Attst

Trigger a system health check for the system. When calling this command, a self-test is triggered in the operating system. When the test fails, the device might not respond with a R-APDU as the chip is reset. If HealthCheckMode is set to HCM_FIPS, the test will only work if the device is running in FIPS approved mode of operation.

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`. In addition to INS_CRYPTO, users can set the INS_ATTEST flag. In that case, attestation applies.
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SANITY	See `SE05x_P2_t`
Lc	#(Payload)	Payload length
Payload	TLV[TAG_1]	2-byte value from HealthCheckMode
TLV[TAG_5]	4-byte attestation object identifier. [Optional] [Conditional: only when INS_ATTEST is set]	
TLV[TAG_6]	1-byte AttestationAlgo [Optional] [Conditional: only when INS_ATTEST is set]	
TLV[TAG_7]	16-byte freshness random [Optional] [Conditional: only when INS_ATTEST is set]	
Le	0x00	2-byte response + attested data (if INS_ATTEST is set).

R-APDU Body

Value	Description
TLV[TAG_1]	TLV containing 1-byte Result.
TLV[TAG_3]	TLV containing 12-byte timestamp [Conditional: only when C-APDU contains INS_ATTEST]
TLV[TAG_4]	TLV containing 16-byte freshness (random) [Conditional: only when C-APDU contains INS_ATTEST]
TLV[TAG_5]	TLV containing 18-byte chip unique ID [Conditional: only when C-APDU contains INS_ATTEST]
TLV[TAG_6]	TLV containing signature over the concatenated values of TLV[TAG_1], TLV[TAG_3], TLV[TAG_4] and TLV[TAG_5]. [Conditional: only when C-APDU contains INS_ATTEST]

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] HealthCheckMode`: The health check mode
- `[in] attestID`: The attest id
- `[in] attestAlgo`: The attest algorithm
- `[in] random`: The random
- `[in] randomLen`: The random length
- `result`: The result of Self Test
- `ptimeStamp`: The ptime stamp
- `outrandom`: The outrandom
- `poutrandomLen`: The poutrandom length
- `chipId`: The chip identifier
- `pchipIdLen`: The pchip identifier length
- `signature`: The signature
- `psignatureLen`: The psignature length

smStatus_t **`Se05x_API_UpdateBinary_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint32_t *version*)

Se05x_API_UpdateBinary_Ver

See Se05x_API_WriteBinary. Also allows to set key version (4 bytes). Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_UpdateCounter`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *size*, uint64_t *value*)

Se05x_API_UpdateCounter

See Se05x_API_SetCounterValue. Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_UpdateECKey_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, SE05x_ECCurve_t *curveID*, **`const`** uint8_t **privKey*, size_t *privKeyLen*, **`const`** uint8_t **pubKey*, size_t *pubKeyLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_KeyPart_t *key_part*, uint32_t *version*)

Se05x_API_UpdateECKey_Ver

See Se05x_API_WriteECKey. Also allows to set key version (4 bytes). Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_UpdatePCR`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *pcrID*, **`const`** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_UpdatePCR

See Se05x_API_WritePCR. Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_UpdateRSAKey_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *size*, **`const`** uint8_t **p*, size_t *pLen*, **`const`** uint8_t **q*, size_t *qLen*, **`const`** uint8_t **dp*, size_t *dpLen*, **`const`** uint8_t **dq*, size_t *dqLen*, **`const`** uint8_t **qInv*, size_t *qInvLen*, **`const`** uint8_t **pubExp*, size_t *pubExpLen*, **`const`** uint8_t **priv*, size_t *privLen*, **`const`** uint8_t **pubMod*, size_t *pubModLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_KeyPart_t *key_part*, **`const`** SE05x_RSAKeyFormat_t *rsa_format*, uint32_t *version*)

Se05x_API_UpdateRSAKey_Ver

See Se05x_API_WriteRSAKey. Also allows to set key version (4 bytes). Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_UpdateSymmKey_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, *SE05x_KeyID_t kekID*, **`const`** uint8_t **keyValue*, size_t *keyValueLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_SymmKeyType_t *type*, uint32_t *version*)

Se05x_API_UpdateSymmKey_Ver

See Se05x_API_WriteSymmKey. Also allows to set key version (4 bytes). Called to update the value of already existing object. If policy is passed, it should match with existing policy on object.

smStatus_t **`Se05x_API_VerifySessionUserID`** (*pSe05xSession_t session_ctx*, **`const`** uint8_t **userId*, size_t *userIdLen*)

Se05x_API_VerifySessionUserID

Verifies the session user identifier (UserID) in order to allow setting up a session. If the UserID is correct, the session establishment is successful; otherwise the session cannot be opened (SW_CONDITIONS_NOT_SATISFIED is returned).

Command to Applet

Field	Value	Description
CLA	0x80	
INS	INS_MGMT	See `SE05x_INS_t`
P1	P1_DEFAULT	See `SE05x_P1_t`
P2	P2_SESSION_USERID	See `SE05x_P2_t`
Lc	#(Payload)	Payload length.
	TLV[TAG_1]	UserID value
Le	-	

R-APDU Body

NA

R-APDU Trailer

SW	Description
SW_NO_ERROR	The command is handled successfully.

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] userId`: userId [1:kSE05x_TAG_1]
- `[in] userIdLen`: Length of userId

smStatus_t **`Se05x_API_WriteBinary`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, **`const`** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_WriteBinary

Creates or writes to a binary file object. Data are written to either the start of the file or (if specified) to the offset passed to the function.

Command to Applet

Field	Value	Description
P1	P1_BINARY	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	2-byte file offset [Optional: default = 0]
	TLV[TAG_3]	2-byte file length (up to 0x7FFF). [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_4]	Data to be written [Optional: if not given, TAG_3 must be filled]
	TLV[TAG_11]	4-byte version [Optional]

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] policy`: policy [1:kSE05x_TAG_POLICY]
- `[in] objectID`: object id [2:kSE05x_TAG_1]
- `[in] offset`: offset [3:kSE05x_TAG_2]
- `[in] length`: length [4:kSE05x_TAG_3]
- `[in] inputData`: input data [5:kSE05x_TAG_4]
- `[in] inputDataLen`: Length of inputData

smStatus_t **`Se05x_API_WriteBinary_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *offset*, uint16_t *length*, **`const`** uint8_t **inputData*, size_t *inputDataLen*, uint32_t *version*)

Se05x_API_WriteBinary_Ver

See Se05x_API_WriteBinary. Also allows to set key version (4 bytes).

smStatus_t **`Se05x_API_WriteECKey`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, SE05x_ECCurve_t *curveID*, **`const`** uint8_t **privKey*, size_t *privKeyLen*, **`const`** uint8_t **pubKey*, size_t *pubKeyLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_KeyPart_t *key_part*)

Se05x_API_WriteECKey

Write or update an EC key object.

P1KeyPart indicates the key type to be created (if the object does not yet exist).

If P1KeyPart = P1_KEY_PAIR, Private Key Value (TLV[TAG_3]) and Public Key Value (TLV[TAG_4) must both be present, or both be absent. If absent, the key pair is generated in the SE05X .

If the object already exists, P1KeyPart is ignored.

Field	Value	Description
P1	`SE05x_P1_t` | P1_EC	See `SE05x_P1_t` , P1KeyType should only be set for new objects.
P2	P2_DEFAULT	See P2
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional - only when the object identifier is not in use yet]
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. [Optional: default unlimited] [Conditional: only when the object identifier is not in use yet and INS includes INS_AUTH_OBJECT; see AuthenticationObjectPolicies]
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	1-byte curve identifier, see ECCurve [Conditional: only when the object identifier is not in use yet;]
	TLV[TAG_3]	Private key value (see `ECKeyRef`) [Conditional: only when the private key is externally generated and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_4]	Public key value (see `ECKeyRef`) [Conditional: only when the public key is externally generated and P1KeyType is either P1_KEY_PAIR or P1_PUBLIC]
	TLV[TAG_11]	4-byte version [Optional]

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] policy`: The policy
- `[in] maxAttempt`: The maximum attempt
- `[in] objectID`: The object id
- `[in] curveID`: The curve id
- `[in] privKey`: The priv key
- `[in] privKeyLen`: The priv key length
- `[in] pubKey`: The pub key
- `[in] pubKeyLen`: The pub key length
- `[in] ins_type`: The insert type
- `[in] key_part`: The key part

smStatus_t **Se05x_API_WriteECKey_Ver** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, SE05x_ECCurve_t *curveID*, **const** uint8_t **privKey*, size_t *privKeyLen*, **const** uint8_t **pubKey*, size_t *pubKeyLen*, **const** SE05x_INS_t *ins_type*, **const** SE05x_KeyPart_t *key_part*, uint32_t *version*)

Se05x_API_WriteECKey_Ver

See Se05x_API_WriteECKey. Also allows to set key version (4 bytes).

smStatus_t **Se05x_API_WritePCR** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *pcrID*, **const** uint8_t **initialValue*, size_t *initialValueLen*, **const** uint8_t **inputData*, size_t *inputDataLen*)

Se05x_API_WritePCR

Creates or writes to a PCR object.

A PCR is a hash to which data can be appended; i.e., writing data to a PCR will update the value of the PCR to be the hash of all previously inserted data concatenated with the new input data.

A PCR will always use DigestMode = DIGEST_SHA256; no other configuration possible.

If TAG_2 and TAG_3 is not passed, the PCR is reset to its initial value (i.e., the value set when the PCR was created).

This reset is controlled under the POLICY_OBJ_ALLOW_DELETE policy, so users that can delete the PCR can also reset the PCR to initial value.

Command to Applet

Field	Value	Description
P1	P1_PCR	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_1]	4-byte PCR identifier.
	TLV[TAG_2]	Initial hash value [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_3]	Data to be extended to the existing PCR. [Conditional: only when the object identifier is already in use] [Optional: not present if a Reset is requested]

R-APDU Body

NA

R-APDU Trailer

Parameters

- `[in] session_ctx`: Session Context [0:kSE05x_pSession]
- `[in] policy`: policy [1:kSE05x_TAG_POLICY]
- `[in] pcrID`: object id [2:kSE05x_TAG_1]
- `[in] initialValue`: initialValue [3:kSE05x_TAG_2]
- `[in] initialValueLen`: Length of initialValue
- `[in] inputData`: inputData [4:kSE05x_TAG_3]
- `[in] inputDataLen`: Length of inputData

smStatus_t **Se05x_API_WritePCR_WithType** (*pSe05xSession_t session_ctx*, **const** SE05x_INS_t *ins_type*, *pSe05xPolicy_t policy*, uint32_t *pcrID*, **const** uint8_t **initialValue*, size_t *initialValueLen*, **const** uint8_t **inputData*, size_t *inputDataLen*)

smStatus_t **Se05x_API_WriteRSAKey** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *size*, **const** uint8_t **p*, size_t *pLen*, **const** uint8_t **q*, size_t *qLen*, **const** uint8_t **dp*, size_t *dpLen*, **const** uint8_t **dq*, size_t *dqLen*, **const** uint8_t **qInv*, size_t *qInvLen*, **const** uint8_t **pubExp*, size_t *pubExpLen*, **const** uint8_t **priv*, size_t *privLen*, **const** uint8_t **pubMod*, size_t *pubModLen*, **const** SE05x_INS_t *transient_type*, **const** SE05x_KeyPart_t *key_part*, **const** SE05x_RSAKeyFormat_t *rsa_format*)

Se05x_API_WriteRSAKey

Creates or writes an RSA key or a key component.

Supported key sizes are listed in RSABitLength. Other values are not supported.

An RSA key creation requires multiple ADPUs to be sent:

- The first APDU must contain:
  - Policy (optional, so only if non-default applies)
  - Object identifier
  - Key size
  - 1 of the key components.
- Each next APDU must contain 1 of the key components.

The policy applies only once all key components are set.

Once an RSAKey object has been created, its format remains fixed and cannot be updated (so CRT or raw mode, no switch possible).

If the object already exists, P1KeyType is ignored.

For key pairs, if no component is present (TAG_3 until TAG_9), the key pair will be generated on chip; otherwise the key pair will be constructed starting with the given component.

For private keys or public keys, there should always be exactly one of the tags TAG_3 until TAG_10.

- TLV[TAG_8] and TLV[TAG_10] must only contain a value if the key pair is to be set to a known value and P1KeyType is either P1_KEY_PAIR or P1_PUBLIC; otherwise the value must be absent and the length must be equal to 0.
- TLV[TAG_9] must only contain a value it the key is to be set in raw mode to a known value and P1KeyType is either P1_KEY_PAIR or P1_PRIVATE; otherwise the value must be absent and the length must be equal to 0.
- If TLV[TAG_3] up to TLV[TAG_10] are absent (except TLV[TAG_8]), the RSA key will be generated on chip in case the object does not yet exist; otherwise it will be regenerated. This only applies to RSA key pairs.
- Keys can be set by setting the different components of a key; only 1 component can be set at a time in this case.

Field	Value	Description
P1	`SE05x_KeyPart_t` | P1_RSA	See `SE05x_P1_t`
P2	P2_DEFAULT or P2_RAW	See `SE05x_P2_t`; P2_RAW only in case P1KeyPart = P1_KEY_PAIR and TLV[TAG_3] until TLV[TAG_10] is empty and the must generate a raw RSA key pair; all other cases: P2_DEFAULT.
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	2-byte key size in bits (`SE05x_RSABitLength_t`) [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_3]	P component [Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyPart is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_4]	Q component [Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyPart is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_5]	DP component [Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyPart is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_6]	DQ component [Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyPart is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_7]	INV_Q component [Conditional: only when the object identifier is in CRT mode and the key is generated externally and P1KeyPart is either P1_KEY_PAIR or P1_PRIVATE]
	TLV[TAG_8]	Public exponent
	TLV[TAG_9]	Private Key (non-CRT mode only)
	TLV[TAG_10]	Public Key (Modulus)
	TLV[TAG_11]	4-byte version [Optional]

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] policy`: The policy
- `[in] objectID`: The object id
- `[in] size`: The size
- `[in] p`: The part p
- `[in] pLen`: The p length
- `[in] q`: The quarter
- `[in] qLen`: The quarter length
- `[in] dp`: The part dp
- `[in] dpLen`: The dp length
- `[in] dq`: The part dq
- `[in] dqLen`: The dq length

- `[in] qInv`: The quarter inv
- `[in] qInvLen`: The quarter inv length
- `[in] pubExp`: The pub exponent
- `[in] pubExpLen`: The pub exponent length
- `[in] priv`: The priv
- `[in] privLen`: The priv length
- `[in] pubMod`: The pub modifier
- `[in] pubModLen`: The pub modifier length
- `[in] transient_type`: The transient type
- `[in] key_part`: The key part
- `[in] rsa_format`: The rsa format

smStatus_t **Se05x_API_WriteRSAKey_Ver** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, uint32_t *objectID*, uint16_t *size*, **const** uint8_t **p*, size_t *pLen*, **const** uint8_t **q*, size_t *qLen*, **const** uint8_t **dp*, size_t *dpLen*, **const** uint8_t **dq*, size_t *dqLen*, **const** uint8_t **qInv*, size_t *qInvLen*, **const** uint8_t **pubExp*, size_t *pubExpLen*, **const** uint8_t **priv*, size_t *privLen*, **const** uint8_t **pubMod*, size_t *pubModLen*, **const** SE05x_INS_t *ins_type*, **const** SE05x_KeyPart_t *key_part*, **const** SE05x_RSAKeyFormat_t *rsa_format*, uint32_t *version*)

Se05x_API_WriteRSAKey_Ver

See Se05x_API_WriteRSAKey. Also allows to set key version (4 bytes).

smStatus_t **Se05x_API_WriteSymmKey** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, *SE05x_KeyID_t kekID*, **const** uint8_t **keyValue*, size_t *keyValueLen*, **const** SE05x_INS_t *ins_type*, **const** SE05x_SymmKeyType_t *type*)

Se05x_API_WriteSymmKey

Creates or writes an AES key, DES key or HMAC key, indicated by P1:

- P1_AES
- P1_DES
- P1_HMAC

Users can pass RFC3394 wrapped keys by indicating the KEK in TLV[TAG_2]. Note that RFC3394 required 8-byte aligned input, so this can only be used when the key has an 8-byte aligned length.

Command to Applet

Field	Value	Description
P1	See above	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
Payload	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. [Optional: default unlimited] [Conditional: only when the object identifier is not in use yet and INS includes INS_AUTH_OBJECT; see AuthenticationObjectPolicies]
	TLV[TAG_1]	4-byte object identifier
	TLV[TAG_2]	4-byte KEK identifier [Conditional: only when the key value is RFC3394 wrapped]
	TLV[TAG_3]	Key value, either plain or RFC3394 wrapped.
	TLV[TAG_4]	Tag length for GCM/GMAC. Will only be used if the object is an AESKey. [Optional]
	TLV[TAG_11]	4-byte version [Optional]

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] policy`: The policy
- `[in] maxAttempt`: The maximum attempt
- `[in] objectID`: The object id
- `[in] kekID`: The kek id
- `[in] keyValue`: The key value
- `[in] keyValueLen`: The key value length
- `[in] ins_type`: The insert type
- `[in] type`: The type

smStatus_t **`Se05x_API_WriteSymmKey_Ver`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, *SE05x_KeyID_t kekID*, **`const`** uint8_t **keyValue*, size_t *keyValueLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_SymmKeyType_t *type*, uint32_t *version*)

Se05x_API_WriteSymmKey_Ver

See Se05x_API_WriteSymmKey. Also allows to set key version (4 bytes).

smStatus_t **`Se05x_API_WriteSymmKey_Ver_extended`** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, *SE05x_KeyID_t kekID*, **`const`** uint8_t **keyValue*, size_t *keyValueLen*, **`const`** SE05x_INS_t *ins_type*, **`const`** SE05x_SymmKeyType_t *type*, uint32_t *version*, uint16_t *min_aead_tag_len*)

Se05x_API_WriteSymmKey_Ver_extended

See Extension of Se05x_API_WriteSymmKey_Ver api. Allows to set minimum tag length for AEAD (2 bytes).

smStatus_t **Se05x_API_WriteUserID** (*pSe05xSession_t session_ctx*, *pSe05xPolicy_t policy*, *SE05x_MaxAttemps_t maxAttempt*, uint32_t *objectID*, **const** uint8_t **userId*, size_t *userIdLen*, **const** SE05x_AttestationType_t *attestation_type*)

Se05x_API_WriteUserID

Creates a UserID object, setting the user identifier value. The policy defines the maximum number of attempts that can be performed as comparison.

Command to Applet

Field	Value	Description
P1	P1_USERID	See `SE05x_P1_t`
P2	P2_DEFAULT	See `SE05x_P2_t`
	TLV[TAG_POLICY]	Byte array containing the object policy. [Optional: default policy applies] [Conditional: only when the object identifier is not in use yet]
	TLV[TAG_MAX_ATTEMPTS]	2-byte maximum number of attempts. If 0 is given, this means unlimited. For pins, the maximum number of attempts must be smaller than 256. [Optional: default = 0] [Conditional: only when the object identifier is not in use yet and INS includes INS_AUTH_OBJECT; see −]
	TLV[TAG_1]	4-byte object identifier.
	TLV[TAG_2]	Byte array containing 4 to 16 bytes user identifier value.

Return The sm status.

Parameters

- `[in] session_ctx`: The session context
- `[in] policy`: The policy
- `[in] maxAttempt`: The maximum attempt
- `[in] objectID`: The object id
- `[in] userId`: The user identifier
- `[in] userIdLen`: The user identifier length
- `[in] attestation_type`: The attestation type

11.12.3 SE05x SCP03 Types and APIs

group **se05x_scp03**

SE05x SCP03 types and API reference.

Enums

enum SE_AuthType_t

Values:

kSSS_AuthType_None = 0

kSSS_AuthType_SCP03 = 1

Global platform SCP03

kSSS_AuthType_ID = 2
(e.g. SE05X) UserID based connection

kSSS_AuthType_AESKey = 3
(e.g. SE05X) Use AESKey for user authentication

```
Earlier this was called  kSSS_AuthType_AppletSCP03
```

kSSS_AuthType_ECKey = 4
(e.g. SE05X) Use ECKey for user authentication

```
Earlier this was called  kSSS_AuthType_FastSCP
```

kSSS_AuthType_INT_ECKey_Counter = 0x14
Used internally, not to be set/used by user.

For the versions of the applet where we have to add the a counter during KDF.

kSSS_SIZE = 0x7FFFFFFF

struct _SE_AuthCtx
#include <nxScp03_Types.h> Authentication mechanims

Public Members

SM_SECURE_SCP03_KEYOBJ **a71chAuthKeys**
Legacy, only for A71CH with Host Crypto

SE_AuthType_t **authType**
How exactly we are going to authenticat ot the system.

Since `ctx` is a union, this is needed to know exactly how we are going to authenticate.

union *_SE_AuthCtx*::**[anonymous] ctx**
Depending on `authType`, the input and output parameters.

This has both input and output parameters.

Input is for Keys that are used to initiate the connection. While connecting, session keys/parameters are generated and they are also part of this context.

In any case, we connect to only one type

uint8_t **data**[**SSS_AUTH_MAX_CONTEXT_SIZE**]

SE05x_AuthCtx_ECKey_t **eckey**
For ECKey

struct *_SE_AuthCtx*::**[anonymous]**::**[anonymous] extension**
Reserved memory for implementation specific extension

SE05x_AuthCtx_ID_t **idobj**
For UserID/PIN based based Authentication

NXSCP03_AuthCtx_t **scp03**
For PlatformSCP / Applet SCP.

Same SCP context will be used for platform and applet scp03

struct NXECKey03_StaticCtx_t
#include <nxScp03_Types.h> Static part of keys for FAST SCP

Public Members

sss_object_t **HostEcdsaObj**
Host ECDSA Private key

sss_object_t **HostEcKeypair**
Host ephemeral ECC key pair

sss_object_t **masterSec**
Host master Secret

sss_object_t **SeEcPubKey**
SE ECC public key

struct NXSCP03_AuthCtx_t
#include <nxScp03_Types.h> Static and Dynamic Context in one Context.

Depending on system, these objects may point to keys inside other security system.

Public Members

NXSCP03_DynCtx_t ***pDyn_ctx**
session keys data

NXSCP03_StaticCtx_t ***pStatic_ctx**
.static keys data

struct NXSCP03_DynCtx_t
#include <nxScp03_Types.h> Dynamic SCP03 Context.

This structure is filled **after** establishing an SCP03 session.

Public Members

SE_AuthType_t **authType**
Handle differnt types of auth.. PlatformSCP / AppletSCP

uint8_t **cCounter**[16]
command counter

sss_object_t **Enc**
session channel encryption key

sss_object_t **Mac**
session command authentication key

uint8_t **MCV**[16]
MAC chaining value.

sss_object_t **Rmac**
session response authentication key

uint8_t **SecurityLevel**
security level set

struct NXSCP03_StaticCtx_t
#include <nxScp03_Types.h> Static SCP03 Context.

This structure is filled **before** establishing an SCP03 session.

Depending on system, these objects may point to keys inside other security system.

Public Members

sss_object_t **Dek**
data encryption key obj

sss_object_t **Enc**
Encryption key object

uint8_t **keyVerNo**
Key version no to use for chanel authentication in SCP03

sss_object_t **Mac**
static secure channel authentication key obj

struct SE05x_AuthCtx_ECKey_t
#include <nxScp03_Types.h> Keys to connect for a ECKey Connection

Public Members

NXSCP03_DynCtx_t ***pDyn_ctx**
The Dynamic part of the ECKey Authentication

We derive/compute the session keys based on the `pStatic_ctx`.

NXECKey03_StaticCtx_t ***pStatic_ctx**
The Input/Static part of the ECKey Authentication

We start/initiate a session with the keys here.

struct SE05x_AuthCtx_ID_t
#include <nxScp03_Types.h> UseID / PIN baed authentication object

This is required to open an UserID / PIN based session to the SE.

Public Members

sss_object_t ***pObj**
The corresponding authentication object on the Host

struct SE_Connect_Ctx_t
#include <nxScp03_Types.h> When connecting to a secure element,

Extension of sss_connect_ctx_t

Public Members

SE_AuthCtx_t **auth**
If we need to authenticate, add required objects for authentication

SSS_Conn_Type_t **connType**
How exactly are we going to connect physically

U32 **i2cAddress**
12C address on embedded devices.

const char ***portName**
Connection port name for Socket names, etc.

uint8_t **refresh_session**
If we need to refresh session, SE050 specific

sss_policy_session_u ***session_policy**
If some policy restrictions apply when we connect, point it here

uint8_t **sessionResume**
Set to 1 if we should resume a session already open with SE

uint16_t **sizeOfStucture**
to support binary compatibility/check, sizeOfStucture helps

uint8_t **skip_select_applet**
In the case of Key Rotation, and other use cases where we do not select the IoT Applet and skip the selection of the IoT Applet.

One of the use cases is to do platform SCP key rotation.

When set to 0: Do not skip IoT Applet selection and run as-is.

When set to 1: Skip selection of card manager. Skip selection of Applet.

Internally, if there is platform SCP selected as Auth mechanism during compile time, the internal logic would Select the card manager. But, skip selection of the Applet.

sss_tunnel_t ***tunnelCtx**
If we connect logically, via some software layer

struct SM_SECURE_SCP03_KEYOBJ
#include <nxScp03_Types.h> Legacy, only for A71CH with Host Crypto

Public Members

sss_object_t **pKeyDek**
SSS AES Dek Key object.

sss_object_t **pKeyEnc**
SSS AES Enc Key object.

sss_object_t **pKeyMac**
SSS AES Mac Key object.

struct sss_connect_ctx_t
#include <nxScp03_Types.h> Wrapper strucutre sss_connect_ctx_t

Public Members

SE_AuthCtx_t **auth**
If we need to authenticate, add required objects for authentication

uint8_t **data**[**SSS_CONNECT_MAX_CONTEXT_SIZE**]

struct *sss_connect_ctx_t*::**[anonymous] extension**
Reserved memory for implementation specific extension

sss_policy_session_u ***session_policy**
If some policy restrictions apply when we connect, point it here

uint16_t **sizeOfStucture**
To support binary compatibility/check, sizeOfStucture helps

CHAPTER TWELVE

INDICES AND TABLES

- genindex
- search

INDEX

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