ARTIK Partner Training – ARTIK 05x Module

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Mar, 2018

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Agenda

- ARTIK 05x Module Overview
- ARTIK 05x Module Security
- ARTIK 05x Module Development
- ARTIK 05x Hands-on Lab

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ARTIK 05x Module Overview

Samsung ARTIK™ 053/053s, 055s Wi-Fi® edge nodes

Create secure, next-gen edge products

- Home health monitors, AEDs, fitness equipment, CPAP
- Smoke detectors, thermostats, energy monitors, appliances
- Sensors, lighting controllers, motors, valves
- Access control, fire monitors, smart switches

Processor	**Main:** ARM Cortex® R4 @ 320 MHz **WLAN:** ARM Cortex® R4 @ 480 MHz Security: ARM Cortex M0
Memory	**RAM:** 1.4 MB **Flash:** 8 MB SPI Flash on module
Connectivity	**WLAN (Wi-Fi):** IEEE 802.11 b/g/n
Security	Secure Subsystem, Hardware-protected key storage with secure point-to-point authentication and data transfer, secure boot*, KMS* ***S-versions only**
I/O	2xSPI, 5xUART (2-pin), 4xI2C, 7xPWM, 28xGPIO, 1xJTAG, 4xADC
Operating voltage	**055s:** 3.3 VDC **053, 053s:** 5-12 VDC
Temperature range	-20° to 85° (°C)
Size	**055s:** 15 mm W x 26 mm H x 3.9 mm D **053, 053s:** 15 mm W x 40 mm H x 3.9 mm D

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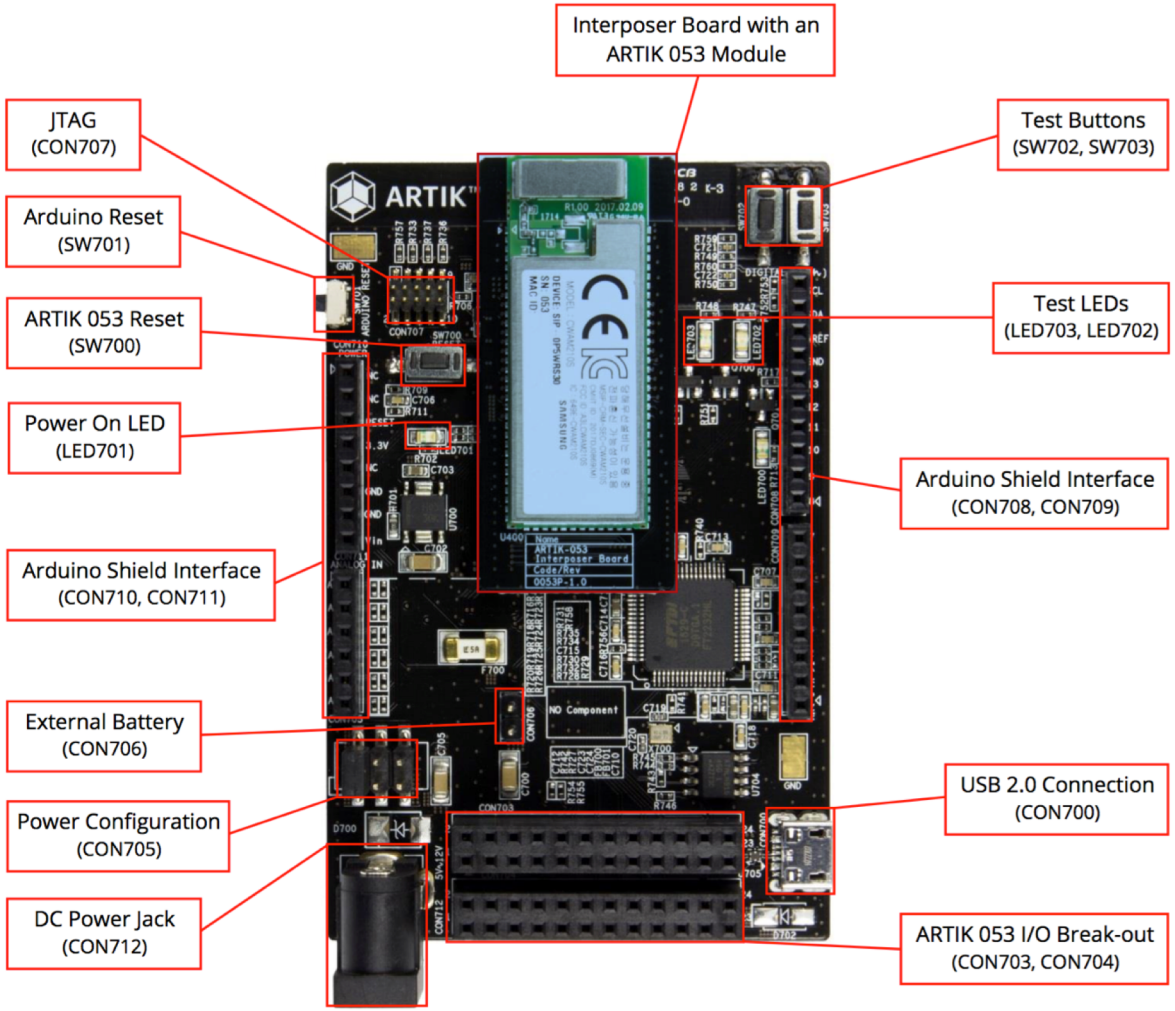
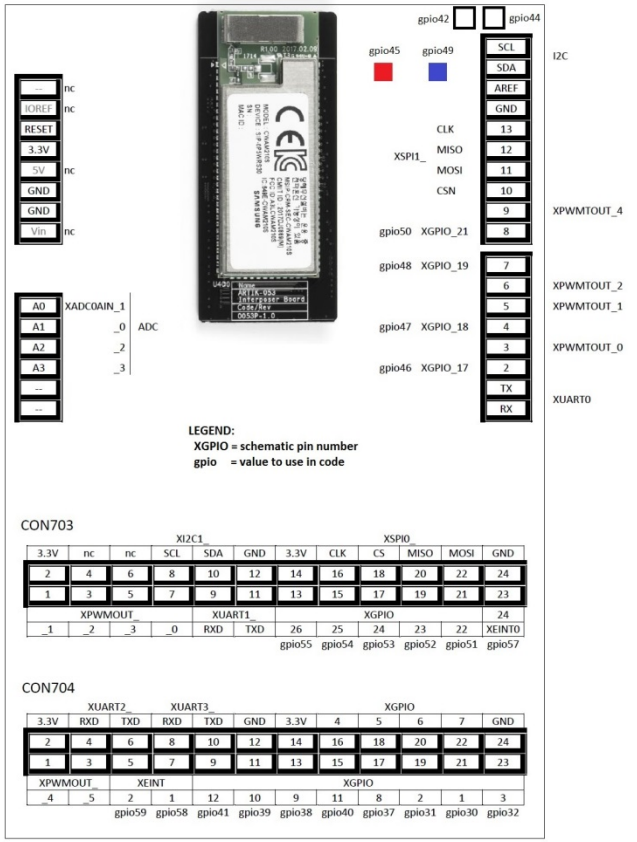
ARTIK 05x Starter Kit





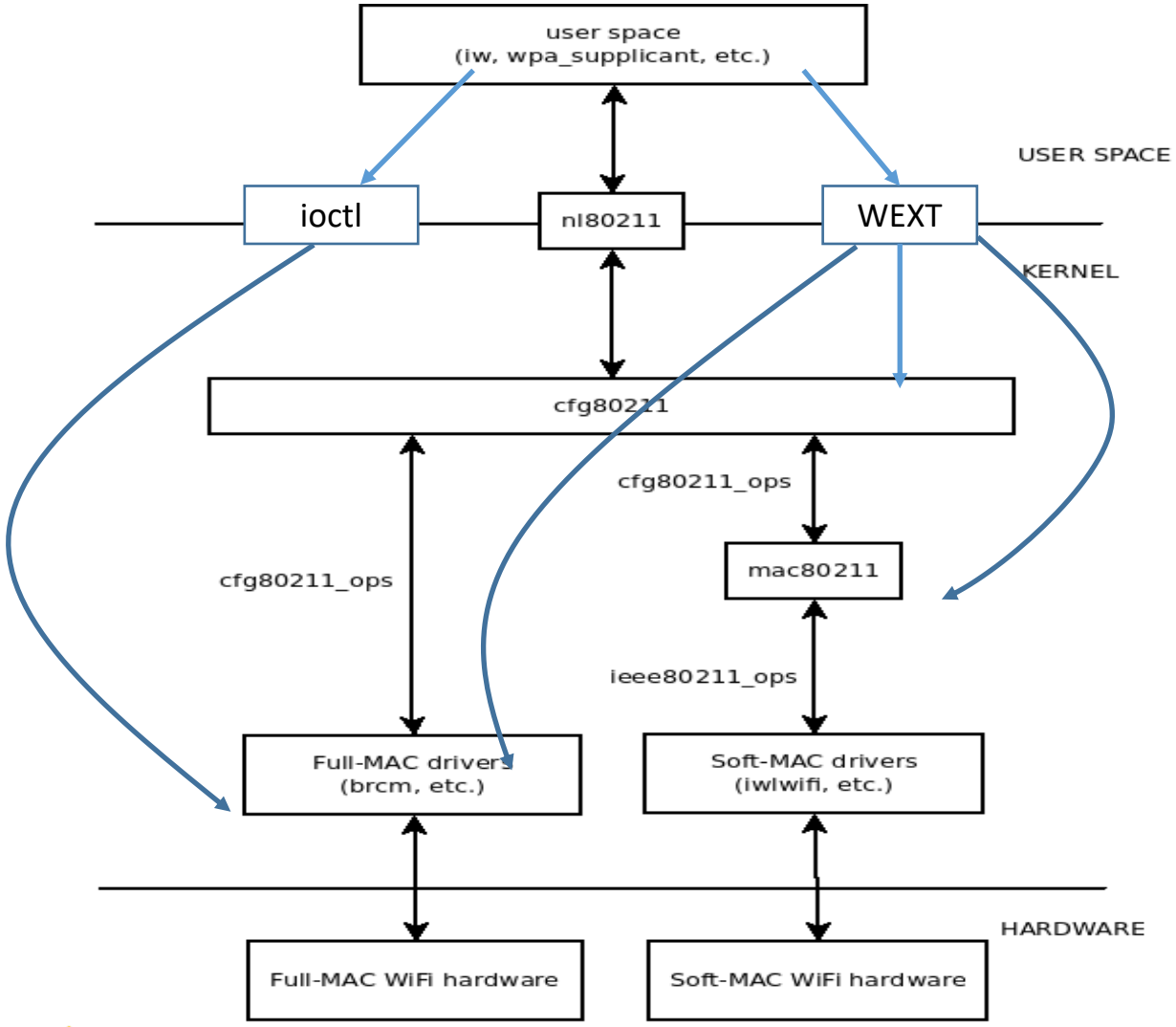
Wi-Fi Subsystem

- ARTIK05x supports 802.11b/g/n Wi-Fi at 2.4GHz
- Dedicated Wi-Fi Processor subsystem with 480MHz 32-bit ARM Cortex R4 supported by 32KB I-Cache and 16KB D-Cache
- WiFi throughput: ~25 Mbps single stream
- WPA/WPA2

Samsung ARTIK™ 05x WiFi – wpa_supplicant

- Supplicant is used in the client stations for key negotiation with a WPA Authenticator.
- wpa_supplicant is designed for Linux, BSD and Windows with support for WPA and WPA2.
- wpa_supplicant was designed to use hardware, driver and OS independent, portable C code for all WPA functionality.
- A daemon program running in the background and acting as the backend component controls the wireless connection.

WiFi Flow



- nl80211: Interface between user space and kernel. This works like a socket.
- cfg80211: configuration API for 802.11 devices.
- mac80211: Implements the MAC layer functions, also the cfg80211 callbacks.
- cfg80211_ops: a set of operations that Full-MAC drivers and mac80211 module register to cfg80211 module
- ieee80211_ops: a set of operations that Soft-MAC drivers register to mac80211 module

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Samsung ARTIK™ 05x Power Management

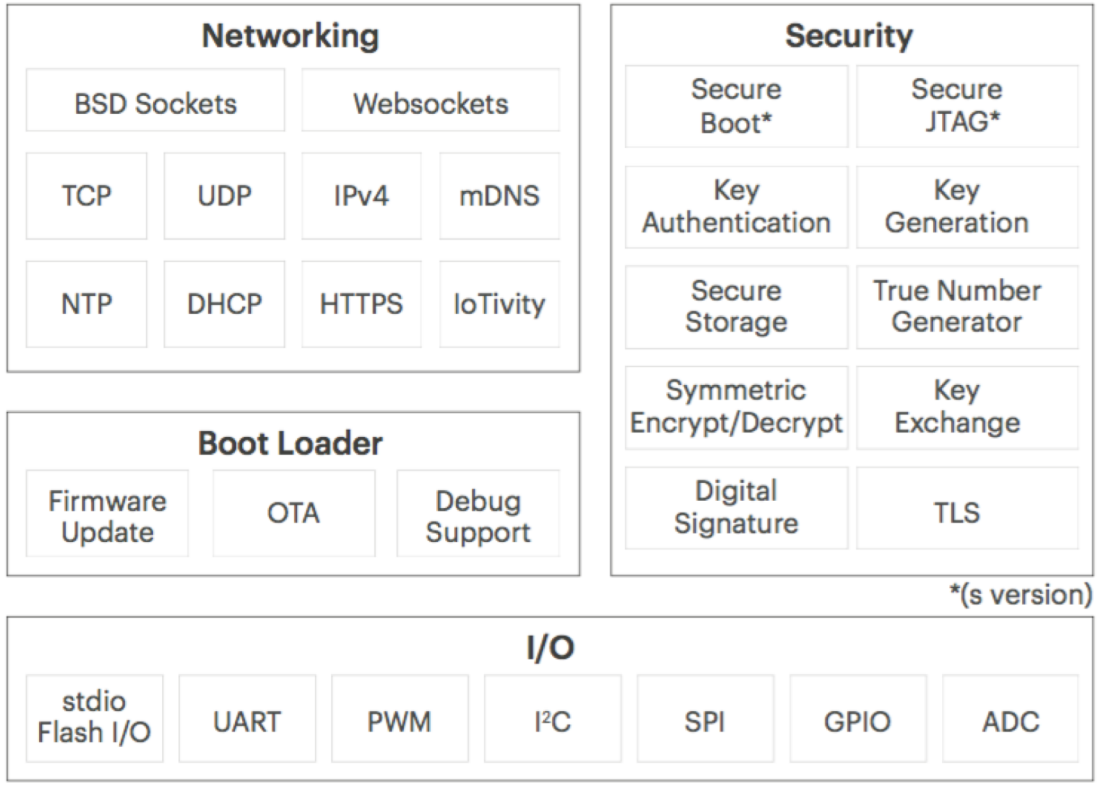
	Description	Power Consumption	Current @ 5V Typical	Current@12V Typical
Normal	Normal states. All components are running.	55mA normal cases	362mA +/- 30	151mA +/- 15
WiFi OFF	In this mode, almost all components are powered down. It consumes low power while downs clock.	Up to 0.05W	46.5mA+/-12	23.3mA+/-1.7
Deep Stop (DSTOP)	Almost all components are powered down except PMU (Power Management Unit).This state is similar to Power Off. However, DSTOP can be waken up by events such as external interrupt(Push button), UART or I2C device. And it also maintains their context before going to DSTOP.	Up to 0.05W	0.1mA	0.15mA

TizenRT OS Basics

- ARTIK 05x are powered by TizenRT
- TizenRT is a lightweight RTOS-based platform to support low-end IoT devices, based on Nuttx
- Primary governing standards are POSIX and ANSI standards
- IP Network Stack

TizenRT OS Hierachy

Kernel Services	
Realtime	Tasks, threads, queues, mutex, semaphore, signal
Time	Real-time clock, date/time, timer, sleep
Network Services	
Internet	DHCP, NTP Client, DNS Client, mDNS, BSD Sockets, Websockets
Services	Web client/server, MQTT client, IoTivity, cJSON
libc Services	
Libc Compatibility	Flash based Stdio, Stdlib, String, Unistd, Time
Security Services	
Encryption	AES 128/256, RSA 1024/2048, ECC BP/NIST 192/224/256/384/512
Authentication	HMAC 128/256, certificate
Certificate Storage	Secure Flash storage
Firmware Integrity	Secure boot and JTAG protection



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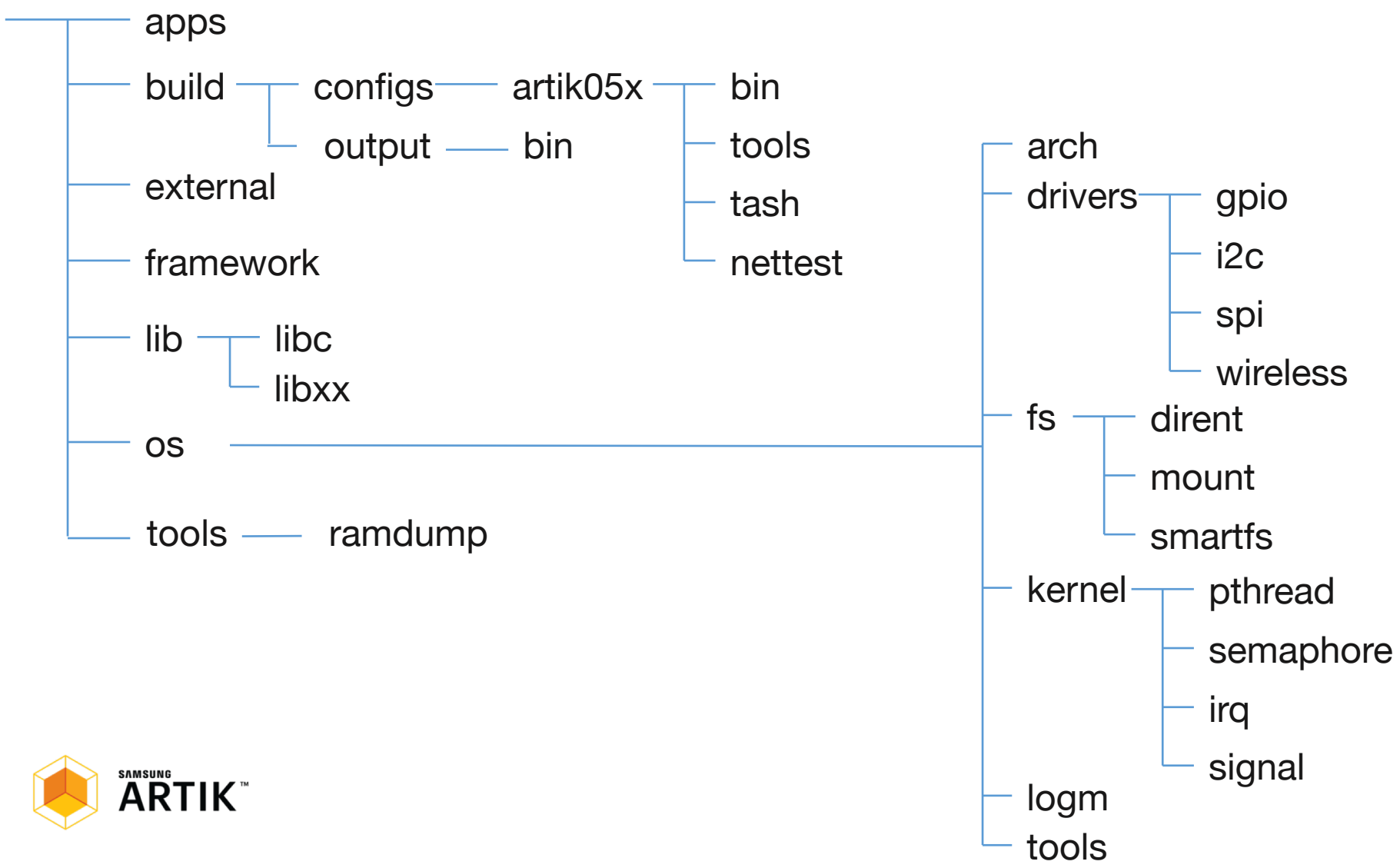
Directory Structure



TizenRT Build Types

- In TizenRT, only Flat Build mode is supported.
- Flat Build:
  - The code is built as a blob that runs in a flat address space out of on-chip FLASH(or SRAM) memory.
  - Designed for resource-limited MCUs that have no MMU
  - Build mode is enabled by configuring CONFIG_BUILD_FLAT = y

Tasks/Threads

- TizenRT provides two different interfaces:
  - from sched.h
    - `int task_create(const char *name, int priority, int stack_size, main_t entry, char *const argv[])`
  - from pthread.h
    - `int pthread_create(pthread_t *thread, const pthread_attr_t *attr, pthread_startroutine_t startroutine, pthread_addr_t arg)`

- task_create() is the same as calling fork() and execv() in Linux environment. It creates a real task (or process).
- pthread_create() has same interface as pthread in Linux. It creates a thread, not an independent task

Semaphore, Mutex, Message Queues

- TizenRT supports the POSIX-like interfaces for Semaphore: `sem_init(), sem_wait(), sem_post()..`
- For mutex support, developers need to use pthread interfaces: `pthread_mutex_init(), pthread_mutex_lock()…`
- TizenRT supports POSIX-like named message queues for inter-task communication:

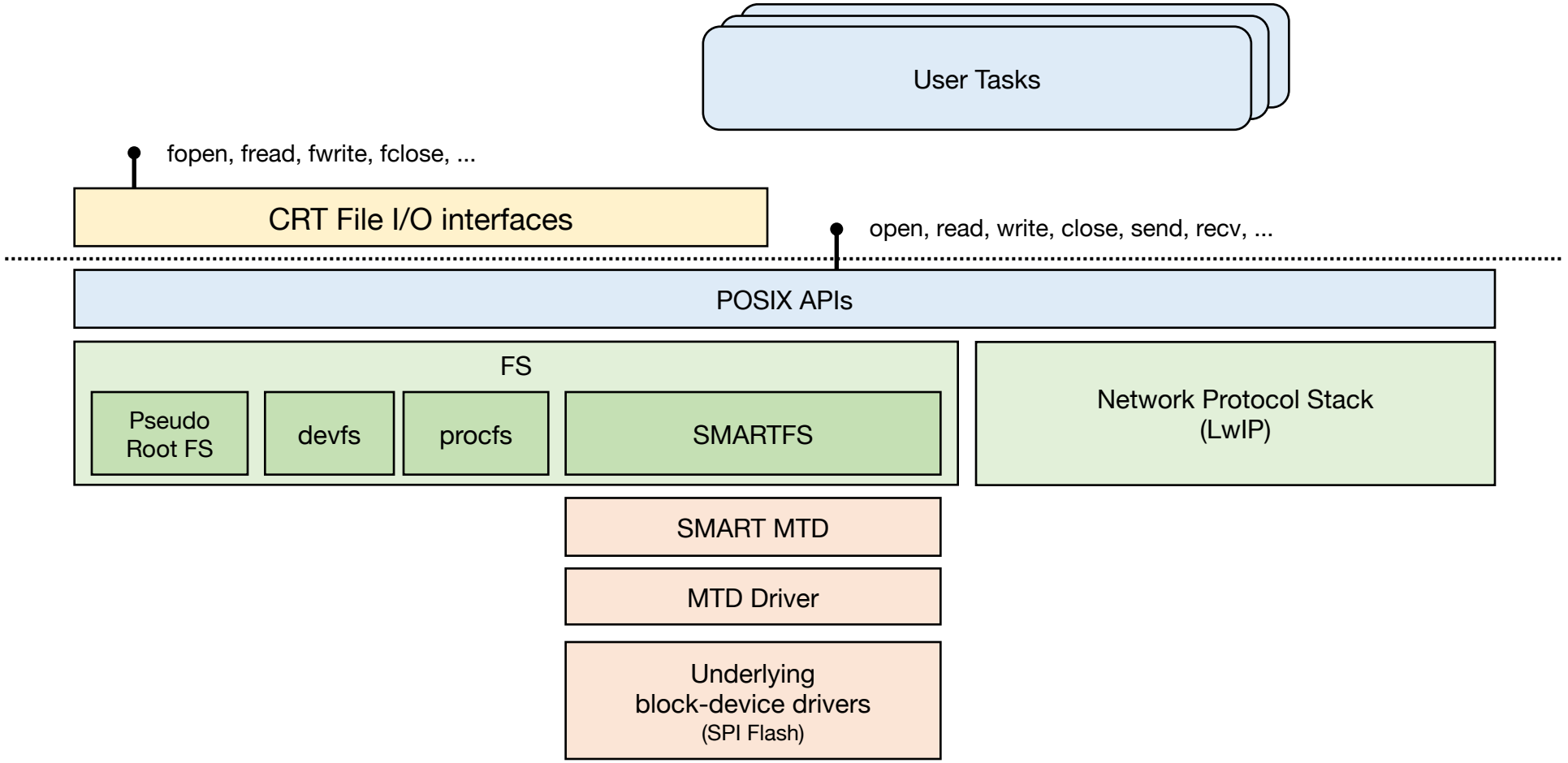
```
mqd_t mq_open(const char *mq_name, int oflags, ...)

int mq_close(mqd_t mqdes)

int mq_send(mqd_t mqdes, const char *msg, size_t msglen, int prio)

int mq_receive(mqd_t mqdes, char *msg, size_t msglen, int *prio)
```

File System Hierarchy



File System

- Pseudo is an in-memory file system which does not require any storage medium or block driver support.
- File system contents in this pseudo file system can be accessible via file system APIs (open, close, read, write, etc.)
- Devfs, procfs or true block-based file systems can be mounted at any empty directory node under the root file system.
- As in Linux, name resources such like named semaphore, message queue, and shared memory special files can be created under the root pseudo-file system.

SmartFS

- TizenRT uses SmartFS as a main file system to manage its files. After boot, a SmartFS volume is mounted at /mnt.
- SmartFS consists of two layers
  - The MTD block layer - Smart MTD handles low-level media operations such as logical sector allocation, freeing and management, erase block management etc.
  - SmartFS layer - SmartFS implements the abstraction of file and directory, such as creating new files, chaining logical sectors together to create files, creating directories
- Filesystem interfaces: fcntl.h, unistd.h, stdio.h, aio.h

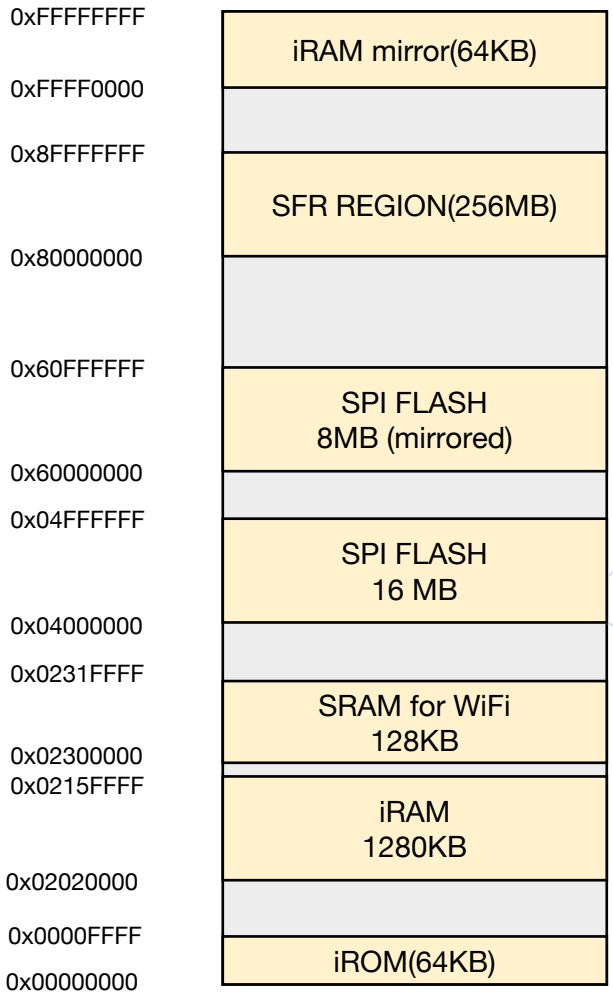
Database (AraStorage)

- A lightweight database named AraStorage is implemented with SQL-compatible interfaces.
- Advanced features, such as:

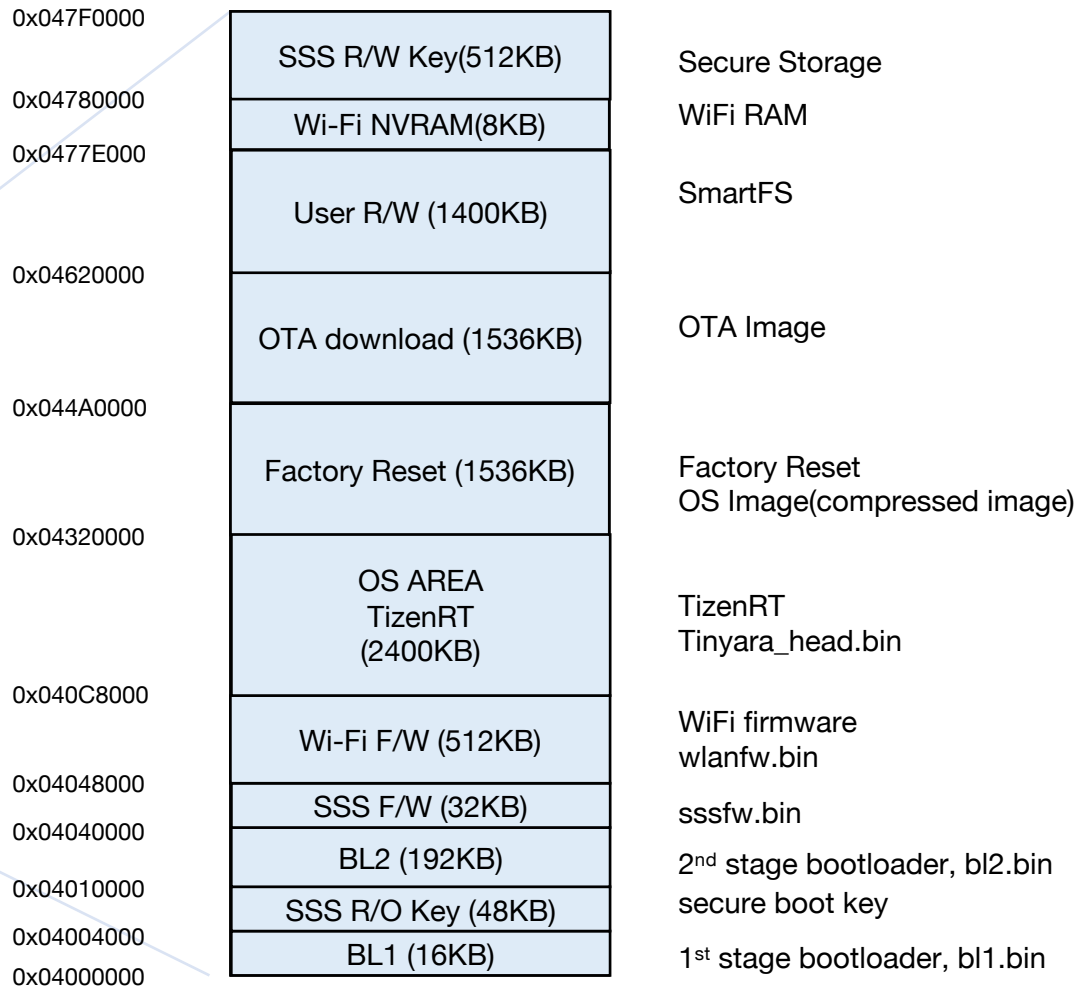
  - b+ tree-based indexing algorithm

  - Cursor structure to improve usability for the application layer

Memory map



Physical Address Space (4GB)



Flash Partitions (8MB)

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IoTBus Framework

- GPIO (General Purpose Input/Output)
- I2C (Inter Integrated Circuit)
- SPI (Serial Peripheral Interface)
- PWM (Pulse Width Modulation)
- UART (Universal Asynchronous Receiver/Transmitter)

Device Management and LWM2M stack

- Lightweight M2M (LWM2M) is a device lifecycle management specification
- Provides a specification for functions like: firmware upgrade, provisioning of certificates, access control policies, connectivity monitoring etc.
- Based on CoAP protocol
- LWM2M allows the use of UDP for communication between client and server
- DTLS security to ensure authentication, data confidentiality and integrity between an LWM2M client and ARTIK Cloud server(an LWM2M server).

ARTIK 05x earns OCF 1.3 Certification

- The Open Connectivity Foundation is dedicated to ensuring secure interoperability

- ARTIK 05x family of systems-on-module for IoT became the first product family that is certified on the latest OCF standards for trust and connectivity for IoT.

- It ensures products created by using ARTIK 05x can work seamlessly with other OCF certified IoT devices regardless of their form factor, OS or service providers etc.

Product Name	Certification Type	Company Name	Device Type(s)	Date Certified
Haier Washer	OCF	Haier Group	Washer (Laundry)	01/24/2018
InstaView ThinQ	OCF	LG Electronics, Inc.	Air Purifier, Fan, Humidifier, Light, Smart Plug, Switch	12/22/2017
Lynx MiND	OCF	Lynx Technology	Door, Fan, Freezer, Generic Sensor, Light, Oven, Refrigerator, Smart Plug, Switch, Thermostat	12/19/2017
SURE Universal Set Top Box	OCF	SURE Universal	Set Top Box	12/19/2017
SURE Universal Remote	OCF	SURE Universal	Air Quality Monitor, Camera, Cooktop, Dehumidifier, Door, Garage Door, Generic Sensor, Oven, Printer Multi-Function, Receiver, Smart Lock	12/19/2017
Sure Universal Remote	OCF	SURE Universal	Air Quality Monitor, Camera, Cooktop, Dehumidifier, Door, Garage Door, Generic Sensor, Oven, Printer Multi-Function, Receiver, Smart Lock	12/19/2017
ARTIKTM 053 Smart IoT Module	OCF	Samsung Electronics Co., Ltd.	Light	12/12/2017
Alegro 100	OCF	VIA Technologies	Smart Plug	02/20/2017
SURE Universal Remote	OCF	SURE Universal	Switch	12/23/2016
Family Hub 1.0	OCF	Samsung Electronics Co., Ltd.	Refrigerator	09/22/2016

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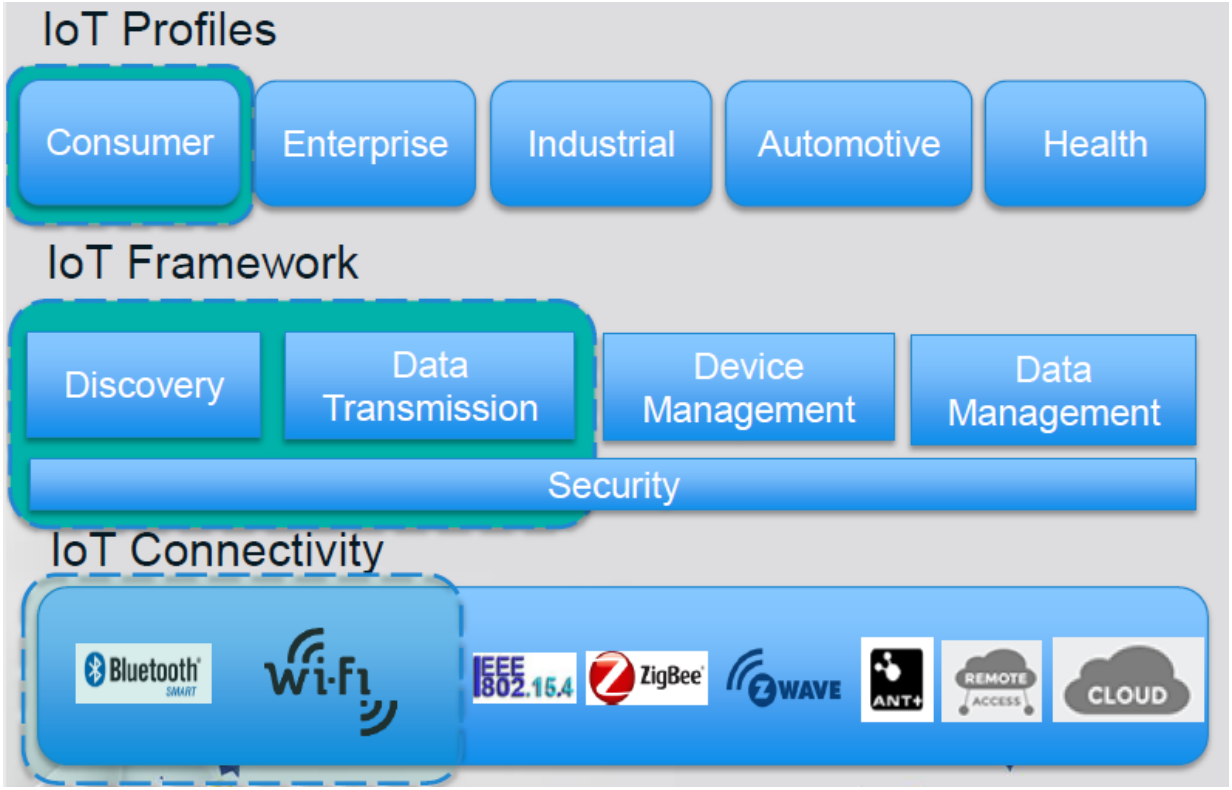
IoTivity

IoTivity is an open source software framework enabling seamless device-to-device connectivity to address the emerging needs of the Internet of Things



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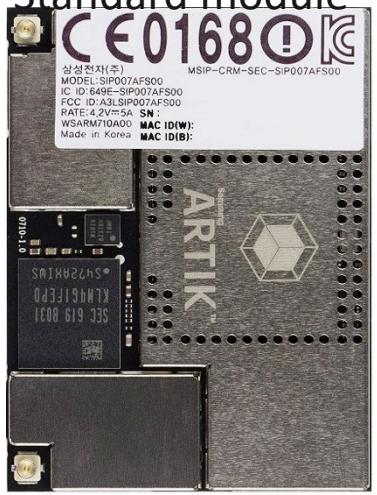
ARTIK 05x Module Security

Module Security

Non-S vs. S Modules

- Same HW specifications other than security features
- "s" type modules can be identified by **blue** labeling

Standard module



"S" module

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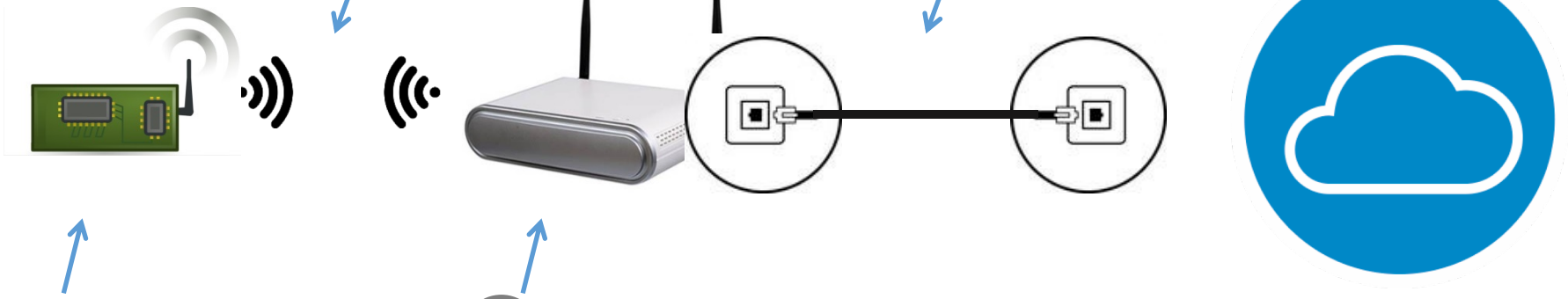
Why S-Module?



Secure Communication

Device Protection
Secure Code Execution

Data Protection

Samsung ARTIK™ S-Module Features

		ARTIK module (05x, 5, 7)	ARTIK S-module	Comments
Secure communication	Per device unique key & certificate	✓	✓	Uniquely identifies device
	Key stored in HW secure element	✓	✓	Secure key storage
	PKI infrastructure: Mutual authentication of device and cloud	✓	✓	Device talks to authorized cloud and vice versa
	Post Provisioning		✓	Provision with your own keys and certificates
Device protection/ secure code execution	KMS infrastructure for code signing		✓	Key Management Service
	Code verification key in HW		✓	Secure key storage
	Secure boot (check for authorized code)		✓	Boot image verification
	JTAG access locked		✓	Lock out debug access
Data protection/ Secure storage	Secure OS (separate normal & secure operations)		✓	Hardware enforced secure applications via TEE
	Security Lib API (27 API calls)	Limited(random number generator, get cert and signature)	✓	Key Manager, Authentication, Secure Storage, Post Provisioning, Encrypt/Decrypt
	Secure storage		✓	Encrypt data stored on Flash

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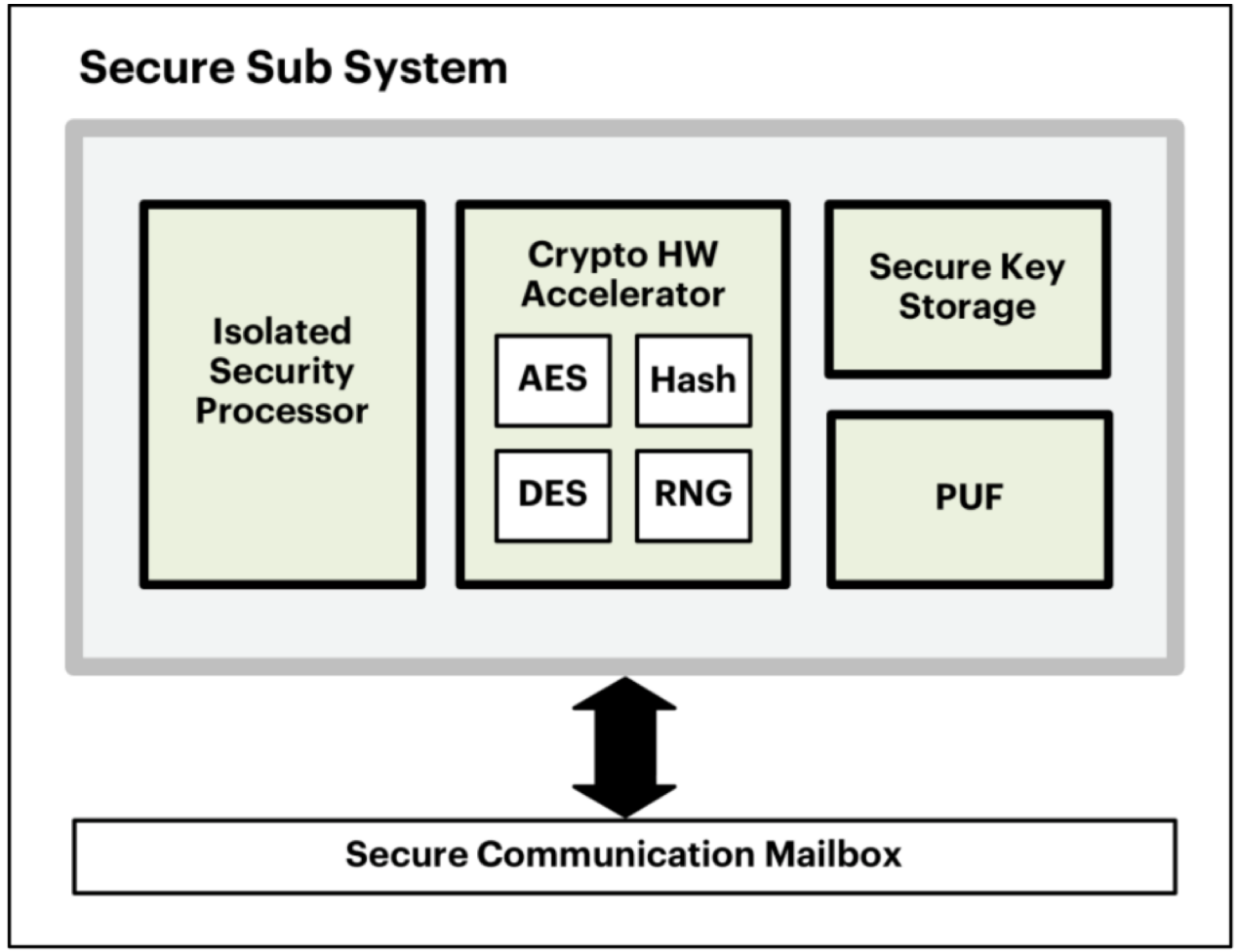
ARTIK 05x Security Subsystem



- Isolated Security Processor
- Cryptographic Hardware Acceleration
- A Physical Uncloneable Function(PUF)
- Secure Key Storage

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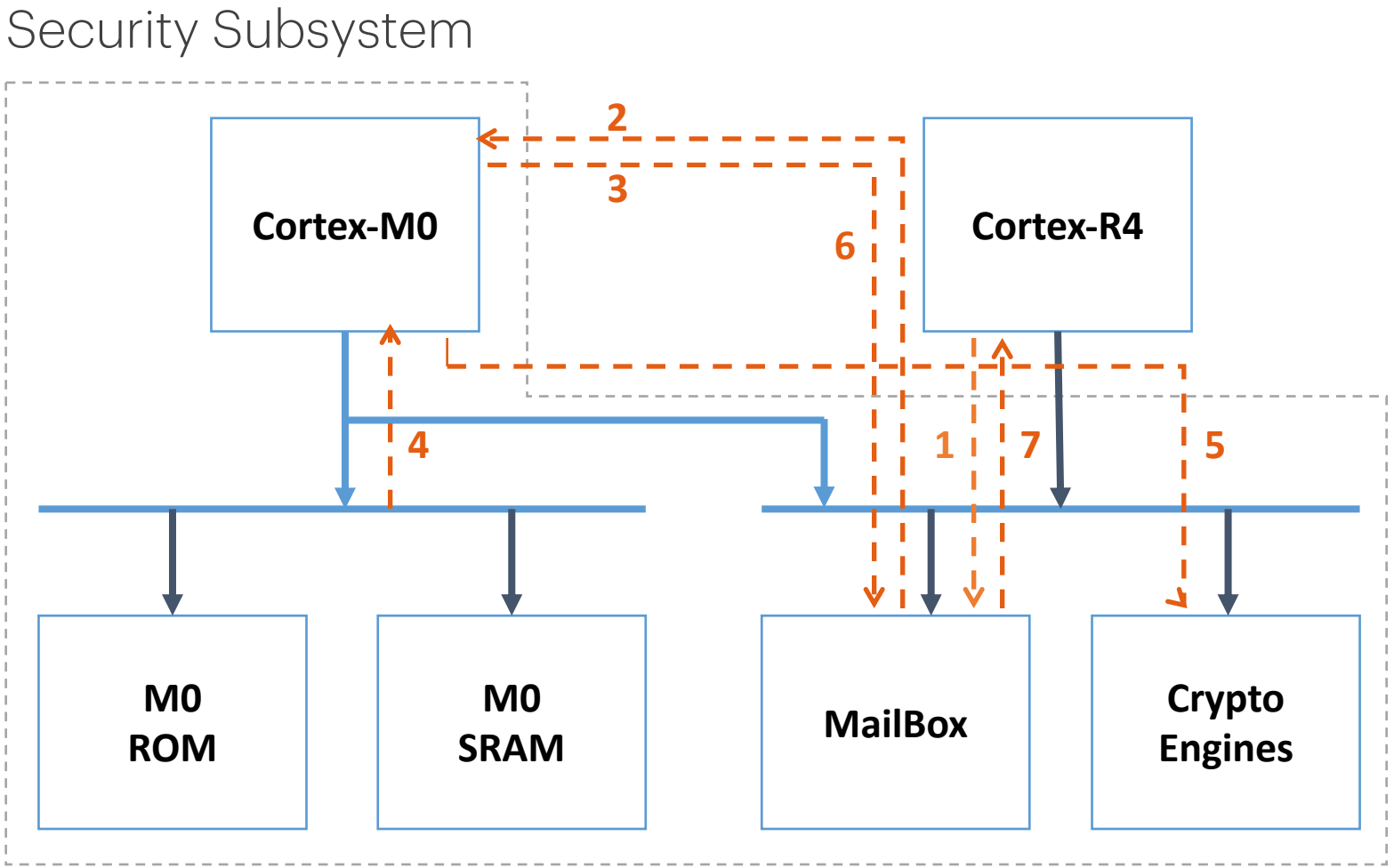
Isolated Security Processor



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Cryptographic Hardware Acceleration

Support for high performance cryptographic acceleration

- Random Number Generation: DTRNG, PRNG
- Block Cipher: Secure AES, DES
- Hash Function: SHA1/SHA2/SHA3 with HMAC
- Public Key Cryptosystem: RSA, ECDSA, DH, ECDH
- FIPS Compliant: CAVP, CMVP, MDFPP

PUF (Physically Unclonable Function)

- Create a cryptographic key(PUF KEY) that can not be cloned by anybody else
  - PUF Key is auto generated using process variation during Manufacturing
  - Unchanging value over product lifetime
  - Unclonable
- Applications of PUF:
  - Device identification
  - Key generation and storage (seed that never generates the same key)
  - IP Protection
  - Protocols with challenge-response pairs

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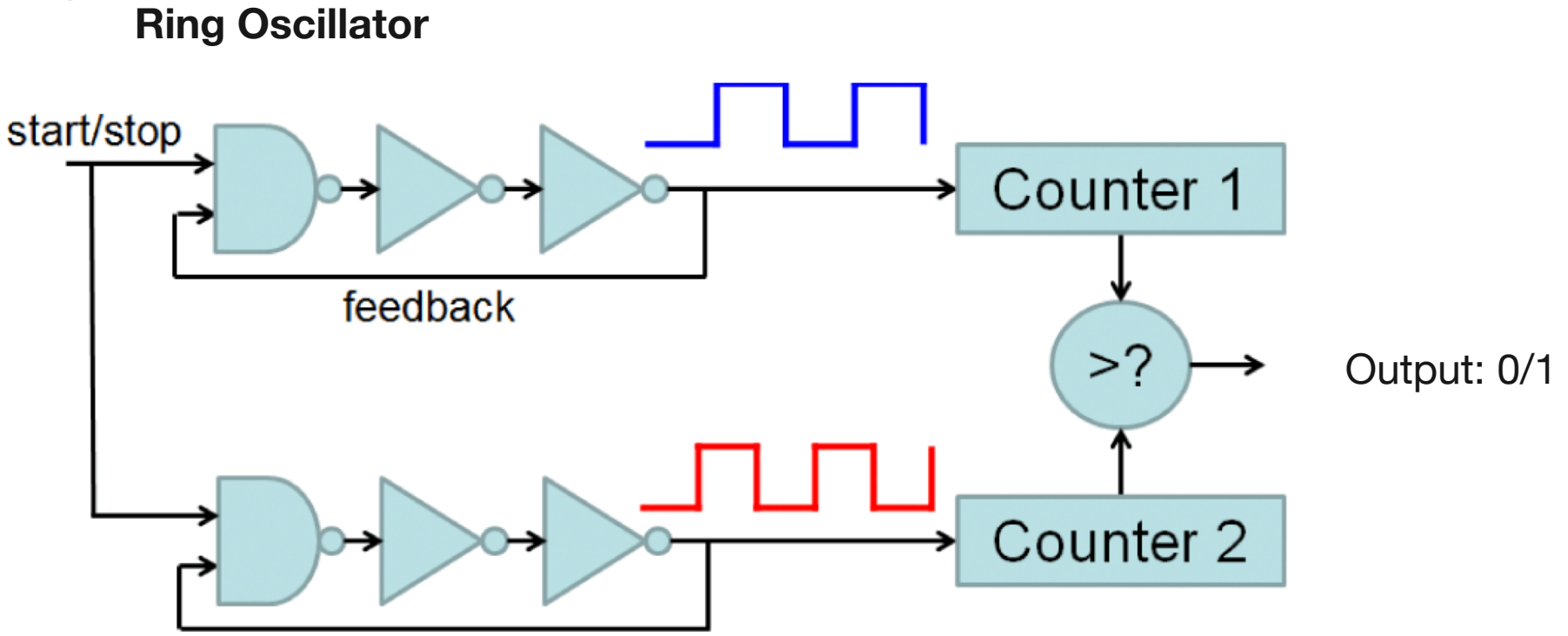
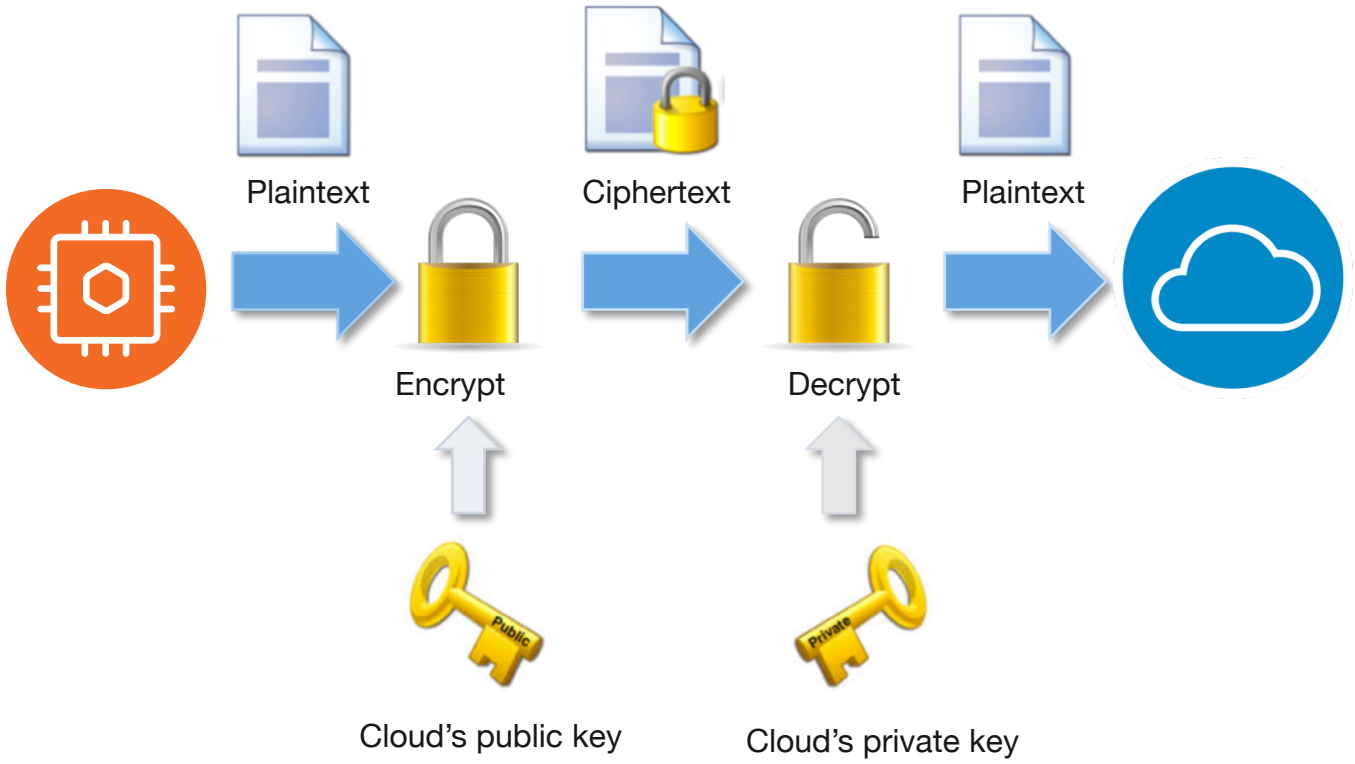
RO Frequency PUF

- RO (Ring-Oscillator) frequency is used as the PUF input to generate a unique key for each chip



Public Key Infrastructure (PKI)



Different keys are used to encrypt and decrypt messages

- A Public Key Infrastructure (PKI) supports the distribution and identification of public encryption keys, enabling users to securely exchange data over networks
- ARTIK provides PKI, which is used to generate and apply unique certificates and key pairs to each ARTIK Module during manufacturing.

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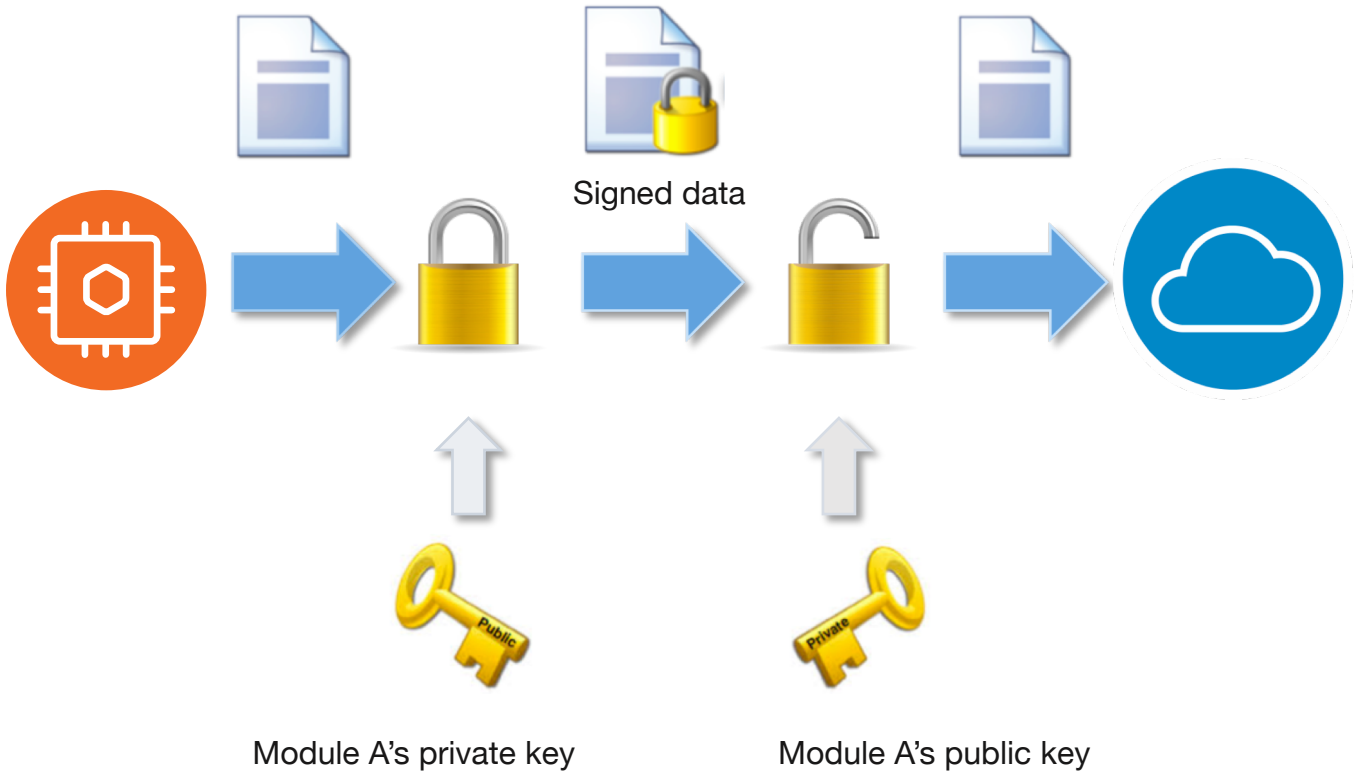
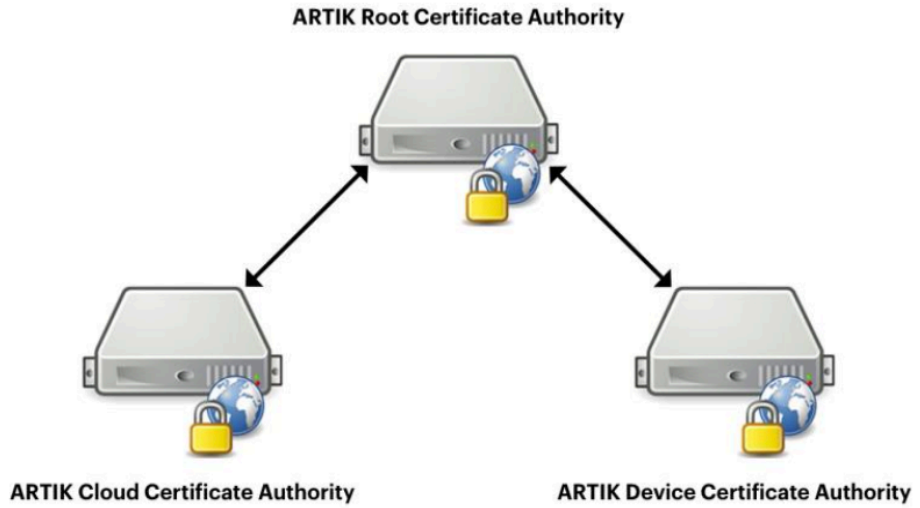
Signature


Signed data
Public
Private
Module A's private key
Module A's public key

Digital Certificate

- PKI's core concept is Digital Certificate
- Issued by a **Certificate Authority,** e.g, GlobalSign, Symantec
- ARTIK Root CA



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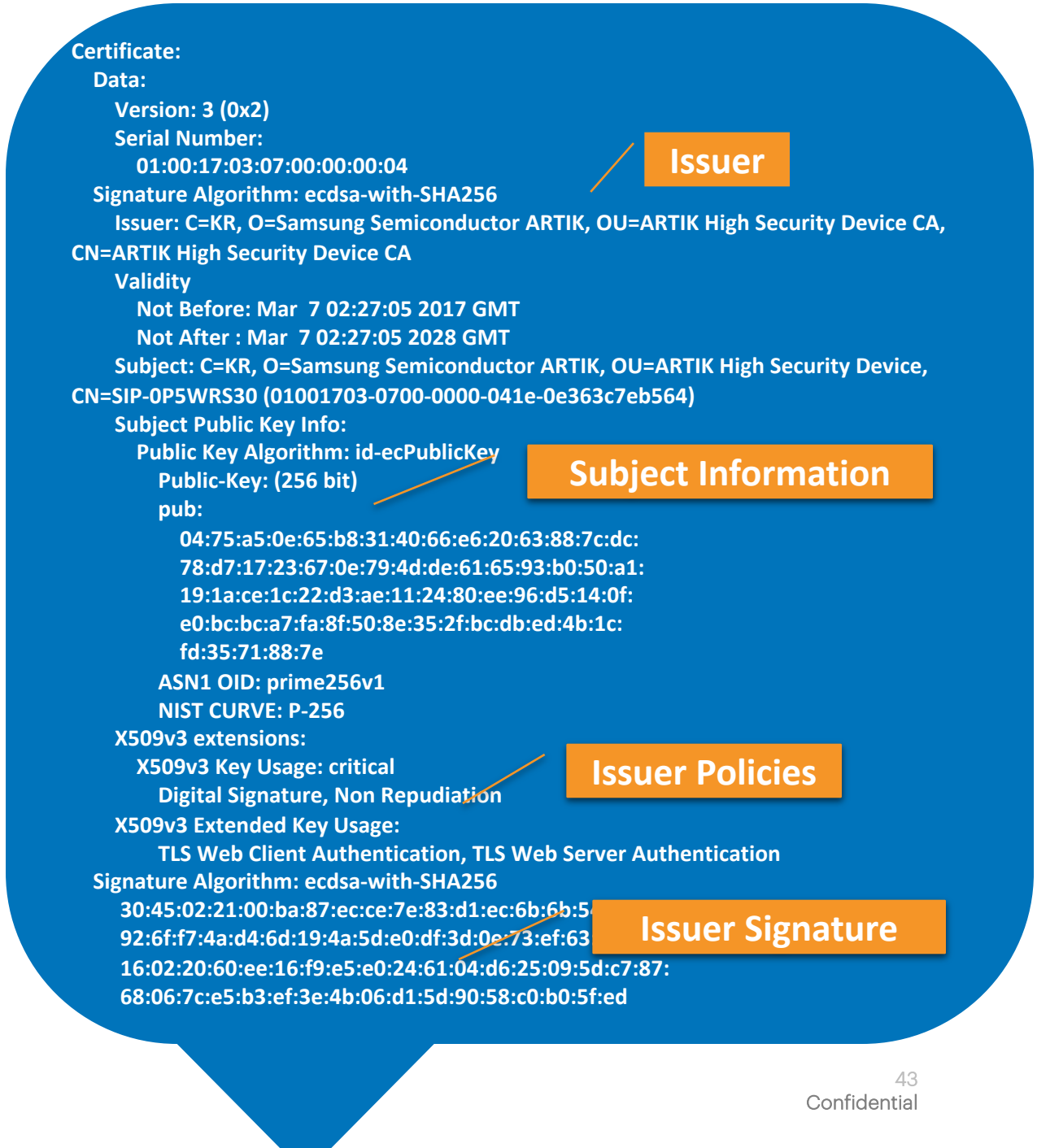
X.509

- A Digital Certificate contains a public key and an identity (a hostname, or an organization, or an individual)
- X.509 is a standard that defines the format of public key certificates. X.509 certificates are used in many Internet protocols, including TLS/SSL, which is the basis for HTTPS



Mutual Authentication

- Each ARTIK module is provisioned with:
  - An unique private key
  - Its associated certificate containing a public version of the key.
  - An ARTIK Root CA certificate
- ARTIK Cloud's server certificate is also rooted to the ARTIK Root CA certificate
- At connect time, server and client exchange certificates for mutual authentication

Post Provisioning

- If you want to connect your ARTIK Module to a 3rd party Cloud service or implement a link between two ARTIK modules, you need to generate your own certificate/key-pair
- We can use Post Provisioning APIs to post provision customer credentials(key, certificate) to Secure Element

Secure Communication

		ARTIK module (05x, 5, 7)	ARTIK S-module (053s, 055s, 530s, 710s)	Comments
Secure communication	**Per device unique key & certificate**	✓	✓	**Uniquely identifies device**
	Key stored in HW secure element	✓	✓	**Secure key storage**
	PKI infrastructure: Mutual authentication of device and cloud	✓	✓	**Device talks to authorized cloud and vice versa**
	Post Provisioning		✓	**Provision with your own keys and certificates**
Device protection/ secure code execution	KMS infrastructure for code signing		✓	Key Management Service
	Code verification key in HW		✓	Secure key storage
	Secure boot (check for authorized code)		✓	Boot image verification
	JTAG access locked		✓	Lock out debug access
Data protection/ Secure storage	Secure OS (separate normal & secure operations)		✓	Hardware enforced secure applications via TEE
	Security Lib API (27 API calls)	Limited(random number generator, get cert and signature)	✓	Key Manager, Authentication, Secure Storage, Post Provisioning, Encrypt/Decrypt
	Secure storage		✓	Encrypt data stored on Flash

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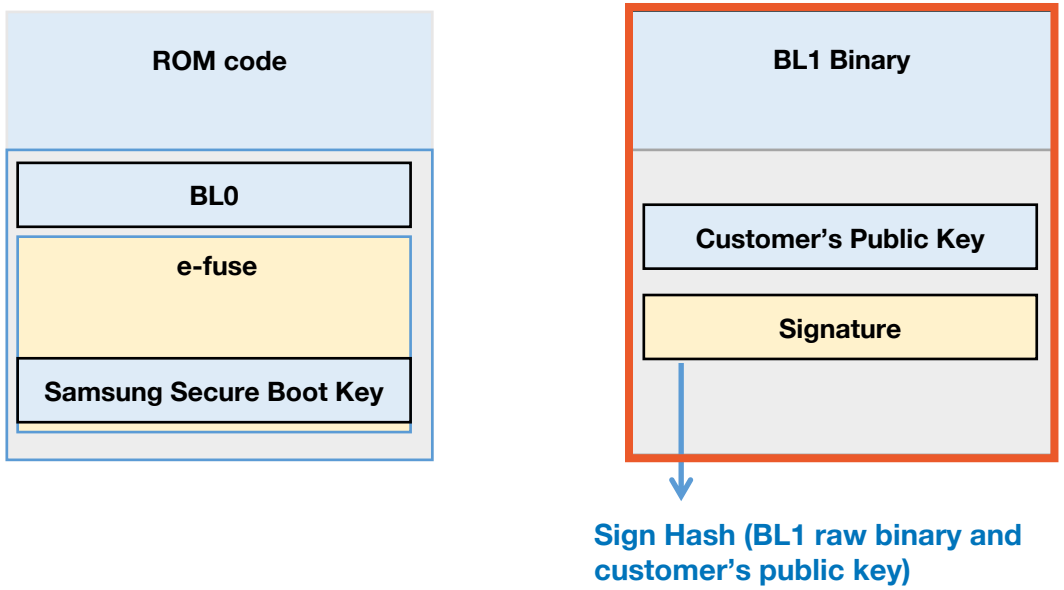
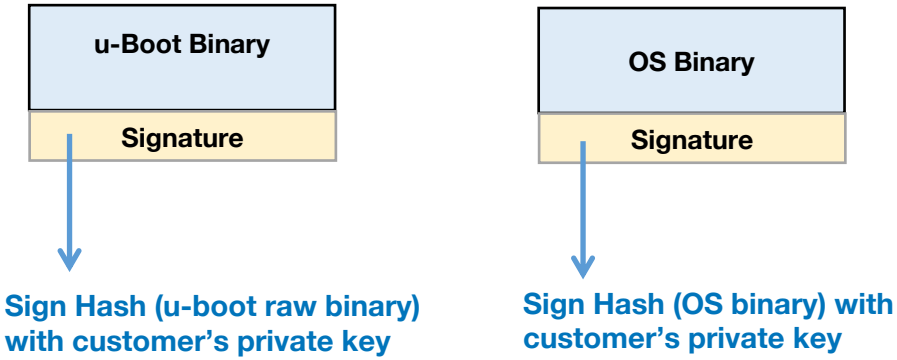
Secure Boot

- Secure Boot adds cryptographic checks to each stage of the boot process.
- The first element in the boot process authenticates the second, the second verifies the third.
- Authentication is based on digital signature verification.
- **Chain of Trust:** Every component can be authenticated before being executed.

Secure Boot for ARTIK 05x S-Module



For ARTIK 05Xs, BL stage 1 and stage 2 files are located under *build/configs/artik05x/bin* directory: `bl1.bin`, `bl2.bin`, `tinyara_head.bin`



BL0:
1. Decrypt BL1
2. Verify signature using BL1 Hash(BL1 binary and customer's public key) and hash

BL1:
1. Verify signature using u-boot Hash (u-boot binary and customer's public key)
2. Load to DRAM

u-boot:
1. Verify signature using (OS binary and customer's public key)
2. Load to DRAM

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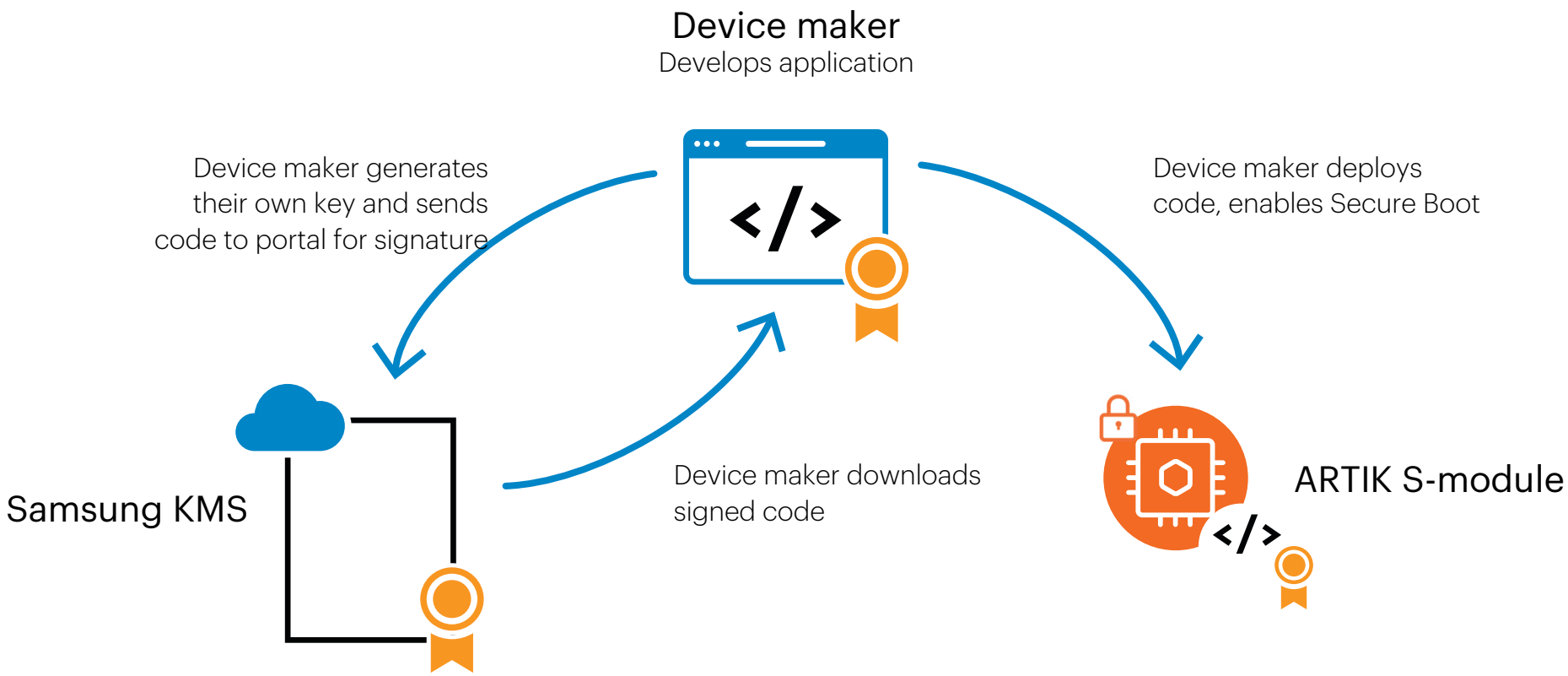
Code Signer (Development Stage)

```
Invoking: ARTIK GCC Create Head Bin
C:/ARTIK/SDK/A055s/v1.7.1/common/tools/s5jchksum.py     "tinyara.bin"
"tinyara_head.bin"
Finished building: tinyara_head.bin


Invoking: ARTIK GCC Create Head Sign
C:/ARTIK/SDK/A055s/v1.7.1/common/codesigner/artik05x_AppCodesigner
C:/ARTIK/SDK/A055s/v1.7.1/common/codesigner/rsa_private.key
"tinyara_head.bin"


  . Seeding the random number generator...
  . Reading private key from
 'C:/ARTIK/SDK/A055s/v1.7.1/common/codesigner/rsa_private.key'
  . Generating the RSA/SHA-256 signature
  . Done (created "tinyara_head.bin-signed")


  + Press Enter to exit this program.
Finished building: tinyara_head.bin-signed
```

NEW Samsung ARTIK™ Key Management System(KMS)

Code signing portal manages key signing



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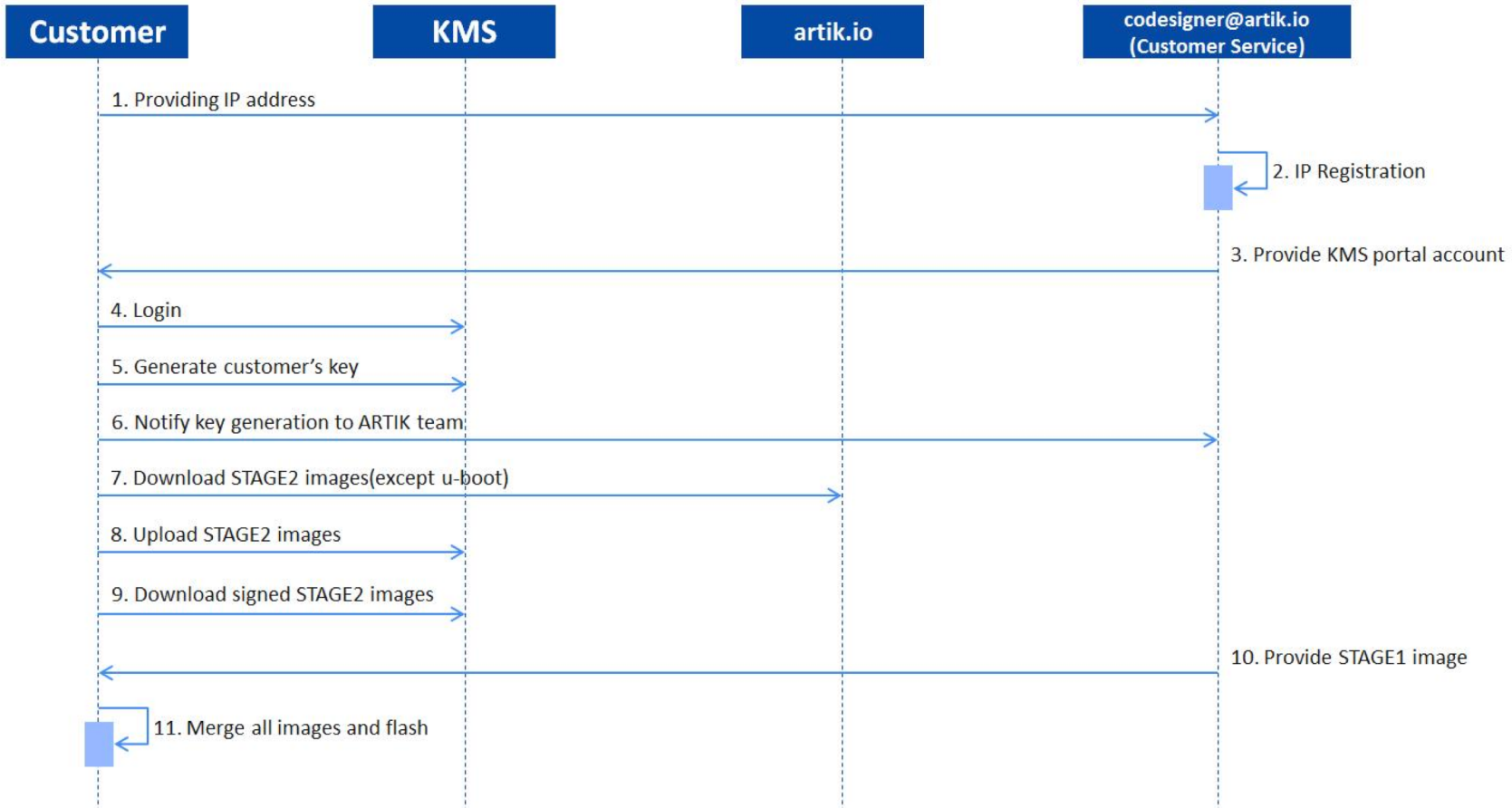
Key Management System

- Images are signed through a highly secure cryptography standard (SHA-256 w/ RSA2048 encryption)
- Signing keys are stored and operated within FIPS 140-2 certified Hardware security modules (HSM)
- Strict access control policies
- Only accessible through whitelisted IPs

Key Management System(Production Stage)



- Key Management System(KMS) is used for the production signing process
- Accessed through a web portal from only whitelisted IP only
- Customer generates signing keys, share the public key with Samsung. Public key gets added to the first bootloader by Samsung signing process. Customer uses private key to sign the second bootloader and OS images.

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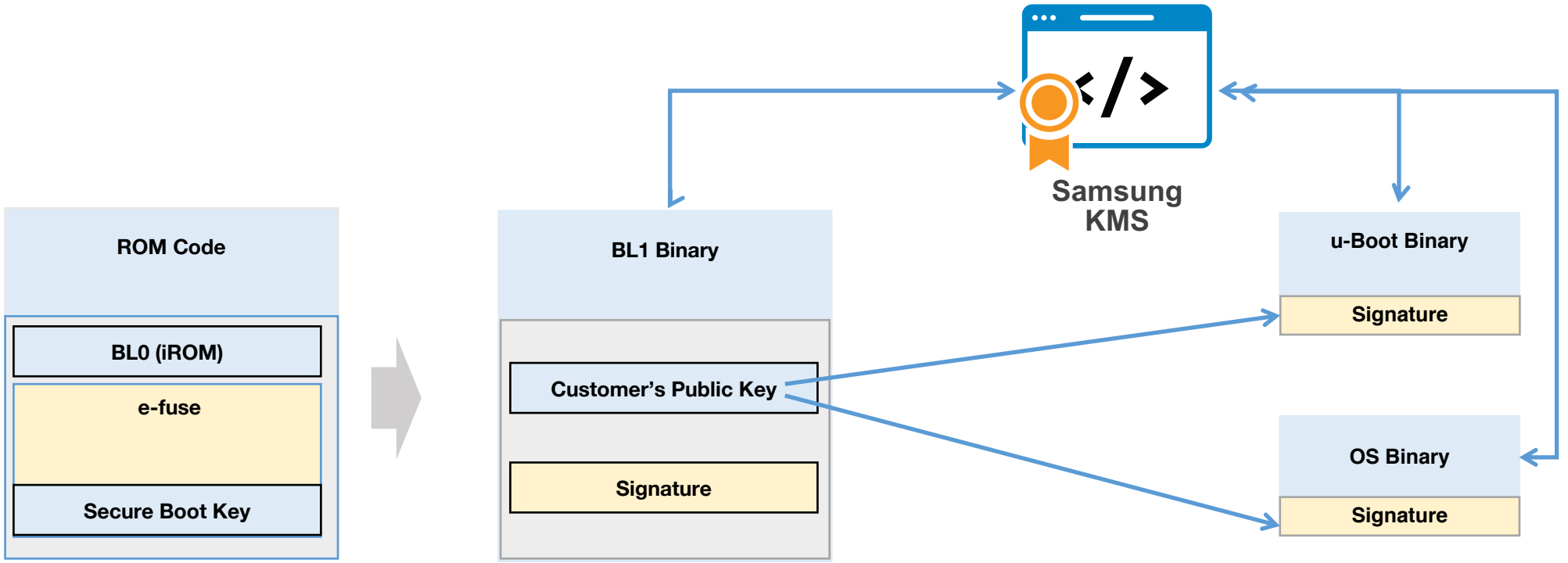
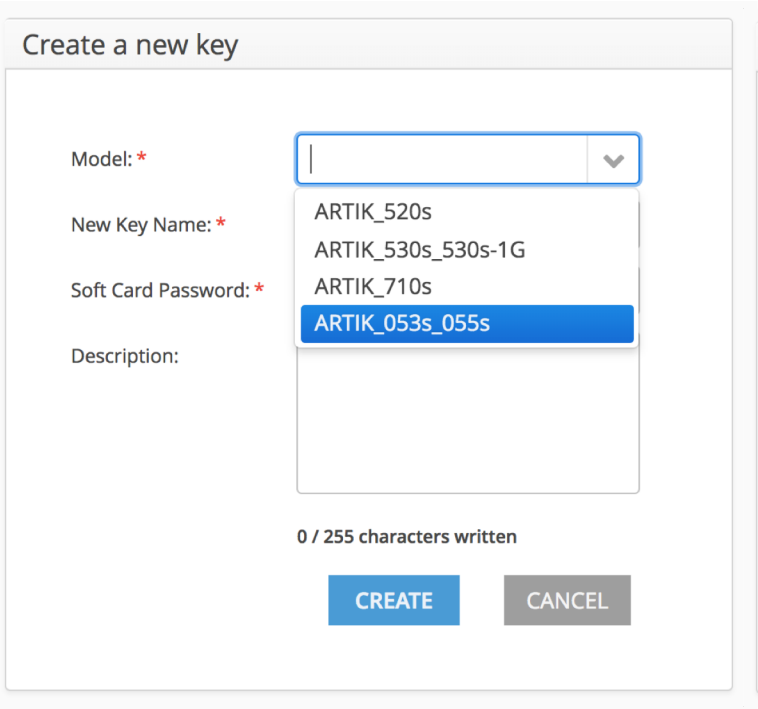
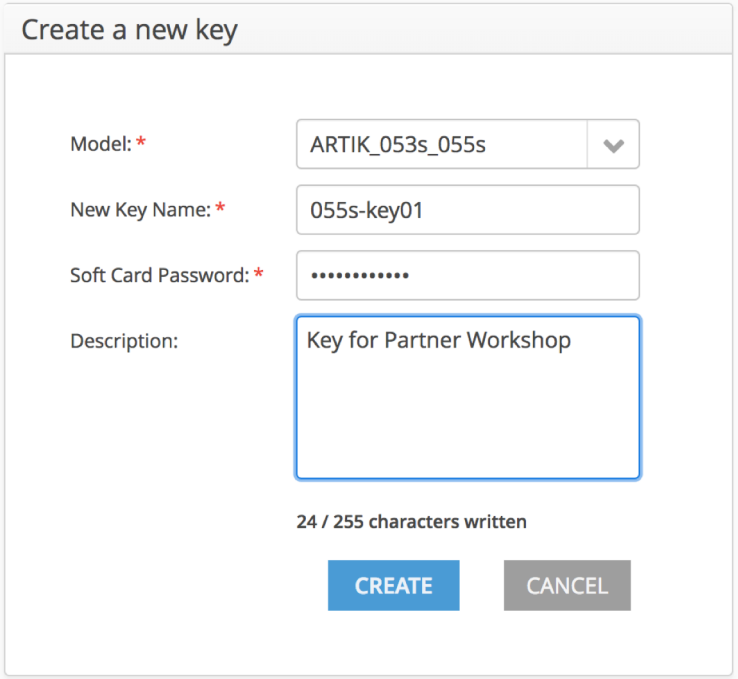
Key Management System Role

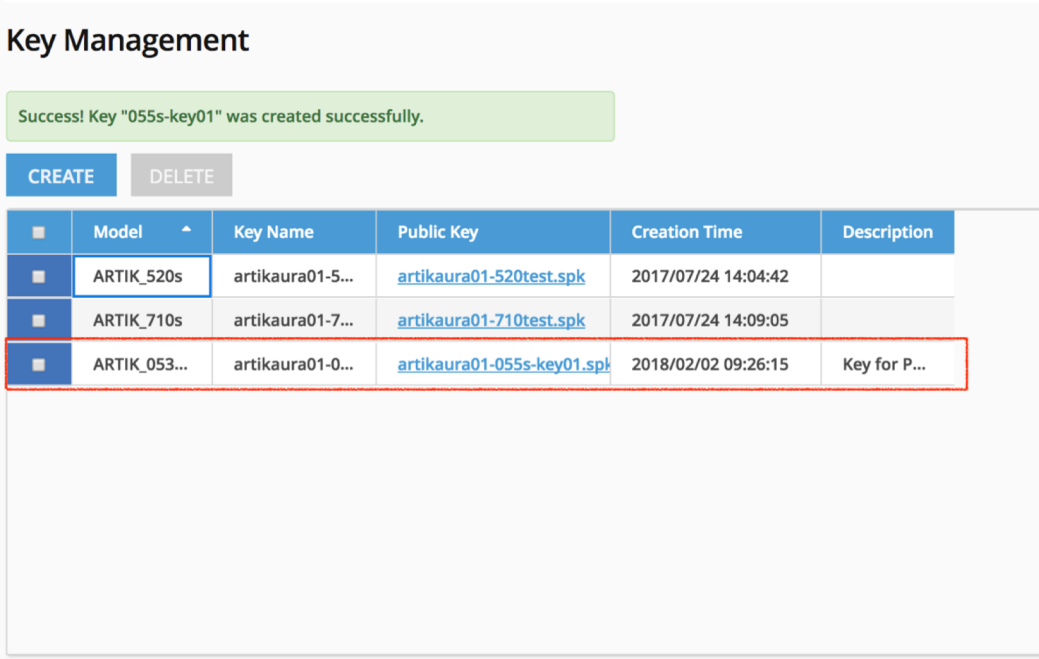


- BL1 image is provided by chip vendor

KMS Key Management







Stage 1:

- Key is immediately available on KMS portal
- Send ARTIK team the resulting public key.
- ARTIK team signs the bootloader stage 1 (BL1) image and deliver it to you by e-mail.

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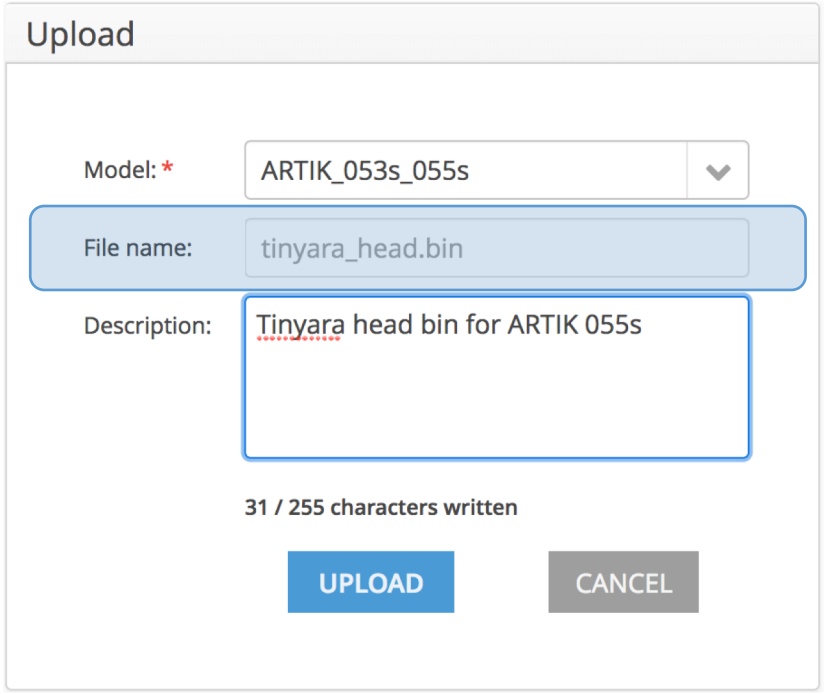
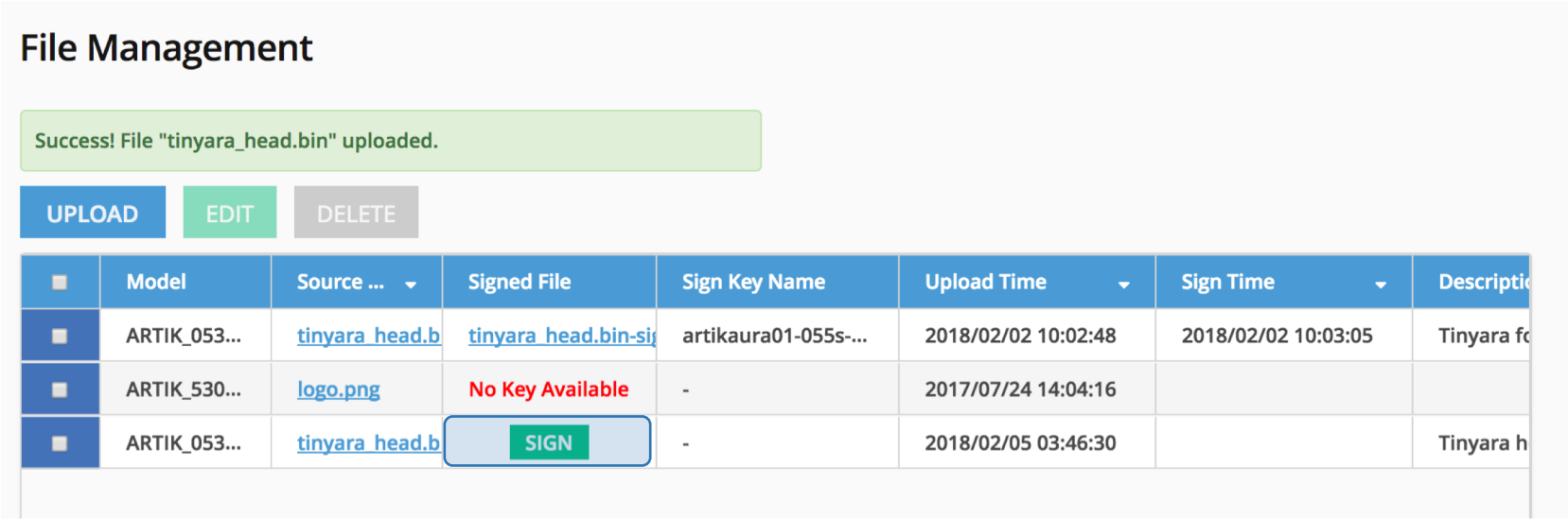
KMS File Management (Stage 2 Images)

Upload bootloader stage 2(BL2) and OS files for self-signing





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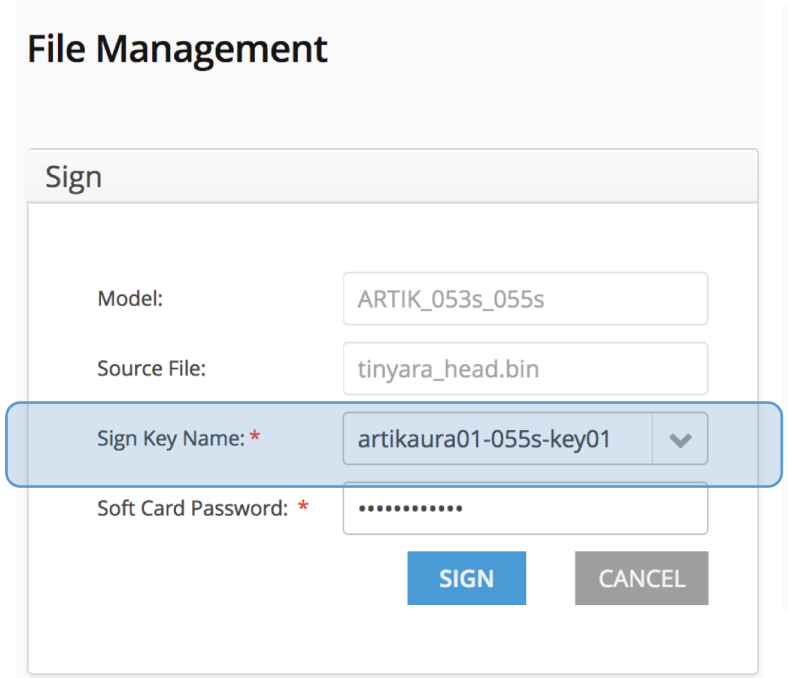
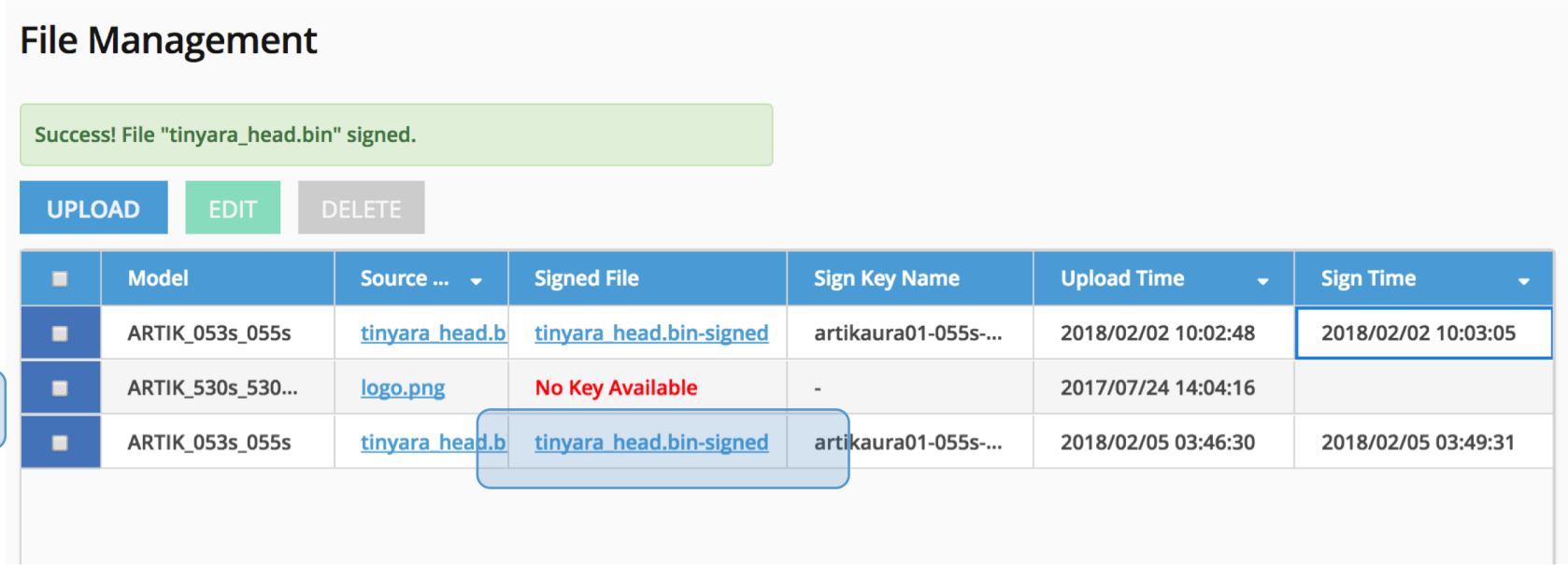
KMS File Management (Stage 2 Images)

Sign BL2/OS image with generated key, and download the signed BL2/OS images.





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Samsung ARTIK™ Module development

CUSTOMER

	STANDARD MODULES	s-MODULES
	BUYS ARTIK IoT module OR	**BUYS** ARTIK IoT s-module
Download	**DOWNLOADS** SDK from github.com	**DOWNLOADS** SDK from github.com
		LOGS ON artik.io
		DOWNLOADS, SIGNS SLA
	DOWNLOADS OS, libraries	**DOWNLOADS** secure OS, libraries, code signer
Modify and develop	**MODIFIES** downloaded software	**MODIFIES** downloaded software
	DEVELOPS custom application	**DEVELOPS** custom application
		RE-SIGN using code signer
	COMPILE development code	**COMPILE** development code
	LOAD DEV CODE on SoM and validate	**LOAD DEV CODE** on SoM and validate
		SETUP KMS ACCOUNT
		CREATE KEY
		SIGN, DOWNLOAD CODE
	LOAD PRODUCTION CODE on SoM and validate	**LOAD PRODUCTION CODE** on SoM and validate
	PRODUCTIZE	**PRODUCTIZE**
OTA update	**BUILDS** OTA image	
	SIGN, DOWNLOAD IMAGE	
	UPLOAD to artik.cloud	
	DELIVER OTA to devices	
	STATUS UPDATES confirmations sent to cloud	

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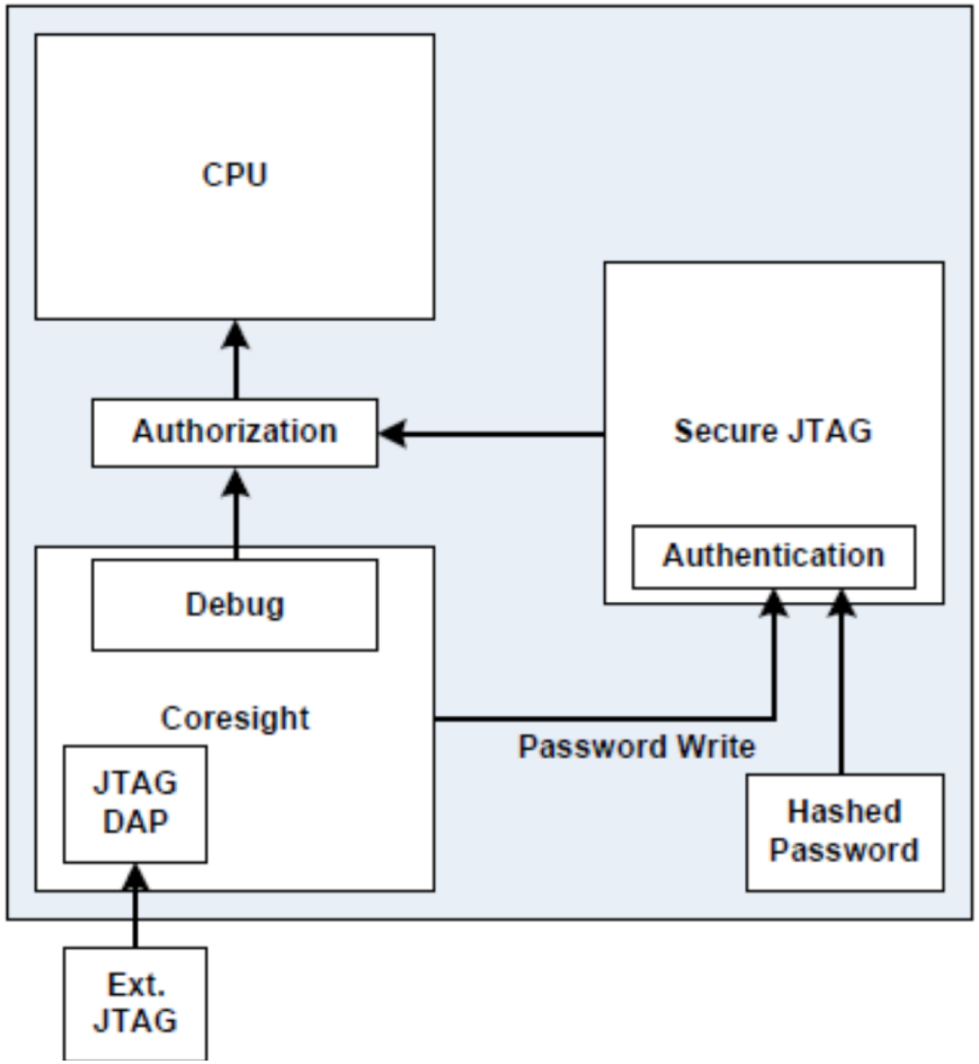
Secure JTAG

- Secure JTAG authenticates and authorizes JTAG access
- It requires a password to gain access to the JTAG chain. The password is based on the serial number of module
- The information is only made available through an authorized request to Samsung.

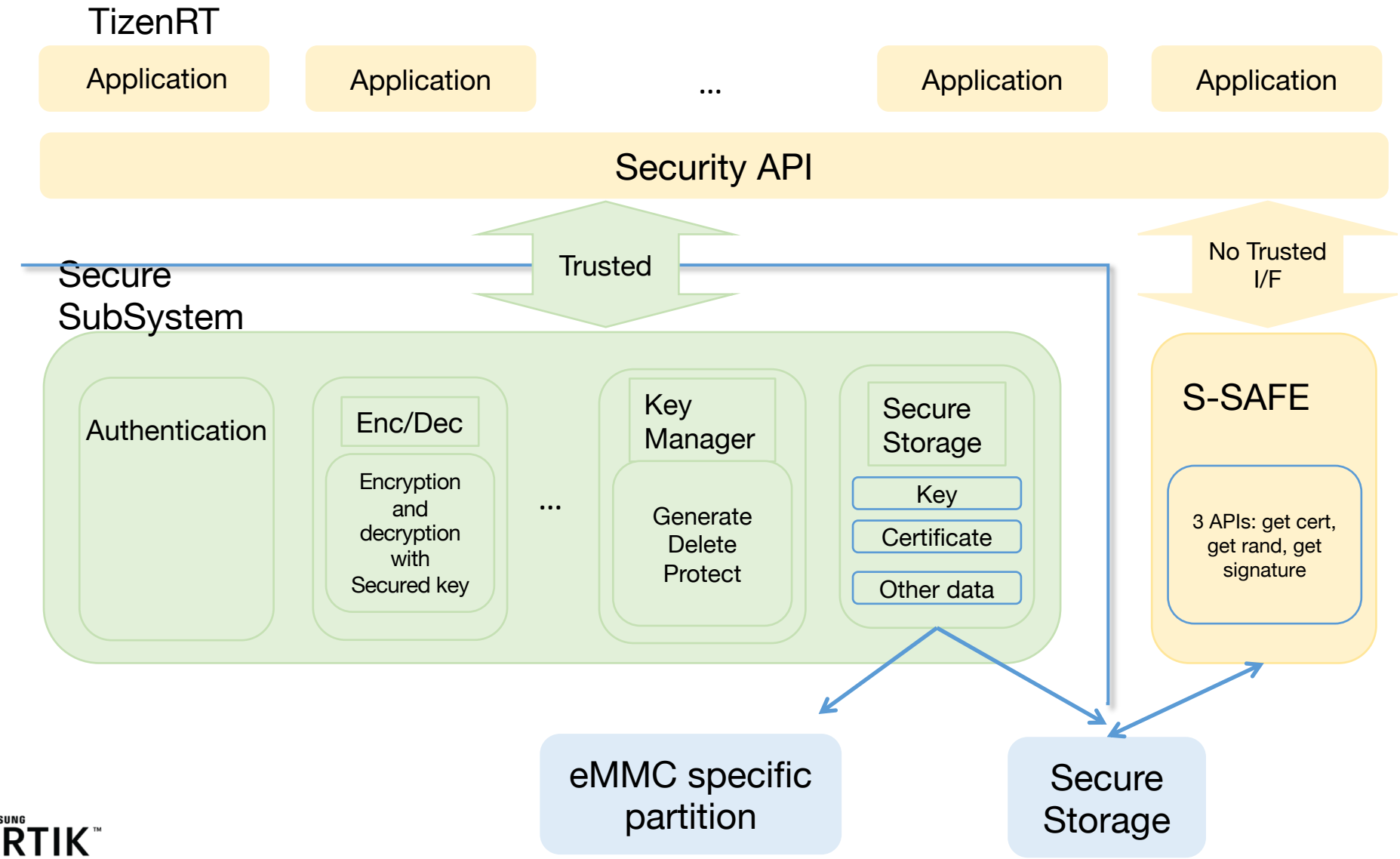


Device Protection

		ARTIK module (05x, 5, 7)	ARTIK S-module (053s, 055s, 530s, 710s)	Comments
Secure communication	Per device unique key & certificate	✓	✓	Uniquely identifies device
	Key stored in HW secure element	✓	✓	Secure key storage
	PKI infrastructure: Mutual authentication of device and cloud	✓	✓	Device talks to authorized cloud and vice versa
	Post Provisioning		✓	Provision with your own keys and certificates
Device protection/ secure code execution	**KMS infrastructure for code signing**		✓	**Key Management Service**
	Code verification key in HW		✓	**Secure key storage**
	Secure boot (check for authorized code)		✓	**Boot image verification**
	JTAG access locked		✓	**Lock out debug access**
Data protection/ Secure storage	Secure OS (separate normal & secure operations)		✓	Hardware enforced secure applications via TEE
	Security Lib API (27 API calls)	Limited(random number generator, get cert and signature)	✓	Key Manager, Authentication, Secure Storage, Post Provisioning, Encrypt/Decrypt
	Secure storage		✓	Encrypt data stored on Flash

SAMSUNG ARTIK™

ARTIK SEE Architecture



ARTIK SEE APIs

Category	ARTIK API	Description
Initialize	see_init	
	see_deinit	
Key Management	see_generate_key	generate symmetric and asymmetric keys(AES, ECC Curve, HMAC type)
	see_set_key	set external symmetric and asymmetric key to secure storage
	see_get_pubkey	get public key of asymmetric key from secure storage
	see_remove_key	remove a key from secure storage
Authentication	see_generate_random	Generate a random number
	see_generate_certificate see_set_certificate see_get_certificate	Generate, set and get a certificate
	see_get_rsa_signature see_verify_rsa_signature see_get_ecdsa_signature see_verify_ecdsa_signature	Get , verify signature using RSA, ECDSA algorithm
	see_get_hash,see_get_hmac	Hash Messages
	see_generate_dhparams(ecdhkey)	

ARTIK SEE APIs

Category	ARTIK API	Description
Secure Storage	see_read_secure_storage	Read data from secure storage
	see_write_secure_storage	Write data to secure storage
	see_delete_secure_storage	Remove data from secure storage
	see_get_size_secure_storage	Get data size from secure storage
	see_get_list_secure_storage	List data in secure storage
Post Provision	see_post_provision	Injecting an HMAC key or asymmetic key pair(ECC/RSA) into the secure element
	see_post_provision_lock	
Encryption/Decryption	see_aes_encryption see_aes_decryption	AES Encryption/Decryption
	see_rsa_encryption see_rsa_decryption	RSA Encryption/Decryption

Device Protection

		ARTIK module (05x, 5, 7)	ARTIK S-module (053s, 055s, 530s, 710s)	Comments
Secure communication	Per device unique key & certificate	✓	✓	Uniquely identifies device
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	Secure storage		✓	**Encrypt data stored on Flash**

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Platform Security

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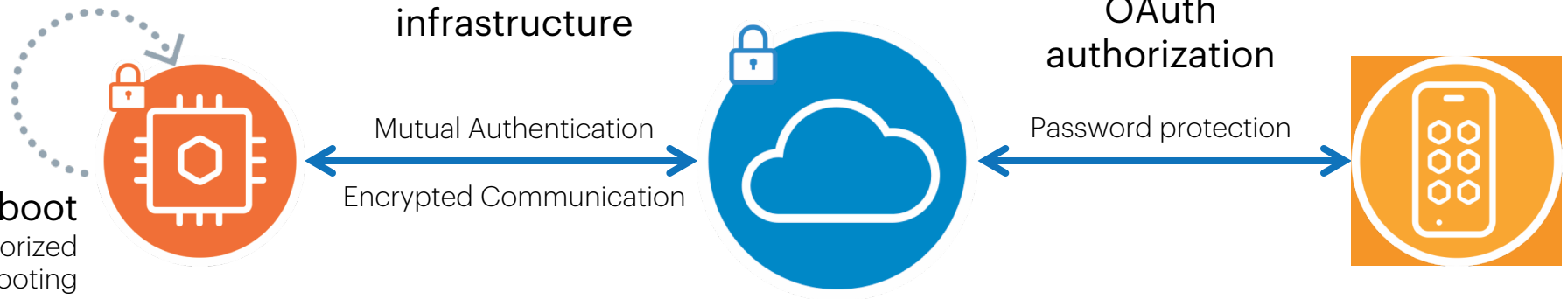
Samsung ARTIK™ End-to-end Platform Security

End-to-end protection for you and your customers

ARTIK Modules

SmartThings Cloud

Mobile apps



Secure boot
Prevents unauthorized software from booting and running on device

Secure OS
Hardware-enforced secure applications

Secure storage
Data encryption

Authentication and authorization, Secure OTA
Cloud services are protected

User data encryption
Protects sensitive info on mobile devices

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Samsung ARTIK™ End-to-end Platform Security*

	Feature	ARTIK
Modules	Secure element key storage, secure boot	**Included**
	Security infrastructure: PKI and KMS	**Included**
	Unique device ID and certificate	**Included**
	Secure data storage with data encryption	**Included**
Platform software	Secure device registration	**Included**
	Secure OTA updates	**Included**
Cloud Infrastructure	Supports HIPAA compliant solutions	**Included**
	OWASP top 10	**Included**
	Internal and external security audits	**Included**
Cloud services	AAA (Authentication, Authorization, Accounting)	**Included**
	API Security	**Included**
	3rd party device discovery and mutual authentication	**Included**
	Data privacy management, identity, permissions,	**Included**
Communications	TLS, VPN	**Included**
	DTLS Application level security; BLE session security	**Included**
Applications	Key and secure app data encryption and storage	**Included**
	2-factor authentication; OAuth; client side certificates	**Included**

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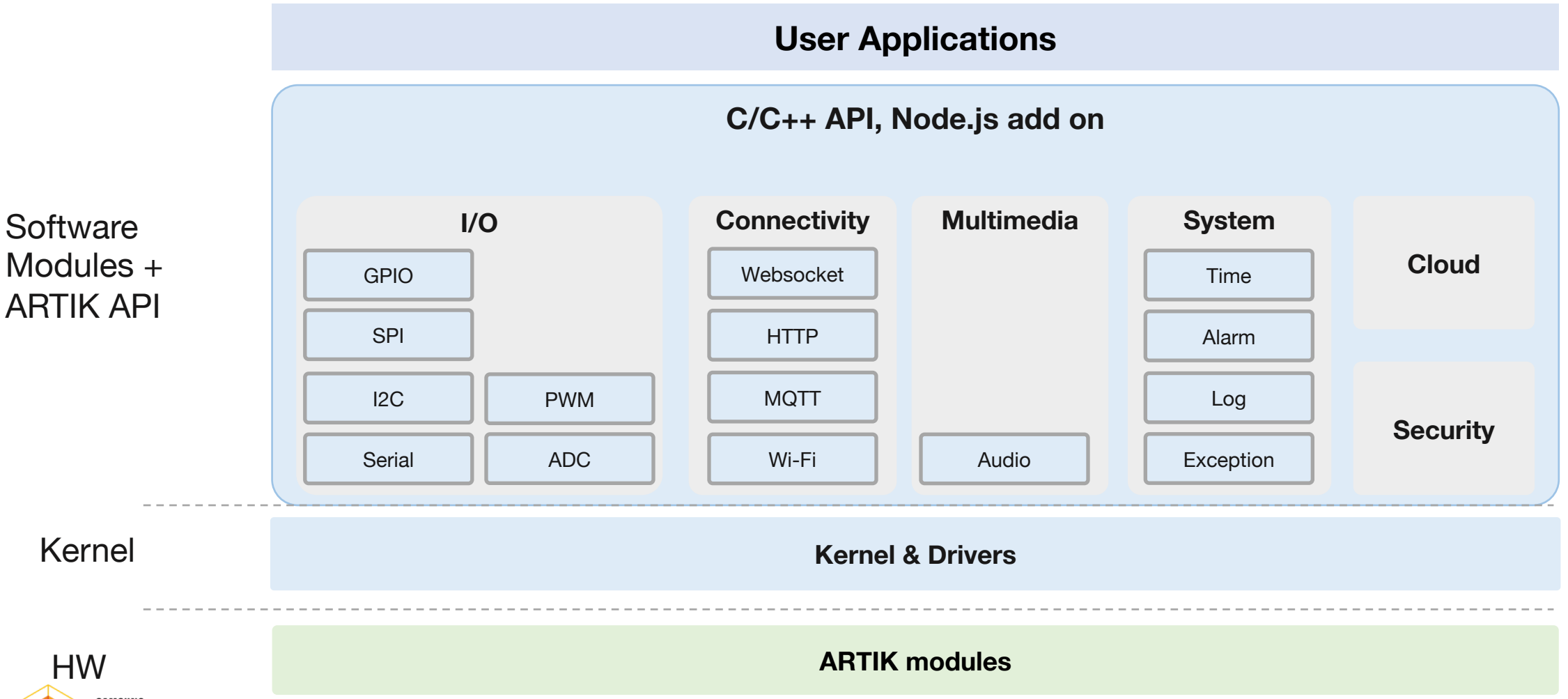
* Feature list is not exhaustive

ARTIK 05x Development

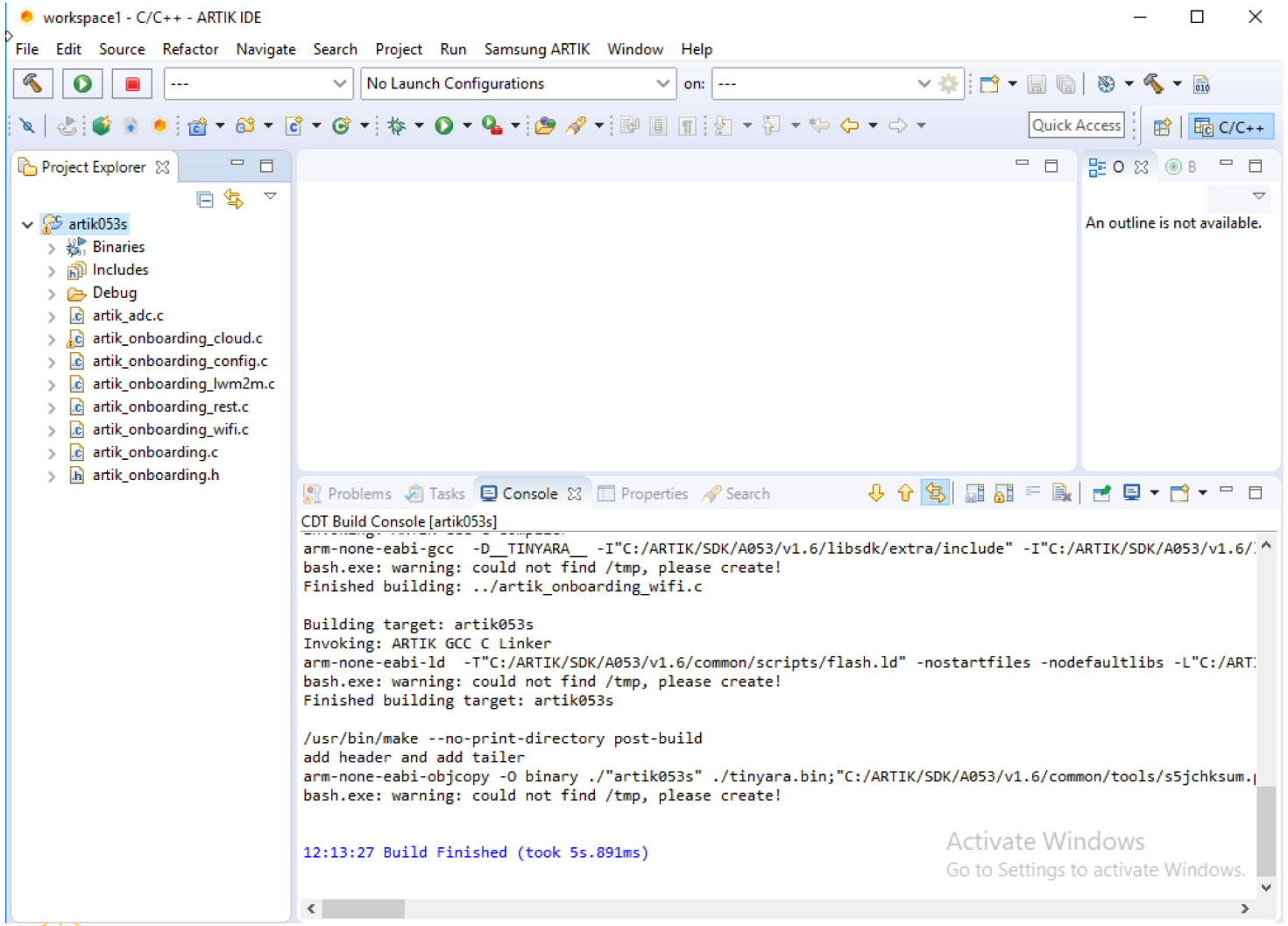
Developing on ARTIK 05x

- ARTIK SDK/IDE (C language)
- Cross-compilation for ARM architecture from command line (C language)
- JerryScript(under development, JS)

ARTIK SDK (05x, 5, 7 series)



ARTIK IDE



gcc-arm-none-eabi

Configuration Files

Typical

OS Kernel
Customized C library
Security(TLS)
BSP(boot loader)
Power
Networking support(LWIP, DHCP (
Watchdog
ARTIK-SDK
JSON
TASH
I2S
DMA
System IO(I2C, UART, GPIO, PWM
Network Utilities(FTP Client, Webs(

Extra

OS Kernel
Customized C library
Security(TLS)
BSP(boot loader)
Power
Networking support(LWIP, DHCP Client, DHCF
Watchdog
ARTIK-SDK
JSON
TASH
I2S
DMA
System IO(I2C, UART, GPIO, PWM, SPI)
Network Utilities(FTP Client, Websocket, Webc
CoAP, MQTT)

Minimal

OS Kernel
Customized C library
Security(TLS)
BSP(boot loader)
Power
Networking support(LWIP, DHCP Client, DHCP Server, Wi-Fi)

Cross Compilation from command line

- Github page: https://github.com/SamsungARTIK/TizenRT
- How to build:

```
$ git clone https://github.com/SamsungARTIK/TizenRT.git
$ cd TizenRT/os
  ….
$ make menuconfig
$ make
```

JerryScript

- Light weight JavaScript Engine. Base footprint is only 10KB of RAM
- Optimized for microcontrollers
- Portable, can run on bare-metal
- OS Support: Nuttx, RIOT, mbed OS, Zephyr, Linux, macOS

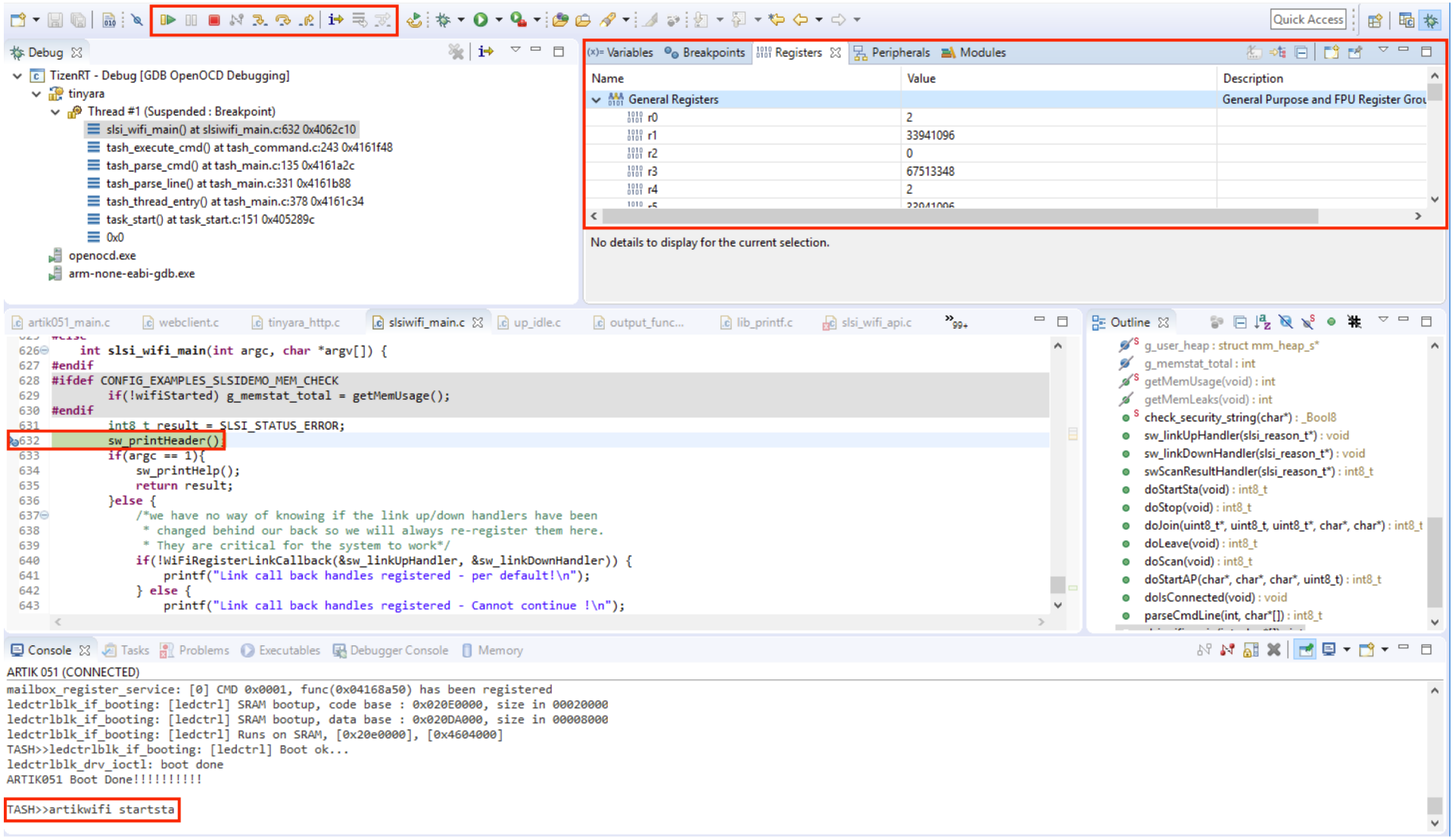
TASH shell

- Github page: https://github.com/SamsungARTIK/TizenRT/tree/artik/apps/shell

```
TASH>>help

         TASH command list
         --------------------
cat              cd               date             df
dhcpd            exit             free             heapinfo
help             ifconfig         ifdown           ifup
kill             killall          ls               mkdir
mksmartfs        mount            onboard          ping
ps               pwd              reboot           rm
rmdir            security         sh               sleep
stkmon           umount           uptime
```

Debugging on ARTIK 05x



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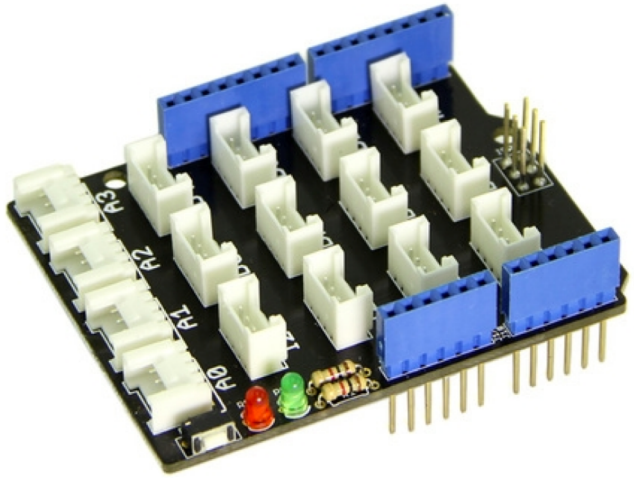
ARTIK 05x Ecosystem

Grove Base Shield and Modules



Grove - Digital Light Sensor

Grove - Light Sensor

Grove - Temperature and Humidity Sensor

Grove - Barometer Sensor

Grove - Dust Sensor

Grove - Gas Sensor

Grove - Temperature Sensor

Grove - Air Quality Sensor

Grove - Temperature and Humidity Sensor Pro

Grove - Gas Sensor(O_2)

Grove - HCHO Sensor

Use Case: iCast 2

- Wi-Fi 2.4GHz, BLE 5.0 including 802.15.4 Radio and Thread SW stack
- Analog I/O, GPIO, I2C etc.
- Isolated RS485 serial port
- Supports ARTIK Cloud, AWS IoT, PTC ThingWorx

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Use Case: Location Service

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3rd Party Cloud Support

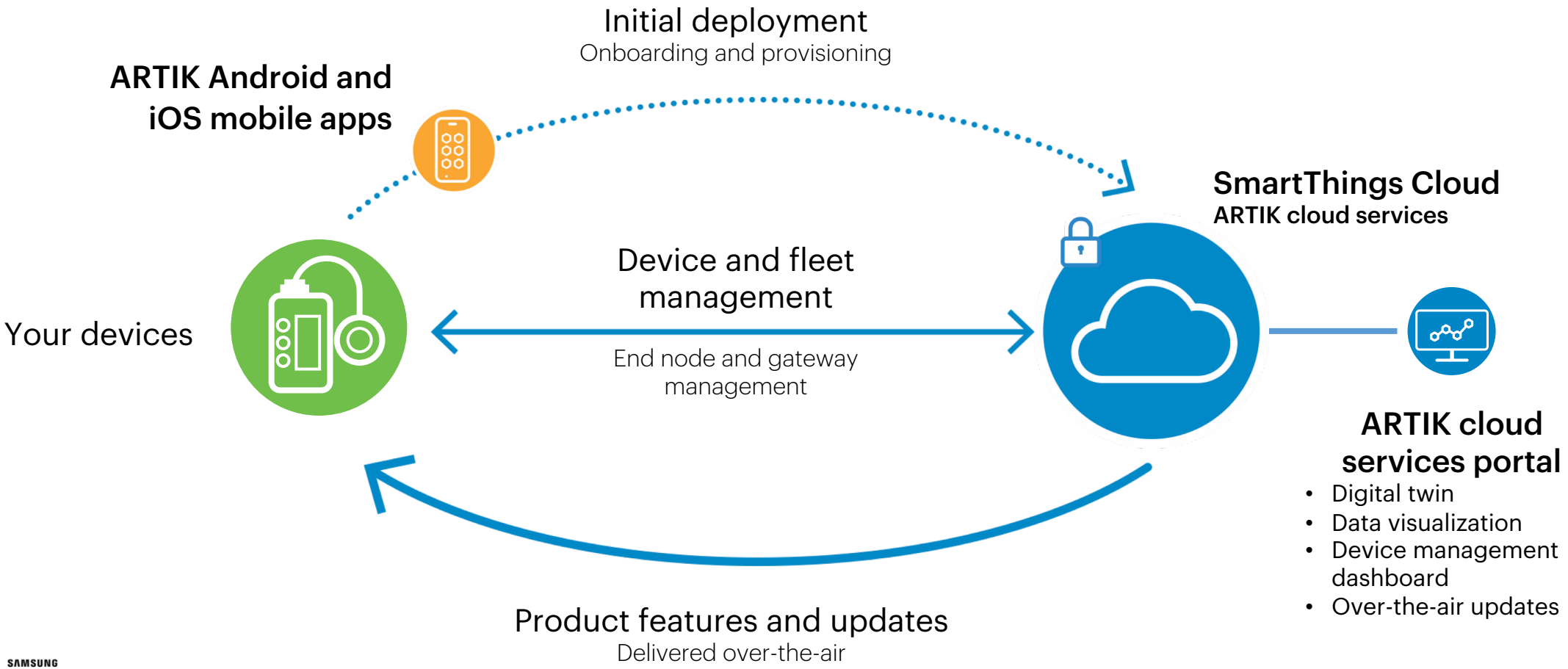
1. AWS IoT:
2. Microsoft Azure:
3. PTC ThingWorx:
4. Other Cloud services that support REST API, MQTT etc.

Lab Sessions

Lab 2: ARTIK 05x Onboarding

Samsung ARTIK™ Device management and OTA

Onboard, manage, and service devices in the field



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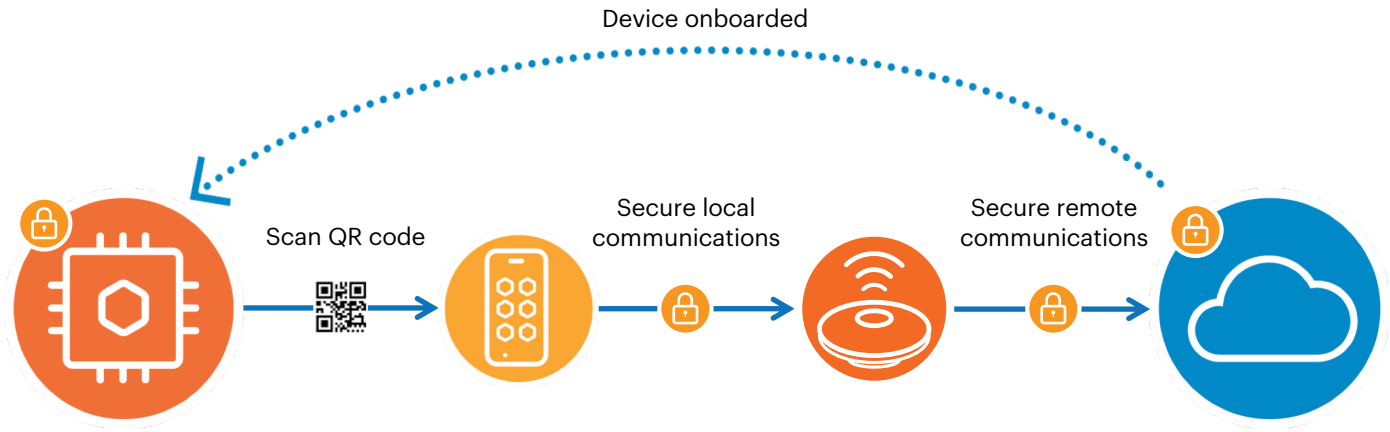
Samsung ARTIK™: Easy, secure onboarding



ARTIK-based device

- Hardware root of trust
- Pre-injected certificates and keys
- Secure element/PUF
- Data encryption
- Secure storage

ARTIK mobile app

SmartThings Cloud

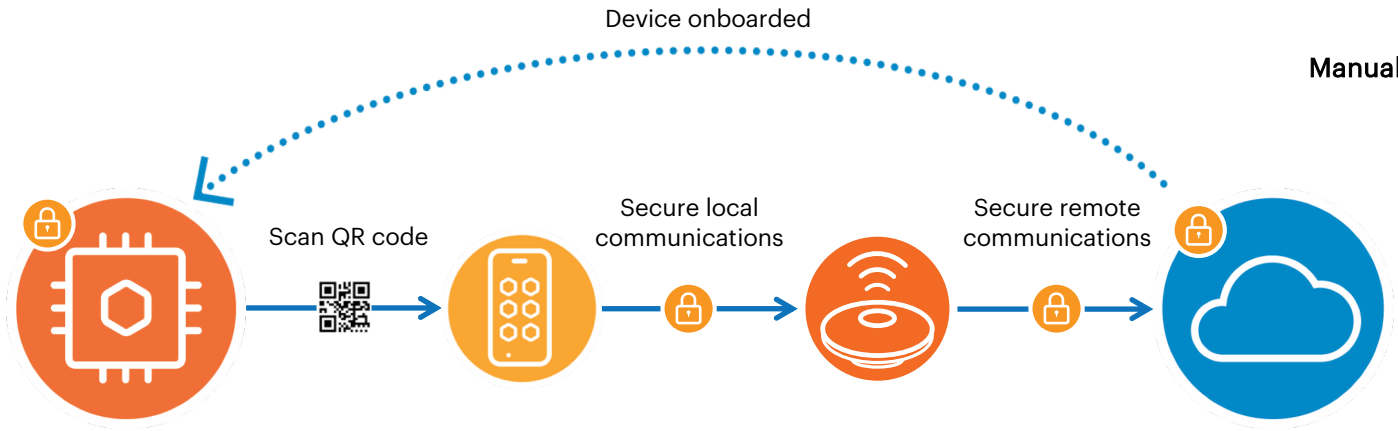
ARTIK cloud services

- Authentication
- Authorization
- Device whitelisting
- Data encryption

SAMSUNG ARTIK™

Samsung ARTIK™

Easy, secure onboarding



ARTIK-based device

- Hardware root of trust
- Pre-injected certificates and keys
- Secure element/PUF
- Data encryption
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ARTIK mobile app

SmartThings Cloud
ARTIK cloud services

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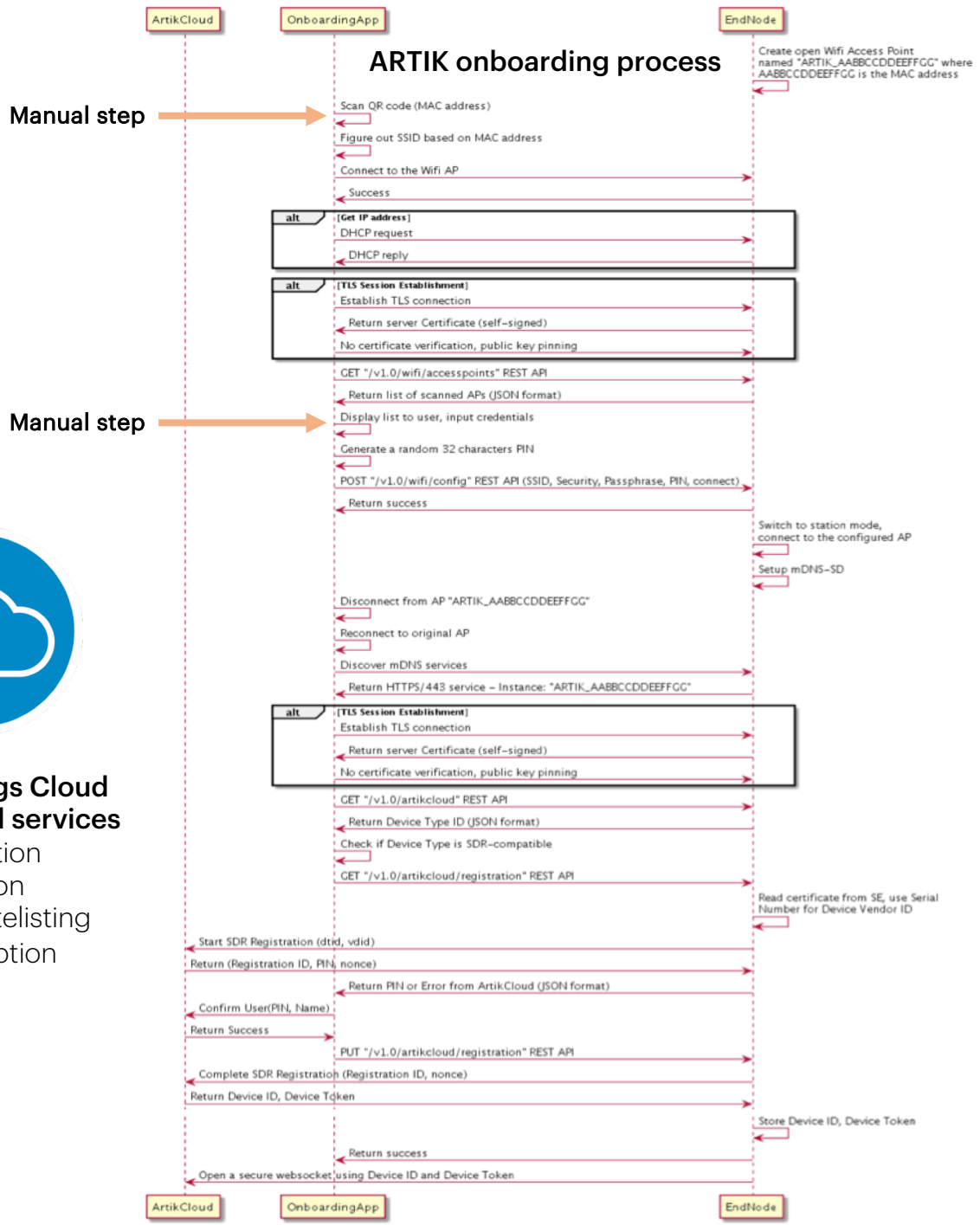
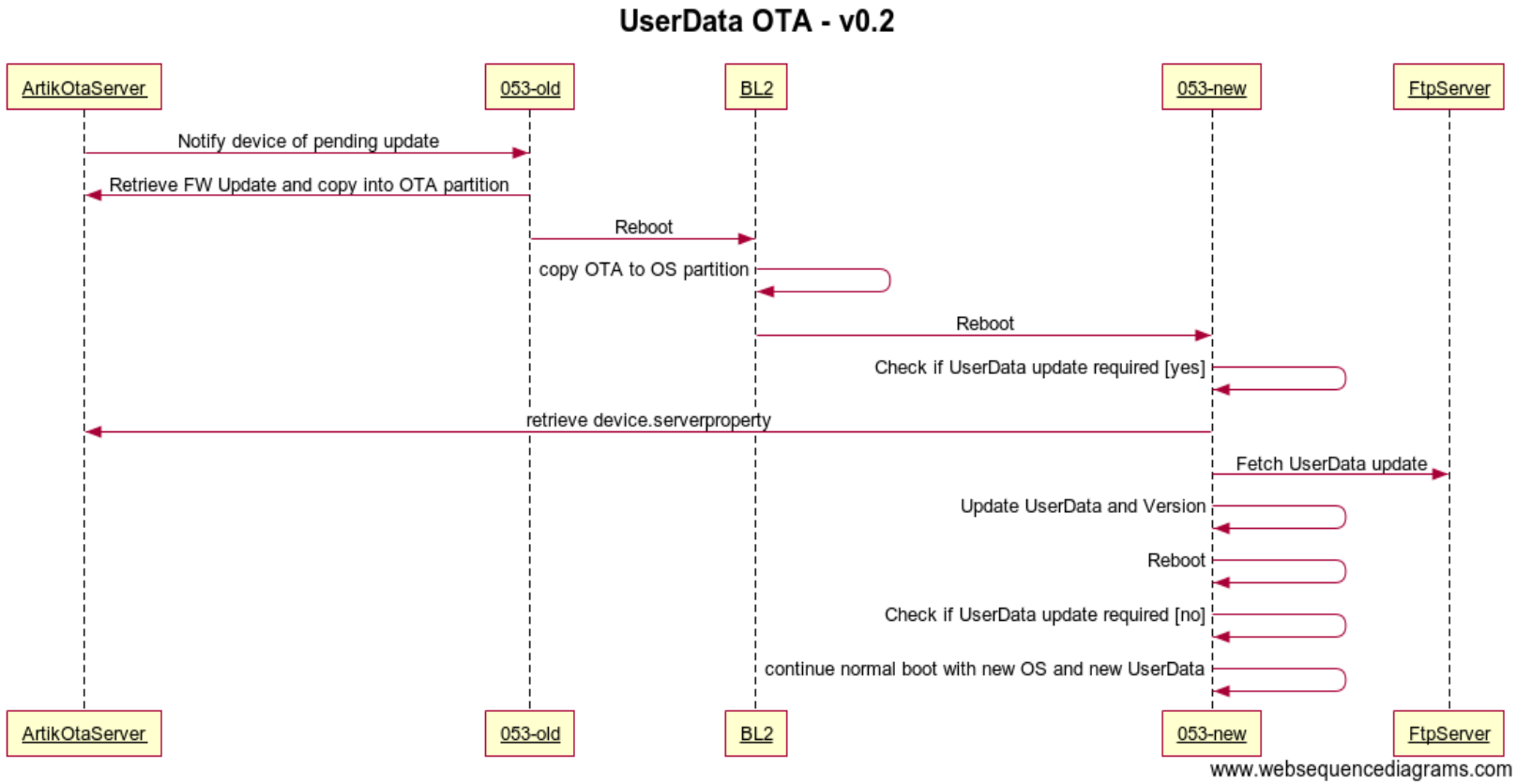
- Authorization
- Device whitelisting
- Data encryption

SAMSUNG ARTIK™



Lab 4: ARTIK 05x
Device Management and OTA

OTA Sequence



SSS R/W Key(512KB)	Secure Storage
Wi-Fi NVRAM(8KB)	WiFi RAM
User R/W (1400KB)	SmartFS
OTA download (1536KB)	OTA Image
Factory Reset (1536KB)	Factory Reset OS Image(compressed image)
OS AREA TizenRT (2400KB)	TizenRT Tinyara_head.bin
Wi-Fi F/W (512KB)	WiFi firmware wlanfw.bin
SSS F/W (32KB)	sssfw.bin
BL2 (192KB)	2nd stage bootloader, bl2.bin
SSS R/O Key (48KB)	secure boot key
BL1 (16KB)	1st stage bootloader, bl1.bin

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Lab 5: ARTIK 05x Security API

Register Commands to TASH shell

- Register commands to TASH

```
int tash_cmd_install(const char *str, TASH_CMD_CALLBACK cb, int thread_exec);

void tash_cmdlist_install(const tash_cmdlist_t list[]);
```

- Two modes of execution:

`TASH_EXECMD_SYNC` – invoked callback in TASH task

`TASH_EXECMD_ASYNC` – execute callback as a separate task

Q & A