

# ARTIK Gateway Modules

Wei Xiao

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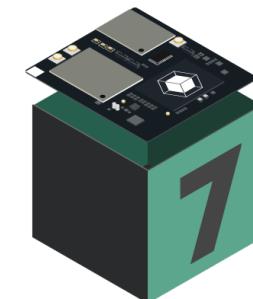
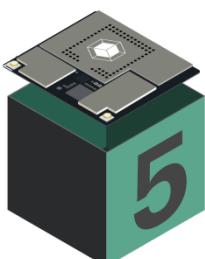
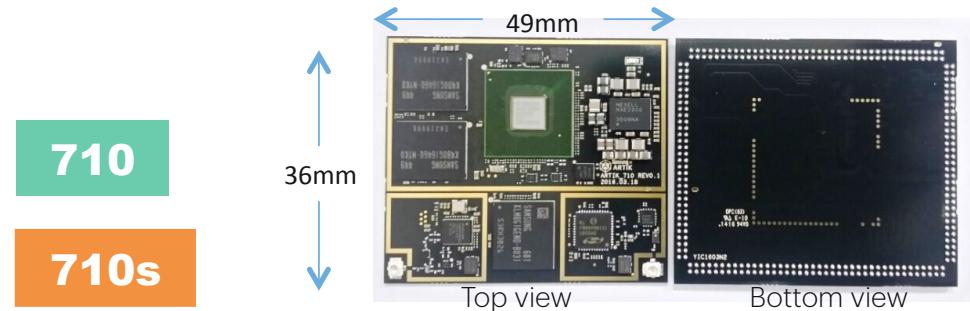
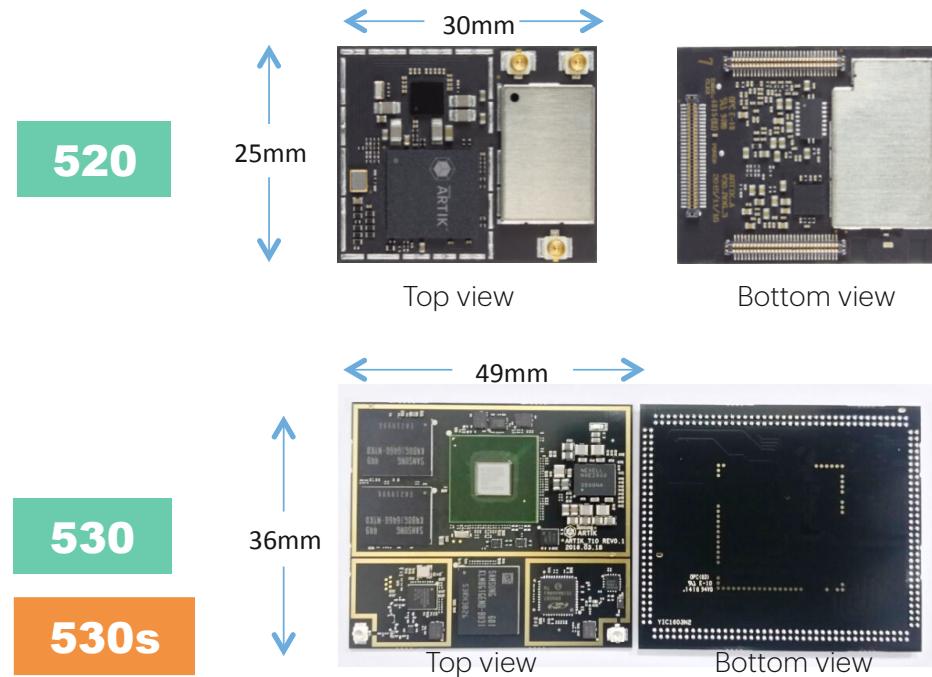


# Agenda

- ARTIK Gateway Module Overview
- ARTIK Gateway Module Use Cases
- ARTIK Gateway Module Software Stack
- ARTIK Gateway Module Security
- ARTIK Gateway Module Development

# ARTIK Gateway Module Overview

# ARTIK High-end module



# Samsung ARTIK™ 530/530s (512 MB, 1 GB) mid-range gateway

## Secure, fully-integrated IoT solution



- Industrial and home gateways
- Voice-controlled speakers
- Building zone controllers
- Display-based healthcare monitors



<b>Processor</b>	CPU: 4x ARM® Cortex® A9 @ 1.2 GHz GPU: 3D graphics accelerator
<b>Memory</b>	DRAM: 512 MB/1 GB DDR3 Flash: 4 GB eMMC v4.5
<b>Multimedia</b>	Camera I/F: 4-lane MIPI CSI up to 5MP Display: 4-lane MIPI DSI, HDMI 1.4 a or LVDS (1280 x 720 @ 60 fps) Audio: 2x I2S audio input/output
<b>Connectivity</b>	WLAN (Wi-Fi): IEEE 802.11 b/g/n single-band SISO Bluetooth: 4.2+ Smart 802.15.4: Zigbee, Thread Ethernet: 10/100/1000 Base-T MAC (external PHY required)
<b>Security</b>	Secure element, EAL Level 5, unique device certificate and keys, PKI with mutual authentication to cloud, hardware crypto engine; secure boot*, KMS*, TEE*, *S-modules
<b>I/O</b>	GPIO, UART, I2C, SPI, USB Host, USB OTG, HSIC, ADC, PWM, I2S, JTAG
<b>Temperature range</b>	-25° to 85° (°C)
<b>Size</b>	36 mm W x 49 mm H x 3.4 mm D

# Samsung ARTIK™ 710/710s high-end gateway

## Secure, fully-integrated IoT solution

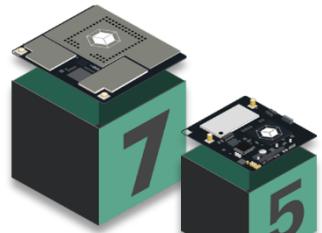
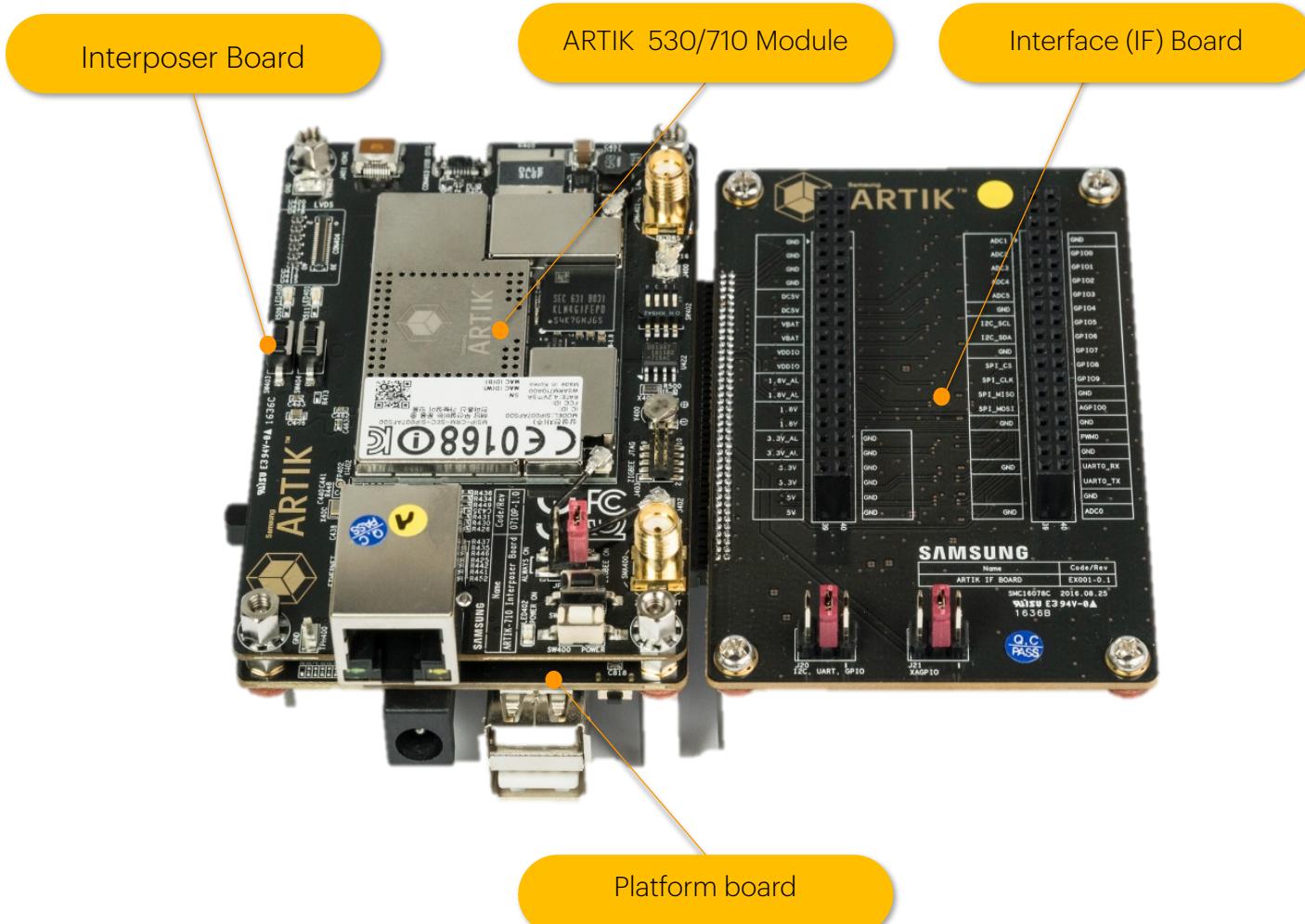


- High-end gateways
- Cameras
- Human-machine interface
- Machine learning

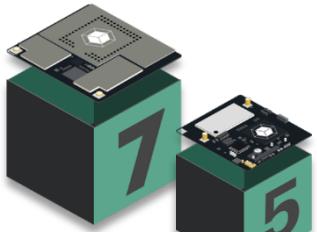
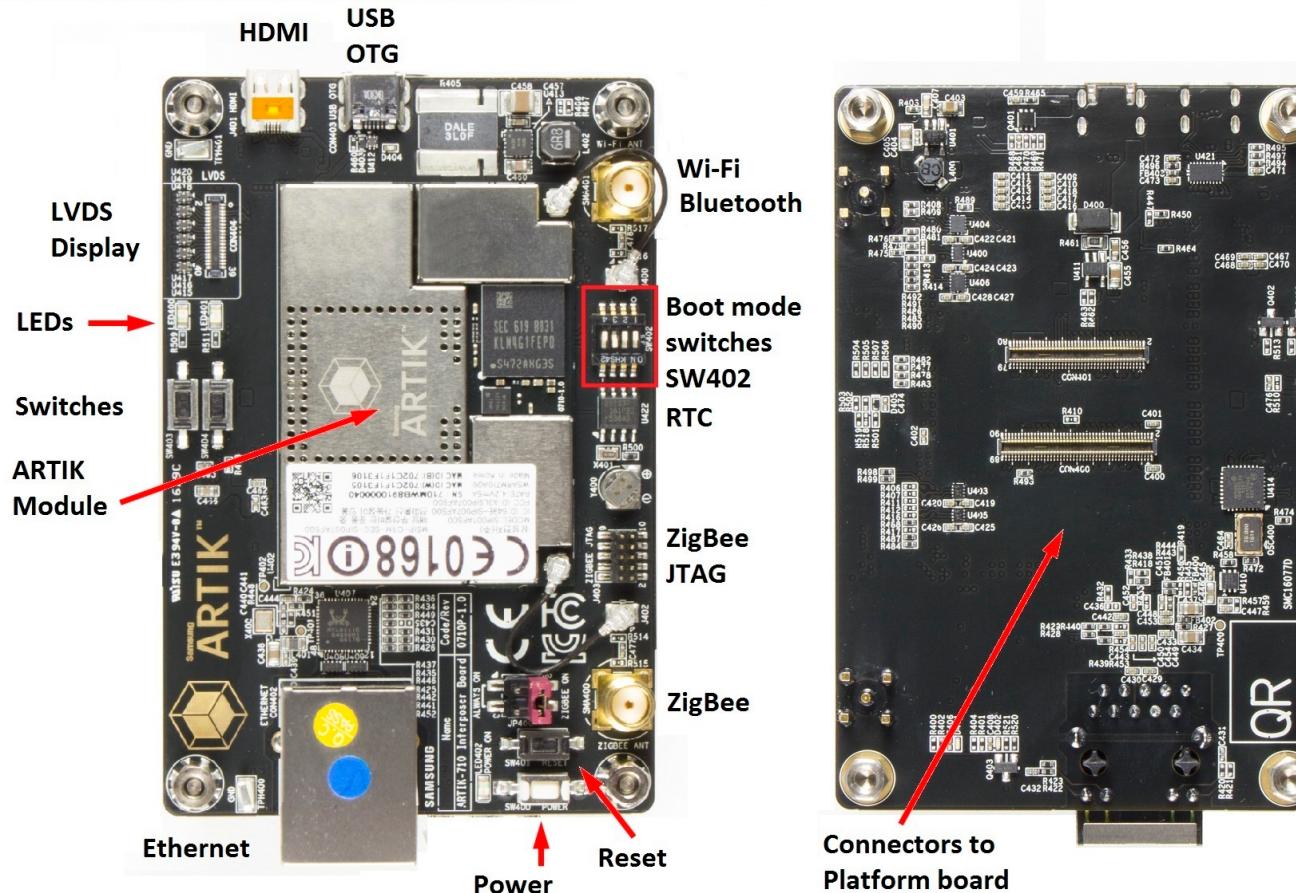


<b>Processor</b>	CPU: 8x ARM® Cortex® A53 @ 1.4 GHz GPU: 3D graphics accelerator
<b>Memory</b>	DRAM: 1 GB DDR3 @ 800 MHz Flash: 4 GB eMMC v4.5
<b>Multimedia</b>	Camera I/F: 4-lane MIPI CSI Display: 4-lane MIPI DSI up to FHD@24 bpp, LVDS, HDMI v1.4 Audio: I²S audio interface
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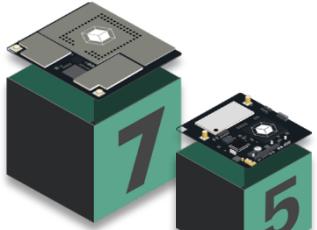
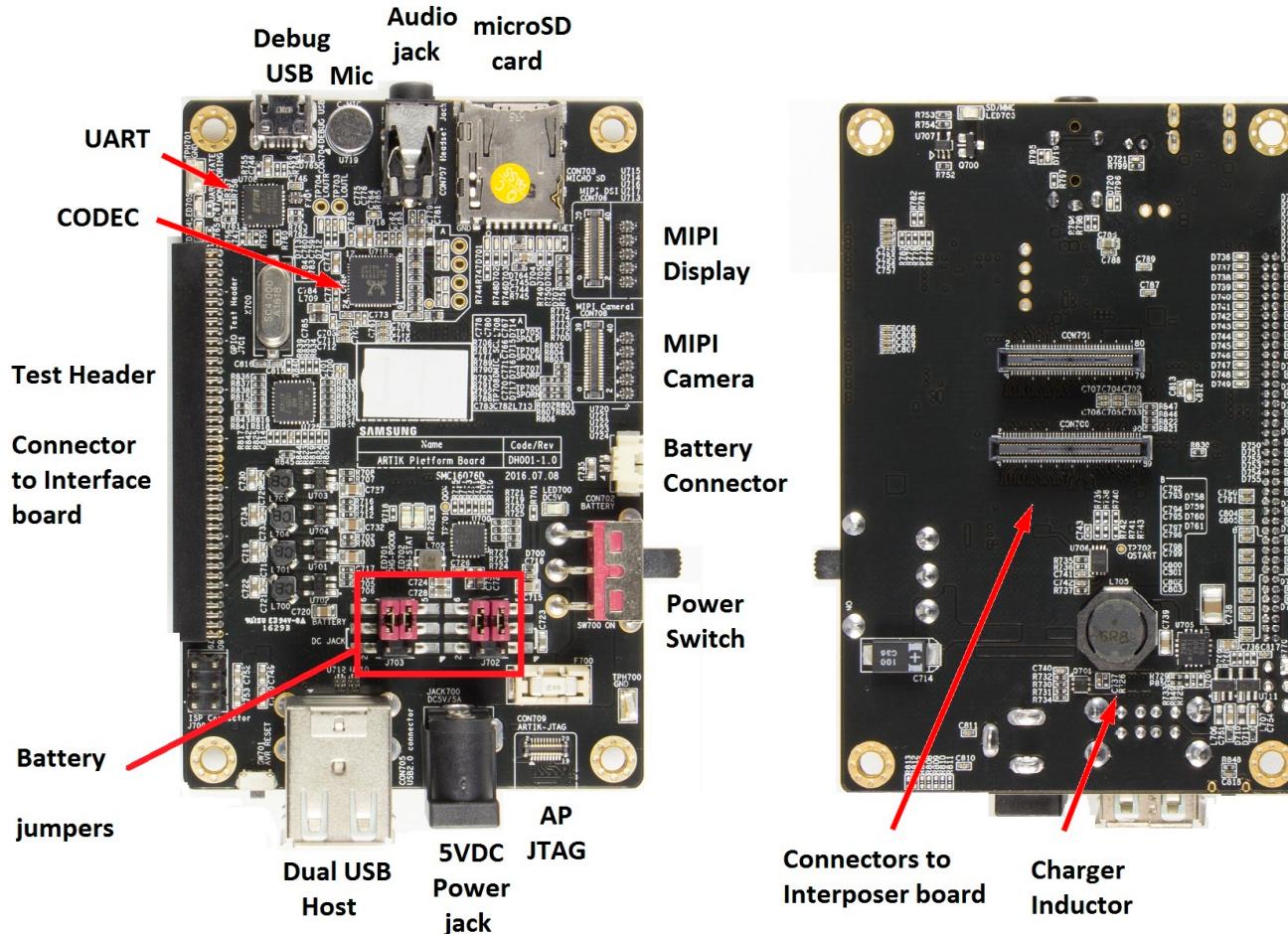
# ARTIK High-end module development board



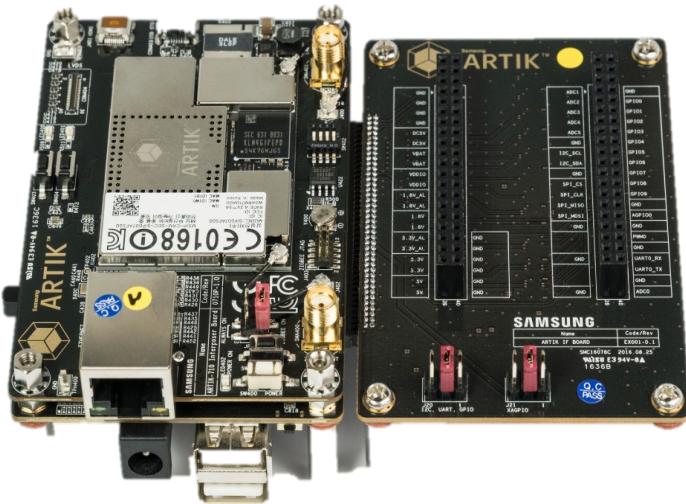
# ARTIK High-End Module Interposer Board



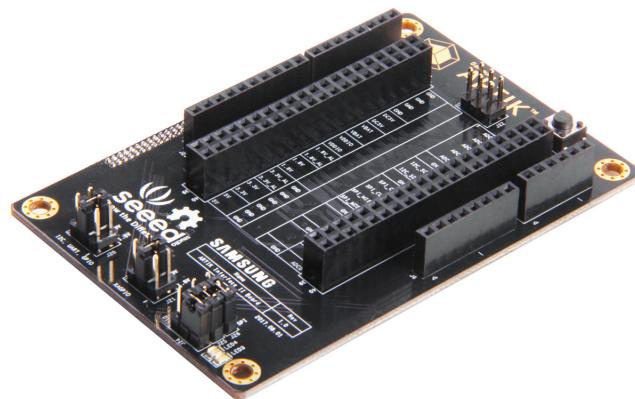
# ARTIK Gateway Module Platform Board



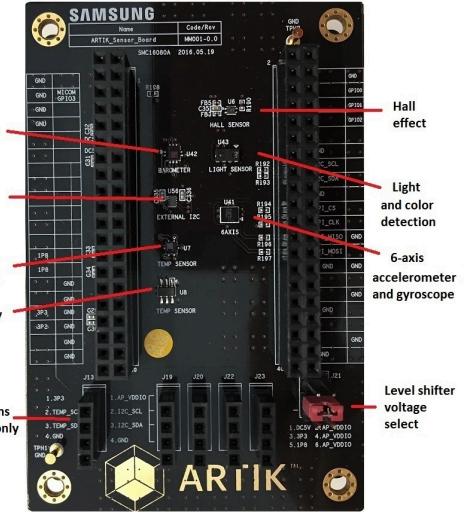
# ARTIK Gateway Module Expansion Boards



Interface Board



Interface Board II



Sensor Board

# ARTIK Gateway Module Use Case

# RushUp Kitra GTI

## Leverage IoT with industrial I/O, sensors, and LTE

Building automation, manufacturing, remote asset management:  
connect easily to existing infrastructure with analog I/O

- **Retrofit in minutes:** Multiple analog I/O for external sensors such as current, temperature and humidity, relay and contact; digital input for contact switches; support for Mod bus
- **Based on ARTIK 710s:** includes 4G LTE, GNSS, for long range connectivity and location; security includes secure boot, secure OS, secure storage, secure communication, KMS, PKI
- **Embedded sensors:** temperature, accelerometer, gyro & microphone
- **Cloud ready:** ARTIK cloud services SDK pre-installed, works with Azeti asset monitoring or PTC Thingworx



# Beck CTS 140.K

## Integrate existing industrial equipment into the IoT

Beck's long experience in the industrial market makes IoT easy.

The CTS 140.K features a wide range of field bus protocols, WIFI, BT, and cellular

- **Cloud native:** use Beck's cloud broker or ARTIK cloud services
- **On premise:** connect to a local server and manage via a simple Web interface using PC, tablet or smartphone
- **Customize:** RS485, Ethernet, I/O options; Beck's experience provides for smooth integration
- **Security features:** ARTIK 710s provides secure boot, secure OS, secure storage, secure communication, KMS, PKI



# Customer Use Cases



**Legrand:** Global residential and commercial digital building infrastructure

**Challenge:** Transform product line to meet new connected digital mkt requirements.  
Fast time to mkt. Interoperability.

**Products:** ARTIK 0x, 5x, 7x secure system-on-modules, ARTIK cloud services

**Why ARTIK?** Reduced product development time. Built-in software eliminated internal dev skills roadblock. Security allows them to meet new customer reqs. Interoperability expands switch capabilities, helped them get POC with Marriott "Room of the Future".

**NDA Customer:** Factory automation provider

**Challenge:** Retrofit customer OT to meet requirements for Industrial 4.0, enable access to data and create digital twins for more efficient operations. Ensure secure operations.

**Products:** ARTIK 530s secure system-on-module, ARTIK partner PTC

**Why ARTIK?** Secure gateway solution for their industrial gateway with access to local sensors, ability to do local processing and edge node management, application to view data via integration with PTC Thingworx front end application.

# Customer Use Cases



## NDA Customer: On-body multimedia hub for first responders

**Challenge:** Performance and capabilities including high-resolution video. Connectivity with other on-body sensors. Reliability.

**Products:** ARTIK 710s secure system-on-module, evaluating cloud services for data capture and management

**Why ARTIK?** Best performance and value relative to cost. Secure data storage and communications.

## Samsung Device Solutions

**Challenge:** Quickly develop a cost affordable android-based multi-dwelling control panel that runs video.

**Products:** ARTIK 7x secure system-on-module, ARTIK cloud services on SmartThings Cloud

**Why ARTIK?** No product on the market which meets their specs for Android/video and security. Ability to customize 710 to meet their high volume requirements. Interoperability and access to additional service with ARTIK cloud services on SmartThings Cloud. Built-in security.

# Customer Use Cases



**NDA Customer:** Assisted Living platform to provide status and data without being intrusive

**Challenge:** Started with Intel Edison, which EOLd the product. Needed a fast replacement, with minimal development time, BT beacon tracking, WiFi, video and sensor inputs.

**Products:** ARTIK 530 system-on-module, evaluating ARTIK cloud services

**Why ARTIK?** Were able to quickly replace the module with factory-ready, pre-certified product, and minimize lost time to market with an added bonus - ability to access ARTIK integrated cloud services.



**NDA Customer:** Telecommunications company providing low-cost high speed data access platform and base station for homes

**Challenge:** Needed high end processor capable of complex operations for edge computing.

**Product:** ARTIK 710 system-on-module

**Why ARTIK?** Provides price performance to meet their requirements. Allowed them to quickly "prove" their product with ability to quickly scale up on production-ready product.

# Machine Learning Inference

## ARTIK 5x/7x

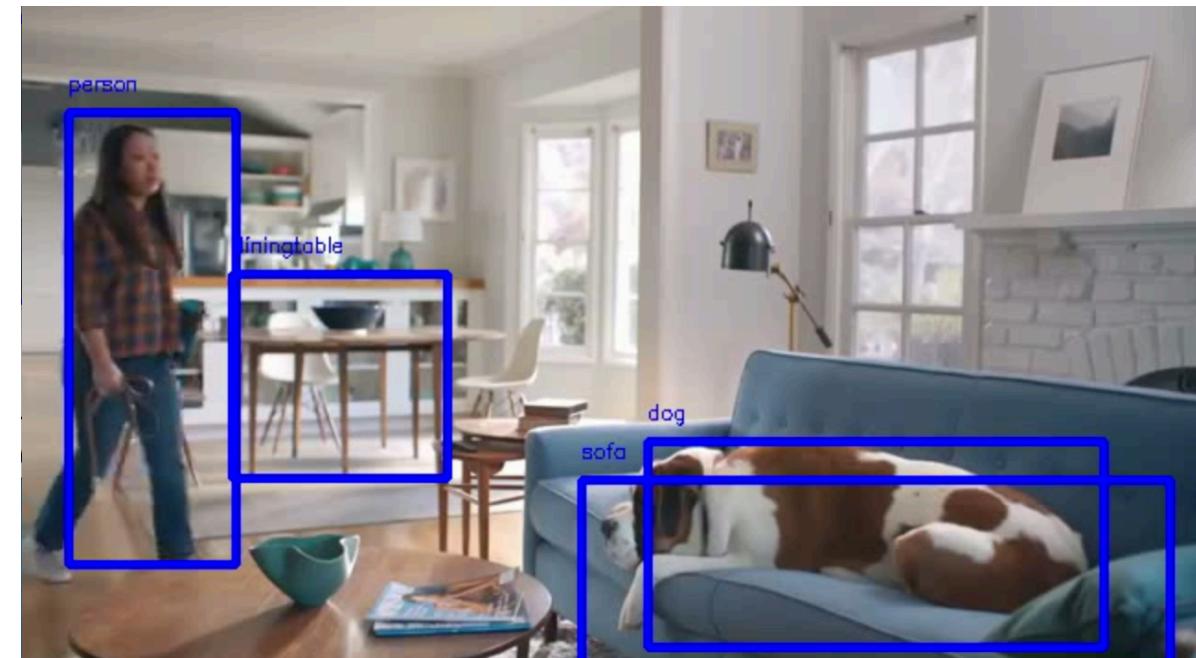
Run Machine Learning Inference on ARTIK gateway devices

**Use case:** Smart Factory, Smart Building for Computer / Machine Vision, Predictive Analysis etc.

**Hardware:** ARTIK 5x/7x

**Software:** Tensorflow (Lite),

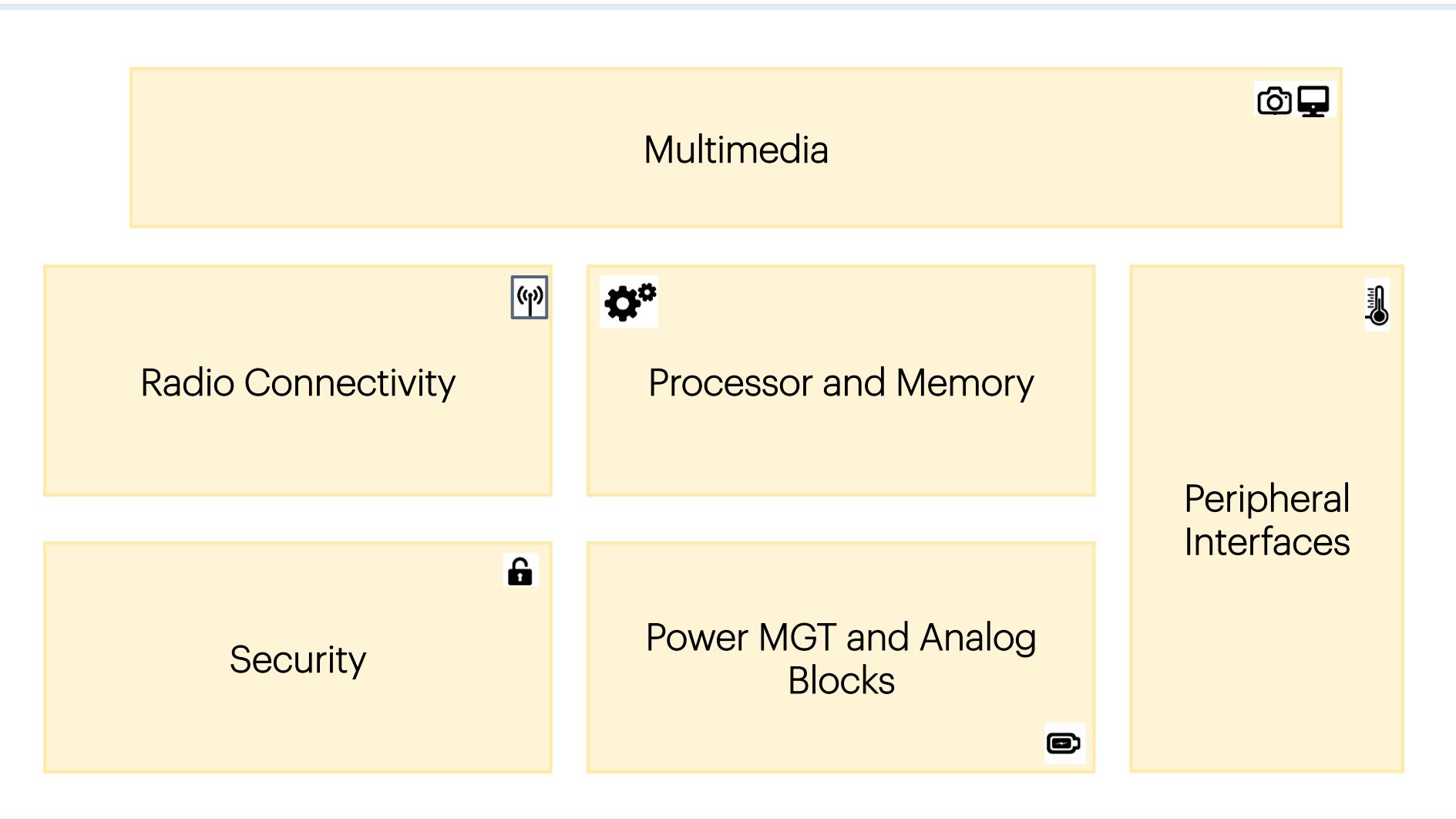
AWS Greengrass ML Inference;



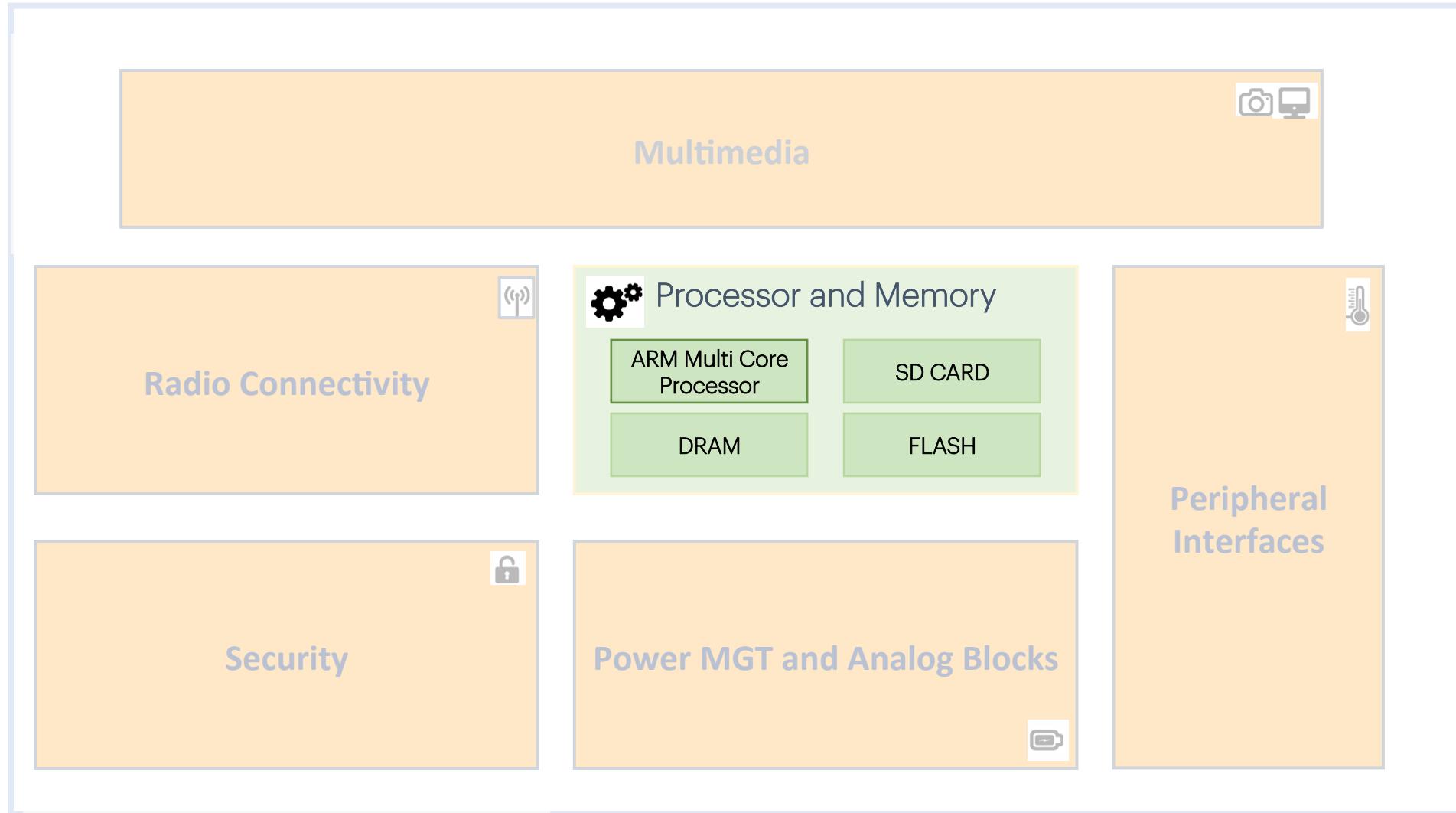
# ARTIK Gateway Module

## Product Details

# Product Details



# Product Details – Processor and Memory



# Radio Connectivity

Radio	Range	Data Rate	520	530	710
BLE	50m	<1Mbps	✓	✓	✓
BT	30m	1-3Mbps	✓	✓	✓
ZigBee	10-100m	10-100Kbps	✓	✓	✓
Thread	N/A	10-100Kbps	✓	✓	✓
Wi-Fi	~50m	10-100Mbps	✓	✓	✓
Ethernet			✓	✓	✓

\*Z-wave and Sigfox chip set is on 520 development boards

# Peripheral Interfaces + Power MGT & Analog blocks

	520	530	710	
Peripheral Interfaces	I2C	6	3	3
	SPI	2	2	2
	GPIO	100	107	108
	UART	2	3	3
	USB	USB 2.0*	USB 2.0	USB 2.0
Analog and Power MGT	ADC	2	6	6
	PWM	2	2	2
	PMIC	✓	✓	✓

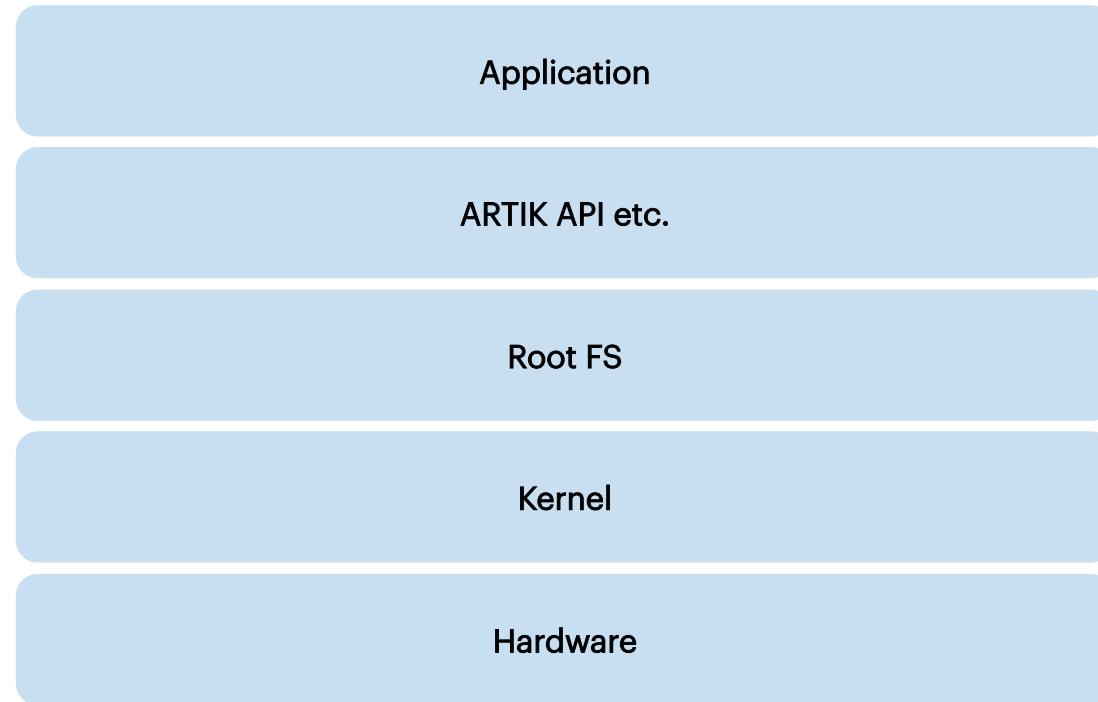
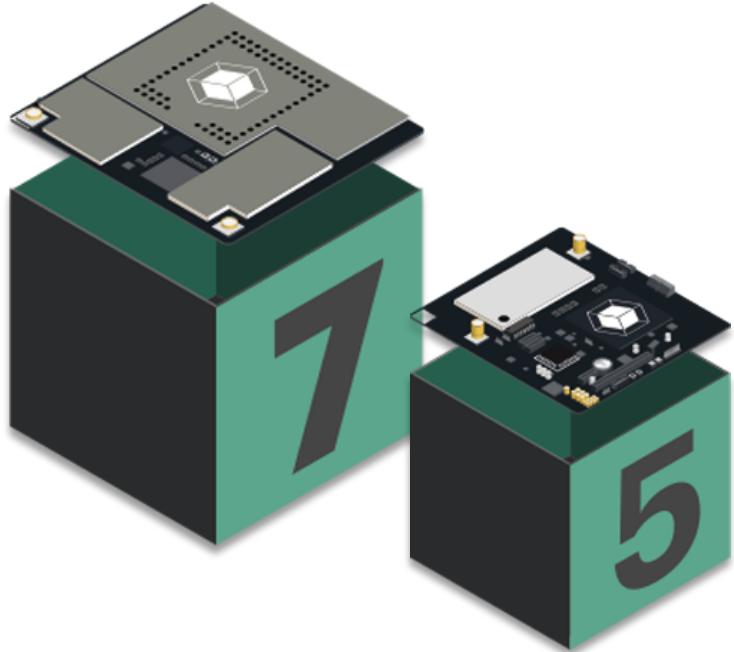
\*USB device mode only for 520, rest of the module is both device and host mode.

# Product Details - Multimedia

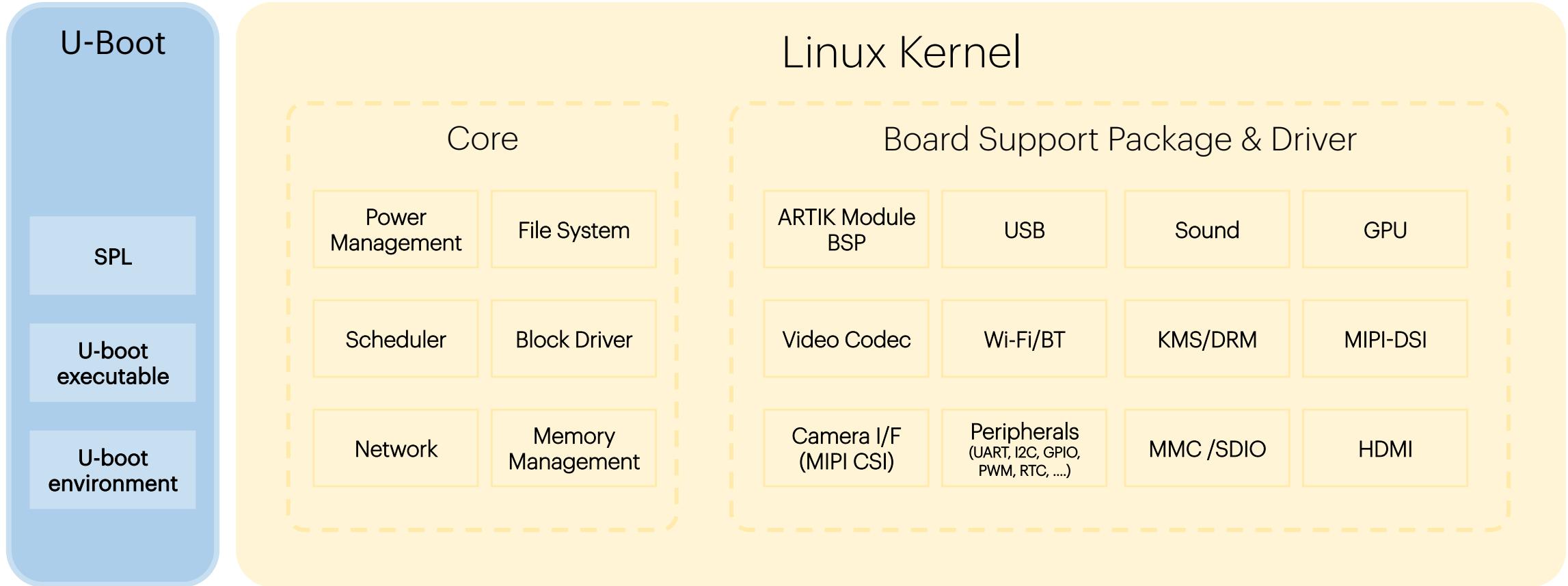
	<b>520</b>	<b>530</b>	<b>710</b>
I2S	1x	2x	2x
HDMI + audio	n/a	1080p @ 60fps	1080p @ 60fps
MIPI – DSI	2-lane 540p @ 24bpp	4-lane 1080p @ 60fps	4-lane 1200p @ 24bpp
MIPI – CSI	2-lane 3MP @ 30fps	4-lane 1080p @ 30fps	4-lane 1080p @ 30fps
LVDS	n/a	720p @ 60fps	720p @ 60fps

# ARTIK Gateway Module Software Stack

# ARTIK Gateway Software Stack

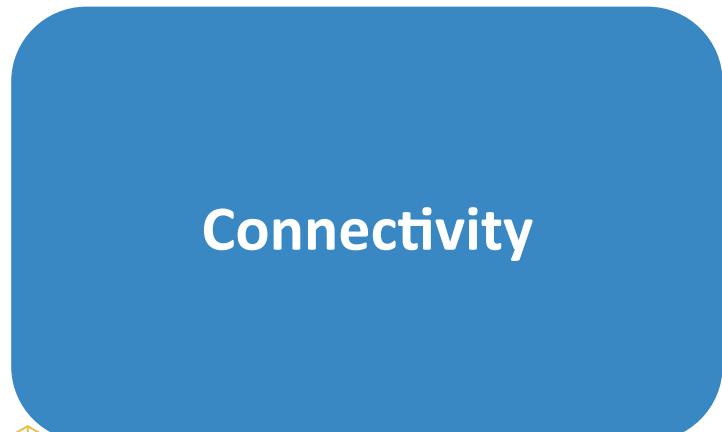
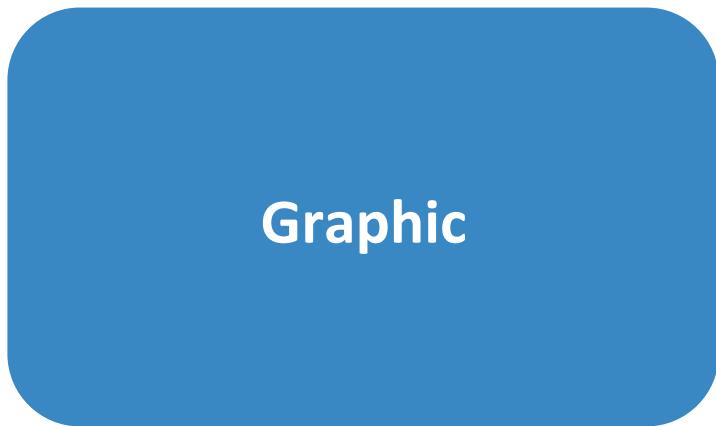
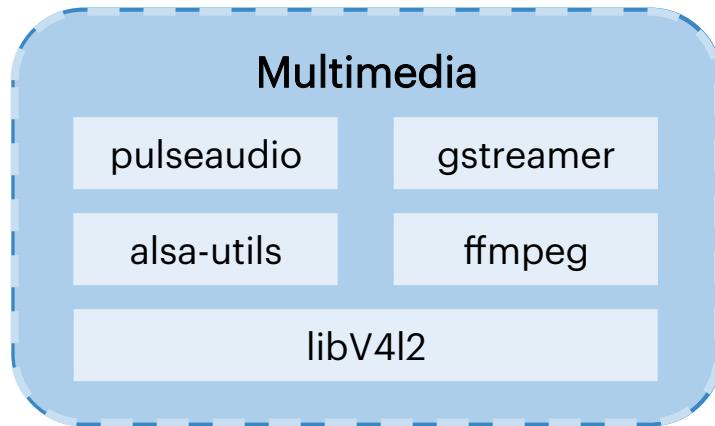
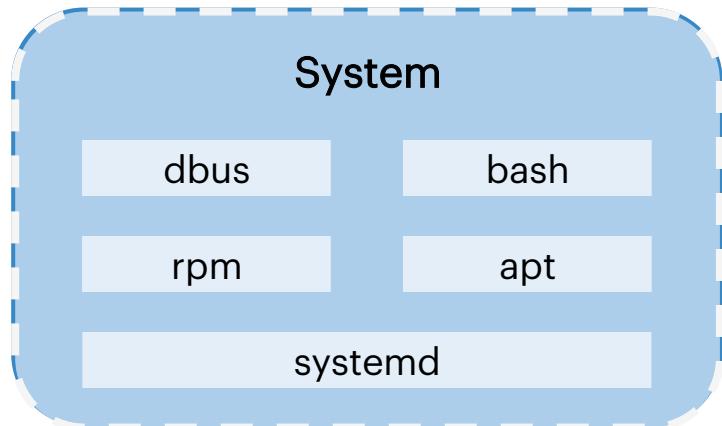


# U-Boot and Linux Kernel Architecture

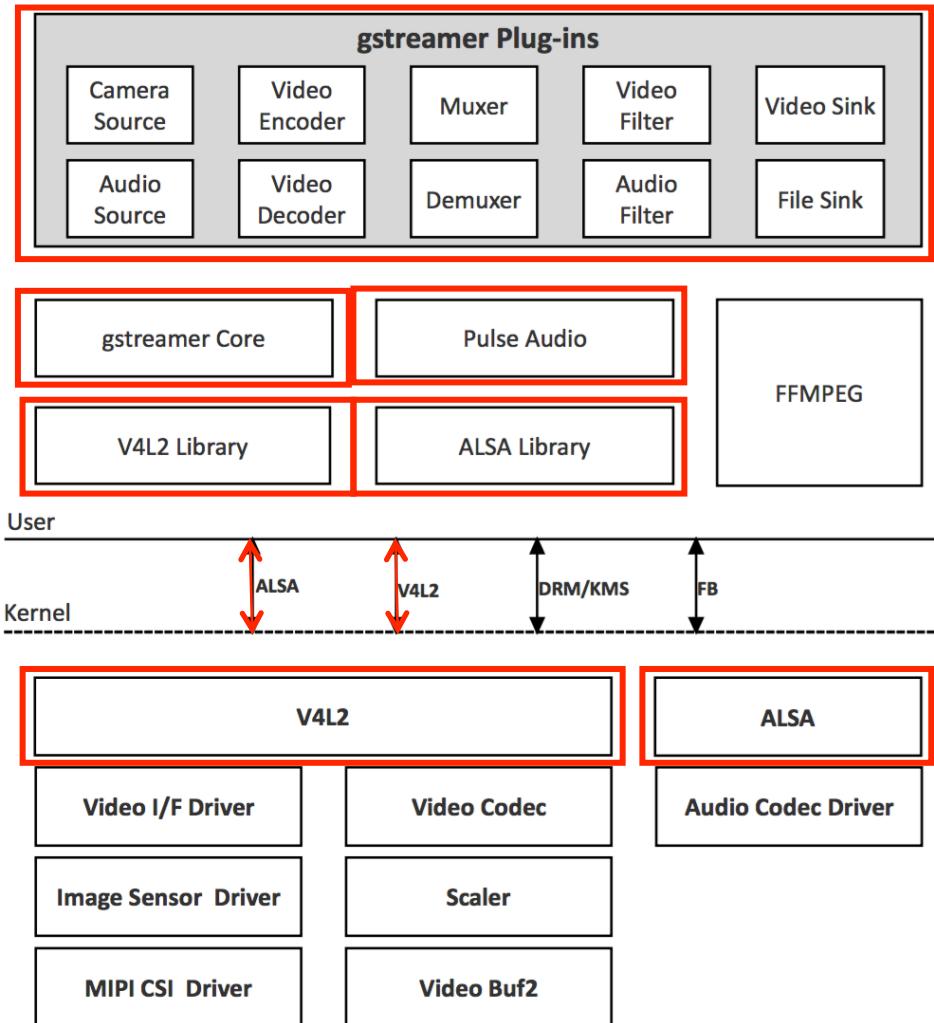


# Architecture of Rootfs

## Rootfs



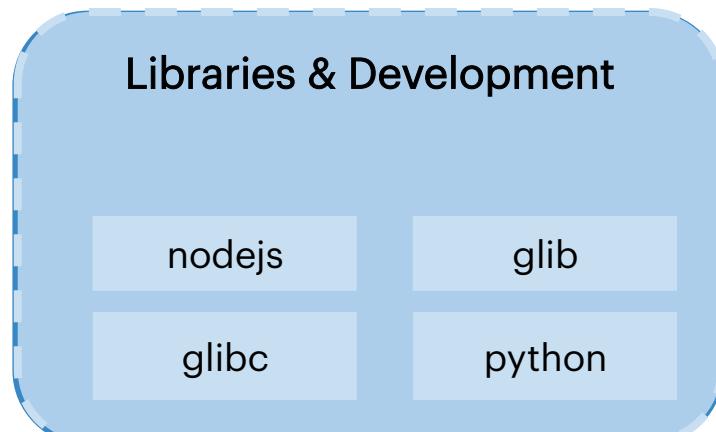
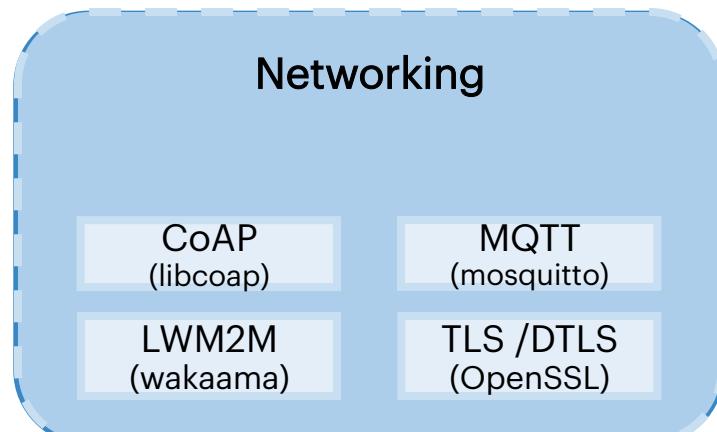
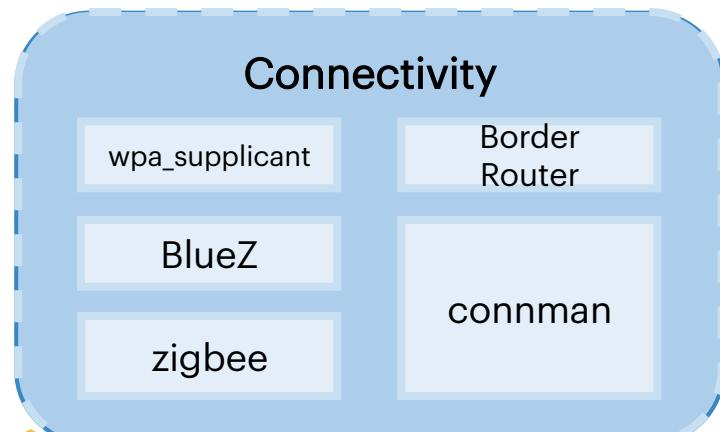
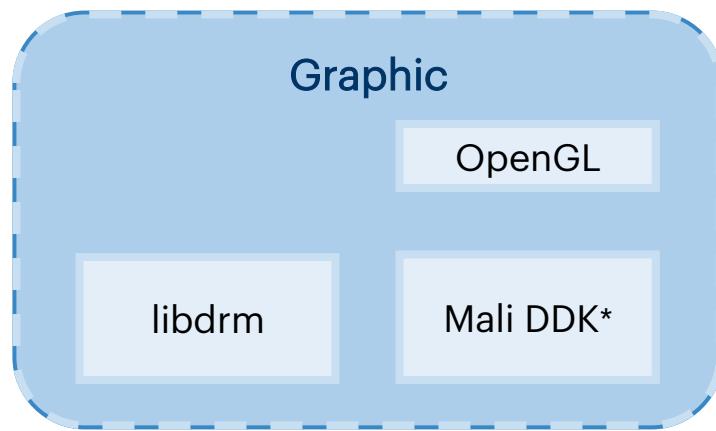
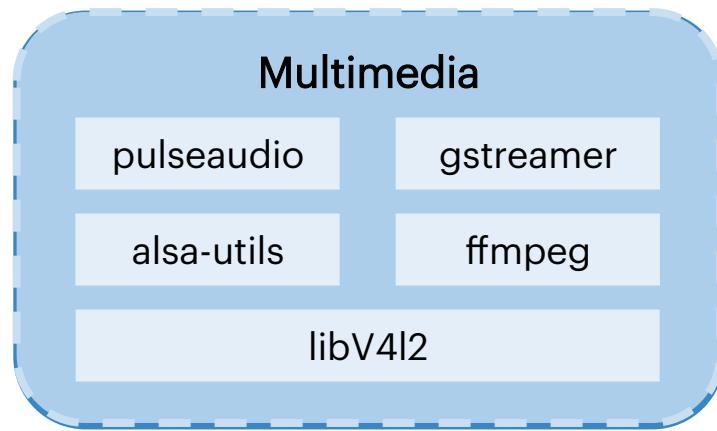
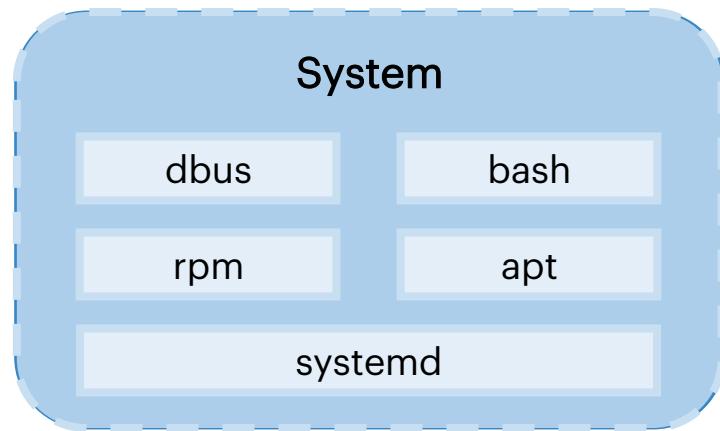
# Multimedia Architecture



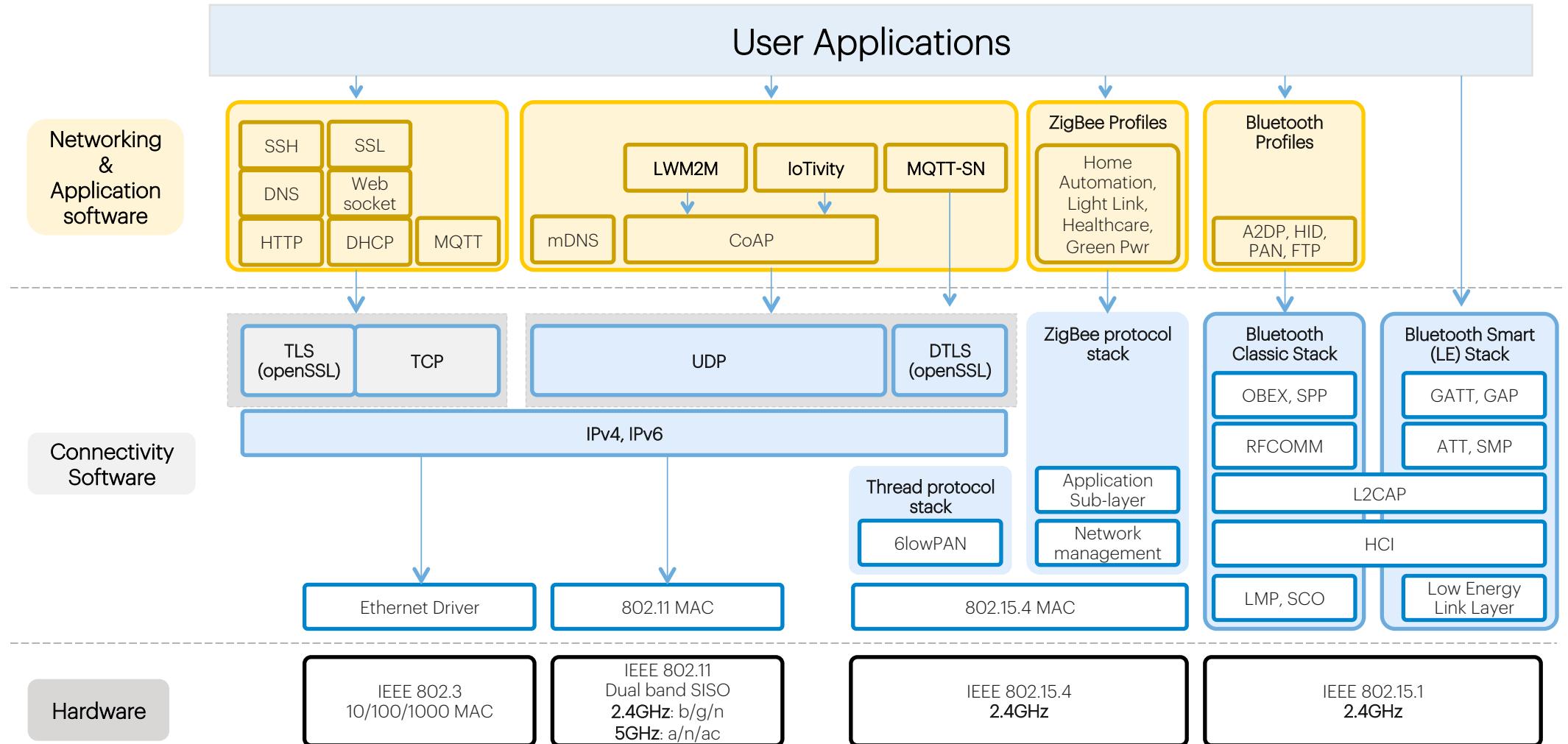
- ALSA lib is a framework that provides software APIs for audio device drivers
- Pulse Audio is based on ALSA lib for supporting sound. It runs a sound server.
- Video for Linux Version 2 (V4L2) is collection of device drivers and API for supporting real-time video capture on Linux systems
- Gstreamer is a pipeline-based multimedia framework that links together a wide variety of media processing system to complete complex workflows

# Architecture of Rootfs

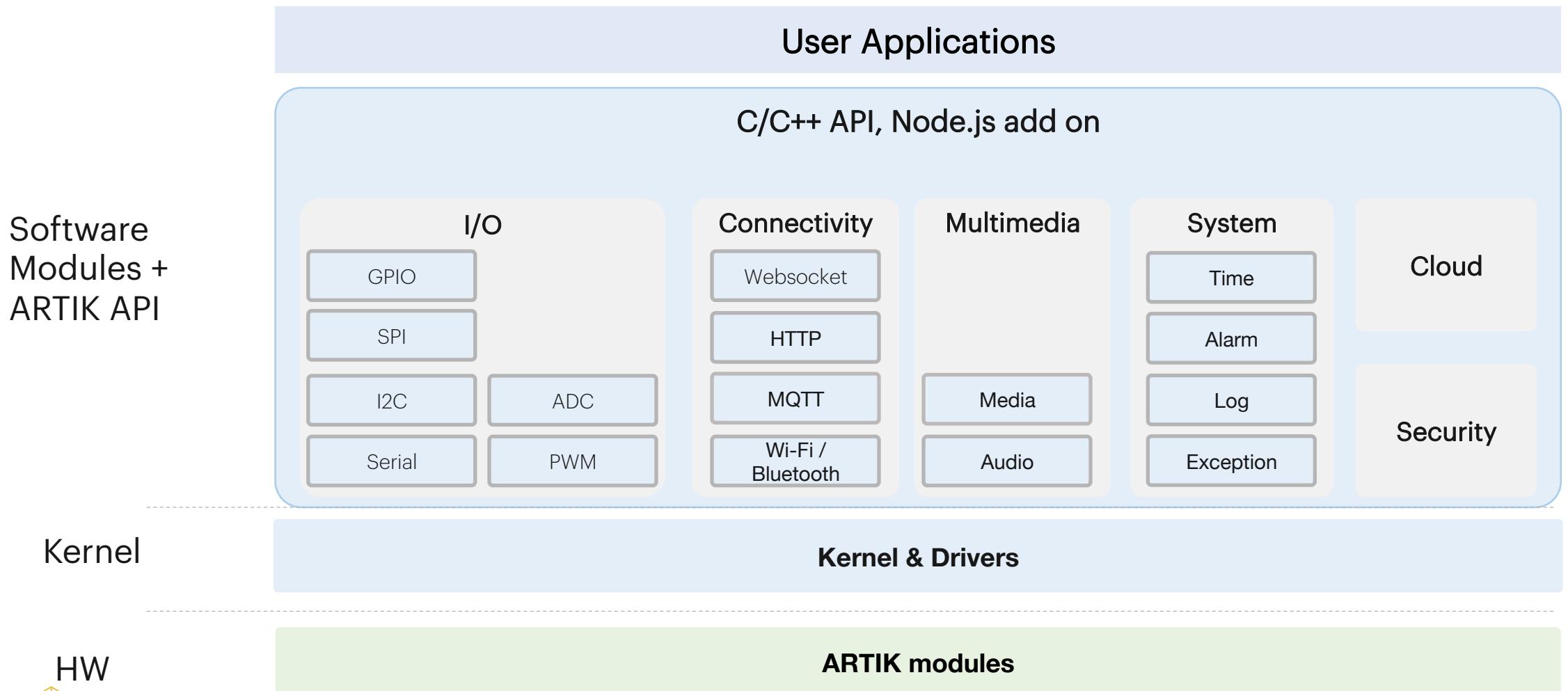
## Rootfs



# Network Stack



# ARTIK SDK (5, 7 series)



# ARTIK Gateway Module Security

# Security Questionnaire

## How do you provide security across all attack surfaces?

Question	ARTIK 5/7/053
Do you support secure communication from device to device or device to cloud? How do you secure communication? Are you using TLS1.2 or higher?	Yes, HTTPs using TLS 1.2
How do you establish identity of device?	Using unique certificate on each device
How does the device establish identity of cloud?	Both device and cloud are chained to ARTIK Root CA and can verify each other certificates
Do you have mutual authentication when enabling secure communication?	Yes
Do you have the infrastructure to inject unique key and certificate in each device to establish unique identity per device? How much does it cost?	Yes (Done at Samsung factory. Cost included in module)
How do you protect your certificate, keys? Are your certificate and keys safe if software is hacked?	Specialized HW on module (secure element)
Is your certificate infrastructure secure? How do you secure your Root Certificates? How much does it cost?	Yes (Root CA secured by 3 <sup>rd</sup> party security vendor)
How do you guarantee your firmware integrity?	Secure Boot

# 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

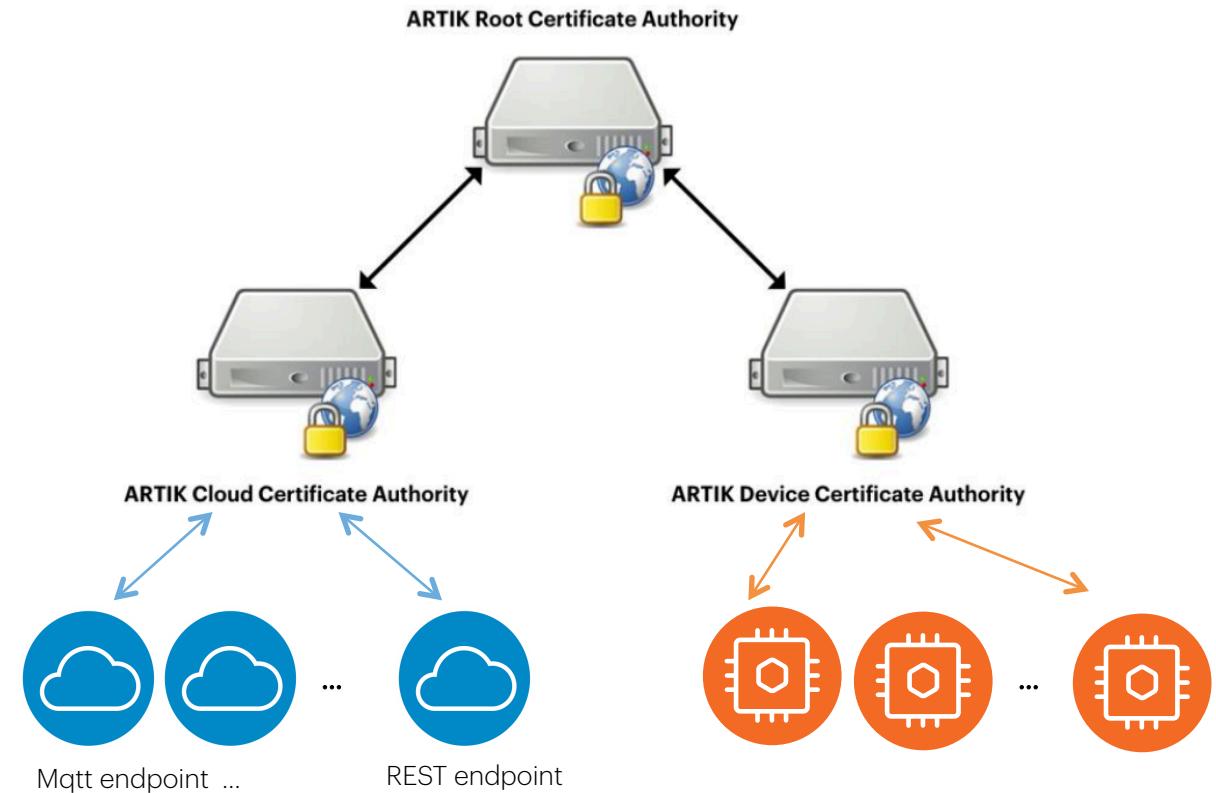


# Samsung ARTIK™ S-Module Features

		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

# ARTIK PKI

- A Public Key Infrastructure (PKI) supports the distribution and identification of public encryption keys, establishing authenticity and trust in a system.
- ARTIK provides its own PKI, which is used to generate and apply unique certificates and key pairs to each ARTIK Module during manufacturing.
- PKI's core concept is (Digital) Certificate. Issued by a **Certificate Authority**, e.g, GlobalSign, Symantec
- ARTIK Root CA



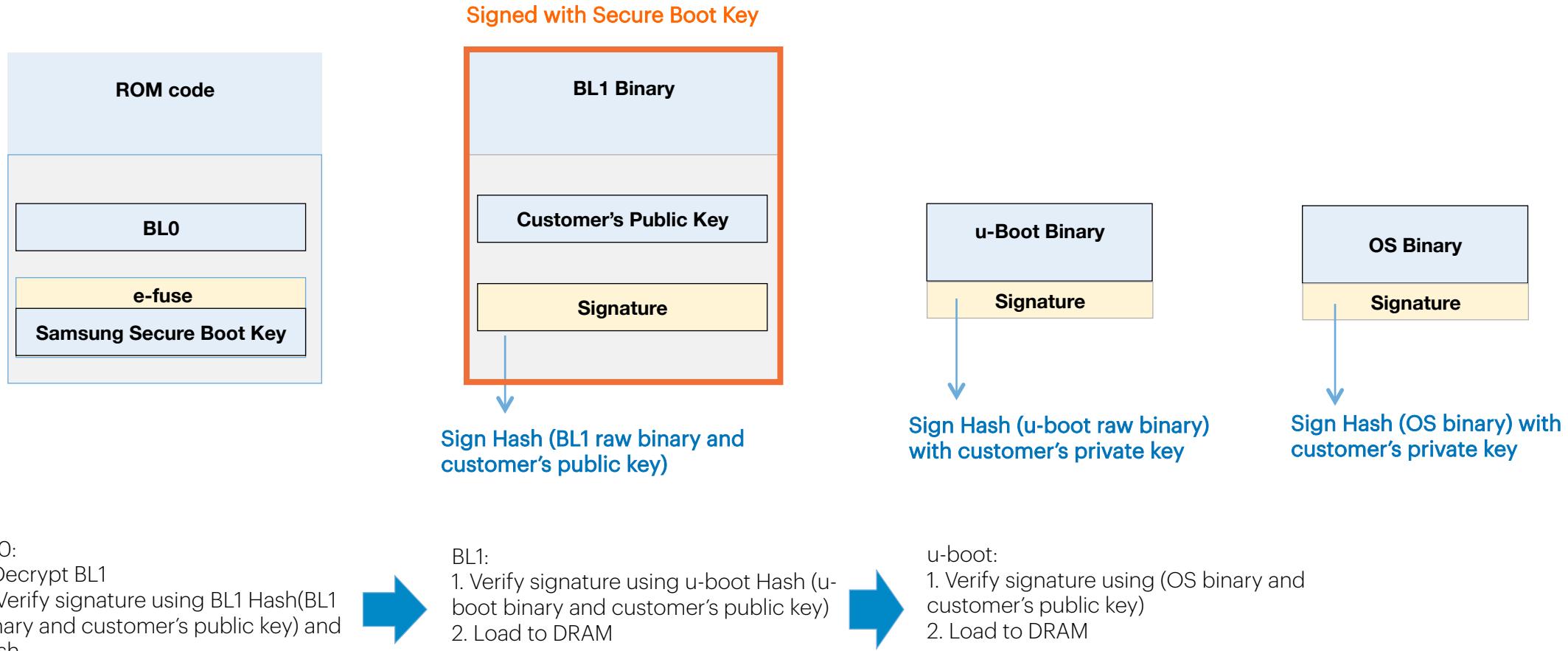
# Mutual Authentication

- 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

# 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.

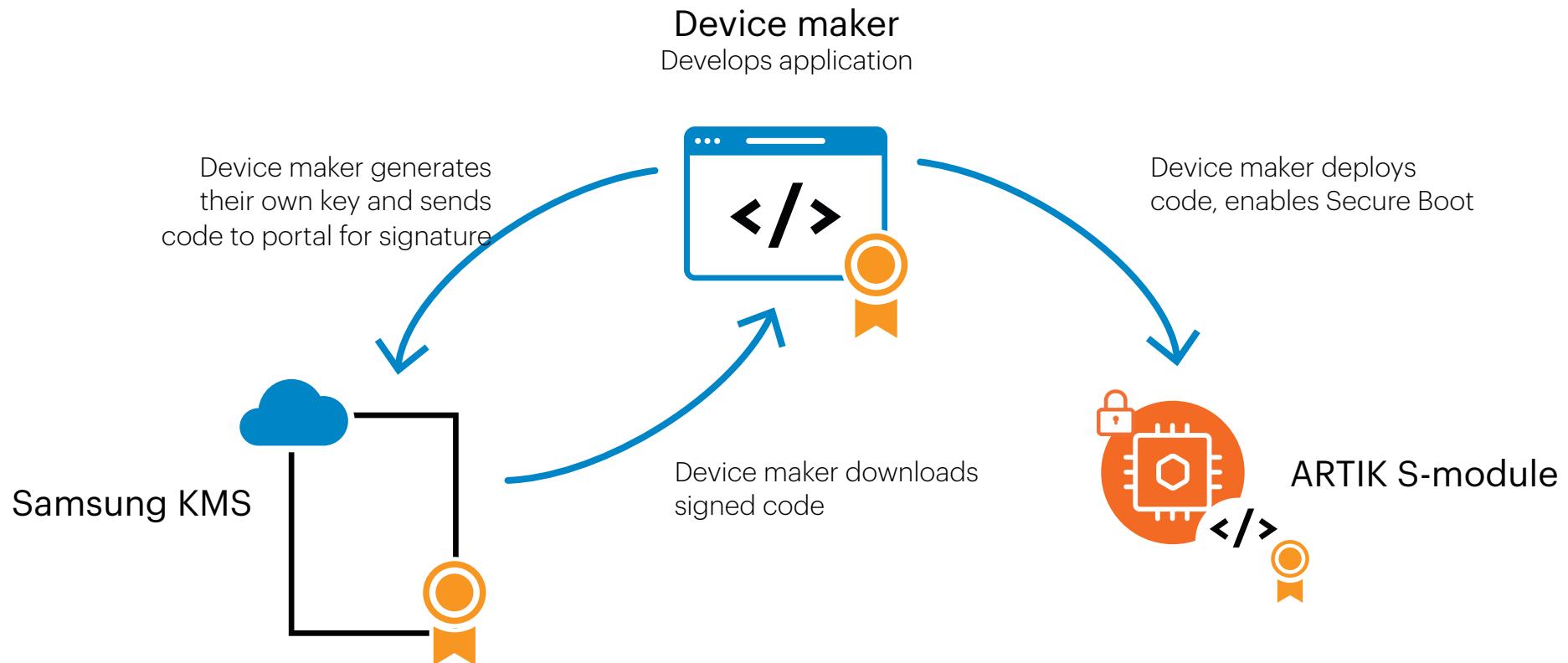
# Secure Boot for ARTIK S-Module



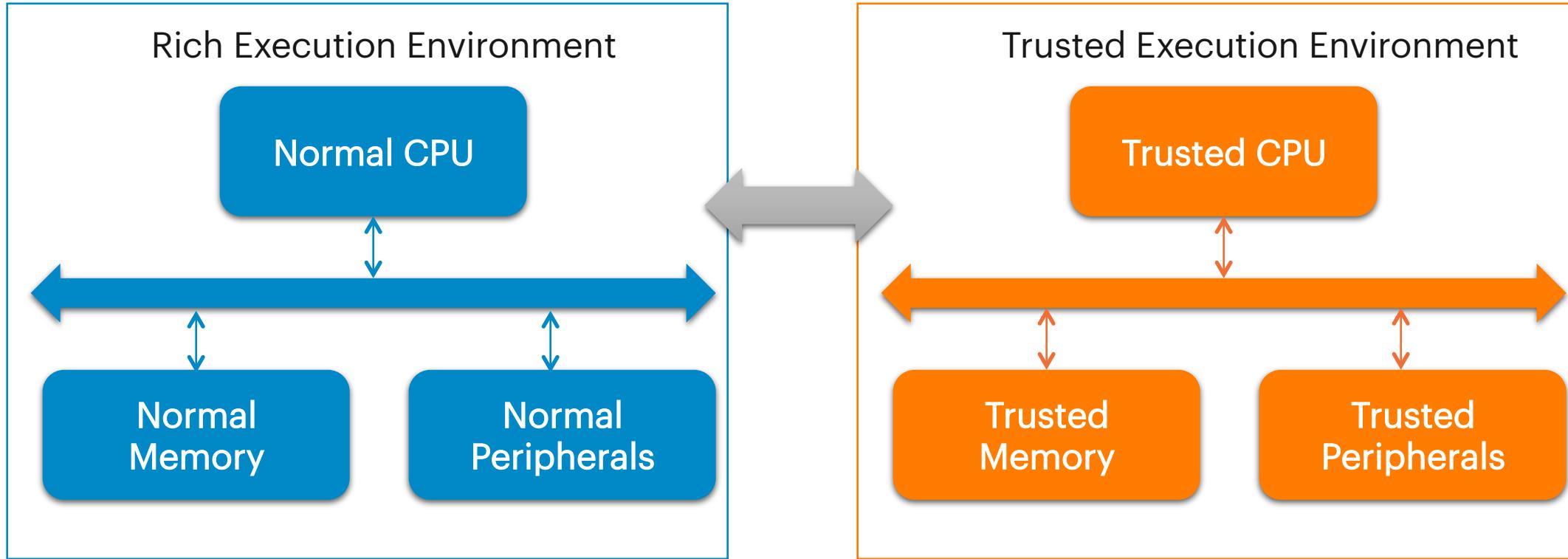
NEW

# Samsung ARTIK™ Key Management System(KMS)

## Code signing portal manages key signing



# Trusted Execution Environment on 5/7x (TEE)



- ARTIK 5 and 7 module families support Trusted Execution Environment(TEE)
- Samsung TEE implementation is based on ARM TrustZone hardware architecture
- TEE provides a fully-isolated and secured operation environment

# Secure Storage

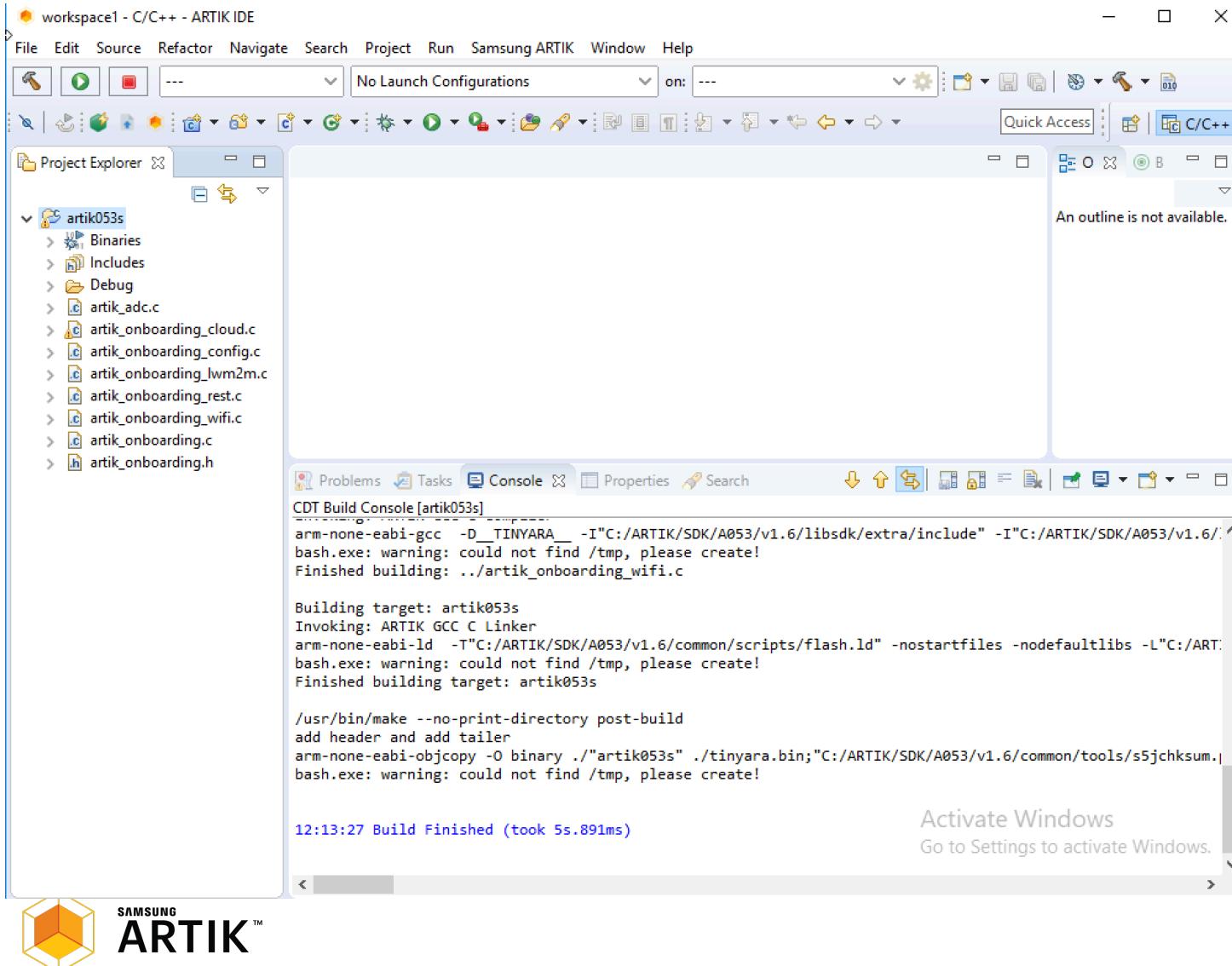
- eMMC file system (Flash-based) : A specific partition is encrypted with an unique key generated at run time. Applies to ARTIK 05x and 5/7 modules.
- Secure Element : an isolated storage device that supports 2 slots of ECDSA key pairs (16 AES 128-bit keys). The Secure Element meets the Common Criteria (CC) certification for security and for Evaluation Assurance Level (EAL) 5.

# ARTIK Security

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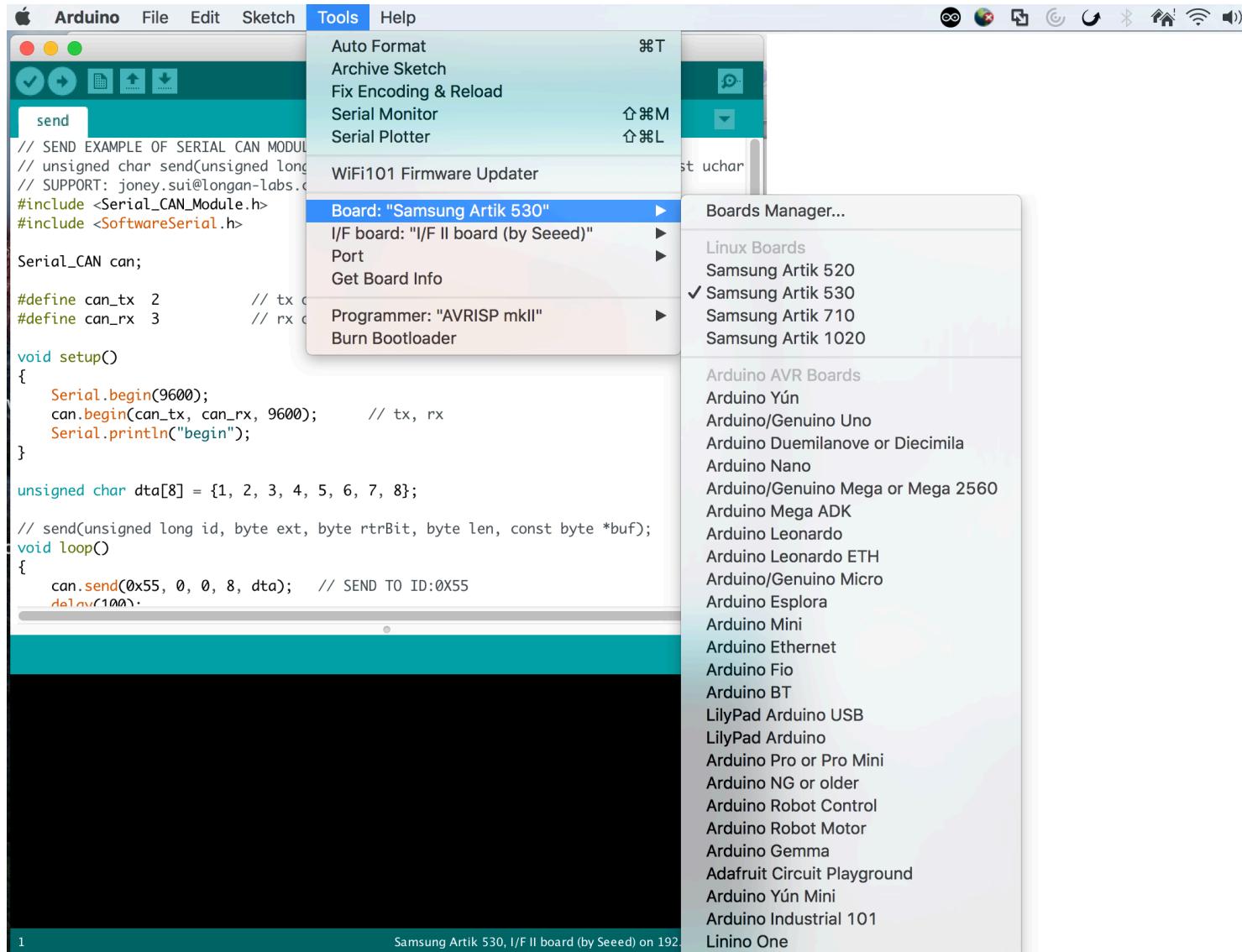
# ARTIK Gateway Module Development

# ARTIK IDE



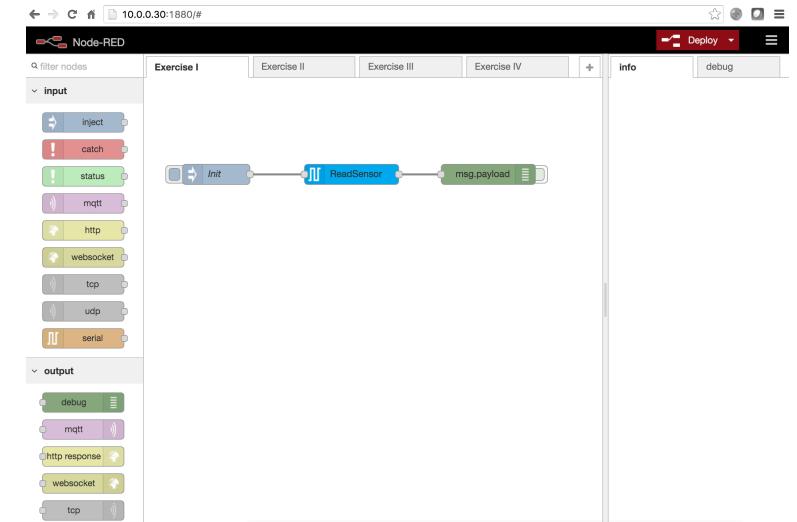
gcc-arm-linux-gnueabihf  
(32 bit for ARTIK 5x)  
and  
aarch64-linux-gnu  
(64 bit for ARTIK 7x)

# Arduino



# Node-RED

- A visual tool for wiring the internet of things, based on Node.js
- Utilizes flow programming technique
- Construct program flow by drag-and-drop
- You have the option not to write code
- Growing ecosystem
- Cloud-based solutions: IBM Bluemix, Front end Node-RED



# Native Development

- C/C++: Most popular programming languages for embedded devices. e.g, ARTIK SDK
- Python: Rich libraries
- JS: Node.js is the most popular JavaScript runtime for high-end IoT devices.
- Java: used in projects like Eclipse Kura, Eclipse Milo

# 3<sup>rd</sup> party Libraries/Frameworks/Open Source projects

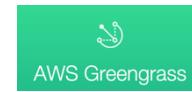
- Multimedia: PyAudio, Speech Recognition, OpenCV for computer vision etc.
- Connectivity: wpa\_supplicant, bluez
- Communication Protocols/Frameworks:
  - MQTT(Eclipse Mosquitto/Paho)
  - CoAP (Eclipse Californium)
  - LWM2M(Eclipse Wakama, Eclipse Leshan)
  - OPC-UA(Eclipse Milo, open62541)
  - IoTivity



# 3<sup>rd</sup> party Gateway/Database Solutions

Gateway:

AWS Greengrass



Microsoft IoT Edge



Eclipse Kura



Edge Foundry



Database:



InfluxDB



# Support Multi Clouds



MQTT, HTTP, AMQP, websocket etc.



Or by using IoT Device SDK



# Samsung ARTIK™ 530/s SoMs

## Competitive advantages



- Fully integrated, production ready SoM:  
Quad Core AP, Secure Element, RAM, Flash, PMIC, passives  
Multimedia capabilities – 3D graphics acceleration  
Fully certified – FCC, CE, IC, KC
- S-module security features: secure boot, secure OS, secure storage, secure communication, KMS, PKI
- Out of the box integration to SmartThings Cloud
- E2E Solution:
- Tools: Eclipse IDE, GNU toolchain

# Training Github Repository

<https://github.com/SamsungARTIK/Training>

# Samsung ARTIK™

## Helpful web resources

Web Documentation	<a href="https://developer.artik.io/documentation/">https://developer.artik.io/documentation/</a>
Document Library	<a href="https://www.artik.io/library/">https://www.artik.io/library/</a>
Forums	<a href="https://developer.artik.io/forums/">https://developer.artik.io/forums/</a>
Blog	<a href="https://www.artik.io/blog/">https://www.artik.io/blog/</a>
File Tickets	<a href="https://support.artik.io">https://support.artik.io</a>
Github Repository	<a href="https://github.com/SamsungARTIK">https://github.com/SamsungARTIK</a>
YouTube Channel	<a href="https://www.youtube.com/channel/UC4rolvSm8ikmnymdbznNJw">https://www.youtube.com/channel/UC4rolvSm8ikmnymdbznNJw</a>



# ARTIK Training Tues

# Samsung ARTIK™ Training Tues

2-hour training sessions every other Tues starting from Aug, 14th

## **Level 1: ARTIK Fundamentals** (No ARTIK knowledge / hardware required)

- L1\_1: ARTIK Intro: ARTIK Intro and guide audience through online resources
- L1\_2: Cloud Communication

## **Level 2: ARTIK HW/SW Features** (Lecture + hands-on)

- L2\_1: ARTIK System Design, ARTIK 05x Overview
- L2\_2: ARTIK Security
- L2\_3: ARTIK Connectivity
- L2\_4: ARTIK HW Interface

## **Level 3: ARTIK Applications and Solutions** (mostly hands-on)

- L3\_1: Getting Started with Machine Learning Inference on ARTIK(5x hands-on)
- L3\_2: Build a Google Assistant/AVS voice-enabled gateway(5x hands-on)

2018																					
January							February					March					April				
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
1	2	3	4	5	6		4	5	6	7	8	9	10	4	5	6	7	8	9	10	
7	8	9	10	11	12	13	11	12	13	14	15	16	17	11	12	13	14	15	16	17	
14	15	16	17	18	19	20	18	19	20	21	22	23	24	18	19	20	21	22	23	24	
21	22	23	24	25	26	27	25	26	27	28				25	26	27	28	29	30	31	
28	29	30	31				25	26	27	28				29	30						
May							June					July					August				
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
		1	2	3	4	5	3	4	5	6	7	8	9	8	9	10	11	12	13	14	
6	7	8	9	10	11	12	10	11	12	13	14	15	16	15	16	17	18	19	20	21	
13	14	15	16	17	18	19	17	18	19	20	21	22	23	22	23	24	25	26	27	28	
20	21	22	23	24	25	26	24	25	26	27	28	29	30	29	30	31					
27	28	29	30	31			24	25	26	27	28	29	30	29	30	31					
September							October					November					December				
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
						1	1	2	3	4	5	6		4	5	6	7	8	9	10	
2	3	4	5	6	7	8	7	8	9	10	11	12	13	11	12	13	14	15	16	17	
9	10	11	12	13	14	15	14	15	16	17	18	19	20	18	19	20	21	22	23	24	
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24	
23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30	31	
30																					

Level 1

Date  
Oct 9<sup>th</sup>  
Oct 23rd  
Nov 13th



Level 2

Topics  
Level 1 –ARTIK Intro  
Level 2- ARTIK Security  
Level 2- ARTIK Connectivity  
Level 3-Getting Started with Predictive Analysis and Image Classification on ARTIK  
Level 1 – ARTIK Intro(with 310)

Level 3