

# ARTIK Gateway Modules

Wei Xiao

August 14, 2018

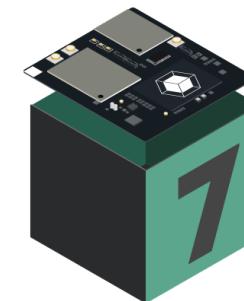
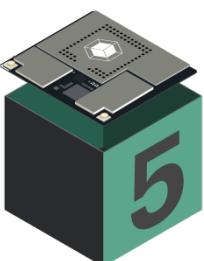
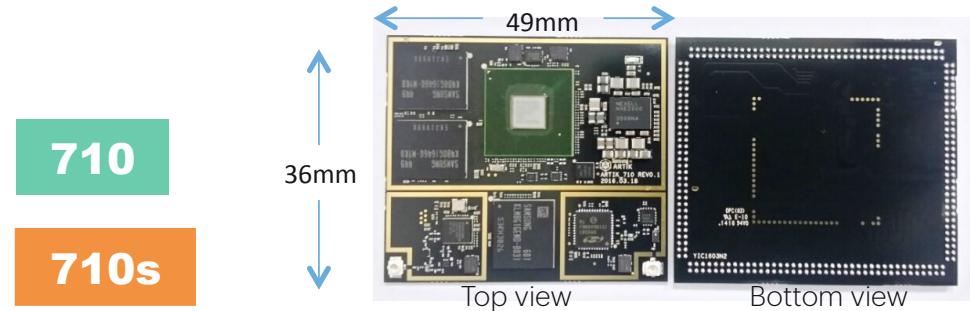
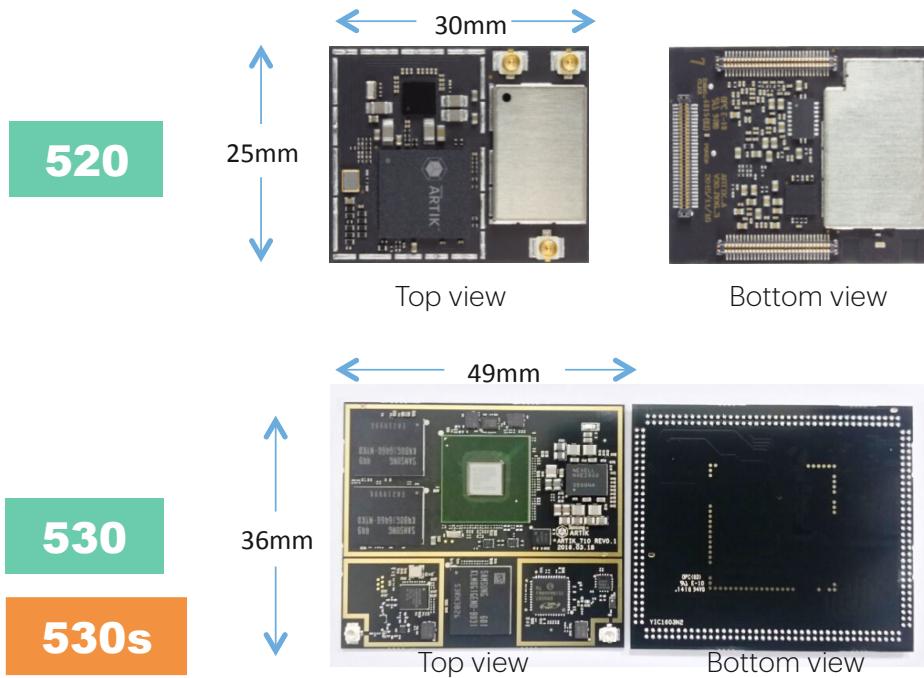


# Agenda

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

# 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

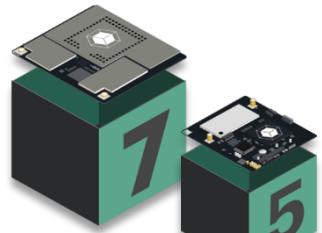
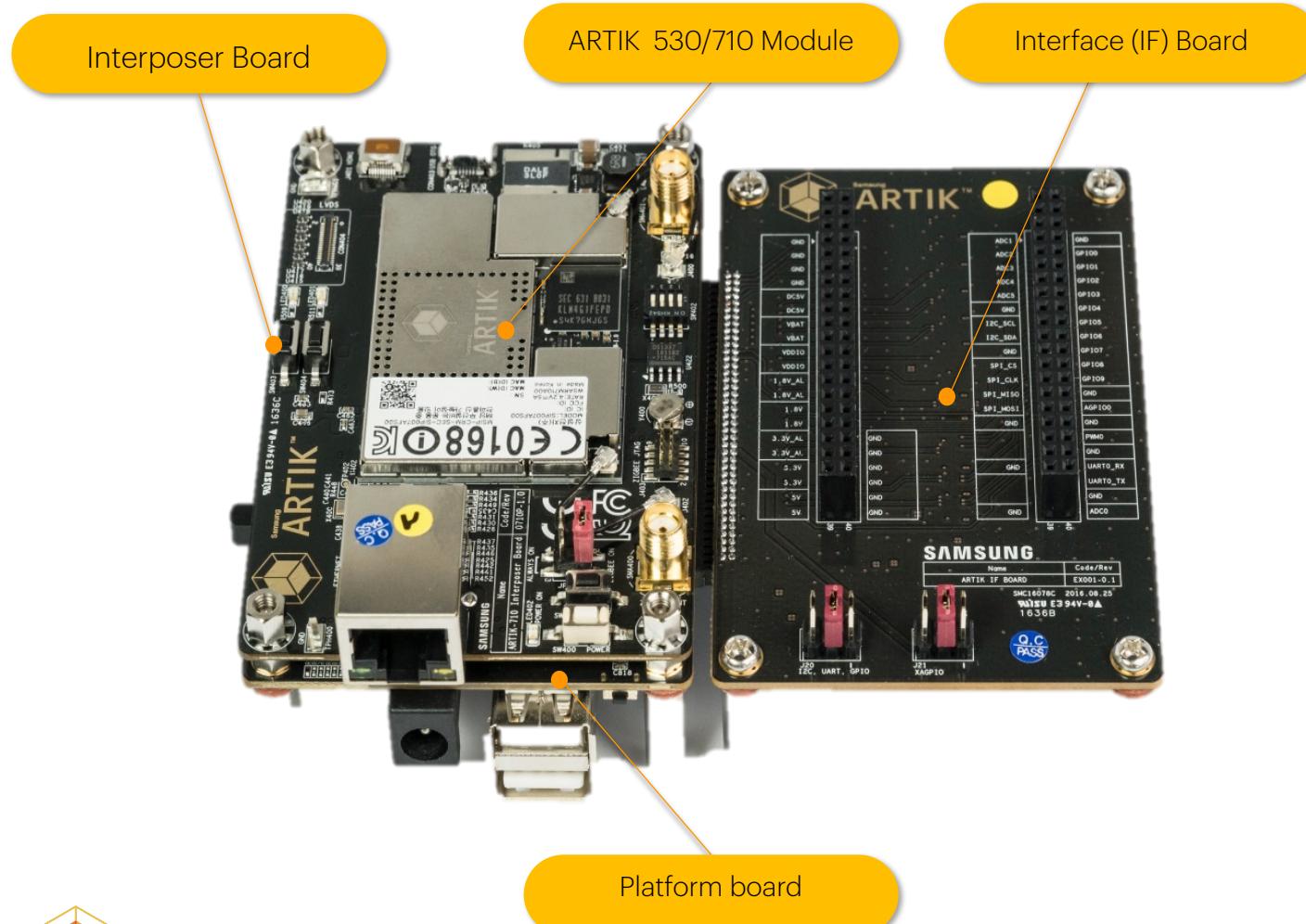


- High-end gateways
- Cameras
- Human-machine interface
- Machine learning

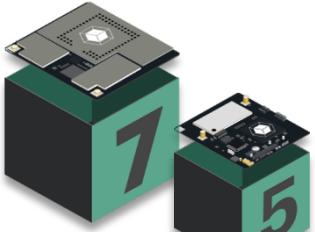
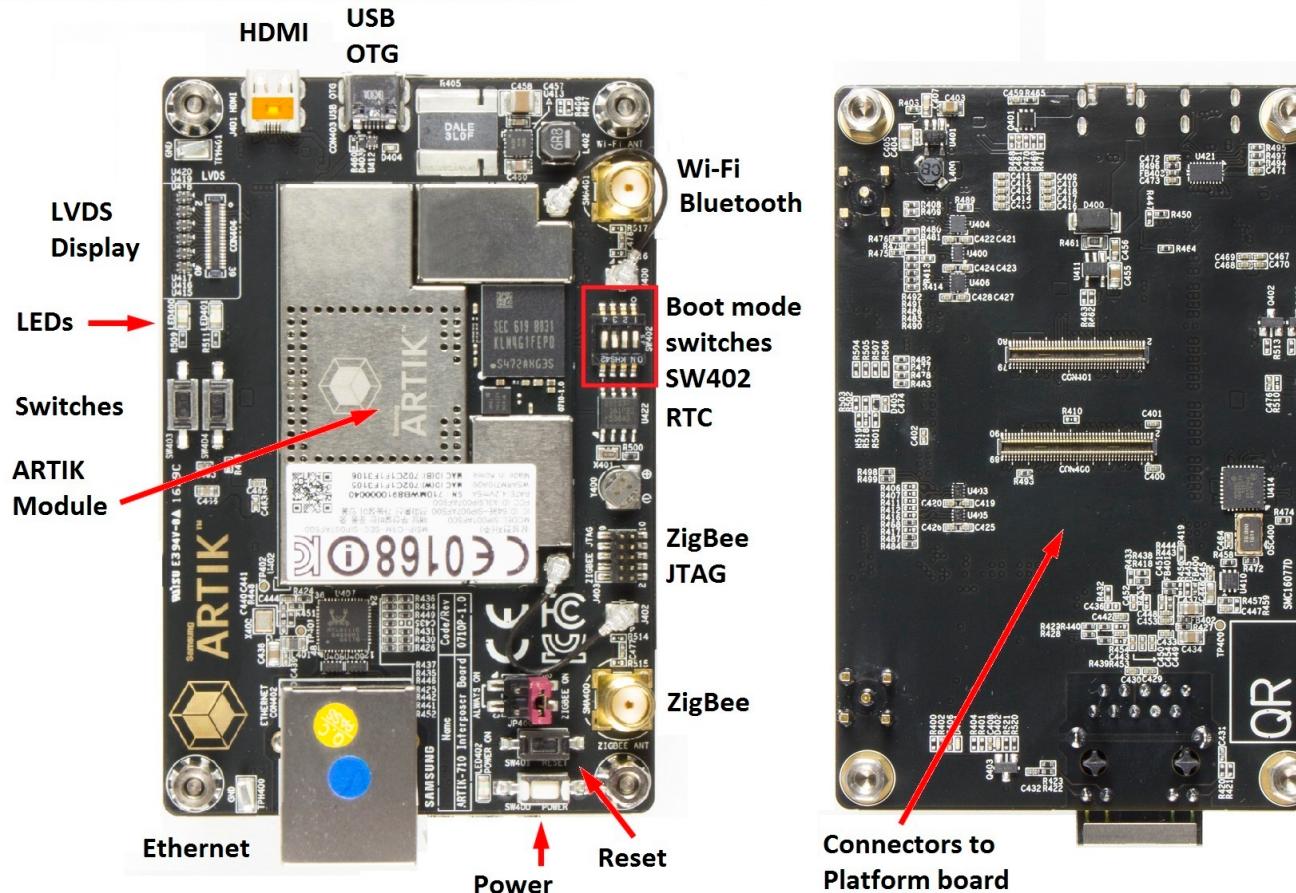


<b>Processor</b>	CPU: 8x ARM® Cortex® A53 @ 1.4 GHz GPU: 3D graphics accelerator
<b>Memory</b>	DRAM: 1 GB DDR3 @ 800 MHz Flash: 4 GB eMMC v4.5
<b>Multimedia</b>	Camera I/F: 4-lane MIPI CSI Display: 4-lane MIPI DSI up to FHD@24 bpp, LVDS, HDMI v1.4 Audio: I²S audio interface
<b>Connectivity</b>	WLAN (Wi-Fi): IEEE 802.11 b/g/n/ac Bluetooth: 4.1+ 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*, <small>*S-modules</small>
<b>I/O</b>	GPIO, I²C, I²S, SPI, UART, PWM, SDIO, USB 2.0, JTAG, analog input
<b>Temperature range</b>	0° to 70° (°C)
<b>Size</b>	36 mm W x 49 mm H x 3.4 mm D

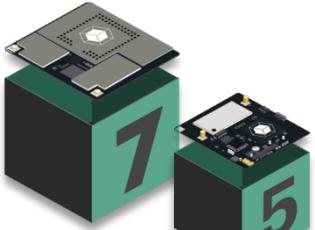
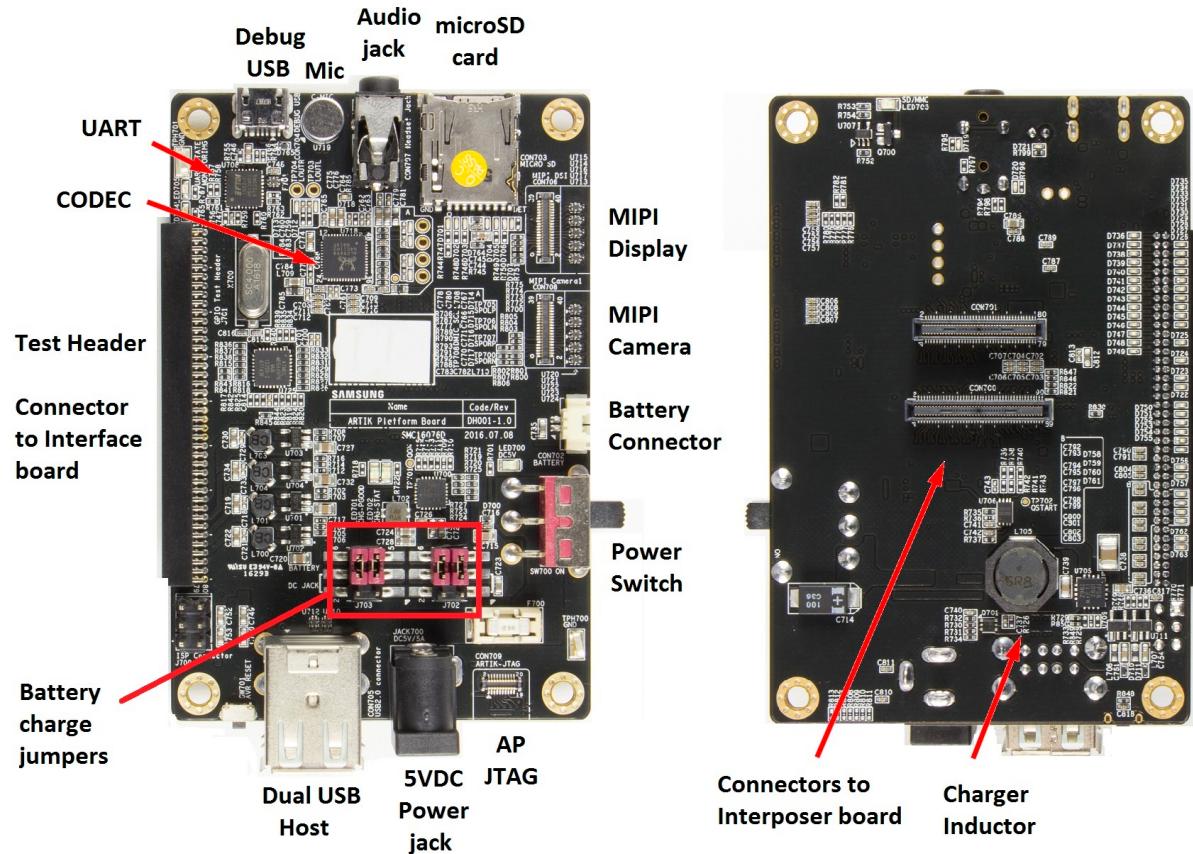
# ARTIK High-end module development board



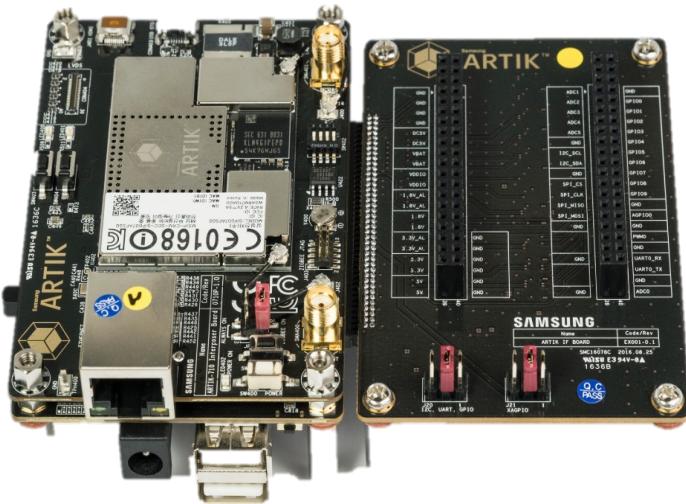
# ARTIK High-End Module Interposer Board



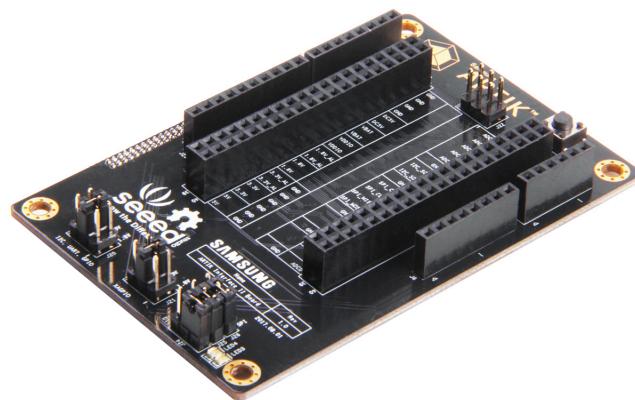
# ARTIK Gateway Module Platform Board



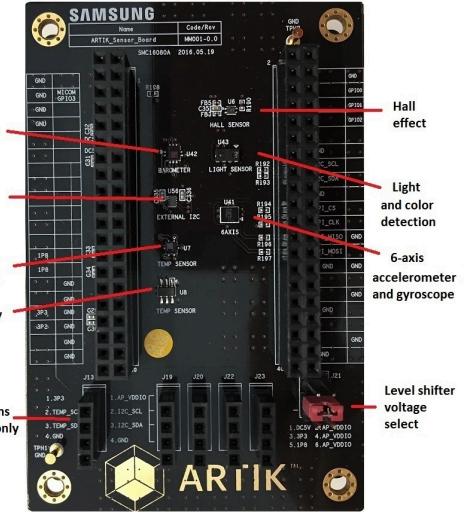
# ARTIK Gateway Module Expansion Boards



Interface Board



Interface Board II

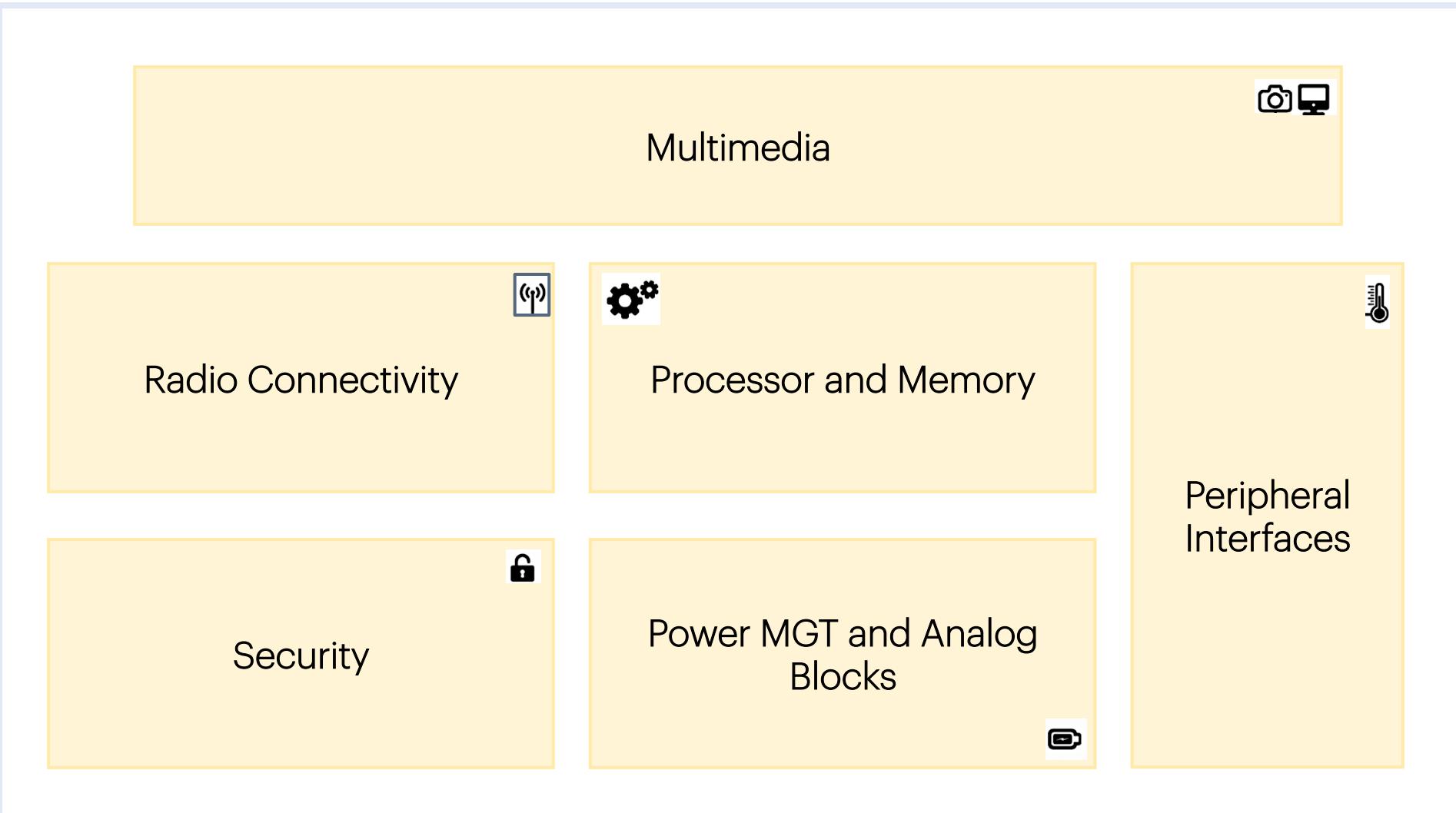


Sensor Board

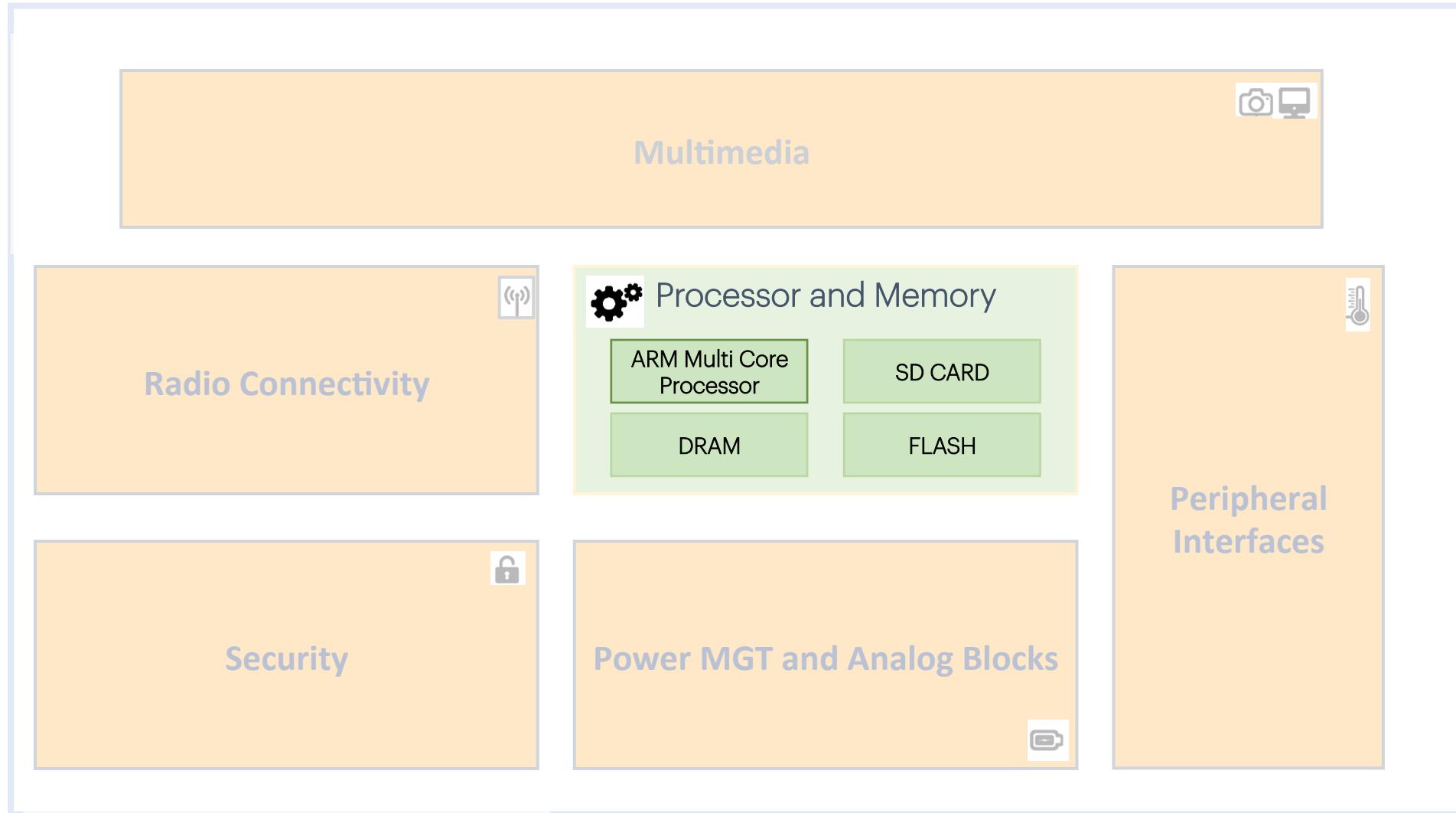
# ARTIK Gateway Module

## 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	✓	✓	✓

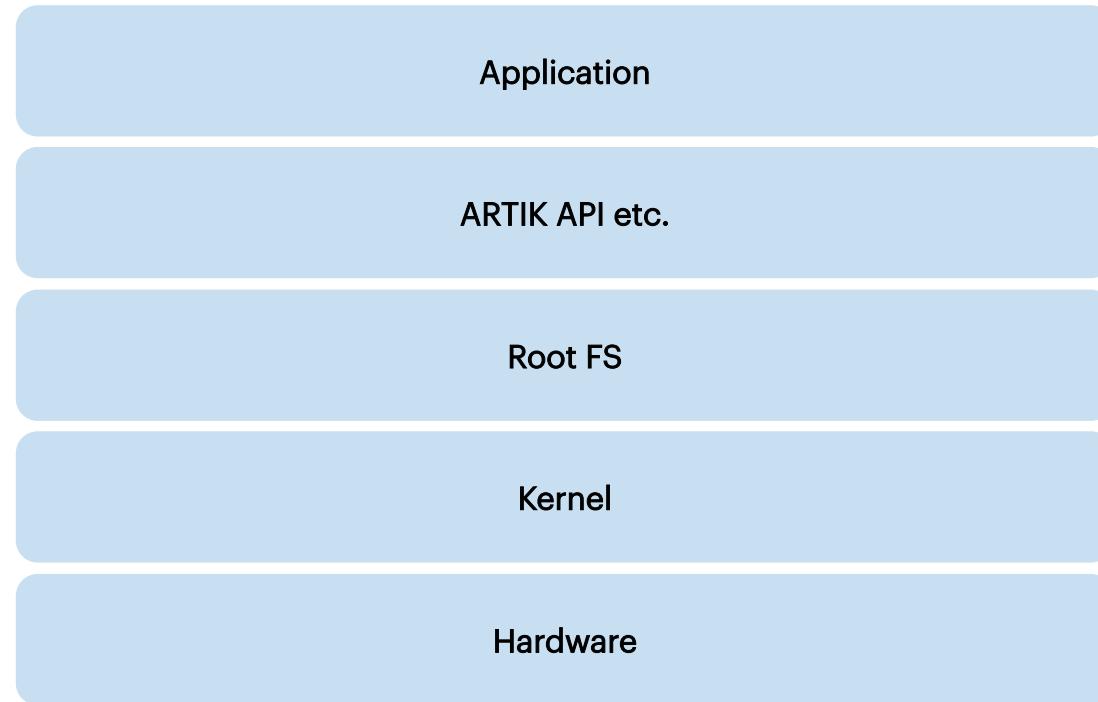
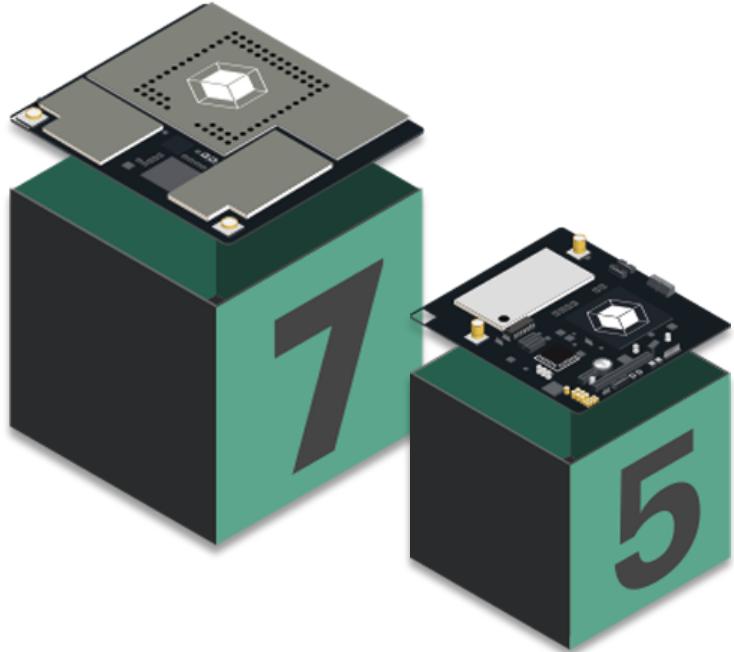
\*USB device mode only for 520, rest of the module is both device and host mode.

# 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

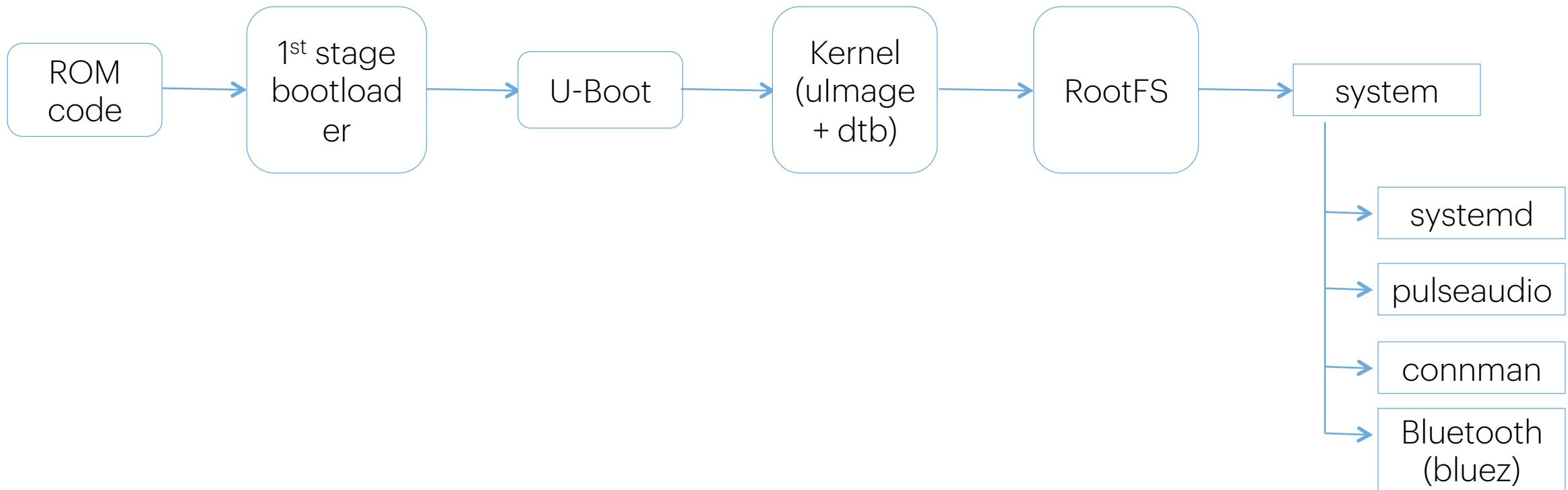
# ARTIK Gateway Module Software Stack

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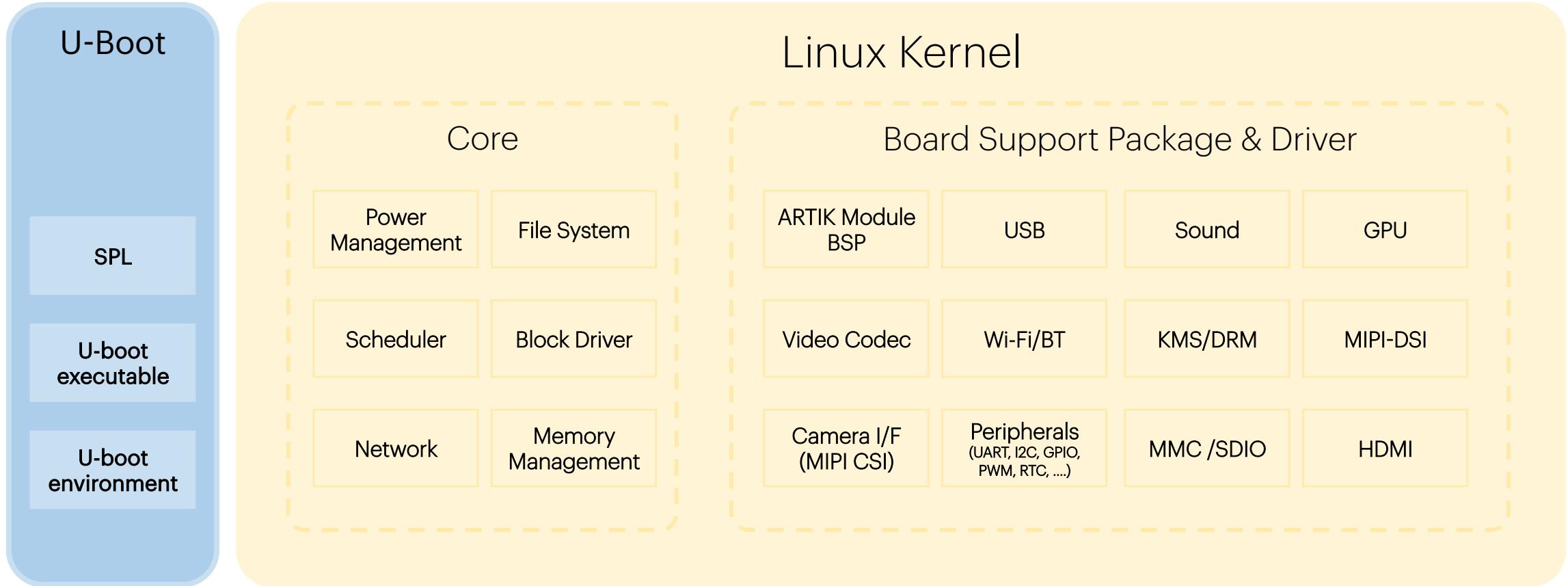


# Boot Modes and Sequence

## eMMC Boot Sequence

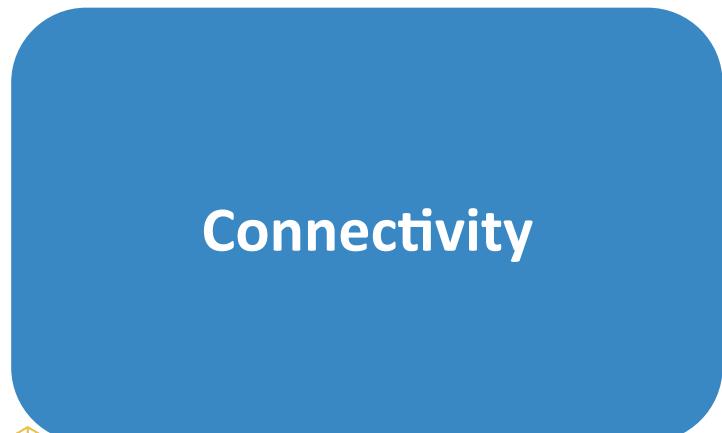
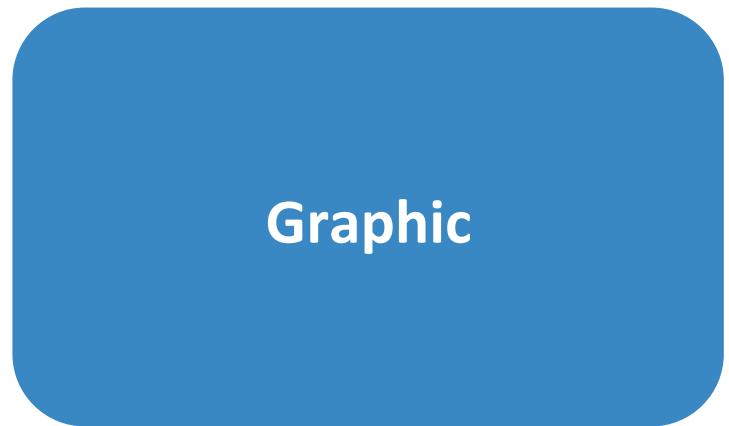
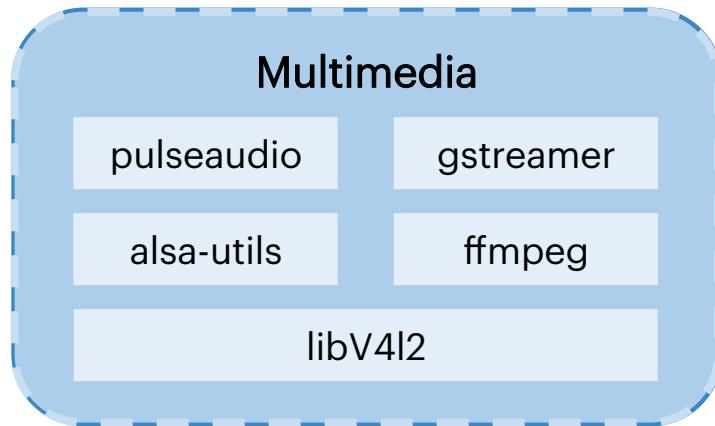
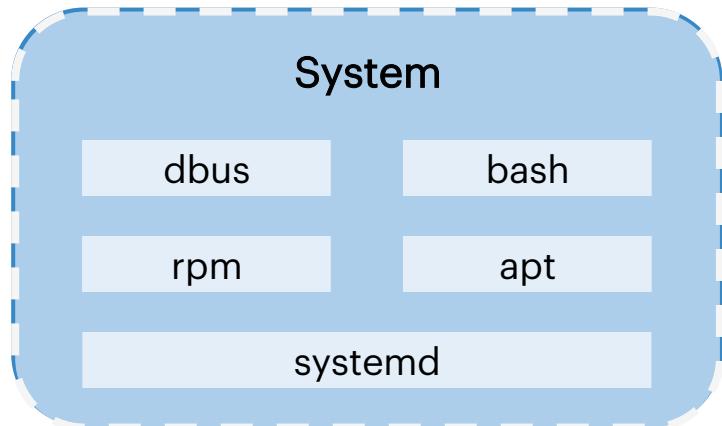


# U-Boot and Linux Kernel Architecture

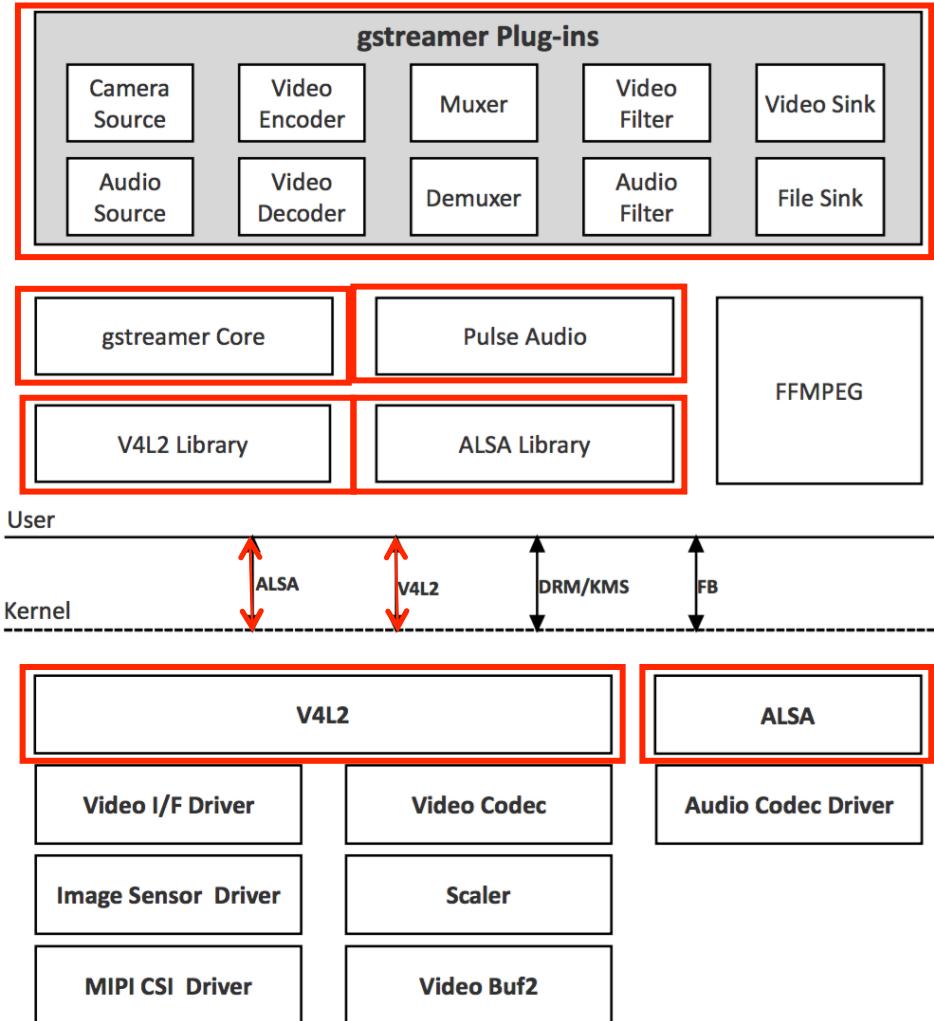


# Architecture of Rootfs

## Rootfs



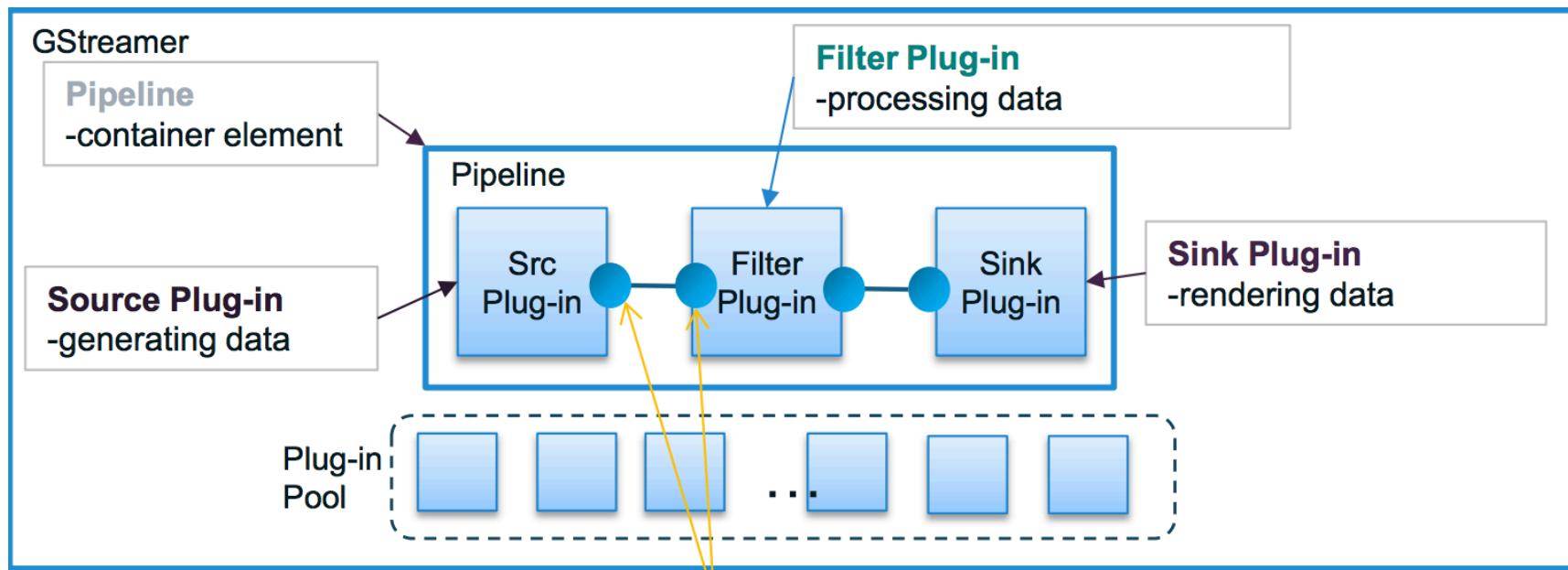
# Multimedia Architecture



- 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

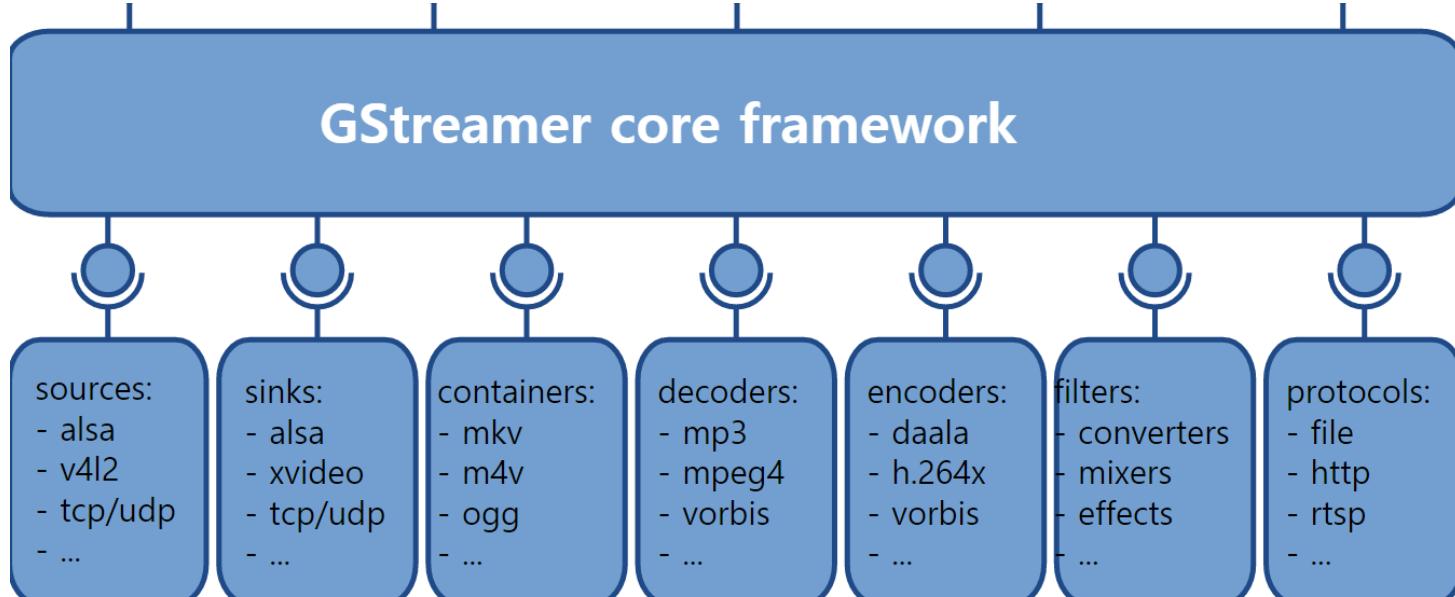
# GStreamer

- Pipeline-based multimedia framework that links together a wide variety of media processing system to complete complex workflows (<https://gstreamer.freedesktop.org/>)



# GStreamer Plugins

- GStreamer uses a plug-in architecture which makes the most of Gstreamer's functionality implemented as shared libraries.
- Various types including source, sinks, filters, etc.



## GStreamer plugins

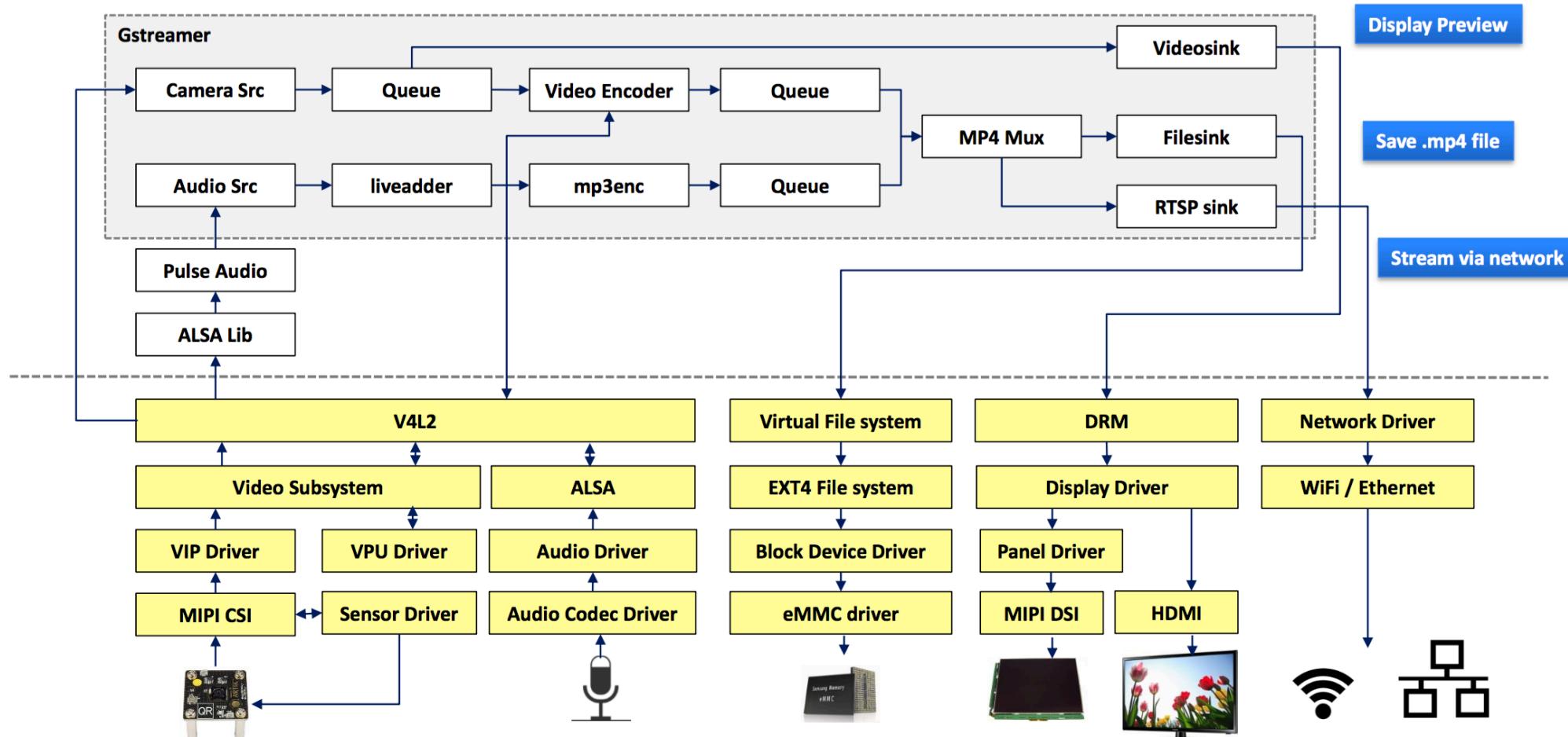
GStreamer includes over 150 plugins  
software plugins are executed on the host CPU  
hw accelerated plugins shunt execution to acceleration DSPs and the result back

## 3rd party plugins

Texas Instruments, Motorola,  
et al.

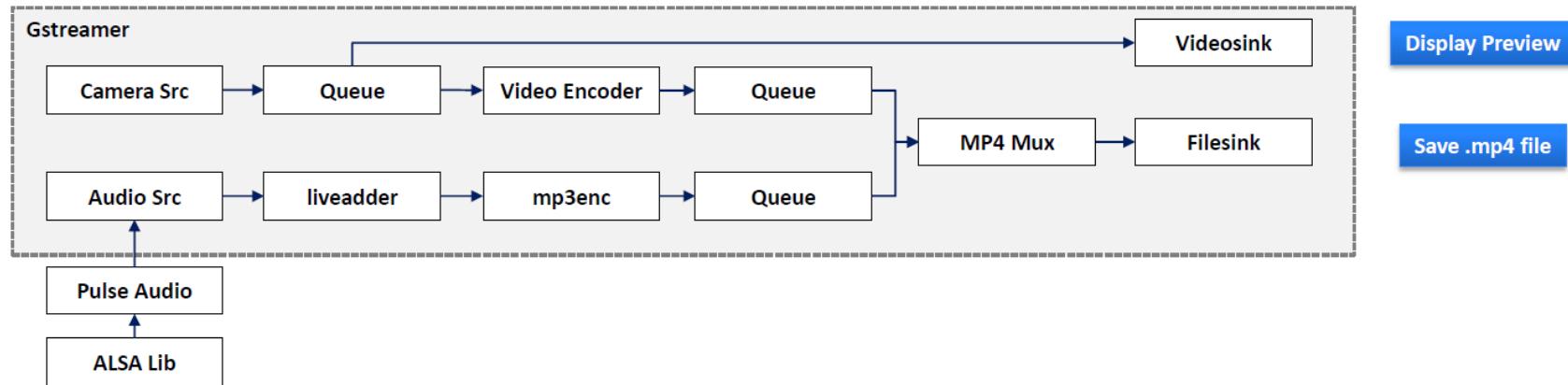
# ARTIK Multimedia Example

Record a HD MP4 movie with sound and simultaneous preview on display, stream via network



# GStreamer Pipeline Example for ARTIK 5x/7x

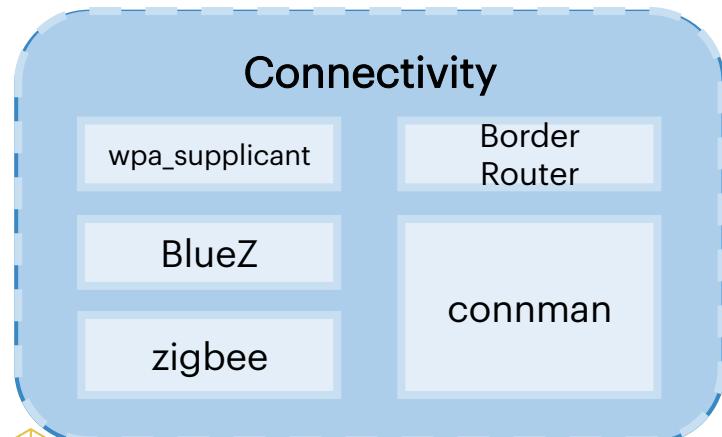
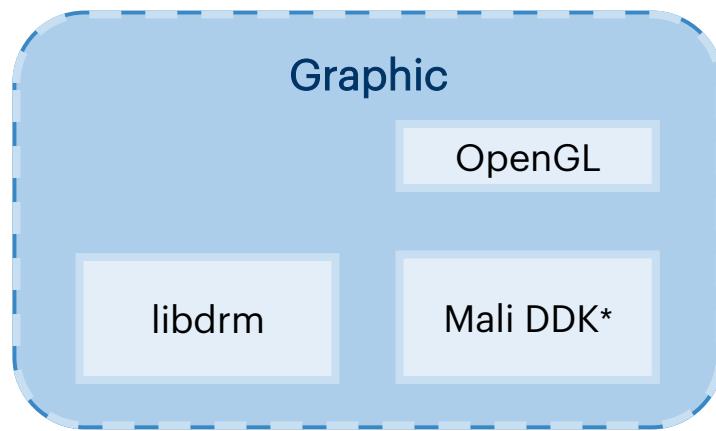
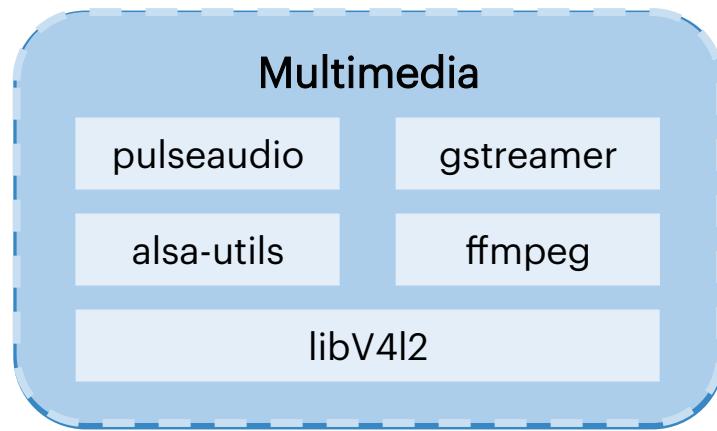
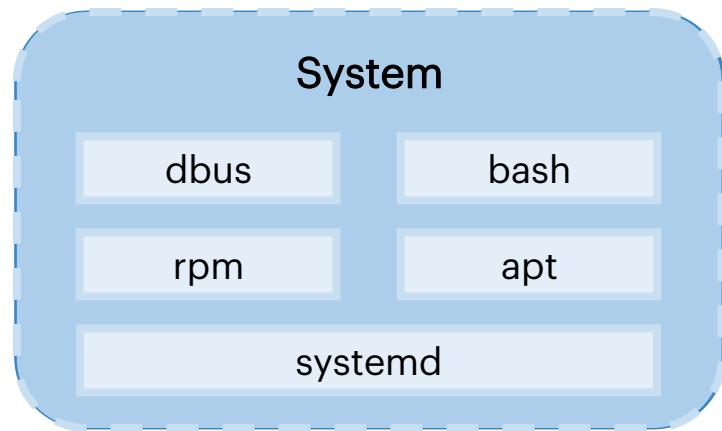
- Record a HD MP4 movie with sound and simultaneous preview on display



```
gst-launch-1.0 -e camerasrc camera-crop-width=1280 camera-crop-height=720 ! tee name=t \
t. ! queue ! nxvideoenc bitrate=12000000 ! queue ! mux. \
autoaudiosrc ! liveadder start-time-selection=2 start-time=600000000! lamemp3enc ! queue ! mux. \
t. ! nxvideosink \
mp4mux name=mux ! filesink location=result_a.mp4
```

# Architecture of Rootfs

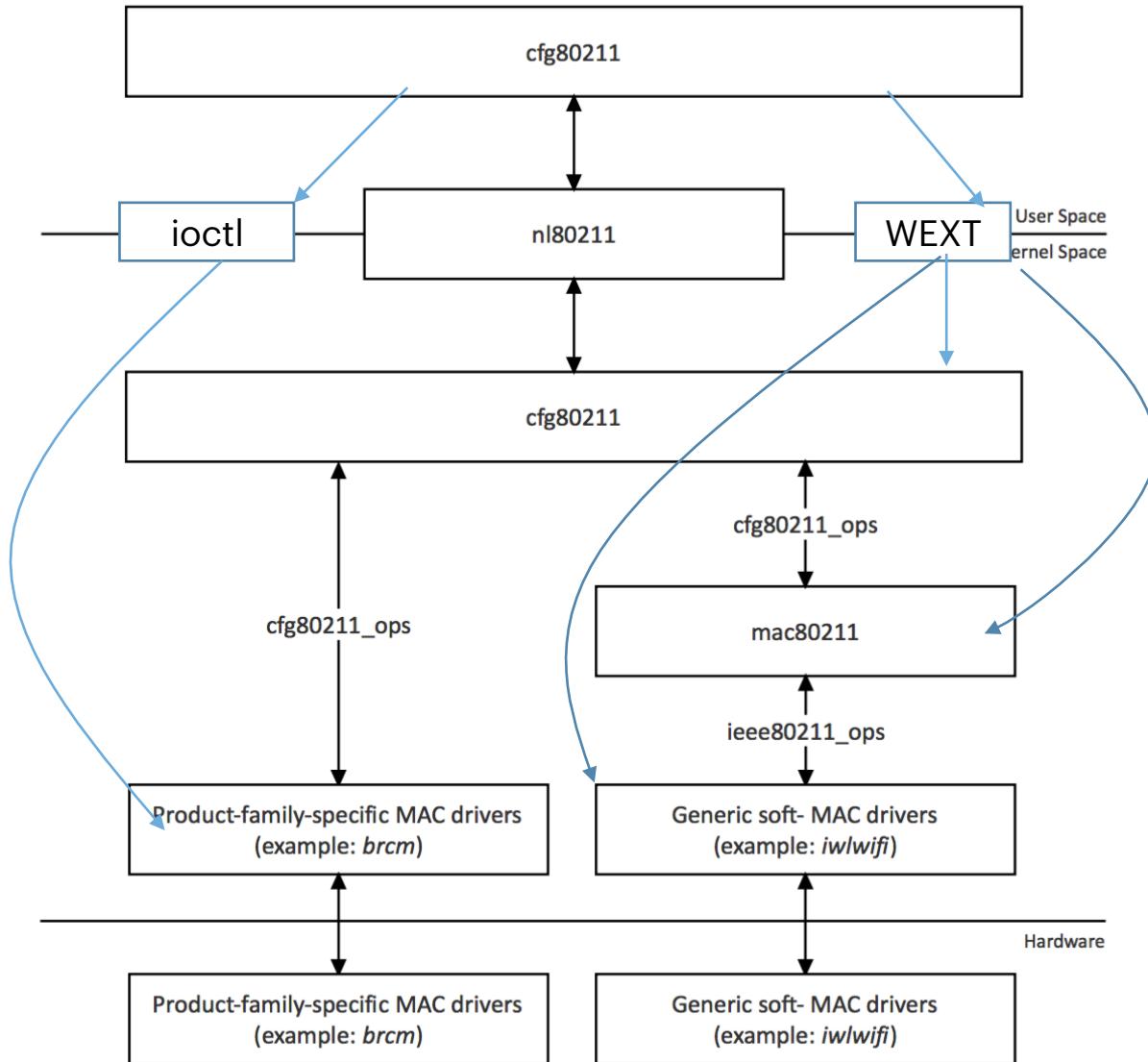
## Rootfs



# wpa\_supplicant

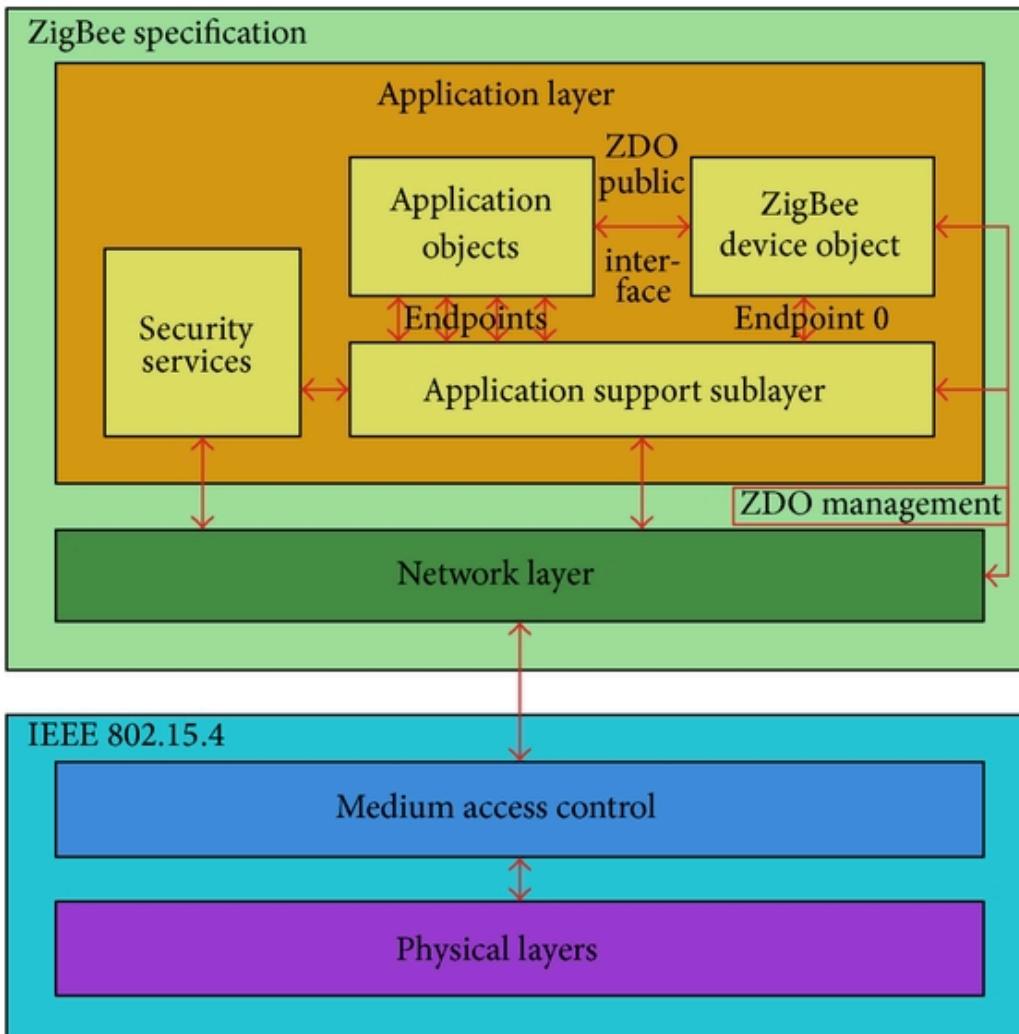
- Supplicant is used in the client stations for key negotiation with a WPA Authenticator.
- wpa\_supplicant is designed for Linux, BSD and Windows with support for WEP, WPA and WPA2. It uses hardware, driver and OS independent, portable C code
- A daemon program running in the background and acting as the backend component controls the wireless connection.

# WiFi Flow



- nl80211: Interface between user space and kernel.
- cfg80211: configuration API for 802.11 devices.
- 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
- mac80211: Implements the MAC layer functions, also the cfg80211 callbacks.

# ZigBee



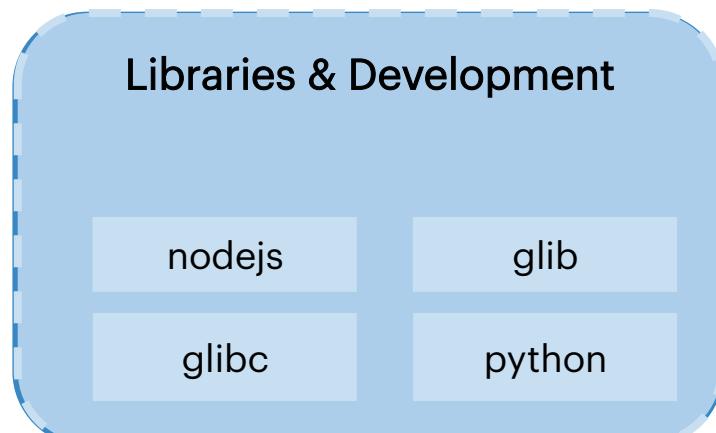
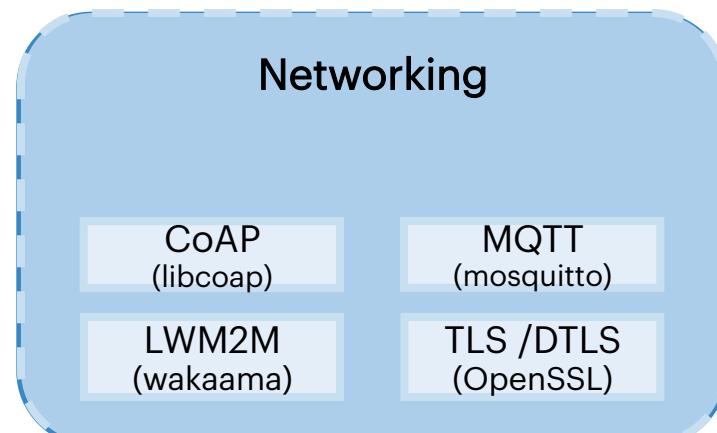
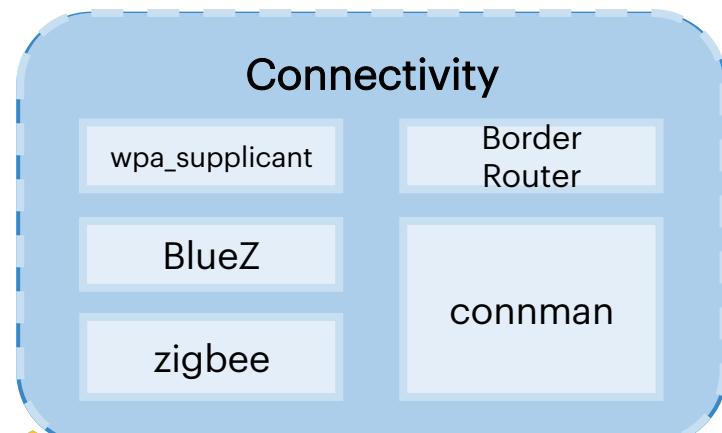
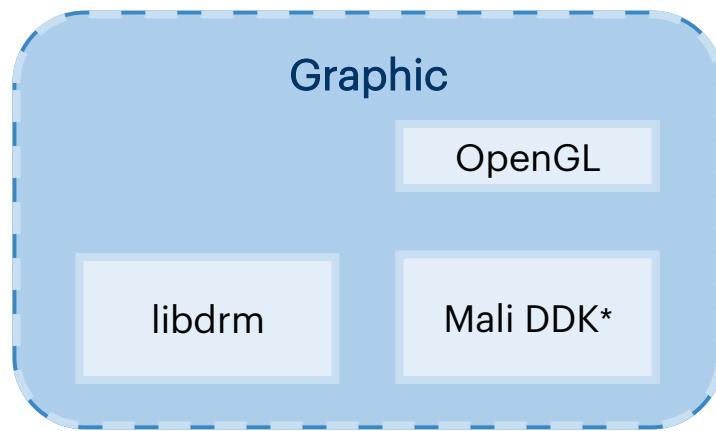
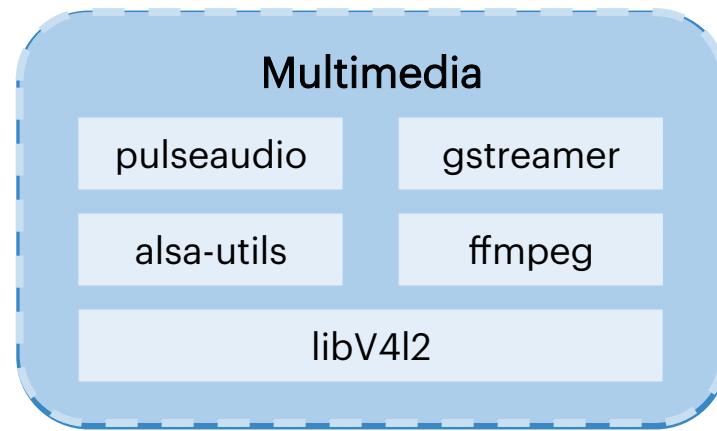
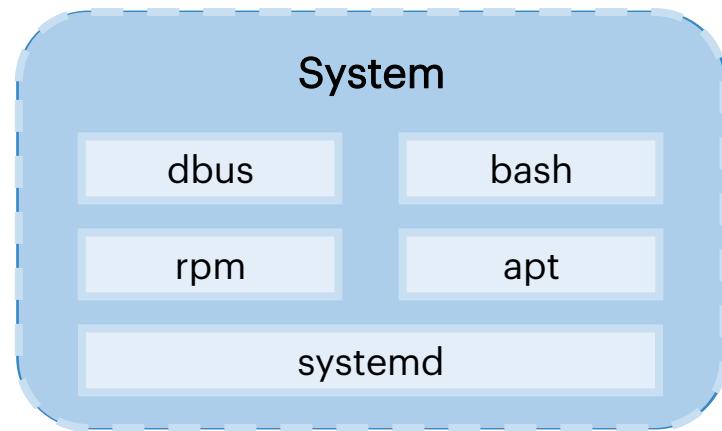
It defines various addressing objects including profiles, clusters and endpoints

How is the network formed?  
How are addresses assigned?

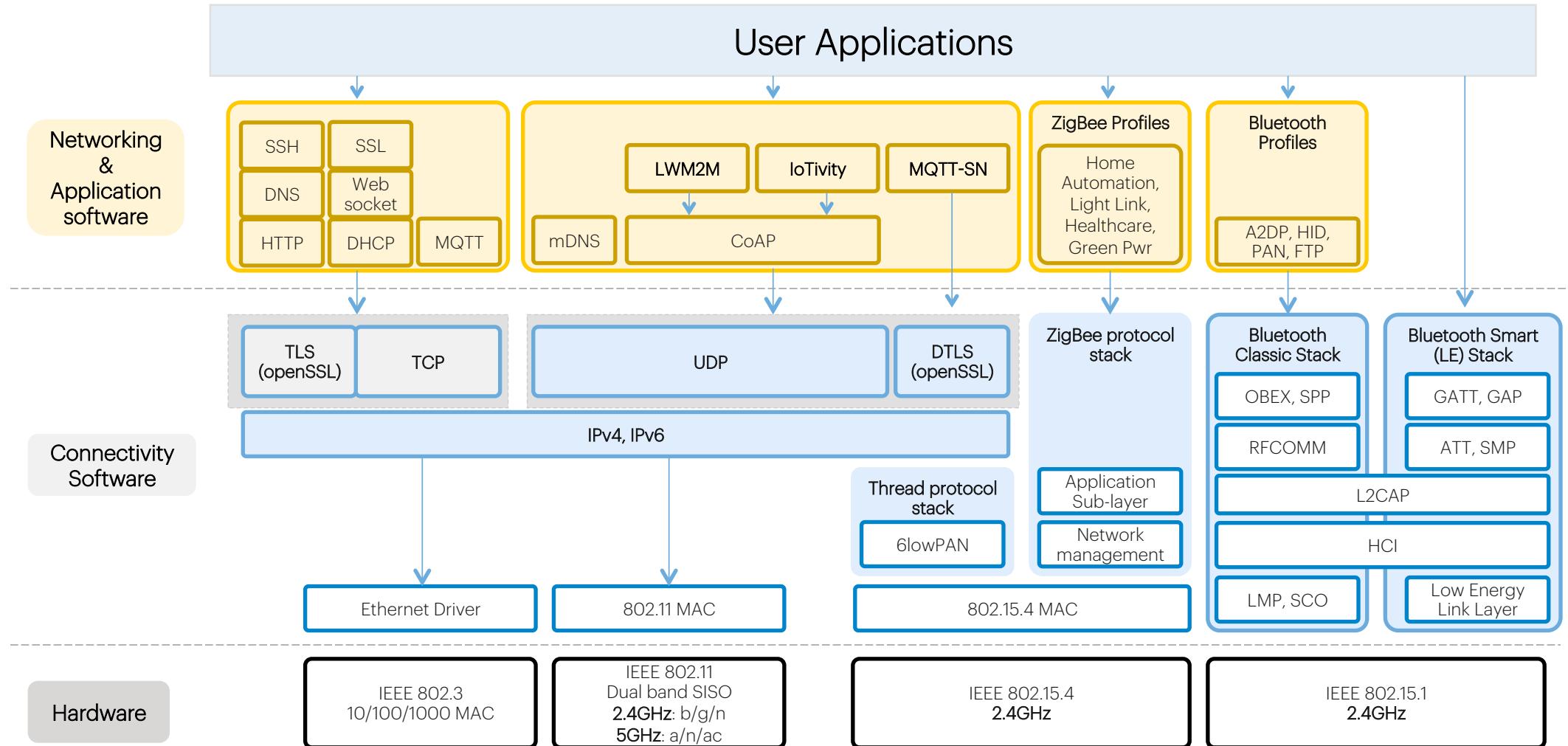
How does transmission work?  
What frequency and channel we should use?

# Architecture of Rootfs

## Rootfs

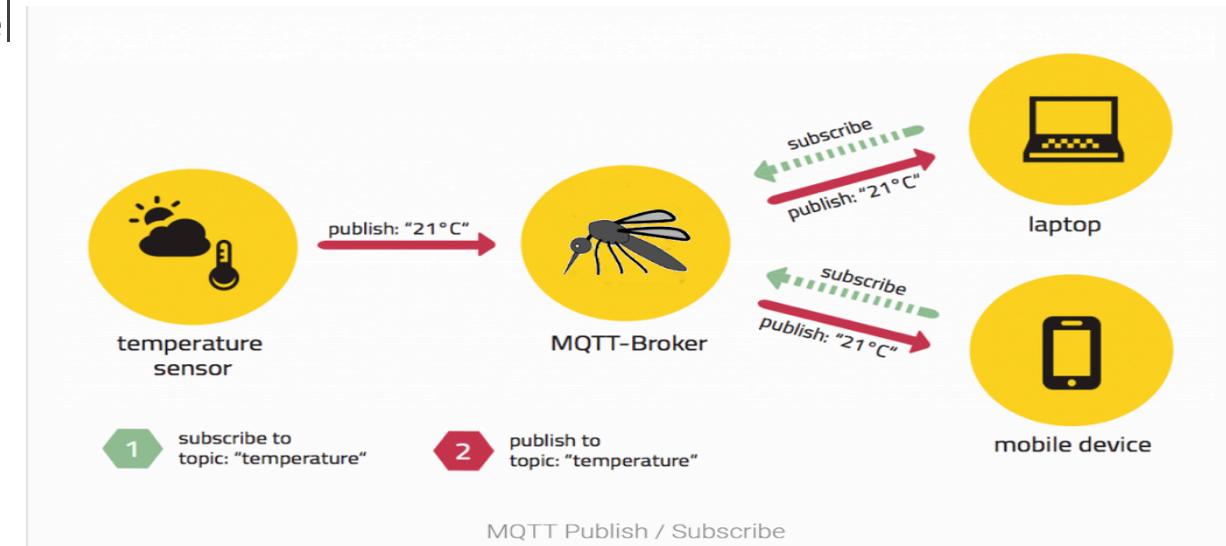


# Network Stack



# Message Queue Telemetry Transport (MQTT)

- MQTT history
- Light-weight messaging protocol, rides on TCP
- Broker / Clients architecture
- Publication / Subscription messaging model
- No pre-defined format for payload



# Message Queue Telemetry Transport (MQTT)

- MQTT client includes publisher or subscriber
- In general, a MQTT client can be both a publisher & subscriber at the same time
- A MQTT client can run on any device from a micro controller up to a server. MQTT C client code only takes 30KB, Java code is about 100KB.
- MQTT client libraries are available for a huge variety of programming languages, e.g, C/C++, Arduino, Java, JavaScript, Android, iOS, C#, .NET

<https://github.com/mqtt/mqtt.github.io/wiki/libraries>

- MQTT client: Eclipse Paho



MQTT.fx (available for Win/MacOS/Linux) etc.

# Message Queue Telemetry Transport (MQTT)

- MQTT Broker is responsible for receiving all messages, filtering them, and sending the messages to all subscribed clients.
- It holds the session of all persistent clients including subscriptions and missed messages
- Authentication and authorization of clients.
- Self Hosted MQTT brokers:

Eclipse Mosquitto



HiveMQ(licensed/open)



- Cloud based MQTT brokers:

AWS



IBM Bluemix



HiveMQ ([broker.hivemq.com](http://broker.hivemq.com))



Microsoft Azure

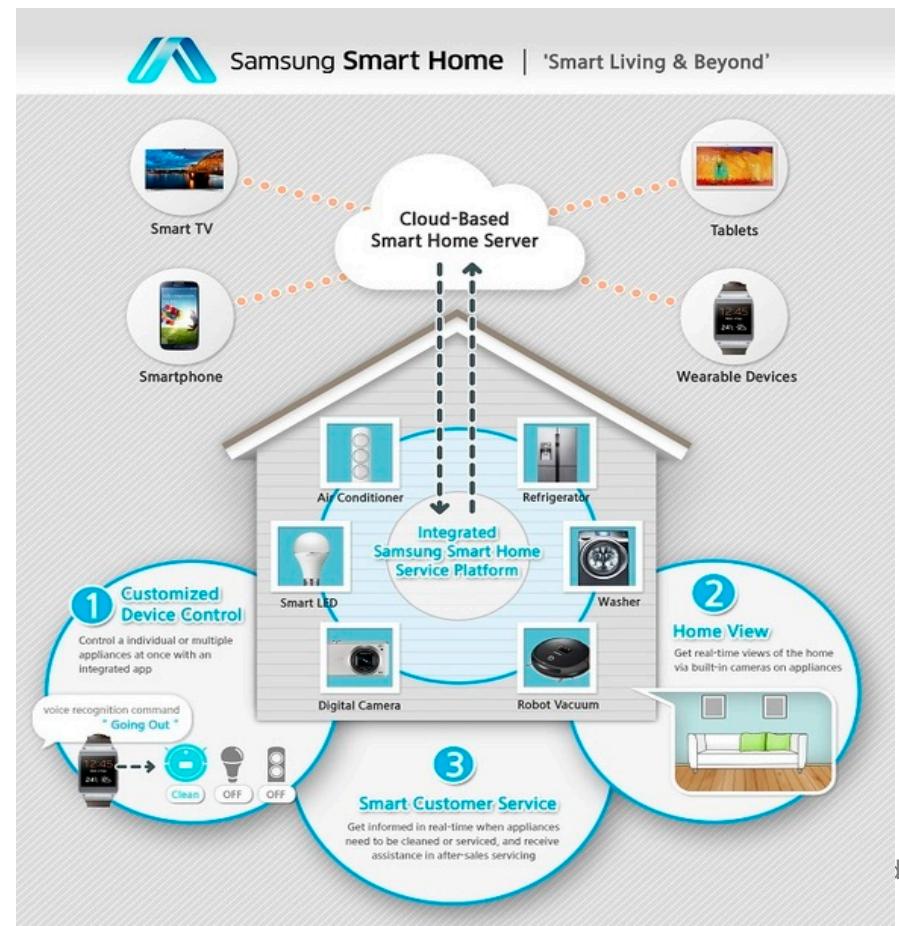


Eclipse Mosquitto ([test.mosquitto.org](http://test.mosquitto.org))



# CoAP

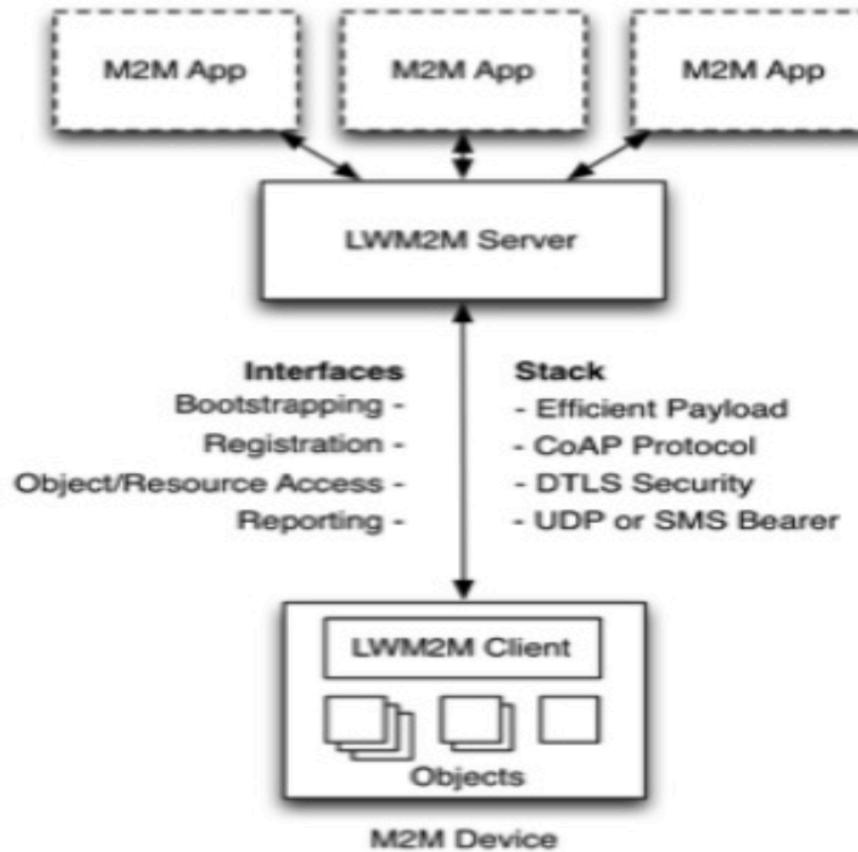
- Similar to HTTP, but designed for the needs of constrained devices
- Client/server model
- Runs over UDP
- Supports resource discovery etc.



# 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 for communication between an LWM2M client and ARTIK Cloud server(an LWM2M server).

# LWM2M Architecture Overview



## LWM2M server

- Persistent endpoint through which devices and apps interact
- Deployable on gateways and/or in the cloud

## LWM2M client

- Hosts resources(objects) that represent a physical device

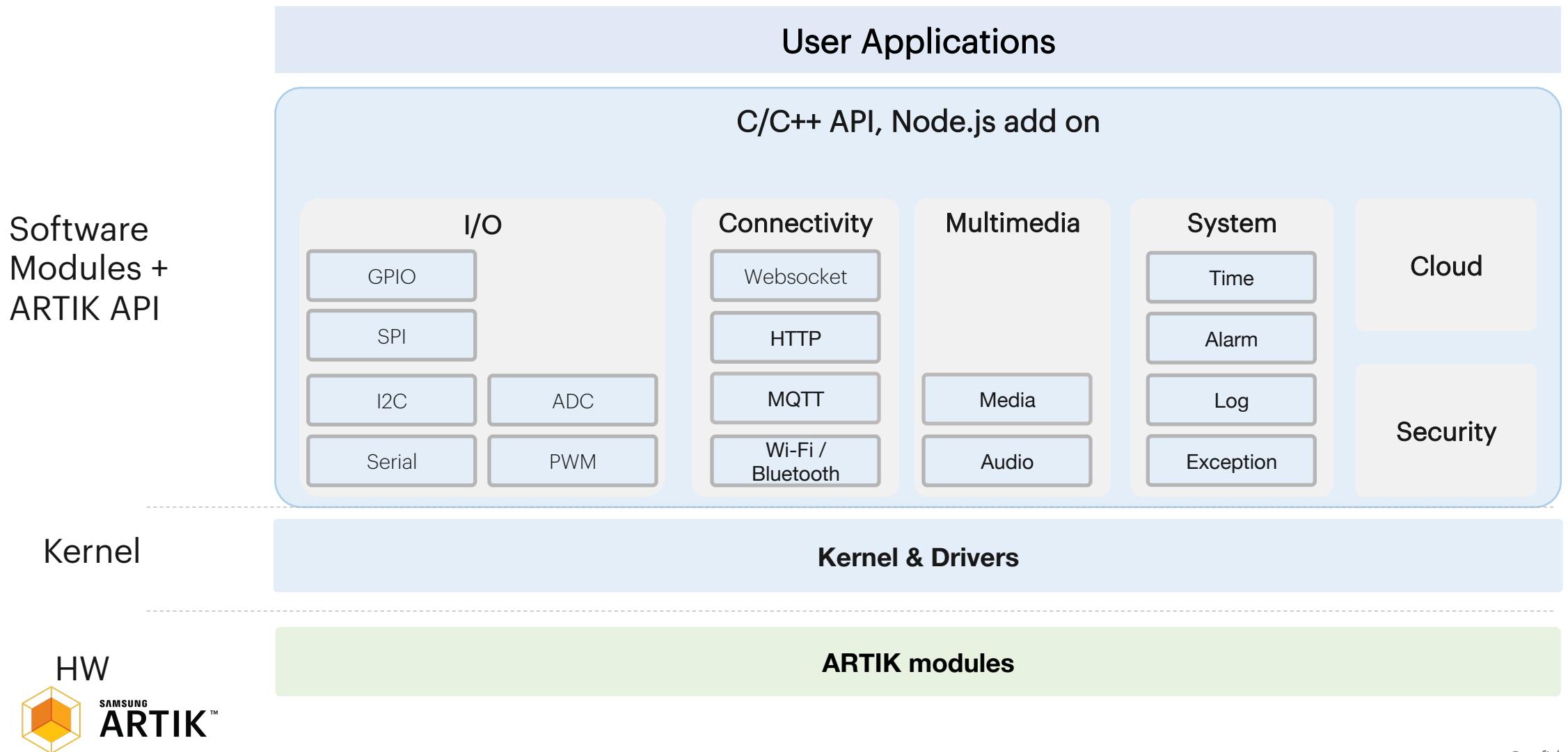
# Eclipse Wakaama



- Eclipse Wakaama is an open source implementation of the OMA LWM2M protocol in C language.
- Includes 3 layers: LWM2M Protocol, CoAP and DTLS layer.
- Implements LWM2M Client, LWM2M Server and LWM2M Bootstrap Server.

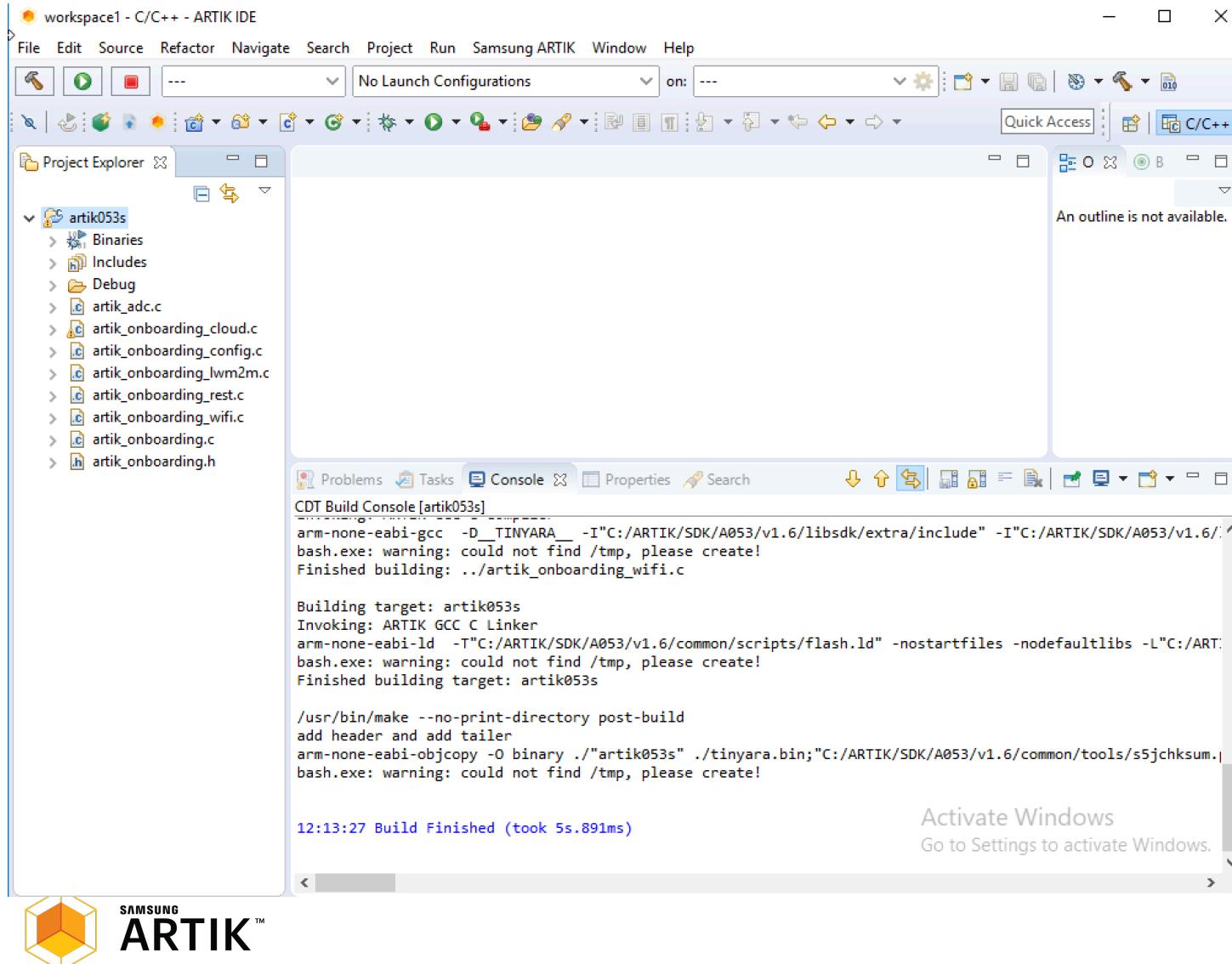


# ARTIK SDK (5, 7 series)



# ARTIK Gateway Module Development

# ARTIK IDE



workspace1 - C/C++ - ARTIK IDE

File Edit Source Refactor Navigate Search Project Run Samsung ARTIK Window Help

No Launch Configurations on: ---

Project Explorer

artik053s

- Binaries
- Includes
- Debug
- artik\_adc.c
- artik\_onboarding\_cloud.c
- artik\_onboarding\_config.c
- artik\_onboarding\_lwm2m.c
- artik\_onboarding\_rest.c
- artik\_onboarding\_wifi.c
- artik\_onboarding.c
- artik\_onboarding.h

An outline is not available.

Problems Tasks Console Properties Search

CDT Build Console [artik053s]

```
arm-none-eabi-gcc -D_TINYARA_ -I"C:/ARTIK/SDK/A053/v1.6/libsdk/extra/include" -I"C:/ARTIK/SDK/A053/v1.6/..^
bash.exe: warning: could not find /tmp, please create!
Finished building: ../artik_onboarding_wifi.c

Building target: artik053s
Invoking: ARTIK GCC C Linker
arm-none-eabi-ld -T"C:/ARTIK/SDK/A053/v1.6/common/scripts/flash.ld" -nostartfiles -nodefaultlibs -L"C:/ARTI^
bash.exe: warning: could not find /tmp, please create!
Finished building target: artik053s

/usr/bin/make --no-print-directory post-build
add header and add tailer
arm-none-eabi-objcopy -O binary ./"artik053s" ./tinyara.bin;"C:/ARTIK/SDK/A053/v1.6/common/tools/s5jchksu^
bash.exe: warning: could not find /tmp, please create!
```

12:13:27 Build Finished (took 5s.891ms)

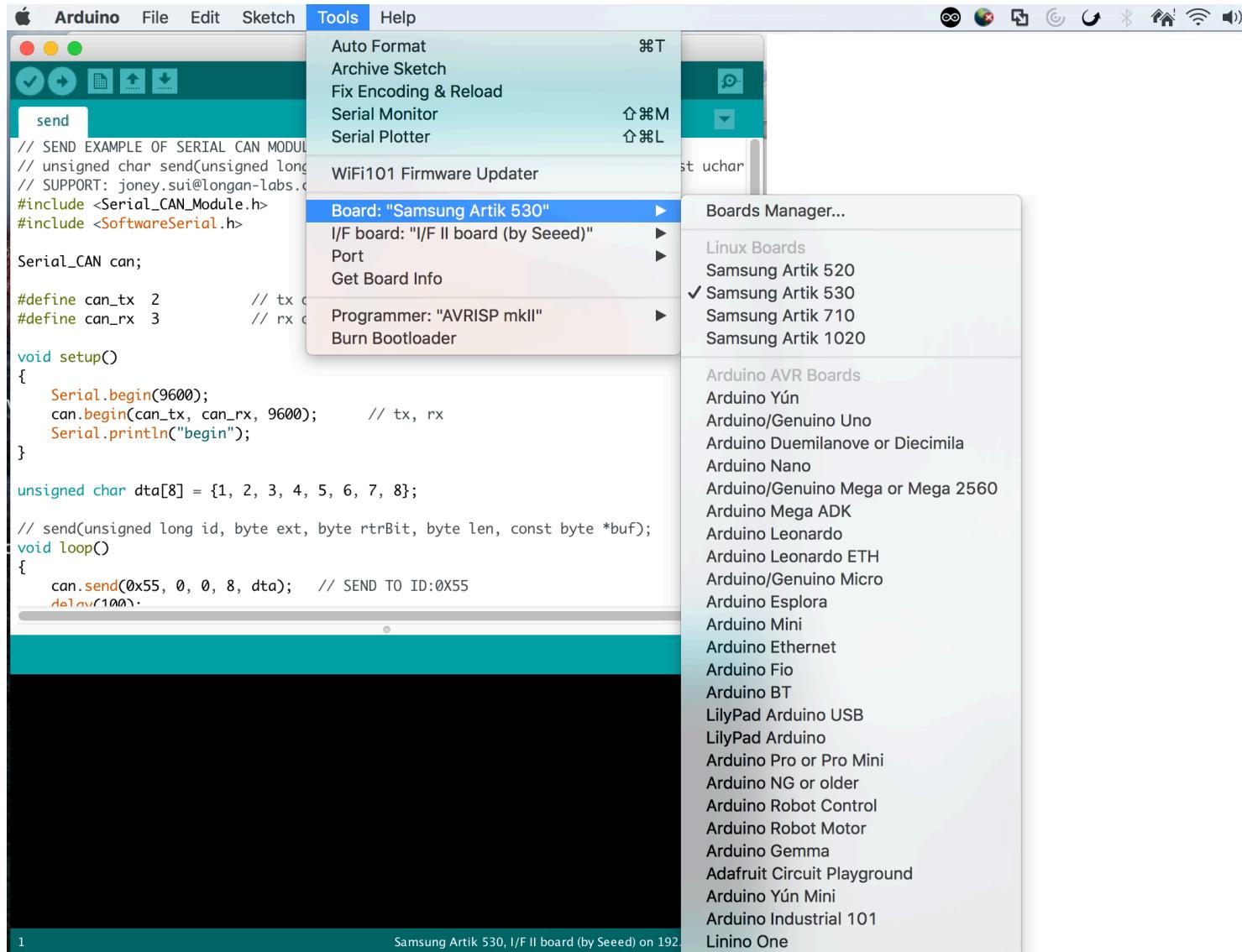
Activate Windows  
Go to Settings to activate Windows.

SAMSUNG ARTIK™



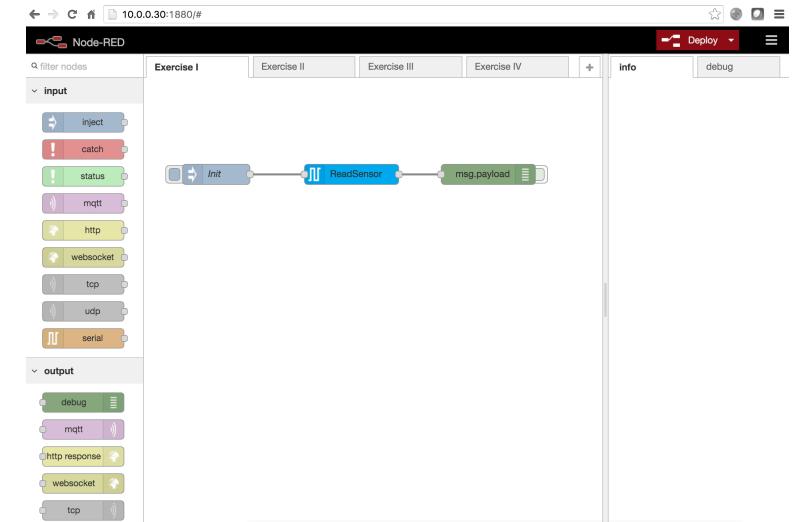
gcc-arm-linux-gnueabihf  
(32 bit for ARTIK 5x)  
and  
aarch64-linux-gnu  
(64 bit for ARTIK 7x)

# 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:

# 3<sup>rd</sup> party Libraries/APIs

- Multimedia: PyAudio, OpenCV, Speech Recognition etc.
- Communication Protocols/Frameworks:
  - MQTT(Eclipse Mosquitto/Paho)
  - CoAP (libcoap)
  - LWM2M(Eclipse Wakama, Eclipse Leshan)
  - OPC-UA(Eclipse Milo, open62541)

# Open Source Frameworks, Solutions

## Gateway Solutions:



## Communication Protocols/Frameworks:



# ARTIK Gateway Module Use Case

# 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 Ox, ARTIK 5/7 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 Industry 4.0, enable access to data and create digital twins for more efficient operations. Ensure secure operations.

**Products:** ARTIK 05x and 530s secure system-on-module, ARTIK Cloud service, PTC ThingWorx

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

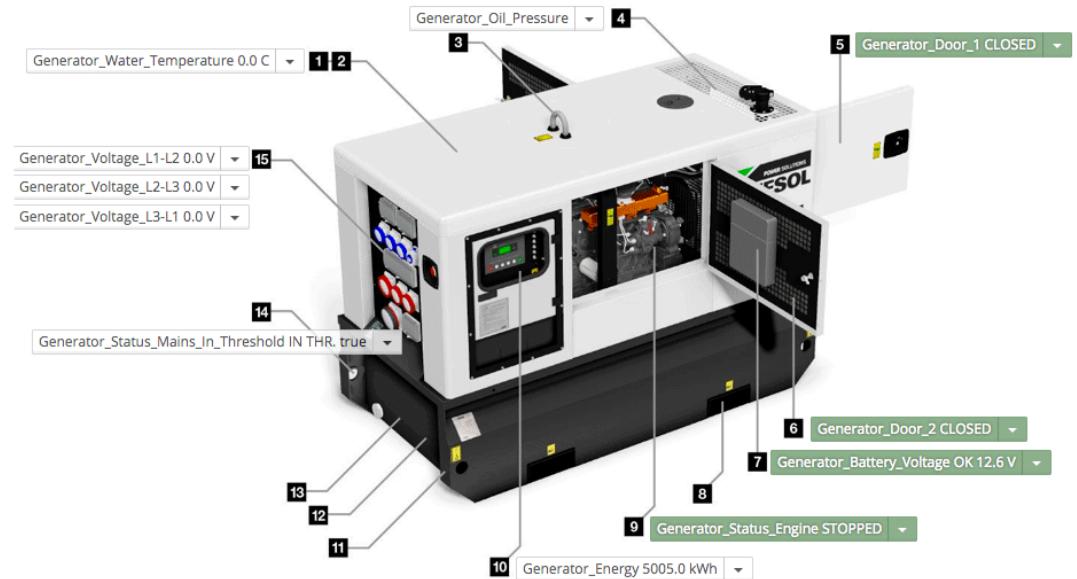
# Kitra GTI ARTIK 710s

Use Kitra GTI as the Industrial IoT Gateway

**Use case:** Industrial IoT Gateway device, hubs

**Hardware:** ARTIK 710S

**Software:** Software based on your application



# Long-range Connectivity

## ARTIK 530s with Multi-tech

Provide LTE support on ARTIK 530s with Multi-tech modem and Twilio SIM. Send a text message to Twilio phone number and receive real-time readings from sensors attached to ARTIK 530s.

**Use case:** Smart city, remote data transmission and monitoring systems, freight management

**Hardware:** ARTIK 530s, Multi-tech modem, Twilio SIM card, (optional) screen LCD

**Software:** Twilio APIs, Qt for UI



# Facial Recognition Security Camera

## ARTIK 530s

Uses ARTIK 530s and camera accessories for facial recognition. Non-enrolled faces will trigger alerts. Motion detection and video capture can be enabled.

**Use case:** Home surveillance, access control system

**Hardware:** ARTIK 530s, OV5640 5M Auto Focus USB camera, 10.1" PCAP Touch Screen LCD, sensors

**Software:** OpenCV, Kairos face recognition APIs, Qt



# Voice Enablement

## ARTIK 530s SoM and Google Assistant

Run Google Assistant or Amazon AVS on ARTIK530s. Use voice commands to control peripherals or sensors attached to ARTIK.

**Use case:** Voice-controlled gateway, home and building products

**Hardware:** ARTIK 530s, speaker, (optional) LCD

**Software:** Google Assistant SDK or Alexa Voice Service Device SDK. Can develop additional Google Actions or Alexa skills to extend basic capabilities.



# Machine Learning Inference

## ARTIK 5x/7x

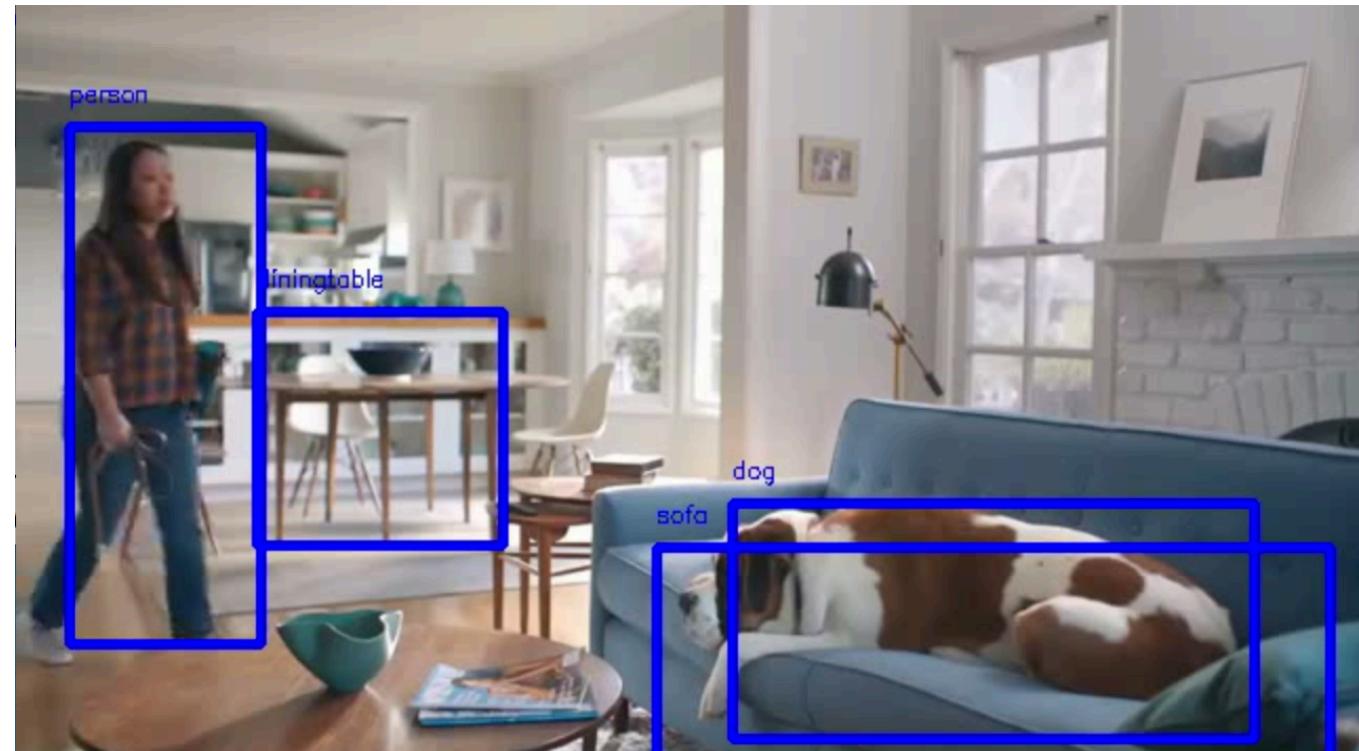
Run Machine Learning Inference on ARTIK gateway devices

**Use case:** Smart Factory, Smart Building etc.

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

**Software:** Tensorflow (Lite);

AWS Greengrass ML Inference;



# 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>

# Training Github Repository

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



# ARTIK Training Tues

# Samsung ARTIK™ Training Tues

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

## **Level 1: ARTIK Fundamentals** (Lecture with interactive exercises. No ARTIK hardware is required)

L1\_1: ARTIK Intro: ARTIK Intro and guide audience through online resources

L1\_2: ARTIK 310 Intro

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

L2\_1: ARTIK System Design, ARTIK 05x Overview

L2\_2: Cloud communication

L2\_3: Security

L2\_4: HW Interfaces

L2\_5: Connectivity

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

L3\_1: How to use ARTIK with AWS (05x hands-on)

L3\_2: Use TensorFlow Lite on ARTIK 5x for Machine Learning Inference(5x hands-on)

L3\_3: Build a Google Assistant/AVS voice-enabled gateway for smart home(5x hands-on)

