

ARTIK 05x Modules

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Agenda

- ARTIK 05x Module Overview
- ARTIK 05x OS
- ARTIK 05x Development
- ARTIK 05x Ecosystem
- Demo



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

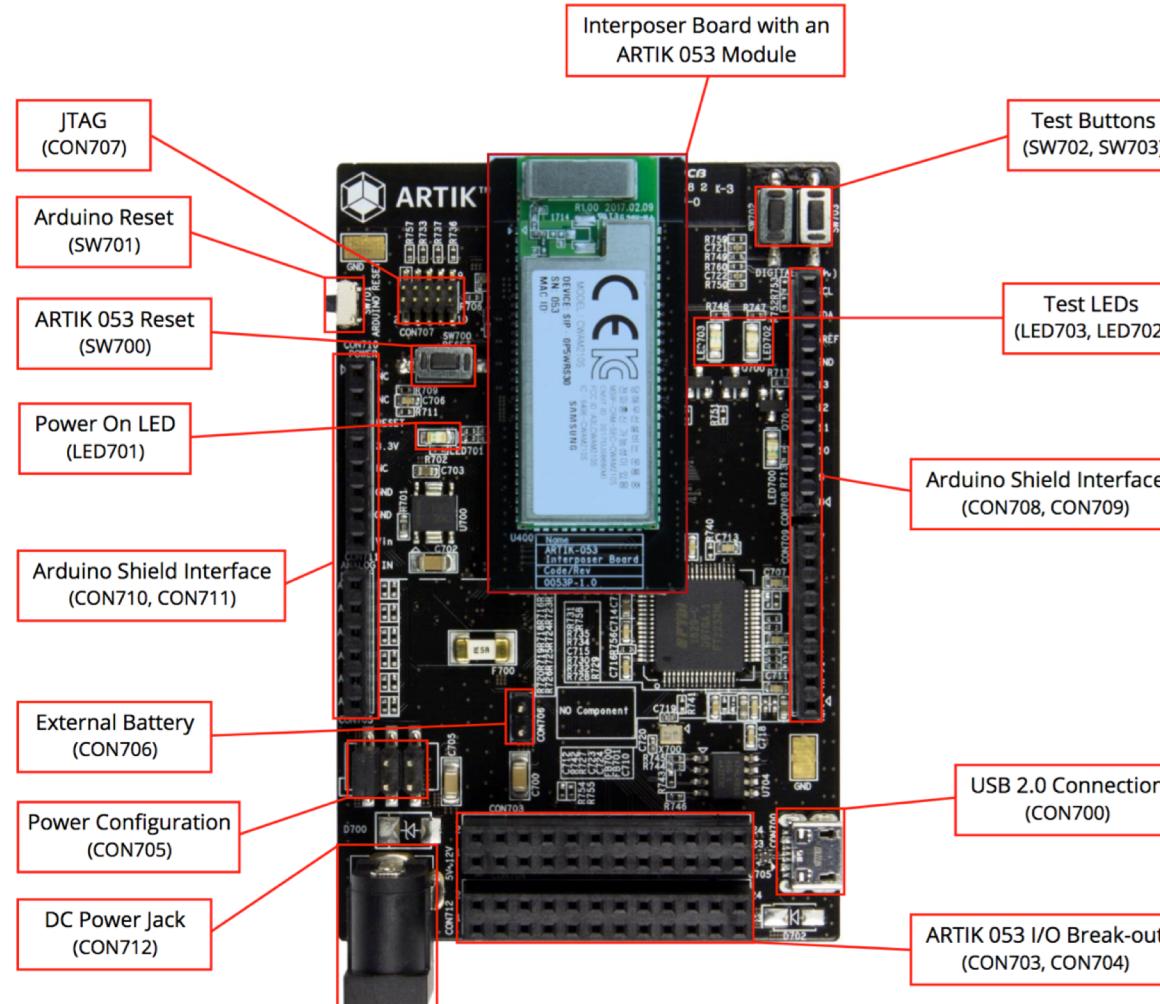
Create secure, next-gen edge products



- 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
Regulatory	FCC (US), IC(Canada), CE(EU), KC(Korea), SRRC(China)
I/O	2xSPI, 5xUART (2-pin), 4xI2C, 7xPWM, 28xGPIO, 1xJTAG, 4xADC
Operating voltage	053, 053s: 5-12 VDC; 055s: 3.3 VDC
Temperature	-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
Security	Secure Subsystem, Hardware-protected key storage with secure point-to-point authentication and data transfer, secure boot*, KMS*

ARTIK 05x Starter Board



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 cross-platform supplicant with support for WEP, WPA and WPA2.
- wpa_supplicant is 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.

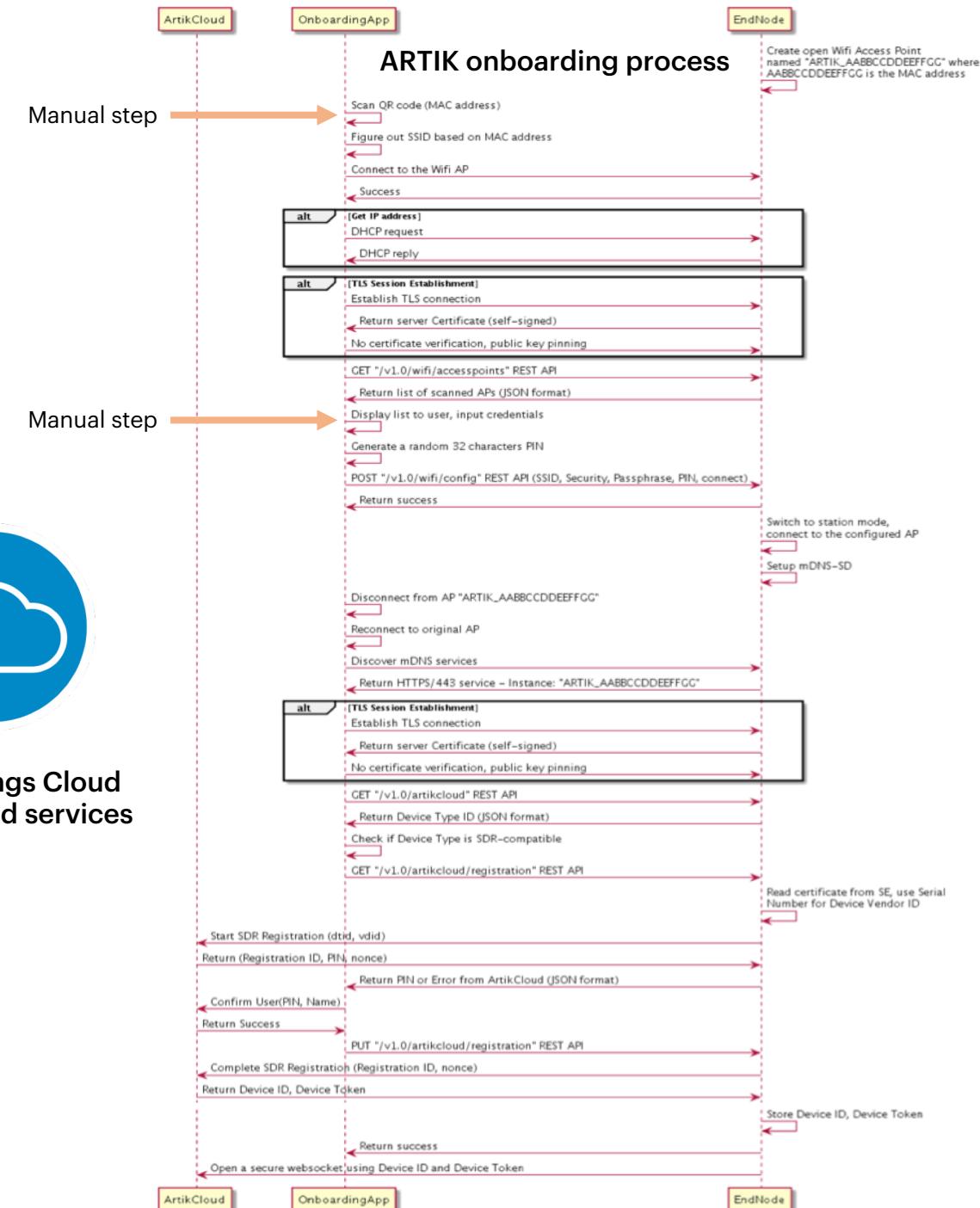
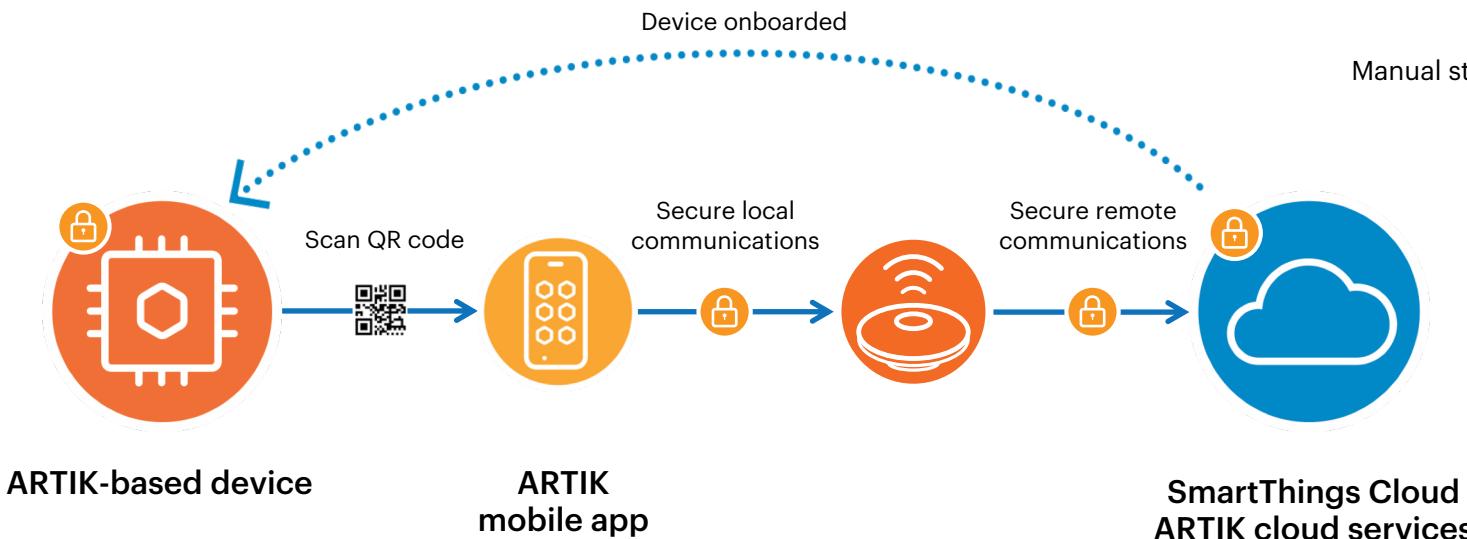


SoftAP mode and Station mode

- ARTIK 05x module WiFi adapter supports both Station mode and SoftAP mode.
- Station: Default operating mode of a WiFi adapter. WiFi adapter operates as a client that connects to a WiFi access point.
- SoftAP(Software enabled access point):
 - WiFi adapter acts as an access point enabling other WiFi devices to connect to it.
 - SoftAP is a common method of onboarding headless WiFi devices.

Samsung ARTIK™

Easy, secure onboarding



Samsung ARTIK™ 05x Power Management

ARTIK 053/053s Module Power Consumption

(measured using 5-12V system power supply)

Category	Scenario	Condition	Throughput Conditions	Current (mA)	Power (W)
Wi-Fi	802.11b Tx	5V supply; transfer packet using iperf3 @ 11 Mbps & max TX power	-	362 ±30	1.8
		12V supply; transfer packet using iperf3 @ 11 Mbps & max TX power	-	151 ±15	1.8
	802.11n Tx	5V supply; transfer packet using iperf3 @ 25 Mbps	Max	254 ±25	1.27
		12V supply; transfer packet using iperf3 @ 25 Mbps	Max	110 ±10	1.32
	802.11n Rx	5V supply; transfer packet using iperf3 @ 25 Mbps	Max	191 ±20	0.955
		12V supply; transfer packet using iperf3 @ 25 Mbps	Max	85 ±10	1.02
	802.11n Idle	5V supply; DTIM3	-	46.5 ±5	0.233
		12V supply; DTIM3	-	23.3 ±3	0.279

ARTIK 055s Module Power Consumption

(measured using 3.3V system power supply)

Category	Scenario	Condition	Throughput Conditions	Current (mA)	Power (W)
Wi-Fi	802.11n Tx	Transfer packet using iperf3 @ 25 Mbps	Max	320	1.06
	802.11n Rx	Transfer packet using iperf3 @ 25 Mbps	Max	240	0.79
	802.11n Idle	DTIM3	-	54	0.18

Samsung ARTIK™ 05x Power Management (Con't)

```
> Power Management > Power management (PM) driver interfaces
      Power management (PM) driver interfaces
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ---). Highlighted letters are hotkeys. Pressing <Y>
includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to
exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
--> Power management (PM) driver interfaces
[ ] Power Management Debug Features (NEW)
[ ] Power Management Functionality Test (NEW)
(32) Registered device name length (NEW)
[*] Power management (PM) metrics --->
(100) PM time slice (msec) (NEW)
(1) Number of PM activity domains (NEW)
(2) PM memory (msec) (NEW)
(1) PM coefficient (NEW)
(1) PM coefficient 1 (NEW)
(1) PM coefficient 2 (NEW)
(1) PM coefficient 3 (NEW)
(1) PM coefficient 4 (NEW)
(1) PM coefficient 5 (NEW)
(1) PM IDLE enter threshold (NEW)
(2) PM IDLE exit threshold (NEW)
(30) PM IDLE enter count (NEW)
(1) PM STANDBY enter threshold (NEW)
(2) PM STANDBY exit threshold (NEW)
(50) PM STANDBY enter count (NEW)
(1) PM SLEEP enter threshold (NEW)
(2) PM SLEEP exit threshold (NEW)
(+)

<Select> < Exit > < Help > < Save > < Load >
```

- Kernel options for Power Management

TizenRT OS Basics

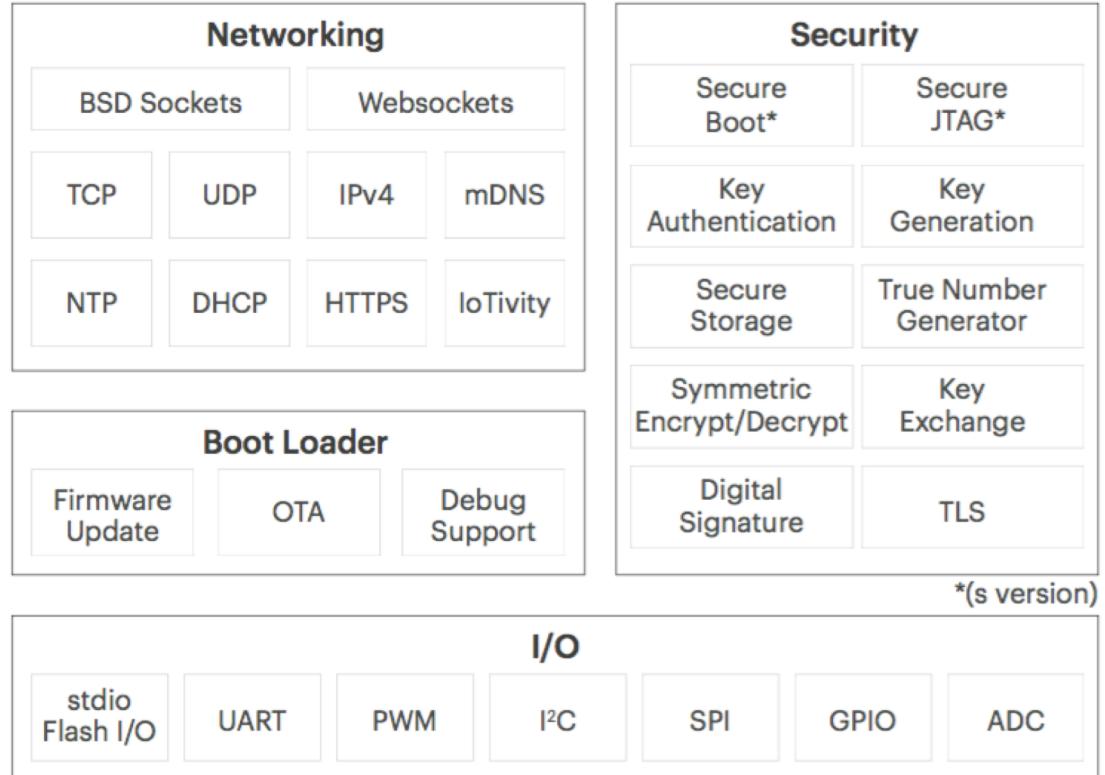
- ARTIK 05x are powered by TizenRT RTOS.
- TizenRT is a lightweight RTOS-based platform to support low-end IoT devices, based on Nuttx
- TizenRT is Nuttx kernel plus middle wares, it is highly configurable and suitable for small to moderate sized embedded system
- Contains IP Network Stack

TizenRT OS Basics (Con't)

- Tizen RT strives to be standards compliant. It contains a small, scalable, bash-like shell, and it adopts Linux-style development components:
 - POSIX API
 - BSD Socket API
 - TASH Shell
 - Kconfig build configuration

TizenRT OS Hierarchy

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



IoT Data Management

- Tizen RT supports
 - light weight file system (Smart FS) , and
 - virtual file system (VFS): Tizen RT root file system does not require any underlying block driver or physical device, it is a pseudo-file system
- VFS provides common interface set in the form of POSIX APIs (open, close, read, write, etc.) and standard libc APIs are also supported

IoT Data Management (Con't)

- In addition, some advanced features are also supported:
 - Proc File System for debug, and ROM File System for read only data.
 - SmartFS for flash file system with wear-leveling, bad sector management, and transaction logging based journaling.
- A lightweight database named AraStorage is implemented with SQL-compatible interfaces.

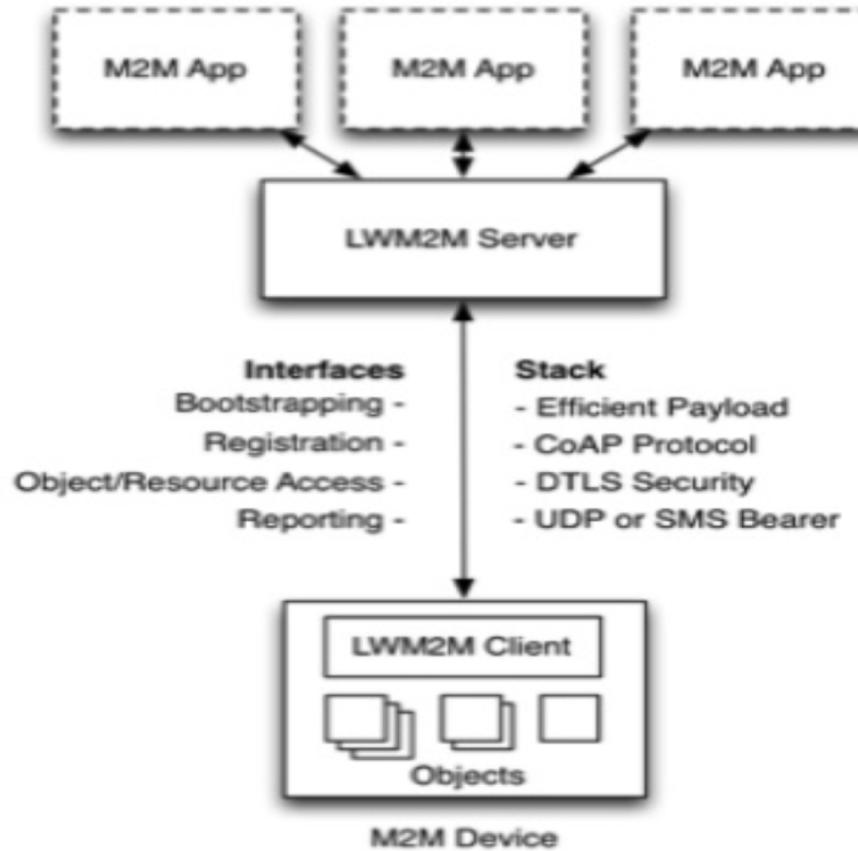
IoTBus Framework

- 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 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.



TizenRT vs. FreeRTOS

Tizen RT

- Easy to extend
- Small RTOS with POSIX compliant
- Unix/Linux device tree
- Linux-like Task Shell
- Core Task Management
- Porting of Linux solutions and 3rd party services are much easier

FreeRTOS

- Longer time in market
- Development needs to start from scratch
- Supports both real time tasks and co-routines
- Stack overflow detection options
- No native device management support

TizenRT – Linux Developer Friendly

- Tizen RT supports POSIX APIs for core services, threads, semaphores, mutex, pseudo file system access
- TASH shell is similar to Linux shell
- Supports Kconfig for modular and configurability

```
TASH>>help
```

TASH command list

cat	cd	date	df
dhcpcd	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	

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
ARTIK™ 053		Samsung		
Smart IoT Module	OCF	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

ARTIK 05x

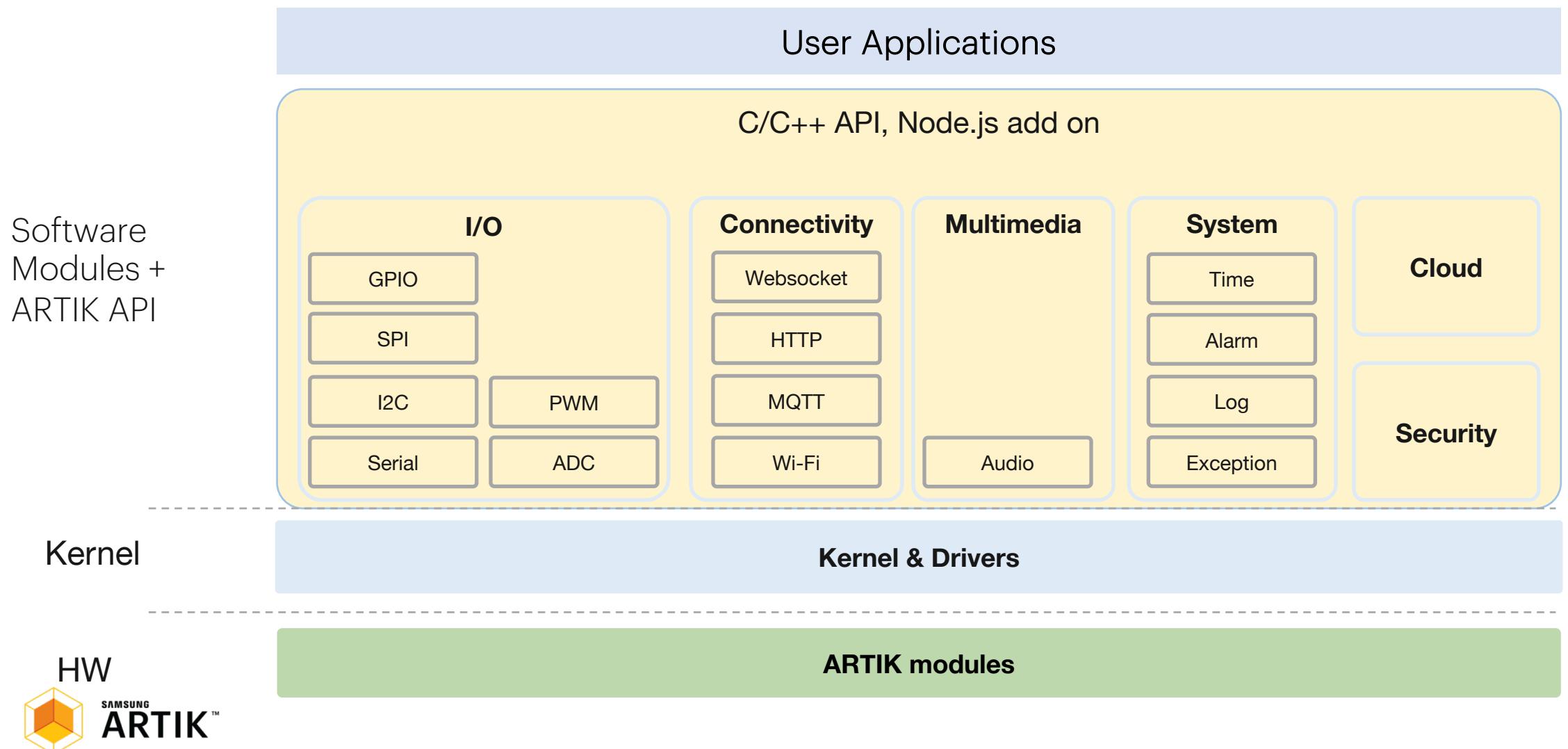
Development

Developing on ARTIK 05x

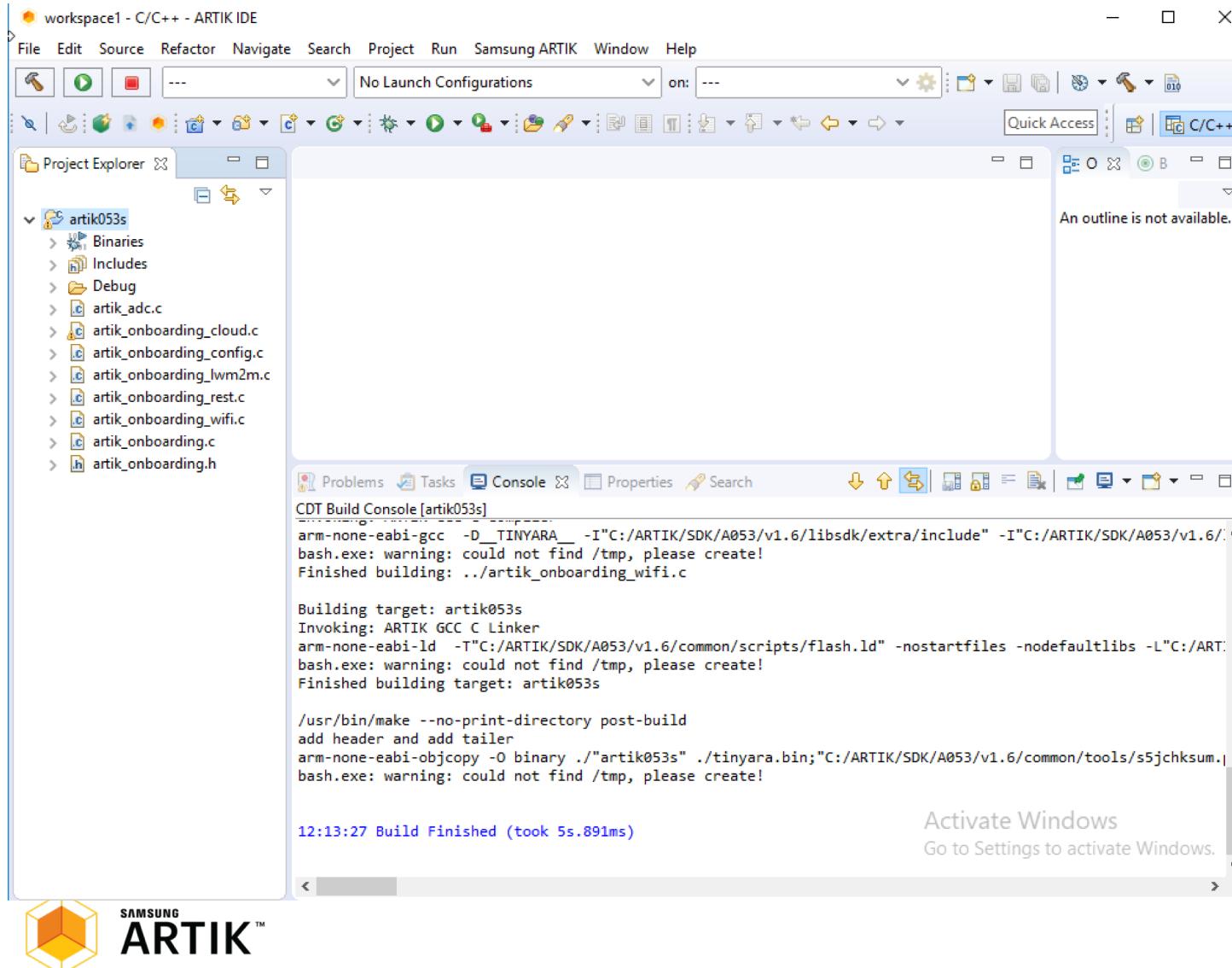
- ARTIK SDK/IDE (C language)
- Cross-compilation for ARM architecture from command line (C language)
- JerryScript(under development, JS)



ARTIK SDK (05x, 5, 7 series)



ARTIK IDE



gcc-arm-none-eabi



Cross Compilation from command line

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

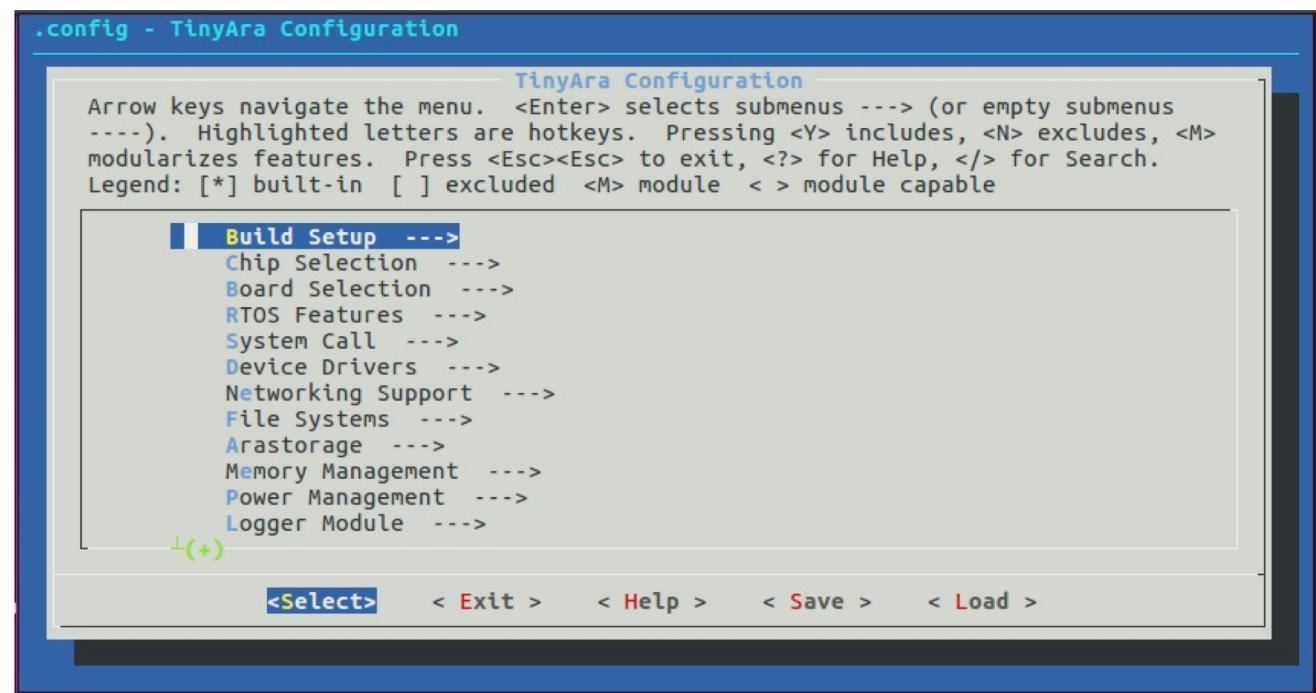
```
$ git clone https://github.com/SamsungARTIK/TizenRT.git
```

```
$ 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

Debugging on ARTIK 05x

The screenshot shows a debugger interface with several windows:

- Registers Window:** Shows the General Registers (r0 to r5) with their values: r0=2, r1=33941096, r2=0, r3=67513348, r4=2, r5=33941096.
- Code View:** Displays the `slsi_wifi_main()` function from `slsiwifi_main.c`. A specific line, `632 sw_printHeader();`, is highlighted with a red box.
- Output Window:** Shows the console output for the ARTIK 051 device, indicating it is connected and booting.
- Memory Dump:** An outline view of memory structures and functions.

At the bottom, a command-line interface shows the command `TASH>>artikwifi startsta`.

```
626     int slsi_wifi_main(int argc, char *argv[]) {
627 #endif
628 #ifdef CONFIG_EXAMPLES_SLSIDEMO_MEM_CHECK
629     if(!wifiStarted) g_memstat_total = getMemUsage();
630 #endif
631     int8_t result = SLSI_STATUS_ERROR;
632     sw_printHeader();
633     if(argc == 1){
634         sw_printhelp();
635         return result;
636     }else {
637         /*we have no way of knowing if the link up/down handlers have been
         * changed behind our back so we will always re-register them here.
         * They are critical for the system to work*/
638         if(!WiFiRegisterLinkCallback(&sw_linkUpHandler, &sw_linkDownHandler)) {
639             printf("Link call back handles registered - per default!\n");
640         } else {
641             printf("Link call back handles registered - Cannot continue !\n");
642         }
643     }
}
```

ARTIK 051 (CONNECTED)

```
mailbox_register_service: [0] CMD 0x0001, func(0x04168a50) has been registered
ledctrlblk_if_booting: [ledctrl] SRAM bootup, code base : 0x020E0000, size in 00020000
ledctrlblk_if_booting: [ledctrl] SRAM bootup, data base : 0x020DA000, size in 00008000
ledctrlblk_if_booting: [ledctrl] Runs on SRAM, [0x20e0000], [0x4604000]
TASH>>ledctrlblk_if_booting: [ledctrl] Boot ok...
ledctrlblk_ioctl: boot done
ARTIK051 Boot Done!!!!!!!!!!
```

TASH>>artikwifi startsta

Production Considerations

Other Considerations



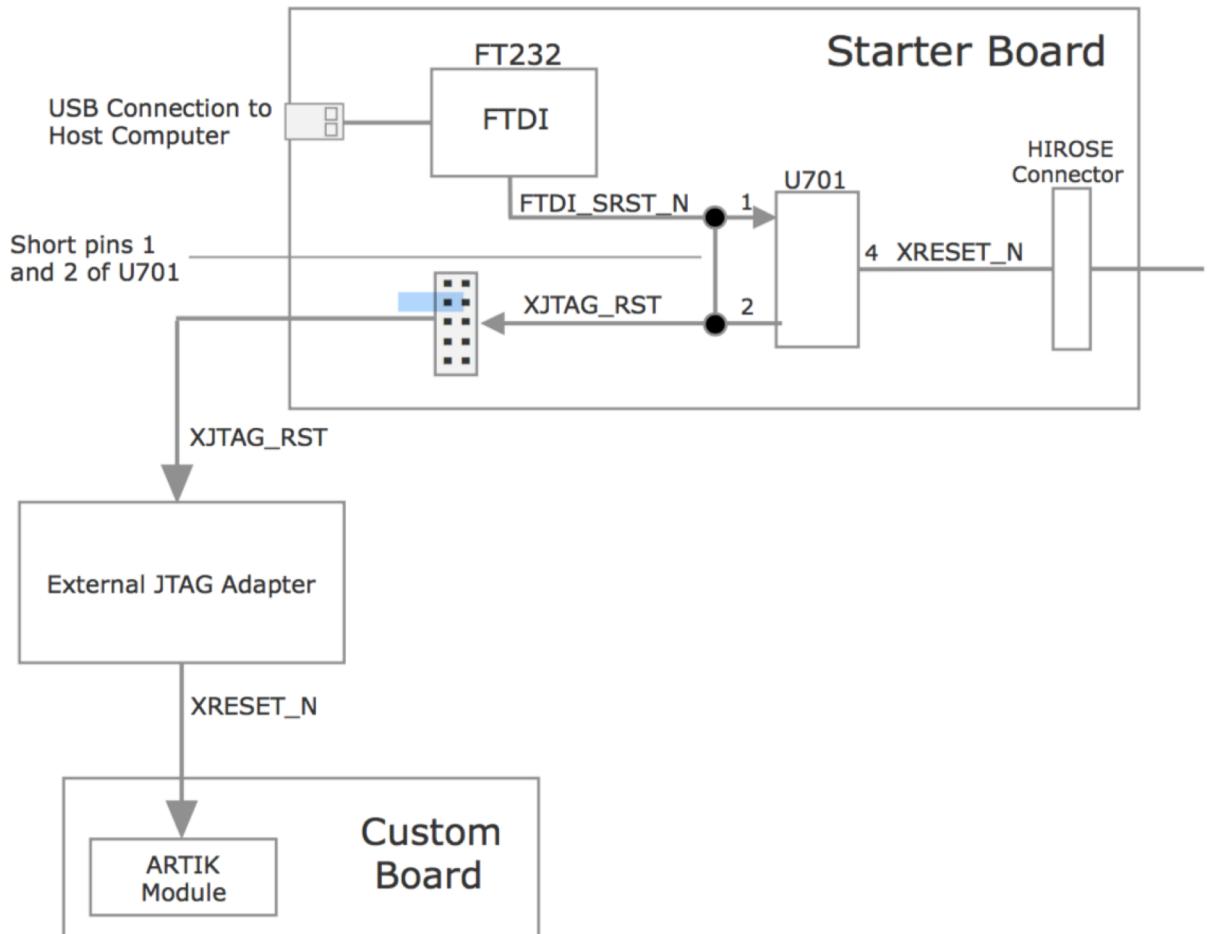
Datasheet

- Which module to choose?
- Where to place antennas?
- What's the I/O drive during power-up?

Module Programming Options

System Design
Guide

- Use the on-board debugger
- Use an external debugger: Lauterbach, Segger J-Link
- Program the ARTIK Module on a custom board using an external JTAG adapter



Use Cases

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

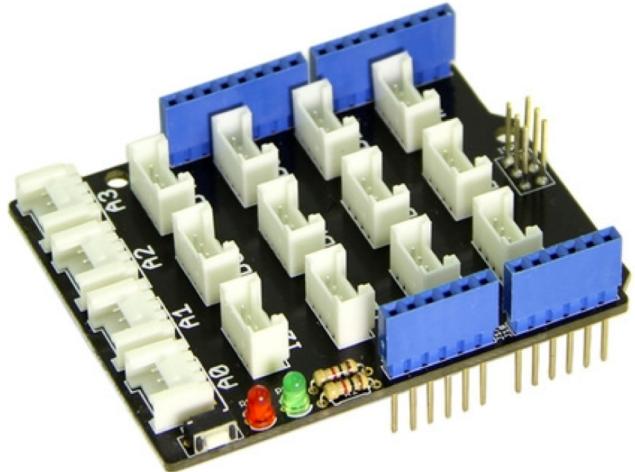
Challenge: Retrofit customer OT to meet requirements for Industry 4.0, enable access to data and create digital twins for more efficient operations. Ensure secure operations.

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.

ARTIK 05x Ecosystem

Grove Base Shield and Modules Support



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(O₂)



Grove - HCHO Sensor

Shoreline iCast2 Modbus Solution

ARTIK 05x

- ARTIK 05x Module
- 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, PTC ThingWorx, AWS IoT



Voice-enabled switch

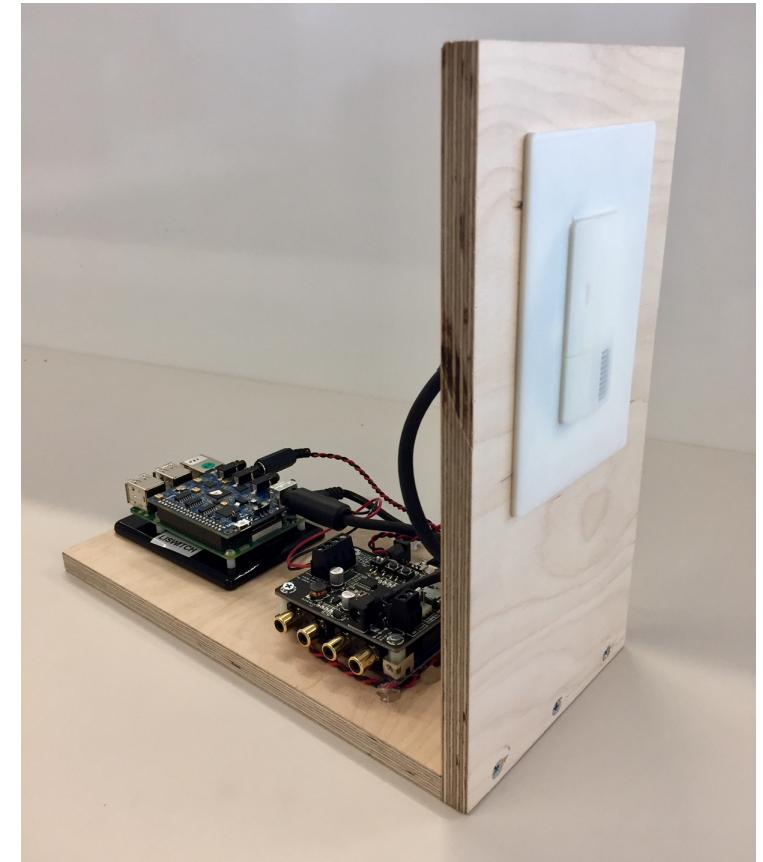
ARTIK 05x, ARTIK 530 SoMs and AVS Gateway

Smart switch based on ARTIK 05x and ARTIK 530 for AVS connectivity. Voice detection done on Synaptics DSP.

Use case: Smart Home, Smart Building, Smart Hotel

Hardware: ARTIK05x, ARTIK 530, DSP

Software: Alexa Voice Service on 530, 05x sensor logic, control logic on 05x, ARTIK Cloud connectivity via 05x



Smart appliances and edge analytics

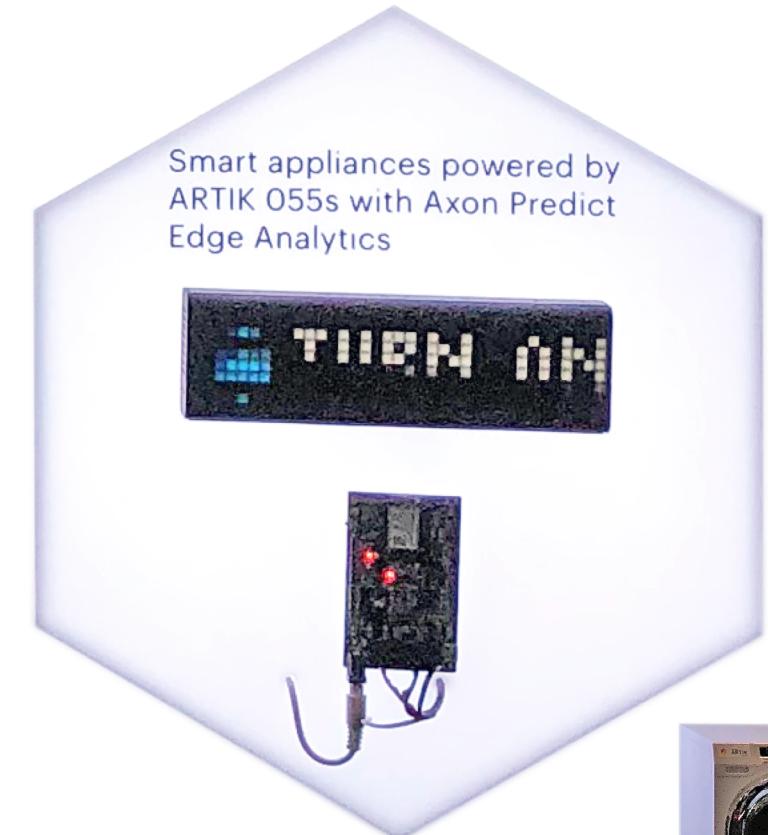
ARTIK 055s SoM and Axon Predict Edge Analytics

ARTIK 055s-powered smart washer with edge analytics for detergent level check, predictive maintenance, etc. Washer can be controlled by a mobile app or voice. Alerts show on LaMetrics display.

Use case: Smart home appliances

Hardware: ARTIK 055s WiFi module, washer with weight sensor, water level sensor etc., mobile device, LaMetrics display (optional)

Software: SmartThings Cloud cloud connector, rules engine; Android mobile app; AXON Predict Analytics



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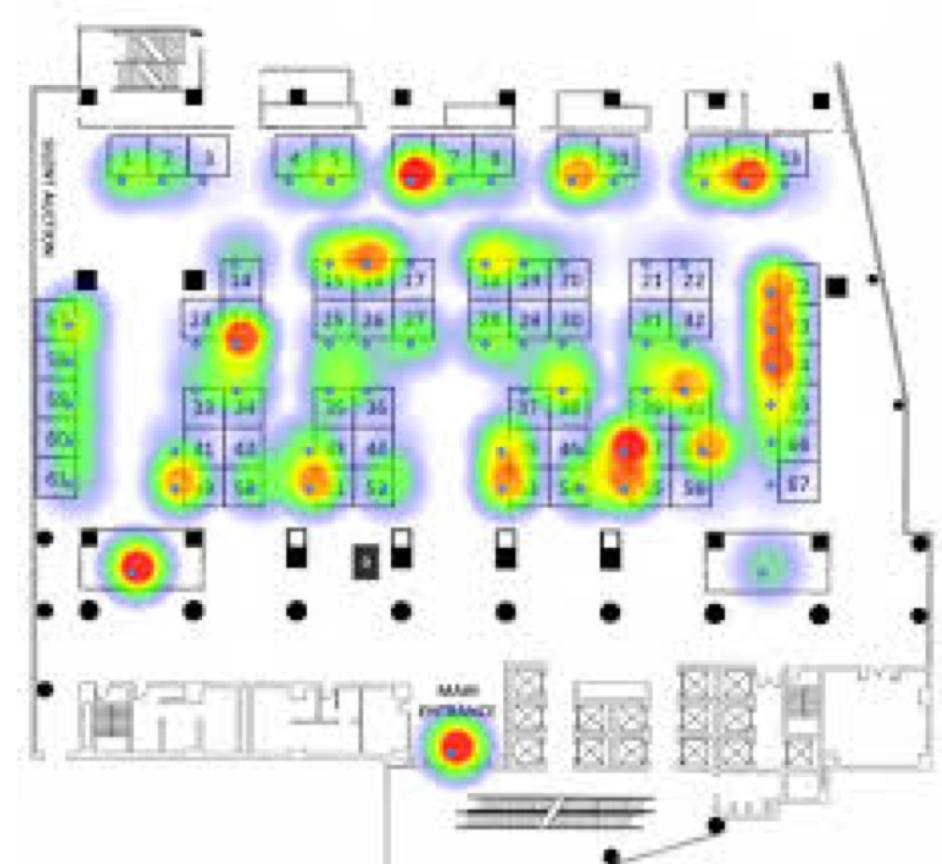
Location based service ARTIK 05x

Leverage 05x WiFi connectivity for location based service.

Use case: Smart Building, Smart Campus

Hardware: ARTIK05x

Software: Comtech Location APIs, ARTIK Cloud Service



3rd Party Software Stack Integration

1. wpa_supplicant
2. MQTT broker: Mosquitto
3. 3rd party Cloud SDKs: AWS IoT, PTC ThingWorx, Microsoft Azure(under development)
4. Codecs: GMM audio codec etc.
5. nghttp2

Appendix

TizenRT Kernel

- Tizen RT supports fully pre-emptible, fixed priority
- Round-robin and “sporadic” scheduling
- Part of Samsung open source and licensed under Apache License 2.0
- Tizen RT scheduling policy:
 - The thread with the highest priority runs (SCHED_FIFO)
 - Tizen RT also support round robin scheduling policy (SCHED_RR) . If a task with round robin scheduling policy is running, then when each time slice elapses, it will give up the CPU to the next task that is at the same priority.
 - If there is only one task at this priority, SCHED_RR and SCHED_FIFO are the same, and SCHED_FIFO tasks are never pre-empted in this way.

TizenRT tasks

- A Tizen RT task is a thread within an environment associated with it, and each task is represented by a data structure called a task control block (TCB)
- Tizen RT task environment consists the following, and can be configured to reduce memory footprint:
 - Environment variables
 - File descriptors
 - Sockets
 - Streams

TizenRT threads

- Tizen RT thread is any controllable sequence of instruction execution that has its own stack.
 - Each thread has its own stack
 - Each thread has an execution priority managed by the OS
 - Each thread is a member of a “task group”
 - Share resources
 - Can wait for events or resource availability
- Tizen RT supports POSIX pthread, this means the Tizen RT thread also shares the resources of the parent task