Software Update (OTA) for Zephyr

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Whoami

- Parthiban Nallathambi - Software Engineer at Linumiz
  - Embedded Linux development: BSP, u-boot, Kernel, Driver, Yocto and consulting
  - Zephyr: SoC, Board support, drivers and consulting
  - www.linumiz.com
- Living in Berlin, Germany

Agenda

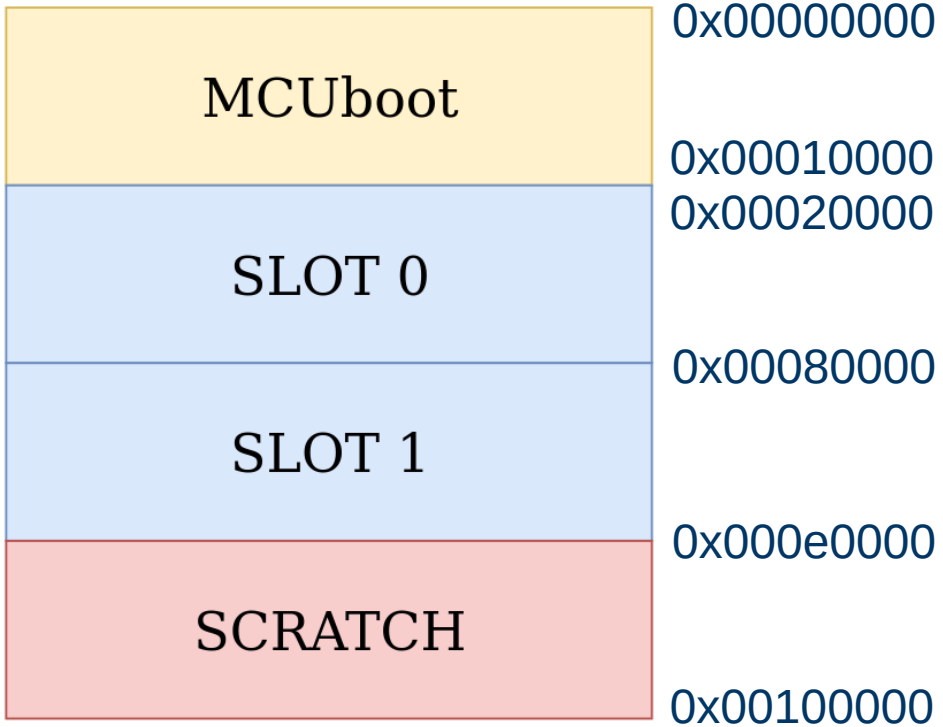
- MCUBoot
- Updatehub
- mcumgr
- ZUpdate
- ZUpdate - Hawkbit
- Future work

MCUBoot

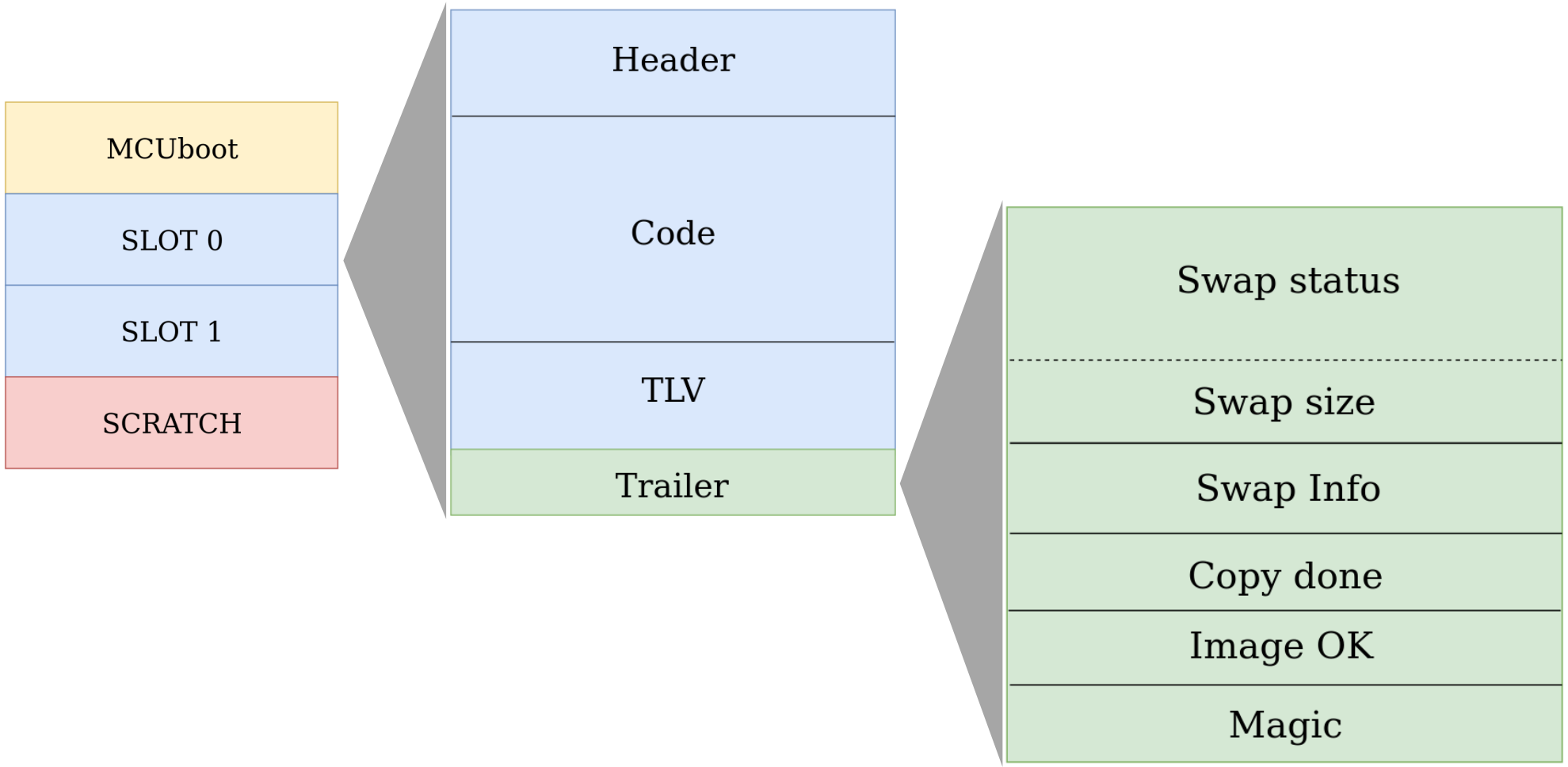
- Bootloader for Zephyr & mynewt
- Integrity and security check
- Multi Image boot support [1]
- Software update heavy lifting

MCUBoot layout

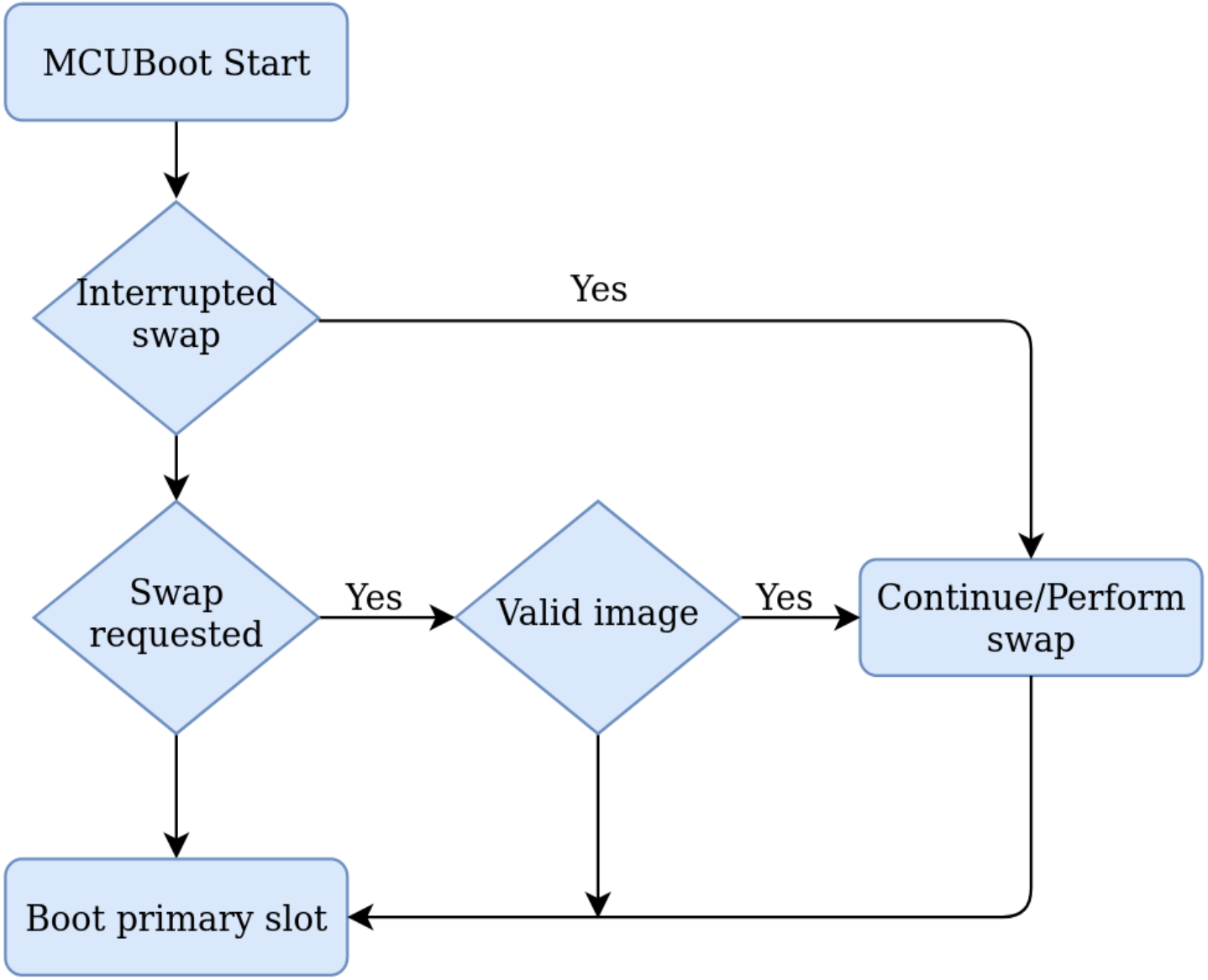
```
chosen {
	zephyr,code-partition = &slot0_partition;
};

&flash0 {
	partitions {
		compatible = "fixed-partitions";
		#address-cells = <1>;
		#size-cells = <1>;

		boot_partition: partition@0 {
			label = "mcuboot";
			reg = <0x00000000 0x00010000>;
			read-only;
		};

		slot0_partition: partition@20000 {
			label = "image-0";
			reg = <0x00020000 0x00060000>;
		};
		slot1_partition: partition@80000 {
			label = "image-1";
			reg = <0x00080000 0x00060000>;
		};
		scratch_partition: partition@e0000 {
			label = "image-scratch";
			reg = <0x000e0000 0x00020000>;
		};
	};
};
```



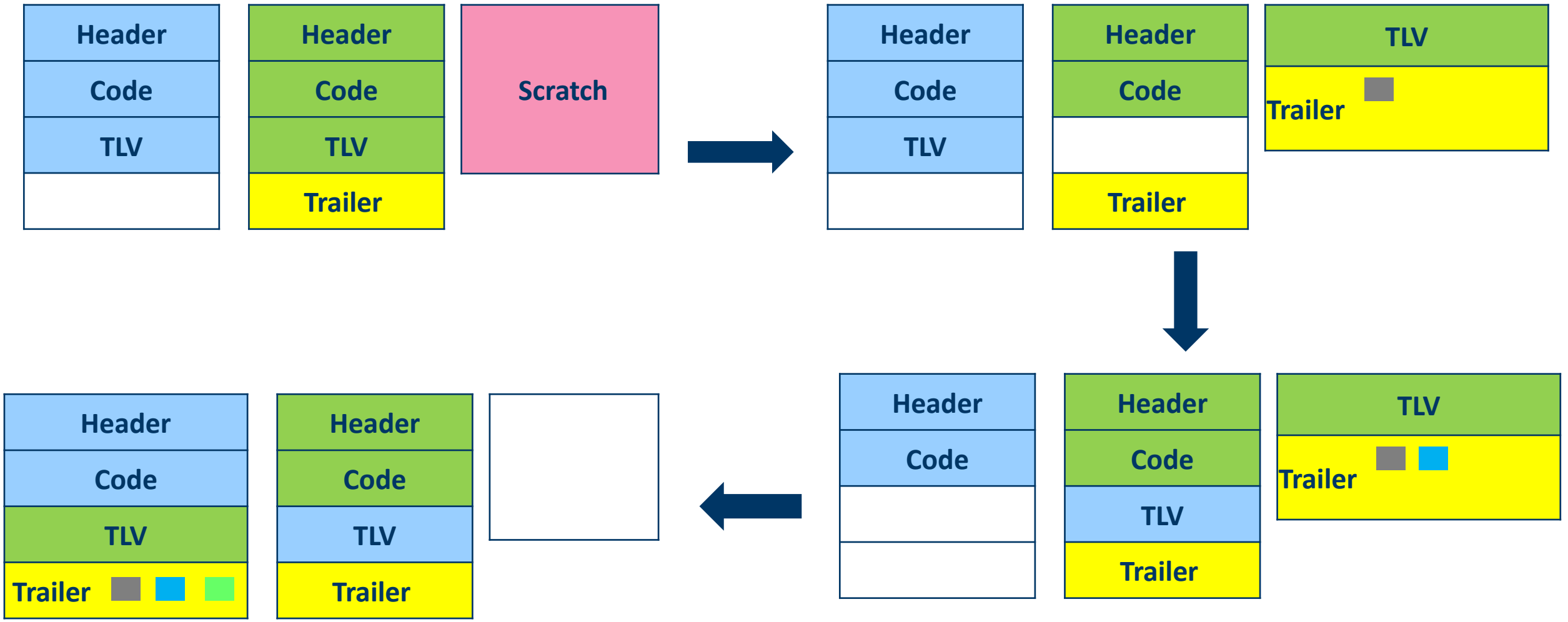
MCUBoot trailer



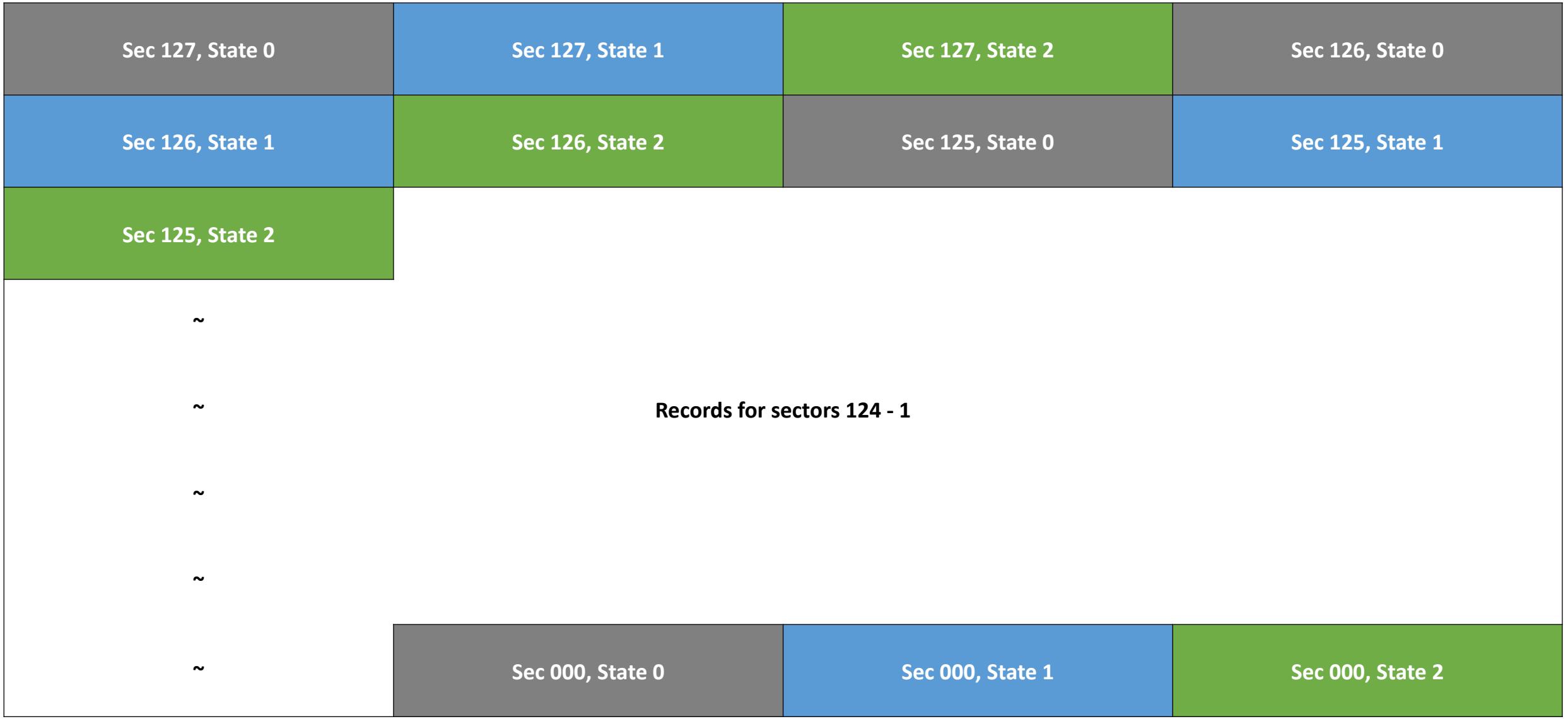
MCUBoot operation



MCUBoot Swap [2]



MCUBoot Swap status



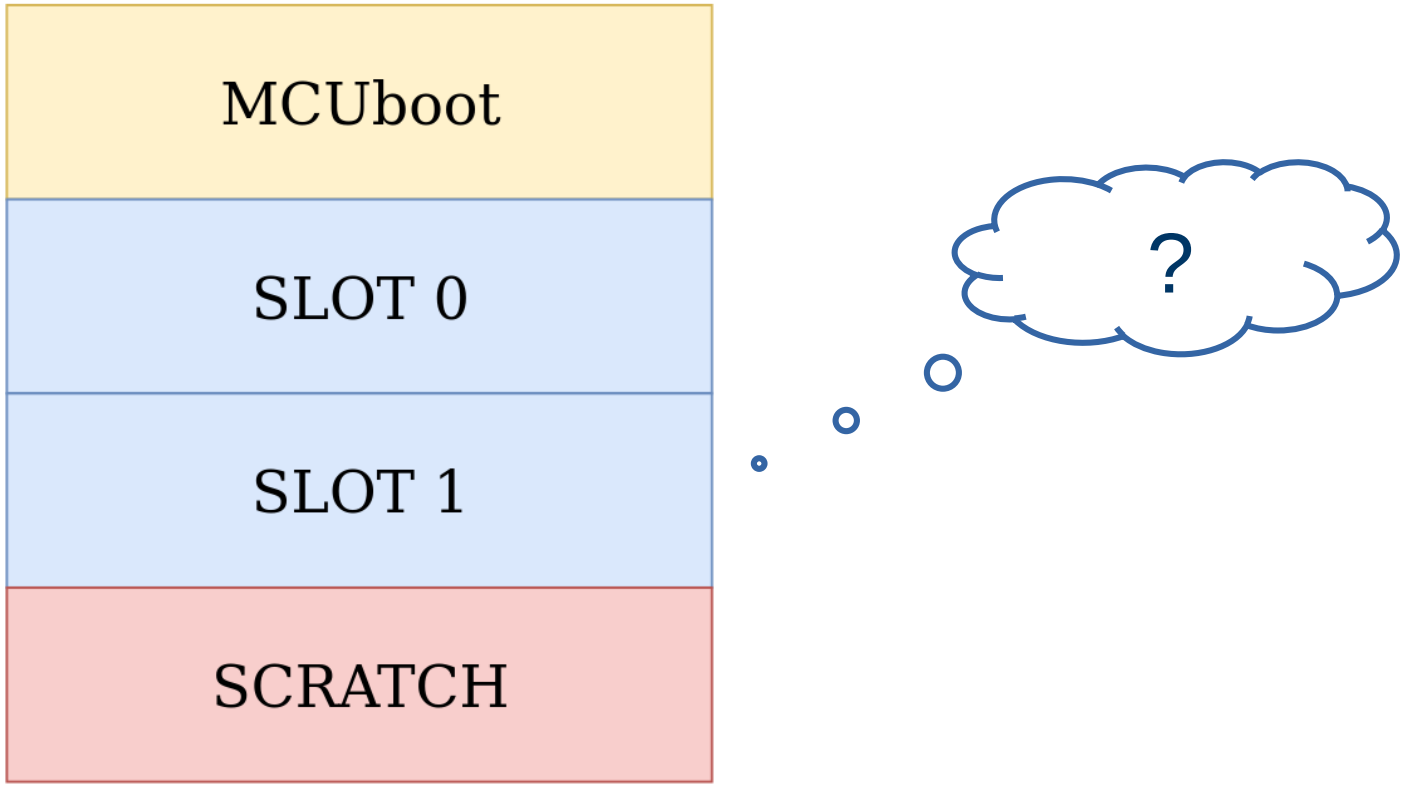
MCUBoot Swap types

```
bool boot_is_img_confirmed(void);

int boot_write_img_confirmed(void);

int boot_request_upgrade(int permanent);

int boot_erase_img_bank(uint8_t area_id);

int mcuboot_swap_type(void);
```

	Magic	Image-OK	Copy-done	Swap type
Primary Slot	Any	Any	Any	BOOT_SWAP_TYPE_TEST
Secondary Slot	Good	Unset	Any	
Primary Slot	Any	Any	Any	BOOT_SWAP_TYPE_PERM
Secondary Slot	Good	0x01	Any	
Primary Slot	Good	0xFF	0x01	BOOT_SWAP_TYPE_REVERT
Secondary Slot	Unset	Any	Any	
Primary Slot	Any	Any	Any	BOOT_SWAP_TYPE_NONE BOOT_SWAP_TYPE_FAIL BOOT_SWAP_TYPE_PANIC
Secondary Slot	Good	Good	Good	

Swap image

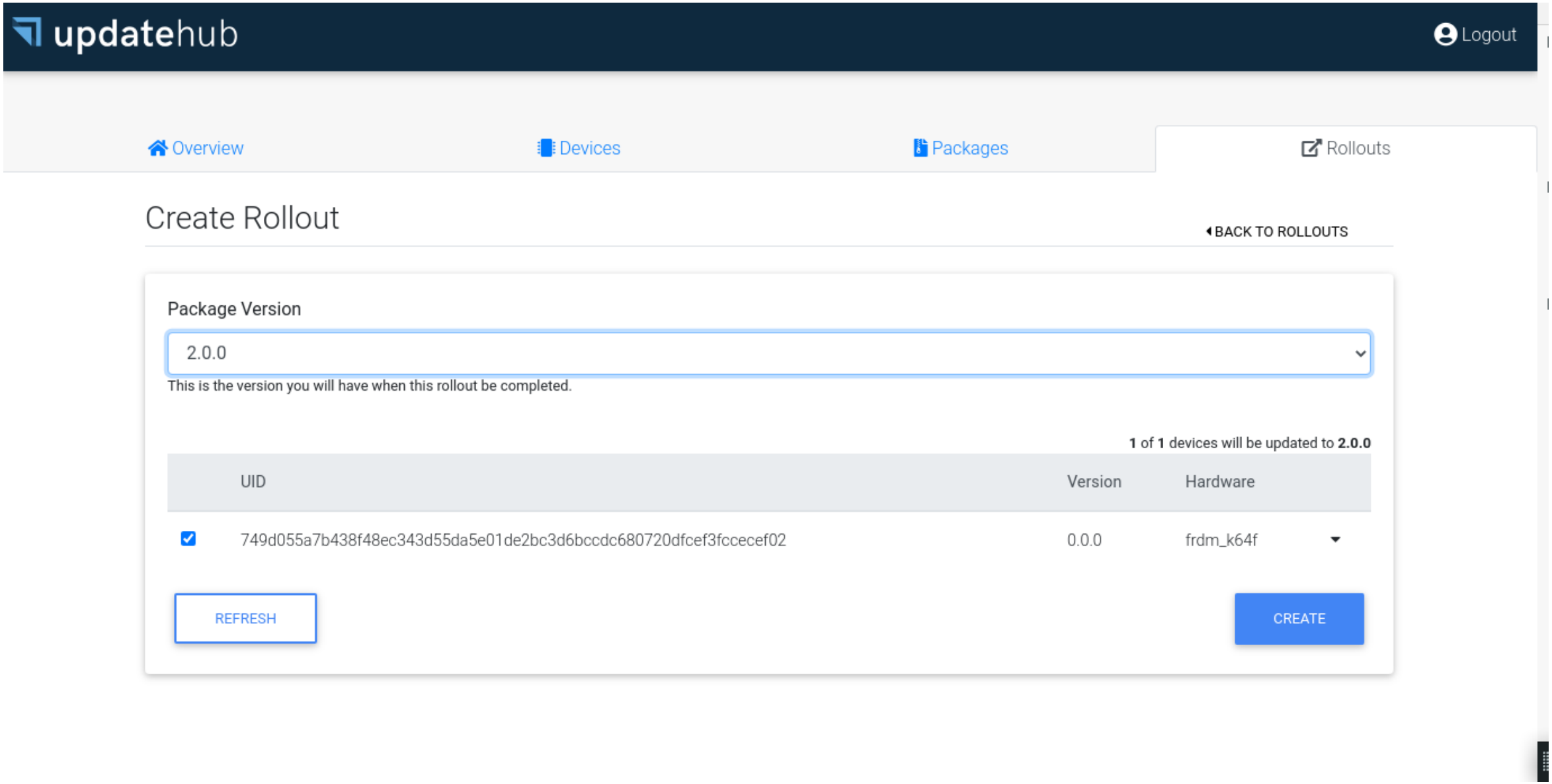
Software Update



Updatehub

- What is UpdateHub ?
- Polling mode
- Manual mode
- Community vs Enterprise edition

Updatehub – Rollout Creation



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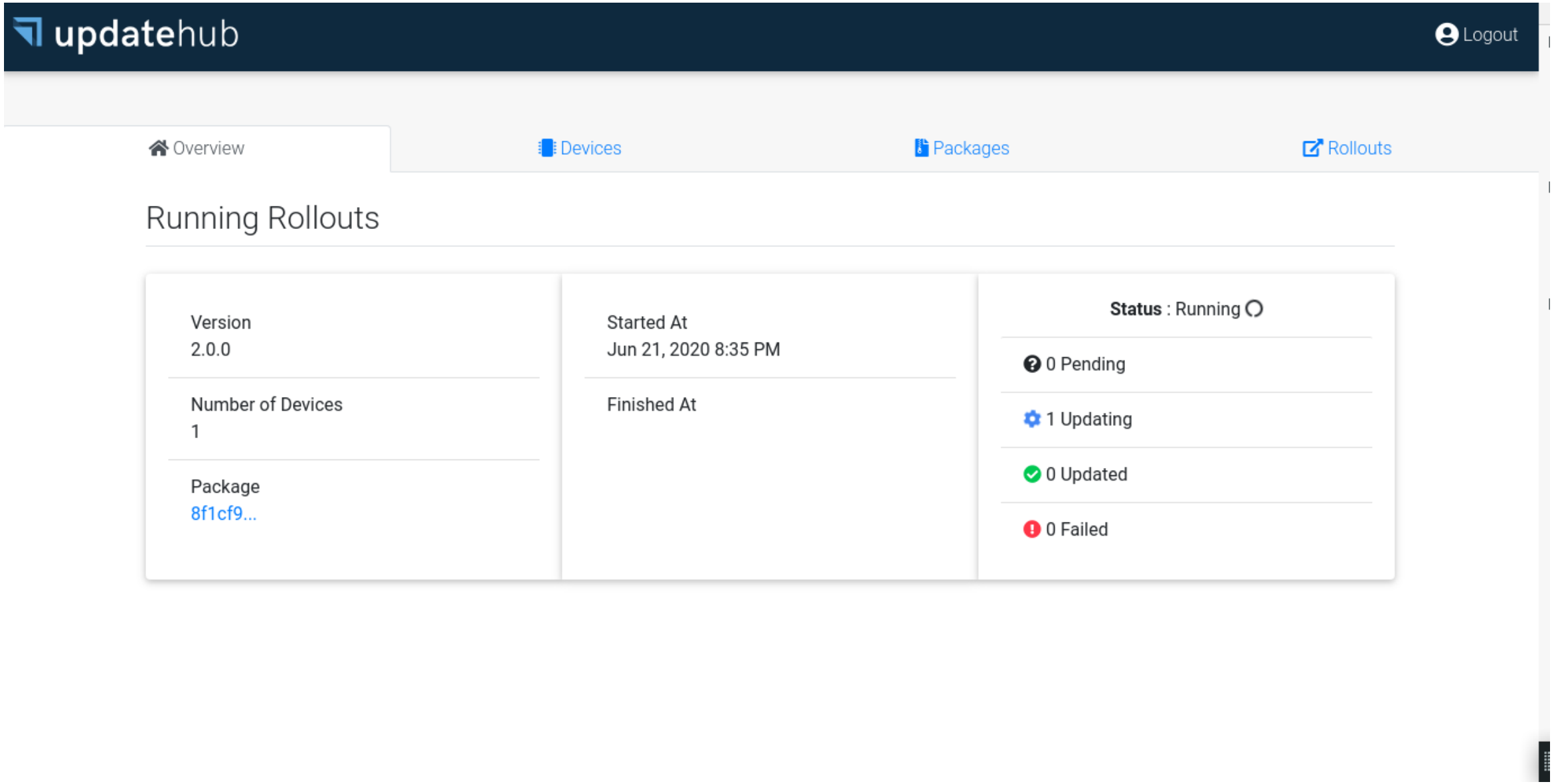
Updatehub - Console

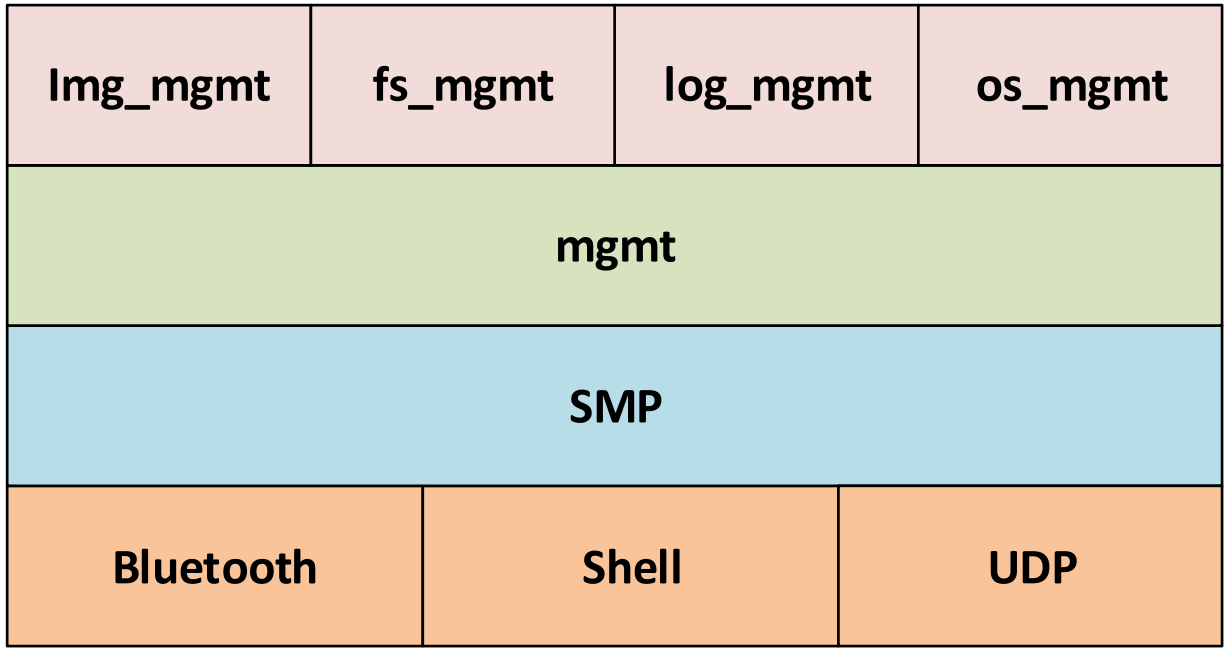
```
*** Booting Zephyr OS build zephyr-v2.3.0-112-g4a8fb854bbc0  ***
[00:00:00.005,000] <inf> mcuboot: Starting bootloader
[00:00:00.006,000] <inf> mcuboot: Primary image: magic=good, swap_type=0x4, copy_done=0x1, image_ok=0x1
[00:00:00.006,000] <inf> mcuboot: Scratch: magic=unset, swap_type=0x1, copy_done=0x3, image_ok=0x3
[00:00:00.006,000] <inf> mcuboot: Boot source: none
[00:00:00.006,000] <inf> mcuboot: Swap type: none
*** Booting Zephyr OS build zephyr-v2.3.0-327-g636d6cd9cdb6  ***


[00:00:03.000,000] <inf> eth_mcux: ETH_0 enabled 100M full-duplex mode.
[00:00:08.003,000] <inf> main: UpdateHub sample app started
[00:00:08.003,000] <inf> main: Confirming the boot image
[00:00:08.003,000] <inf> main: Starting UpdateHub polling mode
[00:00:08.185,000] <inf> updatehub: No update available
[00:01:08.233,000] <inf> updatehub: No update available
[00:02:08.292,000] <inf> updatehub: No update available
[00:03:08.418,000] <inf> updatehub: No update available
[00:04:08.422,000] <inf> updatehub: Probe metadata received
[00:04:09.323,000] <inf> updatehub: Firmware downloaded successfully
```

Updatehub - status



MCUmgr

- Management library for Zephyr and mynewt
- OS and Hardware agnostic



MCUmgr - Reference Screenshots

```
pi@raspberrypi:~/fota/bin $ sudo ./mcumgr --conntype ble --connstring 'peer_name=Zephyr' image list
Images:
 slot=0
    version: 0.0.0
    bootable: true
    flags: active confirmed
    hash: 550fb8cf4229a3d7d5b75cac26ca0f094de76c01709b02233a707faf19b5d49d
Split status: N/A (0)
```

STM32 target initial slot list

```
pi@raspberrypi:~/fota/bin $ ls -lrt
total 16312
-rwxr-xr-x 1 pi pi 16042432 Apr 22 21:23 mcumgr
-rw-r--r-- 1 pi pi    88868 May 17 10:19 signed_1.bin
-rw-r--r-- 1 pi pi   127076 May 30 13:08 signed-zephyr.bin
-rw-r--r-- 1 pi pi    89654 Jun 14 16:20 2.bin
-rw-r--r-- 1 pi pi   252312 Aug  4 20:19 zephyr.signed.hex
-rw-r--r-- 1 pi pi    91730 Aug  4 20:21 zephyr.signed.bin
pi@raspberrypi:~/fota/bin $ ./mcumgr --conntype ble --connstring 'peer_name=Zephyr' image upload ./zephyr.signed.bin
Error: [hci0]: can't init hci: can't down device: operation not permitted
pi@raspberrypi:~/fota/bin $ sudo ./mcumgr --conntype ble --connstring 'peer_name=Zephyr' image upload ./zephyr.signed.bin
 7.87 KiB / 89.58 KiB [=======>-----------------------------------------------------------------------------]   8.78% 3.92 KiB/s 20s
```

Uploading the OTA image via the Bluetooth interface

```
pi@raspberrypi:~/fota/bin $ sudo ./mcumgr --conntype ble --connstring 'peer_name=Zephyr' image test 8360ae52bd1a75ec2a78df0089ca9c328e
16d20379f2b3d623104bddd0e616c9
Images:
 slot=0
    version: 0.0.0
    bootable: true
    flags: active confirmed
    hash: 550fb8cf4229a3d7d5b75cac26ca0f094de76c01709b02233a707faf19b5d49d
 slot=1
    version: 0.0.0
    bootable: true
    flags: pending
    hash: 8360ae52bd1a75ec2a78df0089ca9c328e16d20379f2b3d623104bddd0e616c9
Split status: N/A (0)
```

STM32 target initial slot list after OTA push

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MCUmgr - Reference Screenshots

```
uart:~$ Disconnected (reason 8)
Advertising successfully started
Connected
Disconnected (reason 8)
Advertising successfully started
Connected
Disconnected (reason 8)
Advertising successfully started
Connected
***** Booting Zephyr OS build zephyr-v1.14.0-2845-g77db273f6f84 *****
[00:00:00.000,000] <inf> mcuboot: Starting bootloader
[00:00:00.000,000] <inf> mcuboot: Primary image: magic=unset, swap_type=0x1, copy_done=0x3, image_ok=0x3
[00:00:00.000,000] <inf> mcuboot: Scratch: magic=unset, swap_type=0x1, copy_done=0x3, image_ok=0x3
[00:00:00.000,000] <inf> mcuboot: Boot source: primary slot
[00:00:00.000,000] <inf> mcuboot: Swap type: test

CTRL-A Z for help | 115200 8N1 | NOR | Minicom 2.7.1 | VT102 | Offline | ttyACM0
```

Rebooting the target to swap the slot

```
pi@raspberrypi:~/fota/bin $ sudo ./mcumgr --conntype ble --connstring 'peer_name=Zephyr' image confirm
Images:
 slot=0
    version: 0.0.0
    bootable: true
    flags: active confirmed
    hash: 8360ae52bd1a75ec2a78df0089ca9c328e16d20379f2b3d623104bddd0e616c9
 slot=1
    version: 0.0.0
    bootable: true
    flags:
    hash: 550fb8cf4229a3d7d5b75cac26ca0f094de76c01709b02233a707faf19b5d49d
Split status: N/A (0)
```

STM32 target swap to updated version/slot

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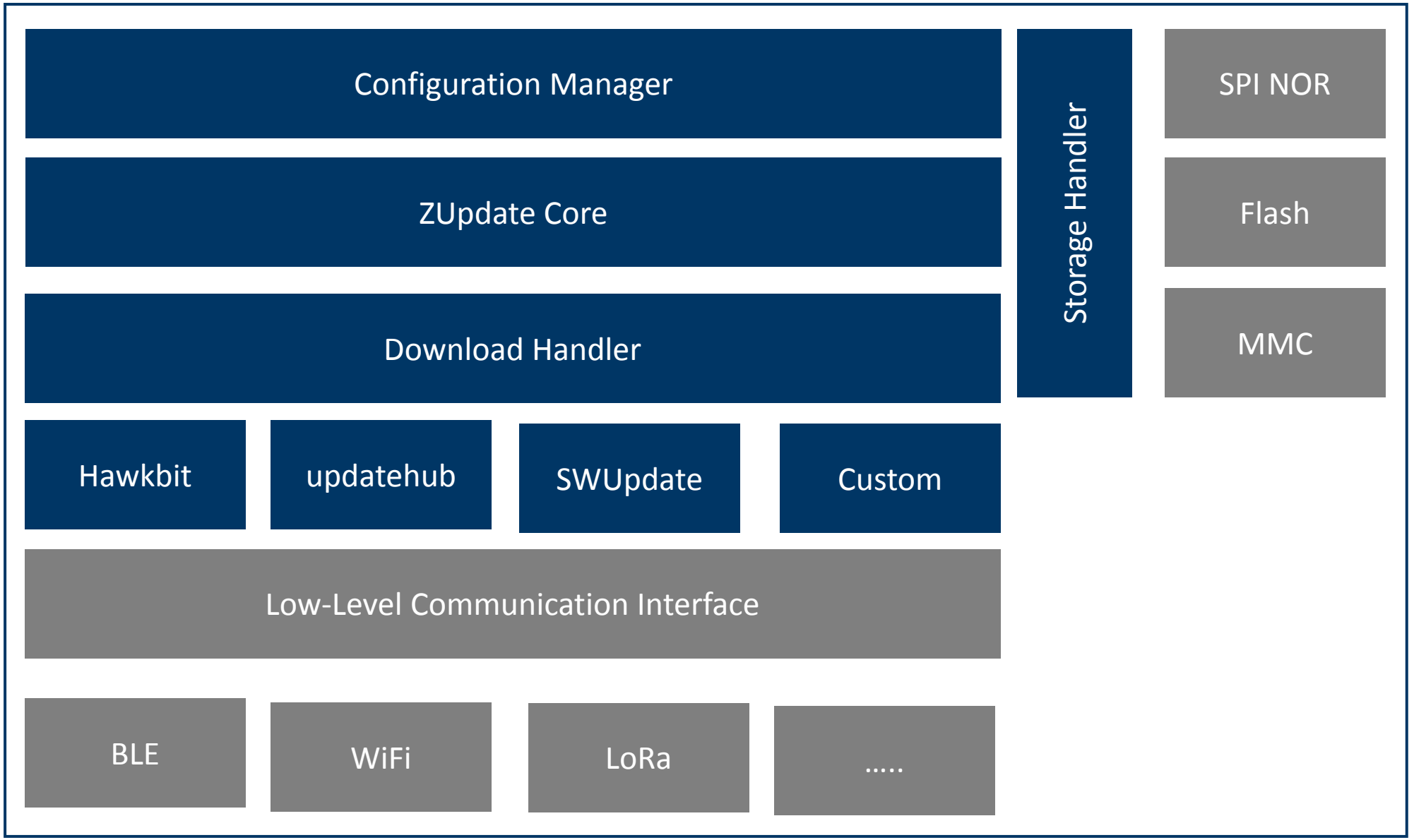
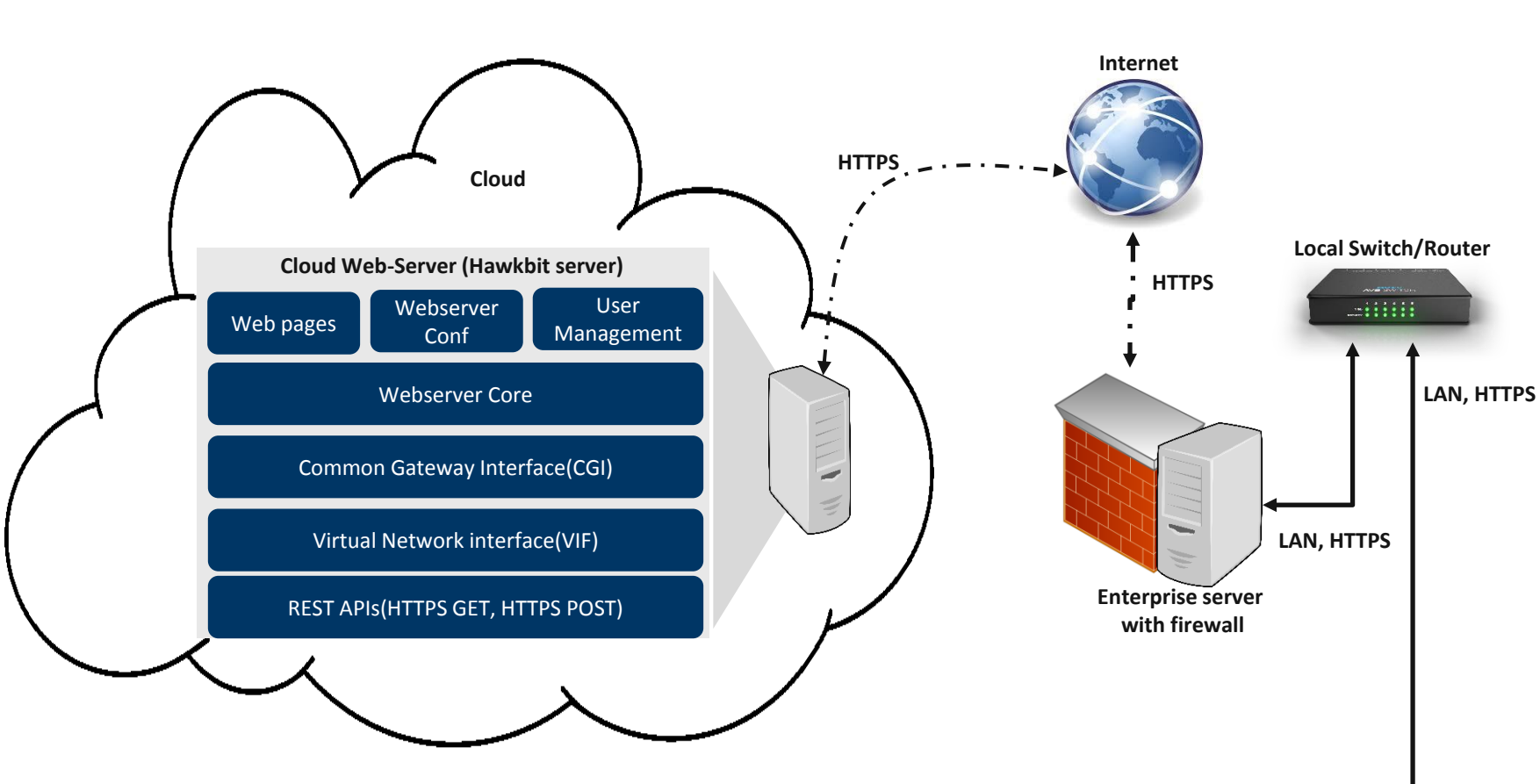
Limitations

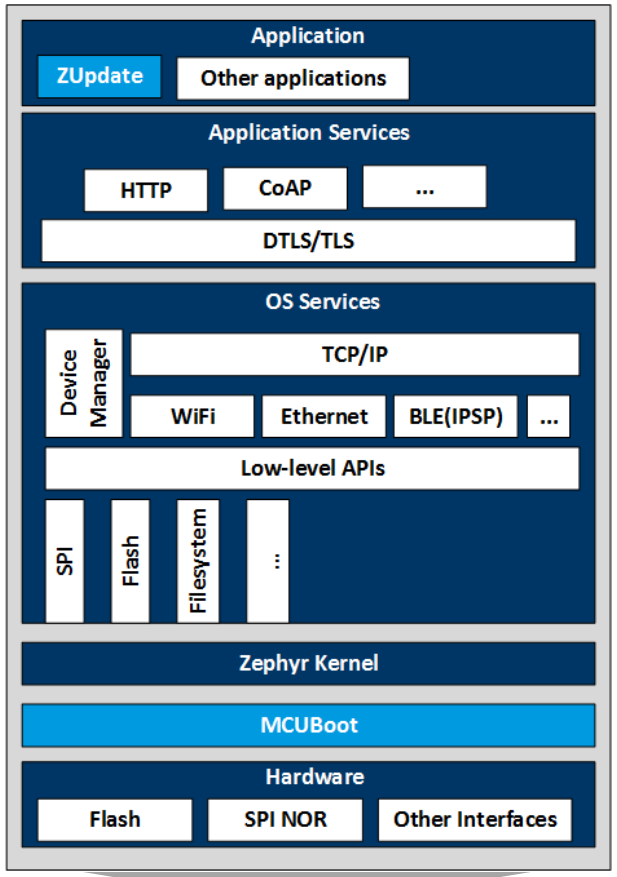
- No unified framework - IP and Local radio
- Edge node update managed by Gateway is not available
- Extension of gateway agents - SWUpdate, Mender, RAUC etc., for Zephyr

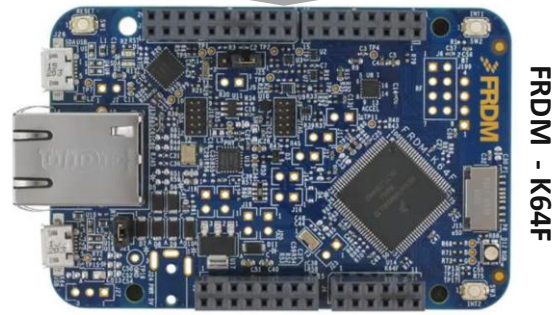
ZUpdate architecture



ZUpdate and Hawkbit – Architecture [3]







- The OTA (Remote update) is carried out by the remote webserver (running on cloud).
- The present framework supports Hawkbit server
- ZUpdate running on target embedded platform downloads and manages the device update
- MCUBoot - Update Install

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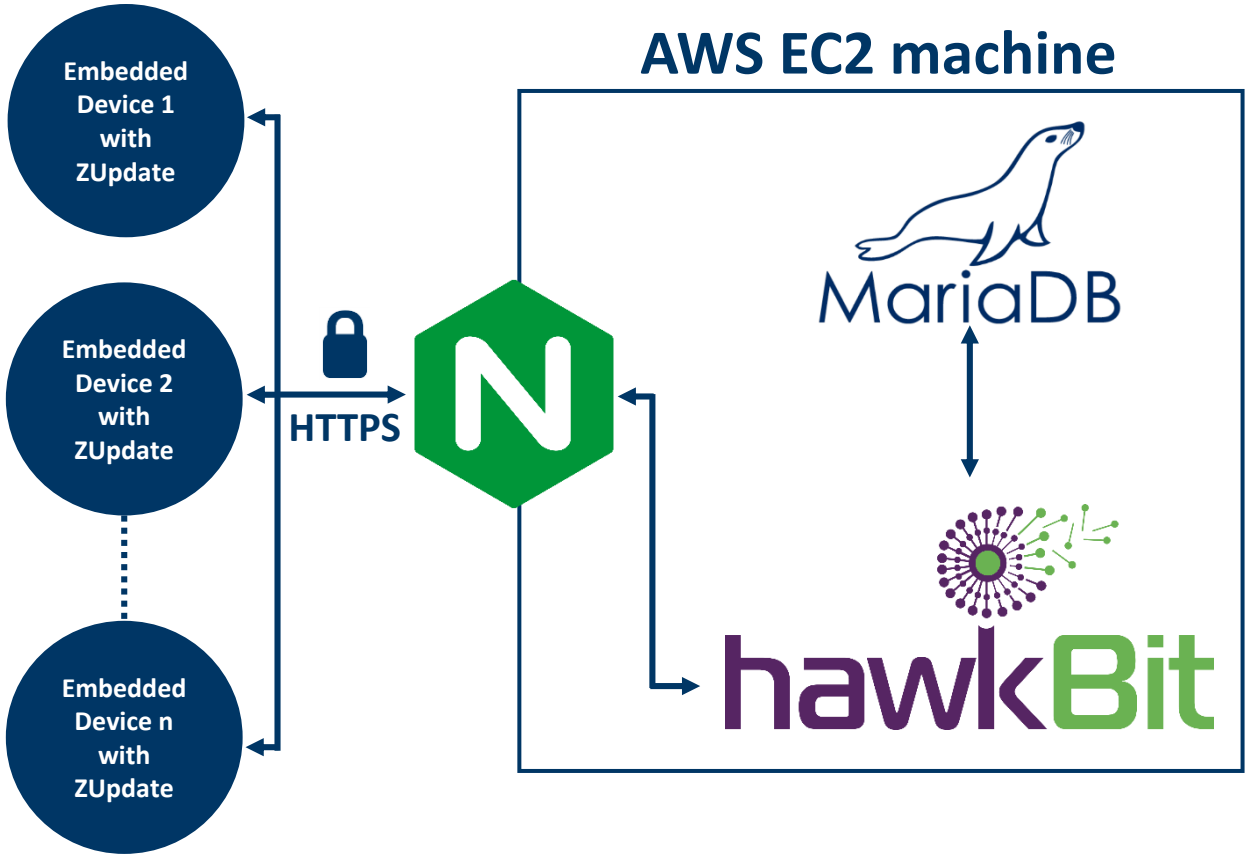
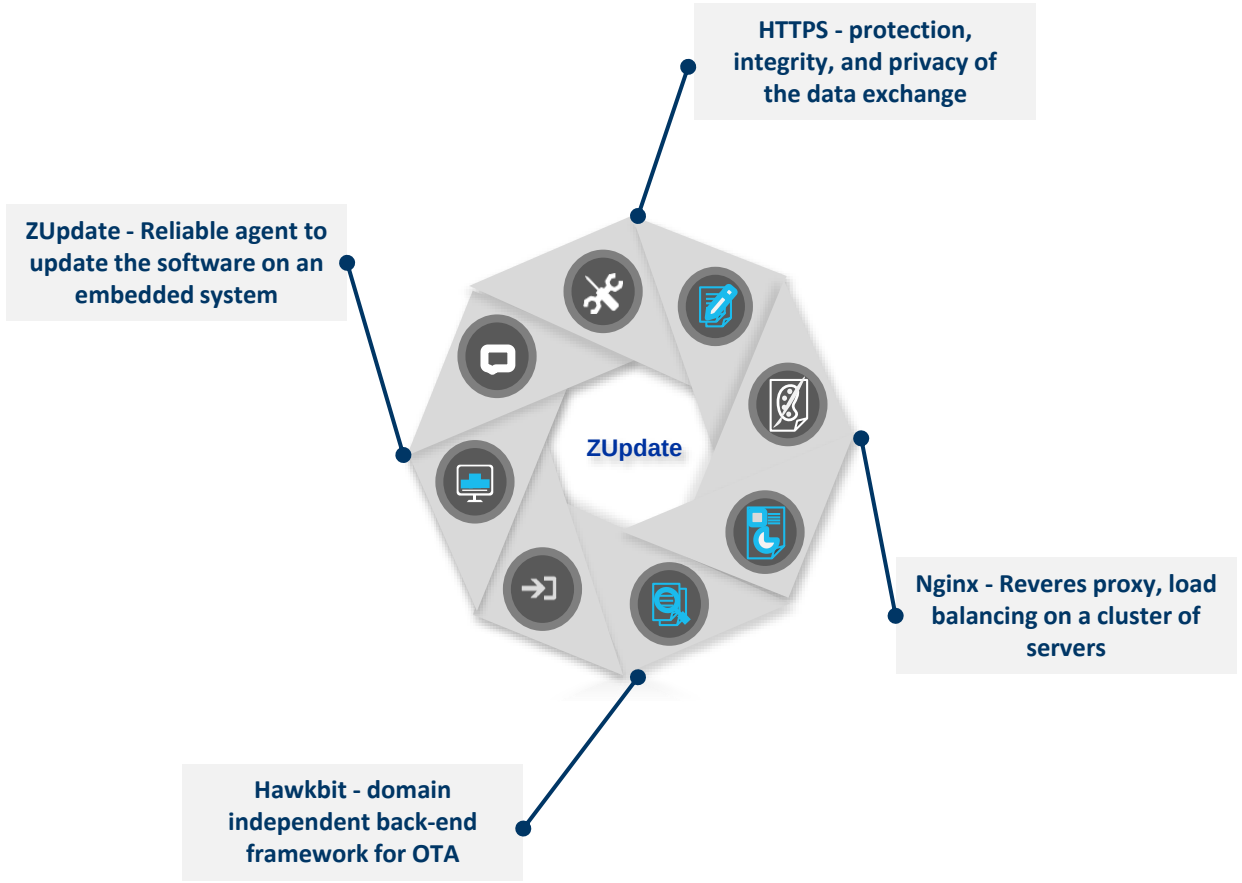
Case study: ZUpdate with HawkBit server





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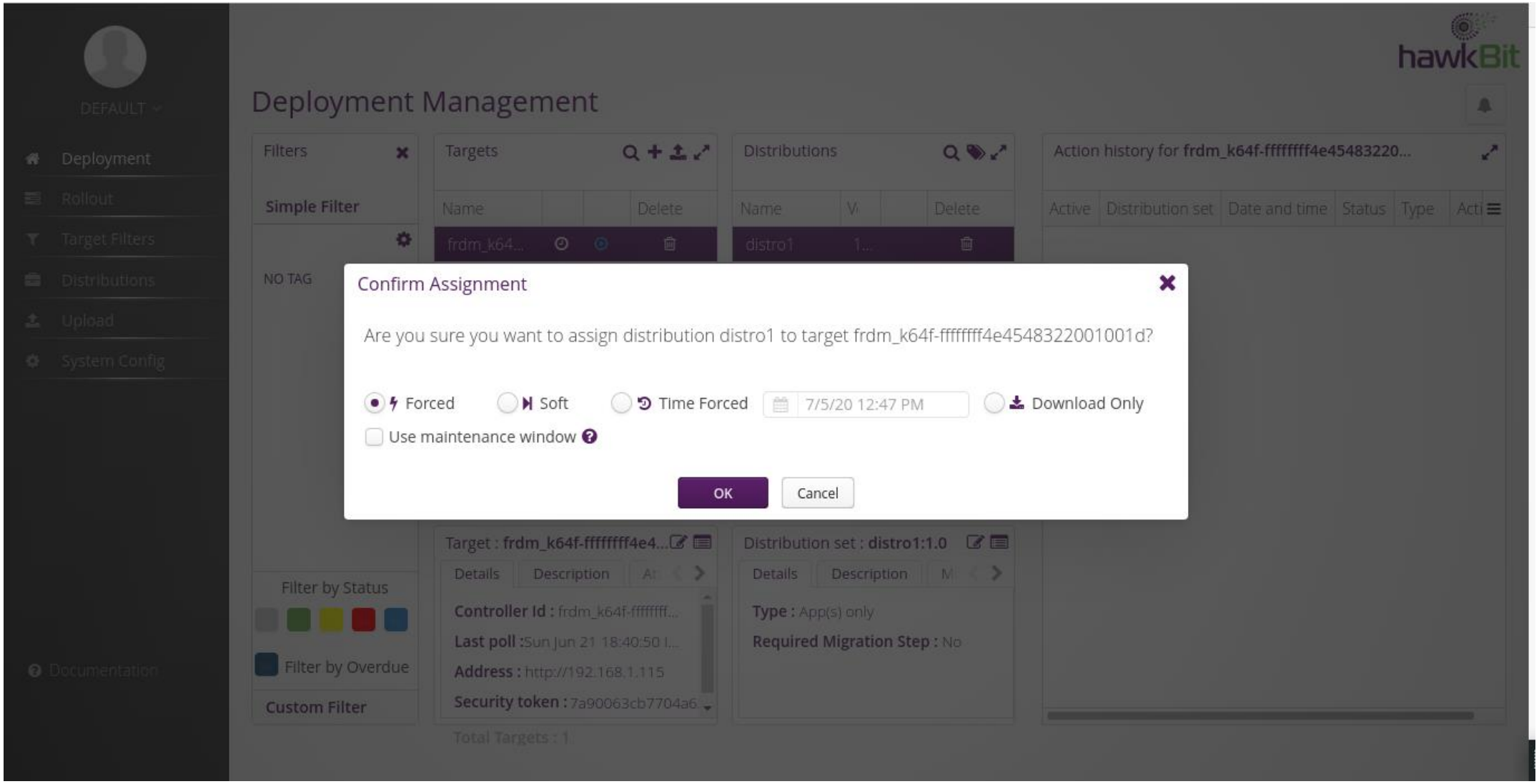
Hawkbit - update assignment



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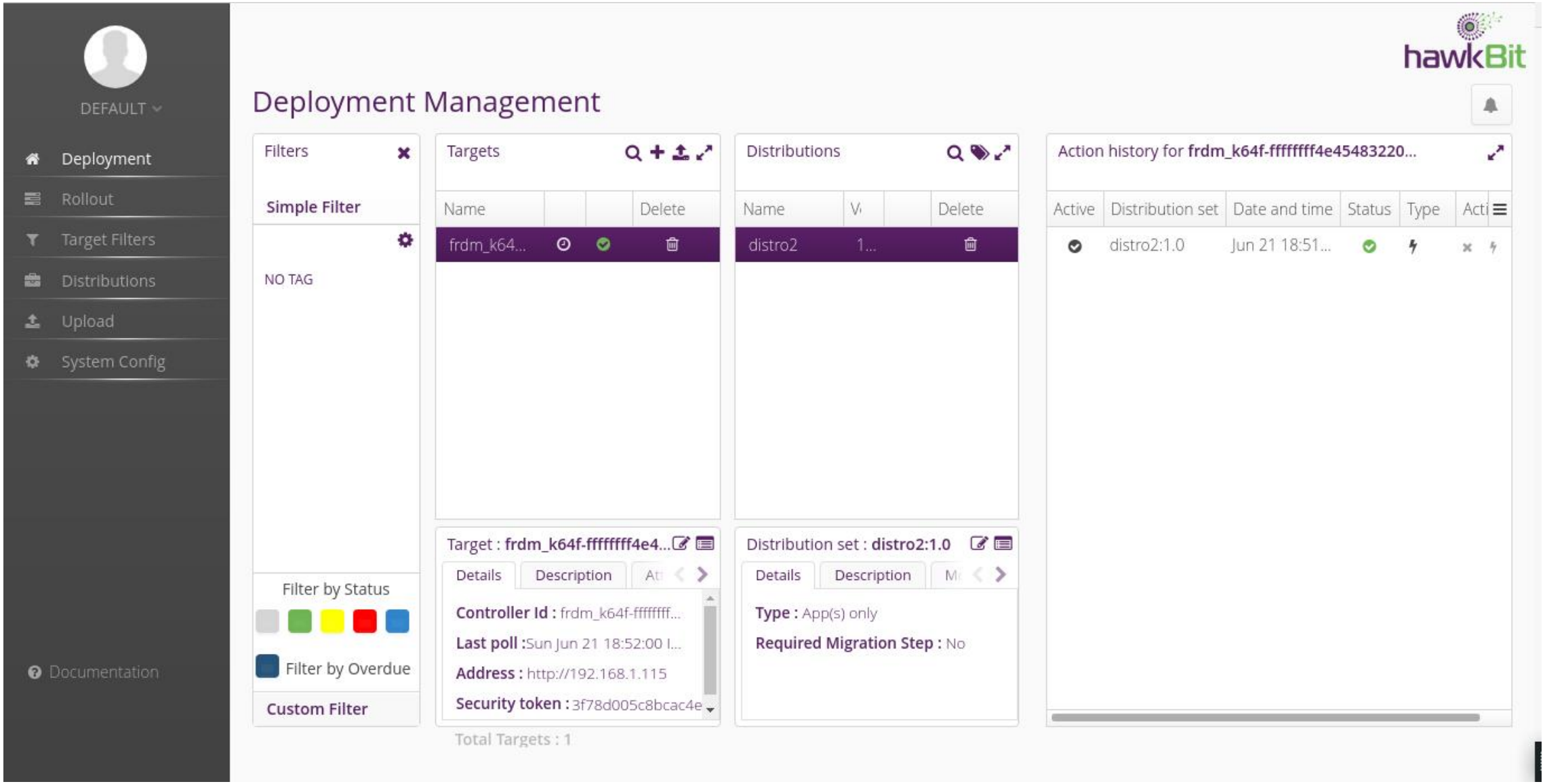
ZUpdate- update download and install

```
[00:00:00.005,000] <inf> main: Hawkbit sample app started
[00:00:03.000,000] <inf> eth_mcux: ETH_0 enabled 100M full-duplex mode.
[00:00:03.004,000] <inf> fs_nvs: 3 Sectors of 4096 bytes
[00:00:03.004,000] <inf> fs_nvs: alloc wra: 0, f98
[00:00:03.004,000] <inf> fs_nvs: data wra: 0, 58
[00:00:03.004,000] <inf> hawkbit: Image is  confirmed OK
[00:00:03.004,000] <inf> main: Starting hawkbit polling mode
[00:00:03.218,000] <inf> hawkbit: Polling target data from Hawkbit
[00:00:03.289,000] <inf> hawkbit: Ready to install update
[00:00:03.319,000] <inf> STREAM_FLASH: Erasing page at offset 0x00080000
[00:00:03.951,000] <inf> STREAM_FLASH: Erasing page at offset 0x00081000
[00:00:04.766,000] <inf> STREAM_FLASH: Erasing page at offset 0x00082000
[00:00:05.204,000] <inf> STREAM_FLASH: Erasing page at offset 0x00083000
[00:00:05.267,000] <inf> STREAM_FLASH: Erasing page at offset 0x00084000
[00:00:05.330,000] <inf> STREAM_FLASH: Erasing page at offset 0x00085000
[00:00:05.394,000] <inf> STREAM_FLASH: Erasing page at offset 0x00086000
[00:00:05.440,000] <inf> STREAM_FLASH: Erasing page at offset 0x000df000
[00:00:05.445,000] <inf> hawkbit: Update Installed. Please Reboot
uart:~$ kernel reboot cold *** Booting Zephyr OS build zephyr-v2.3.0-112-g4a8fb854bbc0  ***
[00:00:00.005,000] <inf> mcuboot: Starting bootloader
[00:00:00.006,000] <inf> mcuboot: Primary image: magic=good, swap_type=0x4, copy_done=0x1, image_ok=0x1
[00:00:00.006,000] <inf> mcuboot: Scratch: magic=unset, swap_type=0x1, copy_done=0x3, image_ok=0x3
[00:00:00.006,000] <inf> mcuboot: Boot source: none
[00:00:00.006,000] <inf> mcuboot: Swap type: test
*** Booting Zephyr OS build zephyr-v2.3.0-327-g636d6cd9cdb6  ***
Toggled led0; counter=0
Toggled led1; counter=0
Toggled led0; counter=1
Toggled led0; counter=2
```

Hawkbit - status



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ZUpdate Plans

- Extension to Linux OTA Agents
- Support for more local radios
- API for Cloud handlers

Reference

[1] MCUboot: Multi-Image Support - David Brown, Linaro, Ltd

[2] MCUboot swap operation – David Brown

[3] Hawkbit PR: https://github.com/zephyrproject-rtos/zephyr/pull/24107

Thank You

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