Cloud-native IoT

OTA Updates and Device Repurposing with k8s

Anastassios Nanos & Charalampos Mainas
Nubis PC / Nubificus LTD

About us

Research team, working on facilitating and optimizing application execution in Cloud and Edge environments

Focus areas:

- Low-level systems software
- Hardware acceleration
- Serverless computing

Involved in Research & Innovation Actions and commercial projects

About us

- Hardware acceleration abstractions
- Cloud-native IoT
- Container runtimes

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Cloud-Native IoT Integration

Enable efficient and secure management of IoT devices in the Cloud-Edge-IoT continuum.

Key Features:

- Secure onboarding
- Secure & fault-tolerant OTA updates
- Cloud-native device management & repurposing

Cloud-Native IoT Integration

Secure Device Onboarding:

- Attestation server: Verify device's authenticity, allow it to proceed in joining the cluster

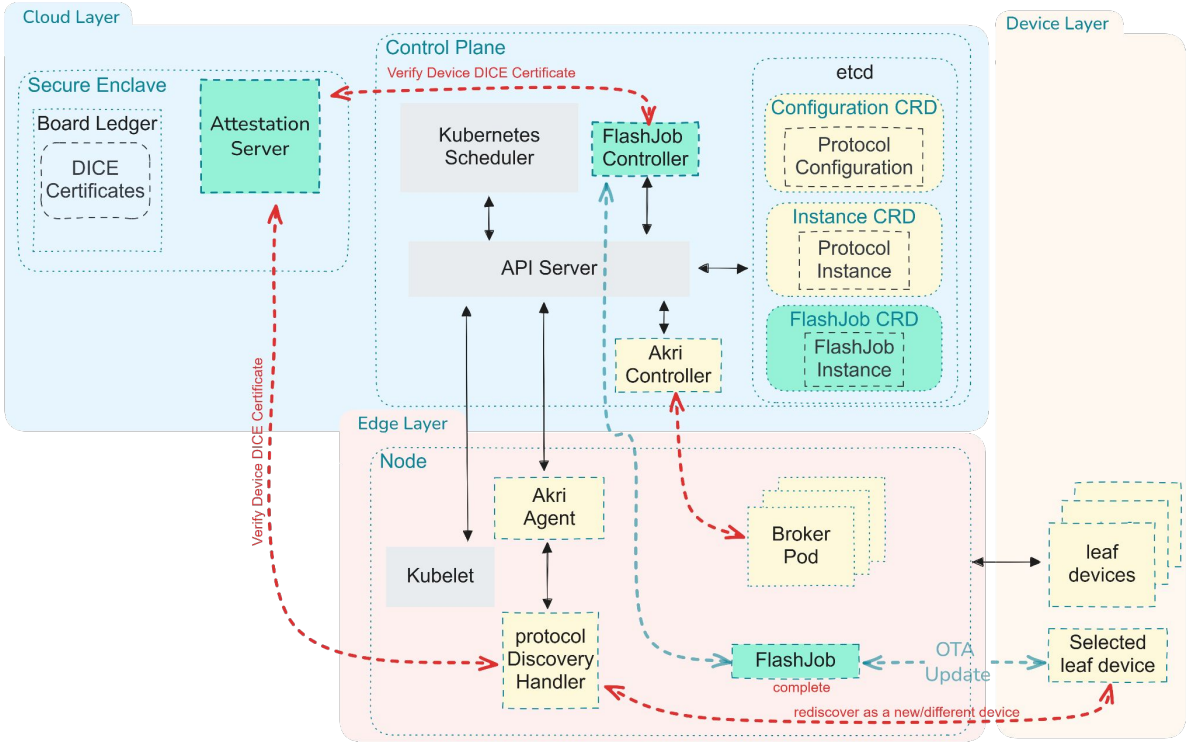
IoT Resource Orchestration:

- Use Akri for k8s device book-keeping and resource management
- Custom CRD operator to perform device repurposing

OTA Firmware Updates:

- Package device firmware as OCI container images
- Unpack these images in a neighboring node, and do an OTA update on the device, all in a cloud-native way

Cloud-Native IoT Integration



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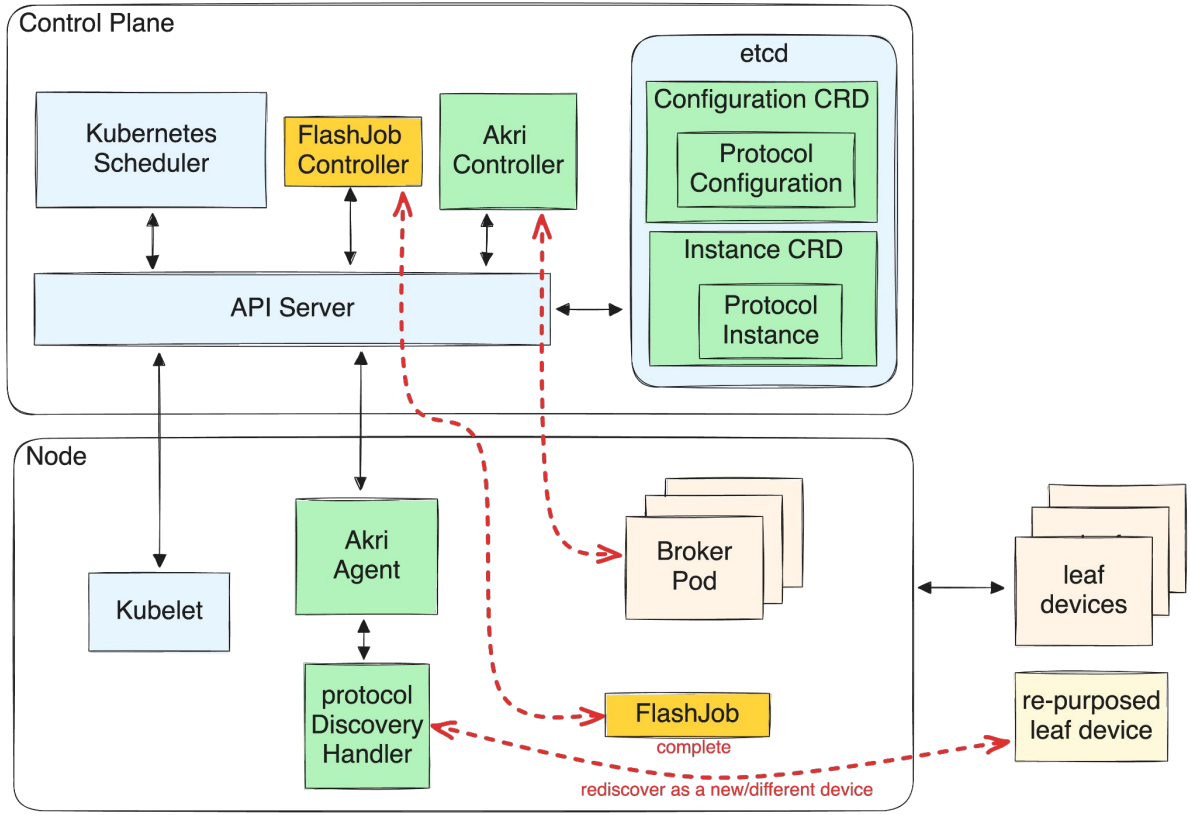

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Example applications involved

Application Type	Github Repo
Dummy `while () vTaskDelay();`	`nubificus/esp32-initial`
Sensor Read & Publish	`nubificus/esp32-sensor-read`
Camera Stream	`nubificus/esp32-cam-stream`
Motion Detection	`nubificus/esp32-cam-motion`

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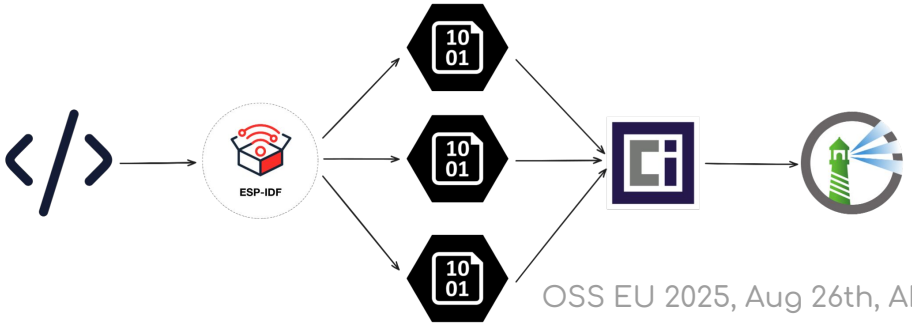
DEMO

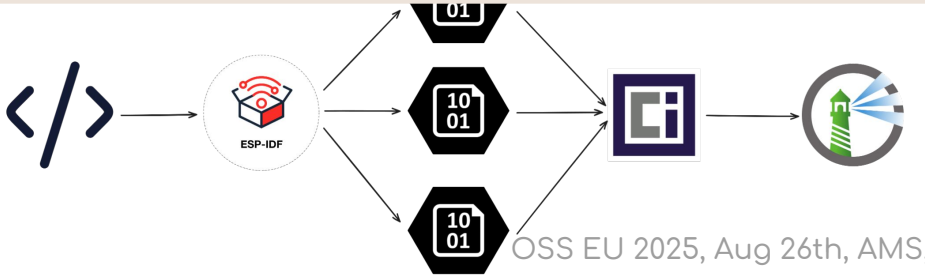
- Firmware blobs are packaged as OCI artifacts (and, thus, can be stored in any OCI-compliant registry).
- Support multiple devices and configs
- Pipeline:
  - **builds** the binary blob,
  - **packages** it as an OCI image and
  - **creates** an image manifest, annotating each OCI image with metadata.
  - **Pushes** the manifest / SHAs to a generic container registry.



Cloud-Native IoT

- Firmware blobs are packaged as OCI artifacts (and, thus, can be stored in any OCI-compliant registry).

Step 0: Build & Package



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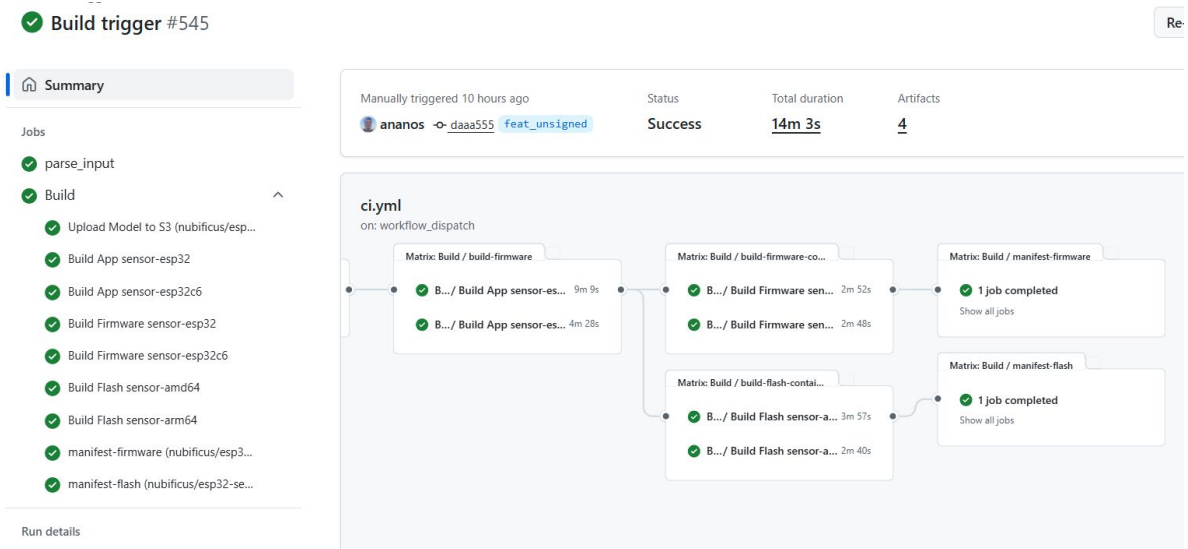
```
{
  "apps": [
    {
      "repo": "nubificus/esp32-sensor-read",
      "branch": "main",
      "version": "0.1.1",
      "type": "sensor",
      "TEMP_START": "20"
    }
  ],
  "targets": ["esp32", "esp32c6" ],
  "builder_image": "nubificus/esp-idf:x86_64-slim"
}
```



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Example OCI artifacts

Application Type	OCI manifest	OCI tags
Dummy `while () vTaskDelay();`	`esp32-null:initial-0.1.2`	`initial-0.1.2-esp32` `initial-0.1.2-esp32c6`
Sensor Read & Publish	`esp32-sensor-read:sensor-0.1.2`	`sensor-0.1.2-esp32` `sensor-0.1.2-esp32c6`
Camera Stream	`esp32-cam-stream:stream-0.2.0`	`stream-0.2.0-esp32`
Motion Detection	`esp32-cam-motion:motion-0.2.0`	`motion-0.2.0-esp32`

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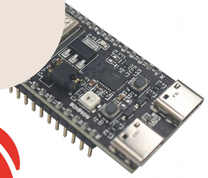
Step 1: Onboard



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Discovery handlers find the devices but do not onboard them (no UDS / Cert present)

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Inject UDS/Cert to attestation server

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Discovery handlers onboard the devices

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Data flow from IoT devices to the MQTT server & is being displayed in the grafana dashboard

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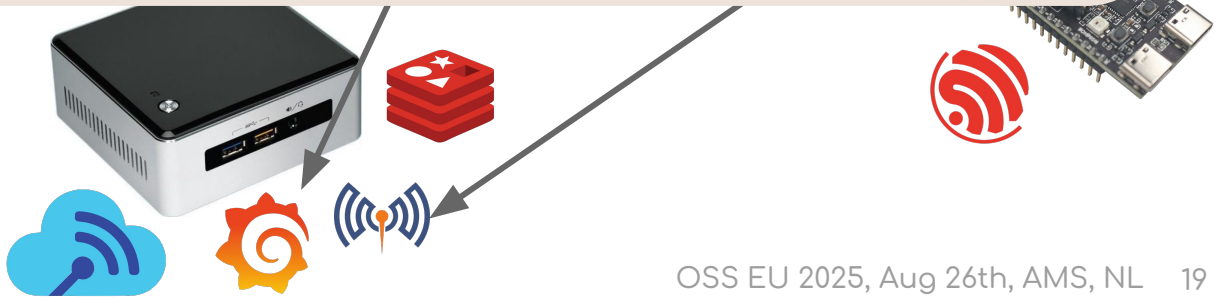
Step 2: Repurpose



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Repurpose both devices to Sensor Read: Apply the flashjob manifest with the specific firmware OCI artifact

```
apiVersion: application.flashjob.nbfc.io/v1alpha1
kind: FlashJob
metadata:
  name: fj-sens
spec:
  uuid:
    - ec2dd715-3563-44de-922a-16c1ba136293
    - b1f0484e-39bc-4504-891a-30e0c109bd50
  firmware: nubificus/esp32-sensor-read:sensor-0.1.2
  flashjobPodImage: nubificus/esp32-flashjob:x86_64
```

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Repurpose both devices to Sensor Read: Apply the flashjob manifest with the specific firmware OCI artifact

```
apiVersion: application.flashjob.nbfc.io/v1alpha1
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  firmware: nubificus/esp32-sensor-read:sensor-0.1.2
  flashjobPodImage: nubificus/esp32-flashjob:x86_64
```

Flashjob pods are created, fetch the OCI firmware images, check the architecture and begin the secure OTA update

Cloud-Native IoT Integration

Data flow from IoT devices to the MQTT server & is being displayed in the grafana dashboard

Thanks!

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Source code:

- GitHub org: https://github.com/nubificus
- Cloud-native IoT: nubificus/cloud-native-iot

DESIRE6G

EMPYREAN

MLSysOps

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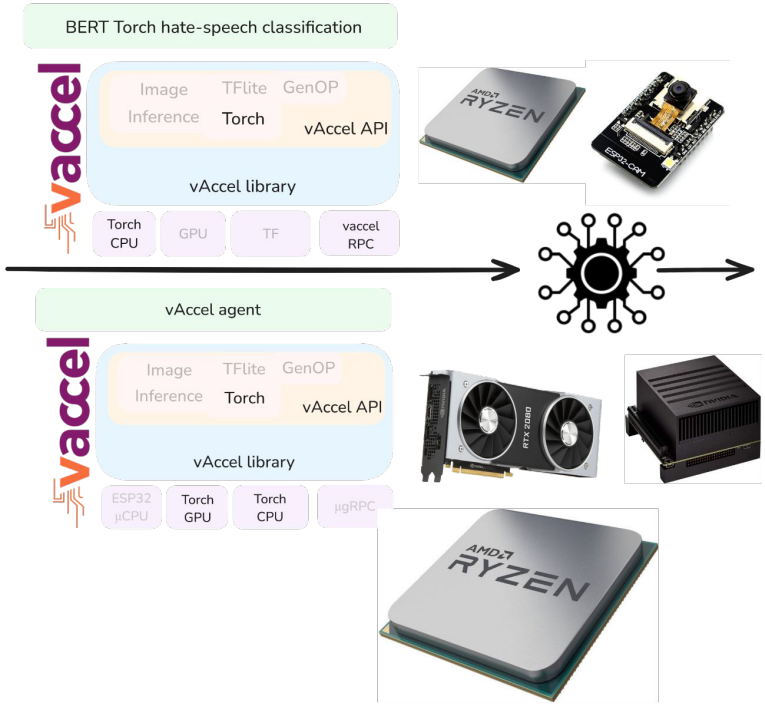
PyTorch



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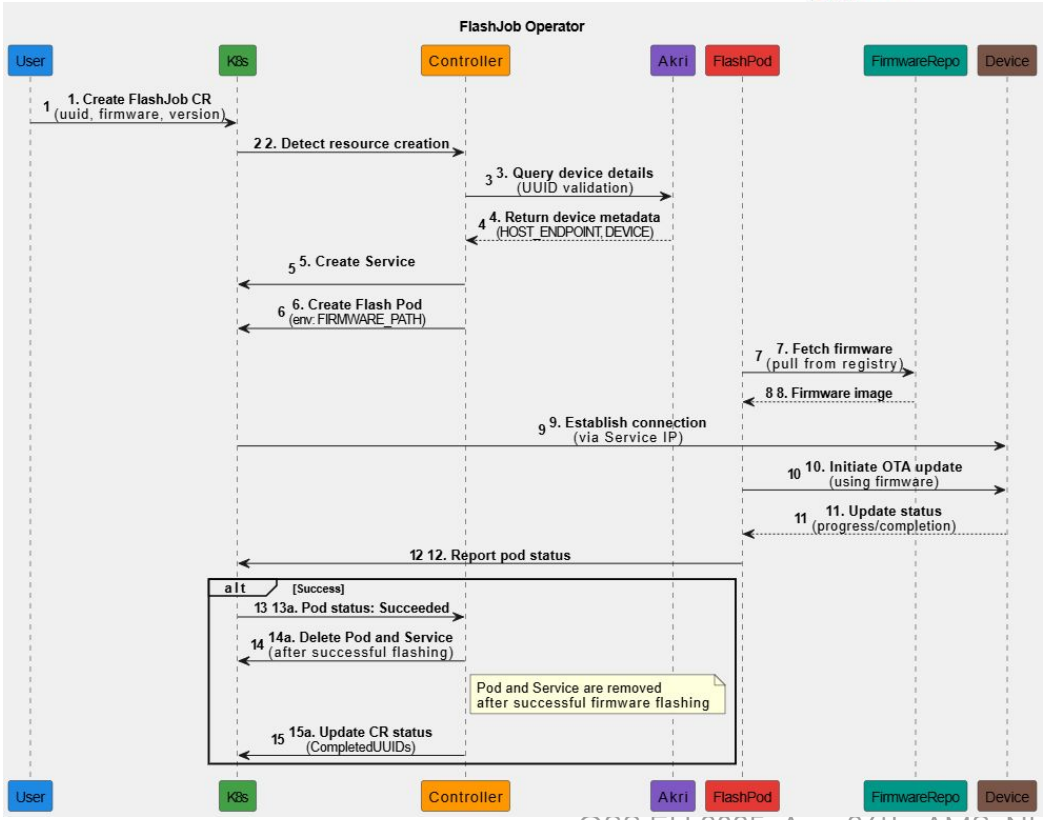

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