You make **possible**

From Zero to IOx Hero

Taming the Edge Compute

Emmanuel Tychon, TME
IoT Business Unit

BRKIOT-2213

Barcelona | January 27-31, 2020

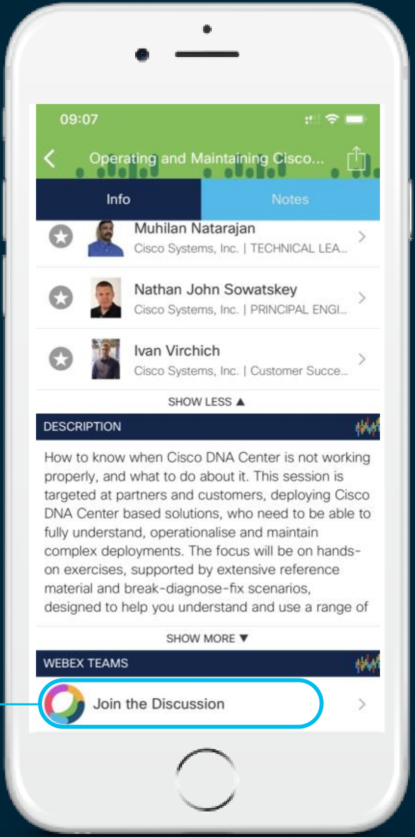
Cisco Webex Teams

Questions?

Use Cisco Webex Teams to chat with the speaker after the session

How

1. Find this session in the Cisco Events Mobile App
2. Click “Join the Discussion”
3. Install Webex Teams or go directly to the team space
4. Enter messages/questions in the team space



09:07

Operating and Maintaining Cisco...

Info | Notes

Muhilan Natarajan
Cisco Systems, Inc. | TECHNICAL LEA...

Nathan John Sowatskey
Cisco Systems, Inc. | PRINCIPAL ENGI...

Ivan Virchich
Cisco Systems, Inc. | Customer Succe...

SHOW LESS ▲

DESCRIPTION

How to know when Cisco DNA Center is not working properly, and what to do about it. This session is targeted at partners and customers, deploying Cisco DNA Center based solutions, who need to be able to fully understand, operationalise and maintain complex deployments. The focus will be on hands-on exercises, supported by extensive reference material and break-diagnose-fix scenarios, designed to help you understand and use a range of

SHOW MORE ▼

WEBEX TEAMS

Join the Discussion

Poll

- Who already knows Cisco IOx ?
- Who knows Docker?
- Who consider itself as a developer?
- Who consider itself as a network engineer?
- Who consider itself as both a developer and network engineer?

Agenda

- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

Agenda

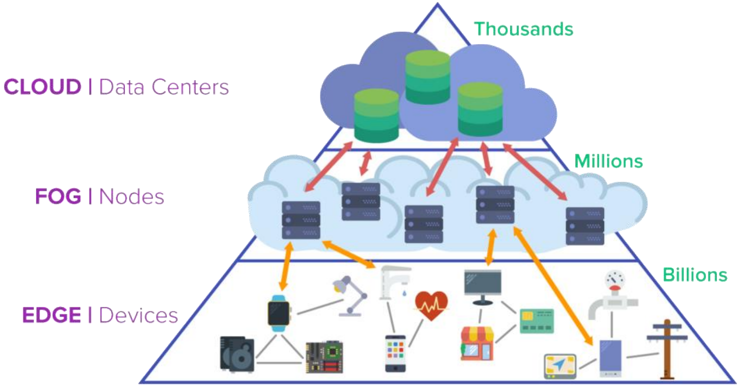
- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

What is Cisco IOx

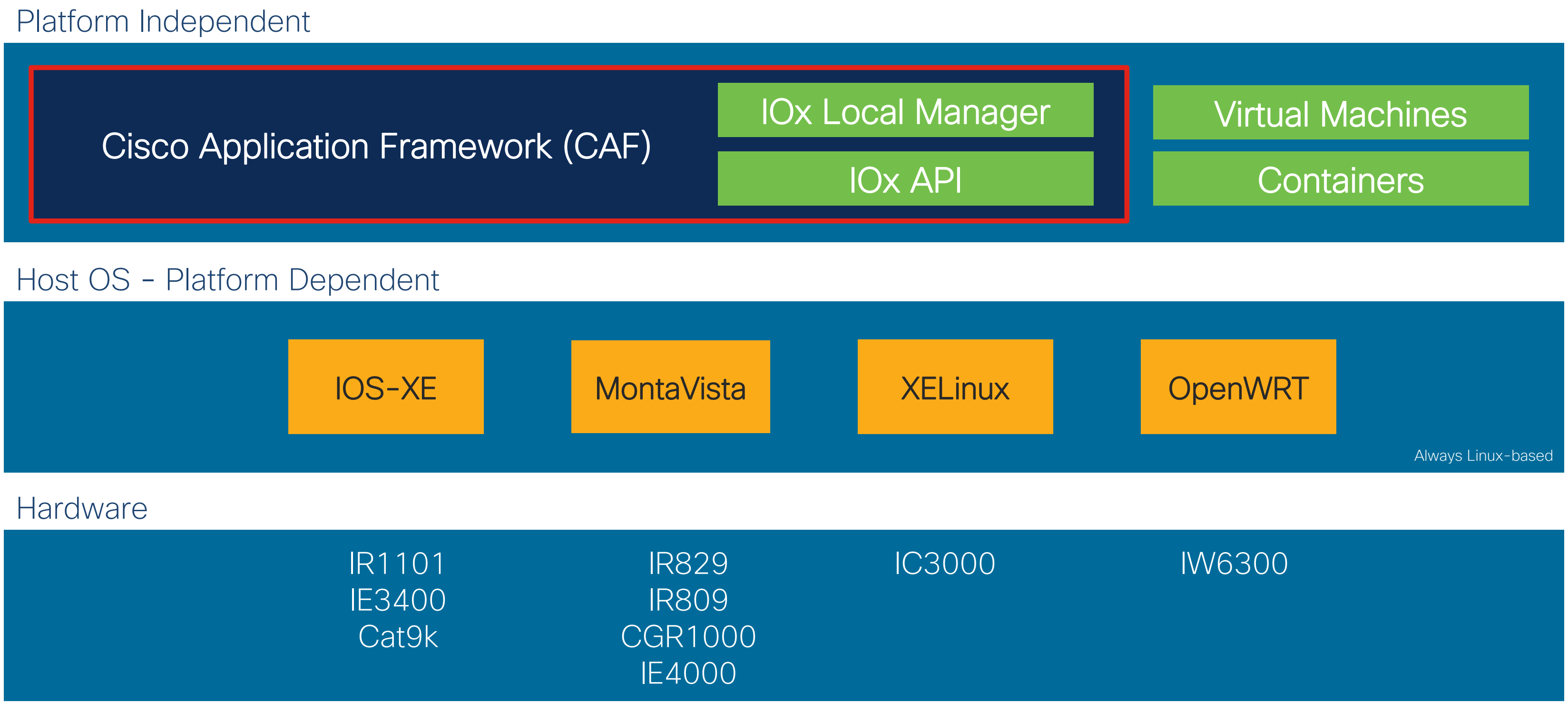
- IOS and Linux = IOx
- Cisco IOx is an application hosting environment
- Hosts Virtual Machines as well as Containers
- Supports docker tooling for development
- Provisions services like GPS & Secure Storage, for applications
- Local Manager for application monitoring and resource usage

Why Cisco IOx

- Run distributed compute at the edge
- Leverage secure connectivity of Cisco IOS software
- Manageable with on-premises or cloud-based interface
- Runs on wide variety of IoT platforms
- Builds on existing developer tools and trainings on DevNet



IOx Platform Architecture



Platform Independent

Cisco Application Framework (CAF)

IOx Local Manager

IOx API

Virtual Machines

Containers

Host OS - Platform Dependent

IOS-XE

MontaVista

XELinux

OpenWRT

Always Linux-based

Hardware

IR1101
IE3400
Cat9k

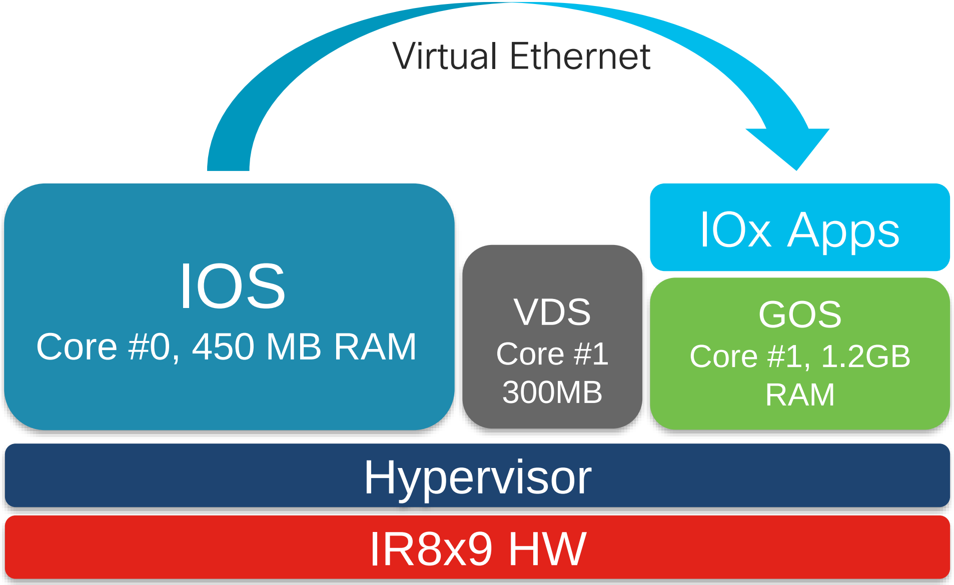
IR829
IR809
CGR1000
IE4000

IC3000

IW6300

Example: IOx on IR8x9

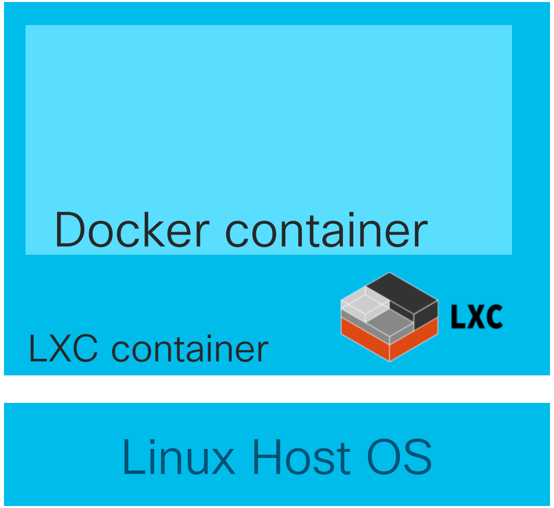
- IR8x9 HW runs hypervisor
- Guest OS (GOS) is Linux Yocto
- Virtual Device Server (VDS) – handles device’s sharing, eg. Console, USB,… not seen from users
- IOS and Guest OS communicate only through an internal virtual Ethernet connection: full isolation otherwise



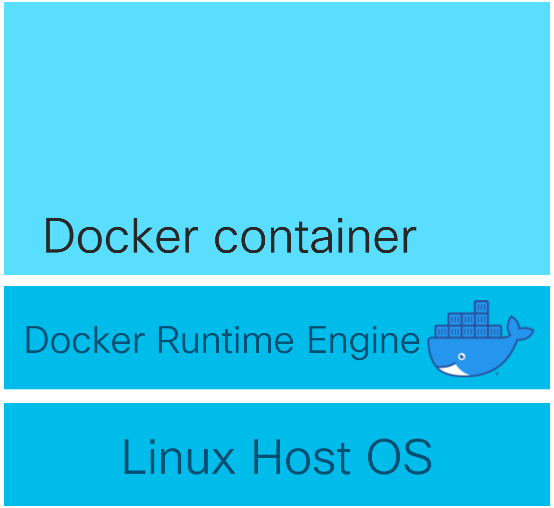
Docker Compatible or Docker Native?

TIP

Docker Compatible platforms run Docker in an LXC container, or do support native Docker engine.



Docker Native platforms run Docker engine natively. They run Docker images as Docker Containers. They may not.



IOx Hardware Platforms Summary

	IC3000	IR809 / IR829	IR1101	IE3400	IE4000
CPU	Intel Atom C2508 4-Core Rangeley, 1.2 GHz	Intel Atom C2308 2-Core Rangeley, 1.2GHz	Marvell Armada 4-Core A72 @ 600MHz	Zynq UltraScale+ 4-Core A53, 1.2GHz	AppliedMicro APM86392 PowerPC4 465 600Mhz
CPU Arch	x86_64	x86_64	aarch64	aarch64	ppc
CPU Units	10260	732	1000	1000	1035
OS	specific firmware	Cisco IOS	Cisco IOS-XE	Cisco IOS-XE	Cisco IOS
RAM Usable	8GB DDR3 1333Mhz	767MB DDR3 1333Mhz	862 MB DDR4 ECC	4GB DDR4	512MB
Application Storage	96GB SSD disk	512MB - 1.8GB Optional SSD disk	450 MB or 65GB with SSD	4GB eMMC partition shared with IOS-XE	256MB flash
LXC Containers	No	Yes	Yes	No	Yes
Docker Compatible	Yes	Yes	Yes	Yes	Yes
Docker Native	Yes	No	Q2CY20 (17.2)	Q2CY20 (17.2)	No
Virtual Machines	Yes	No	No	No	No
Use Cases	Faster compute Paired with non-IOx Capable gear	RaMA with LTE 829: In vehicle, wifi	Modular LTE Serial ports	Manufacturing Road infra	Legacy

DevNet IOx Platform Matrix: https://developer.cisco.com/docs/iox/#!platform-support-matrix/platform-support-matrix
DevNet IOx feature support matrix: https://developer.cisco.com/docs/iox/#!feature-compatibility-matrix

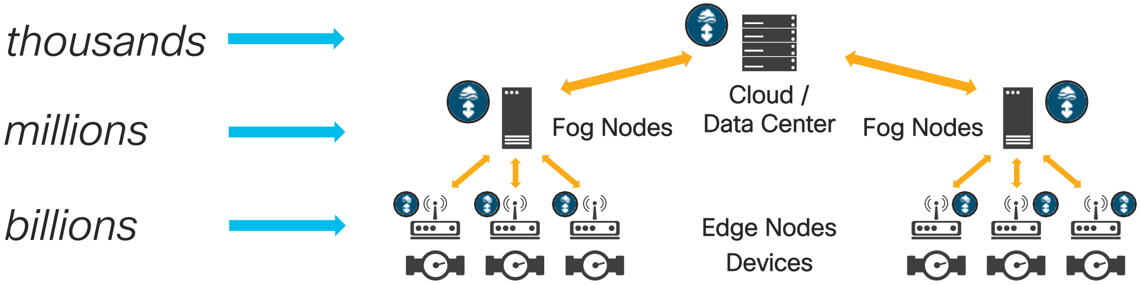
IOx Hardware Platforms Summary

	Catalyst 9000	ASR1000	ISR4000	CGR1000 Compute Module
CPU	Intel	Intel	Intel	AMD GX-410VC. 4-Core @ 800Mhz
CPU Arch	x86_64	x86_64	x86_64	x86_64
CPU Units	7400	73000	13000	7318
OS	Cisco IOS-XE	Cisco IOS-XE	Cisco IOS-XE	Cisco IOS
RAM Usable	4GB+	4GB+	4GB+	4GB
Application Storage	120-960GB SSD disk	40-400GB SSD	20-200GB SSD	50 - 100GB SSD
LXC Containers	No	Yes	Yes	Yes
Docker Compatible	Yes	Yes	Yes	Yes
Docker Native	Yes (16.12+)	No	No	no
Virtual Machines	No	Yes	Yes	Yes
Use Cases	Core Network Telemetry	Edge network telemetry	Edge network telemetry	Adds IOx to existing Connected Grid Routers (CGR)

DevNet IOx Platform Matrix: https://developer.cisco.com/docs/iox/#!platform-support-matrix/platform-support-matrix
DevNet IOx feature support matrix: https://developer.cisco.com/docs/iox/#!feature-compatibility-matrix

The Edge

- Edge deals with large volume of real-time data
- Runs at data source, on premise
- Small and ephemeral data storage
- Saves bandwidth, makes faster decisions, act locally



The birth (and death) of an IOx application

App Dev/Porting

- language
- CPU platform

Packaging

- operating system
- container
- virtual machine

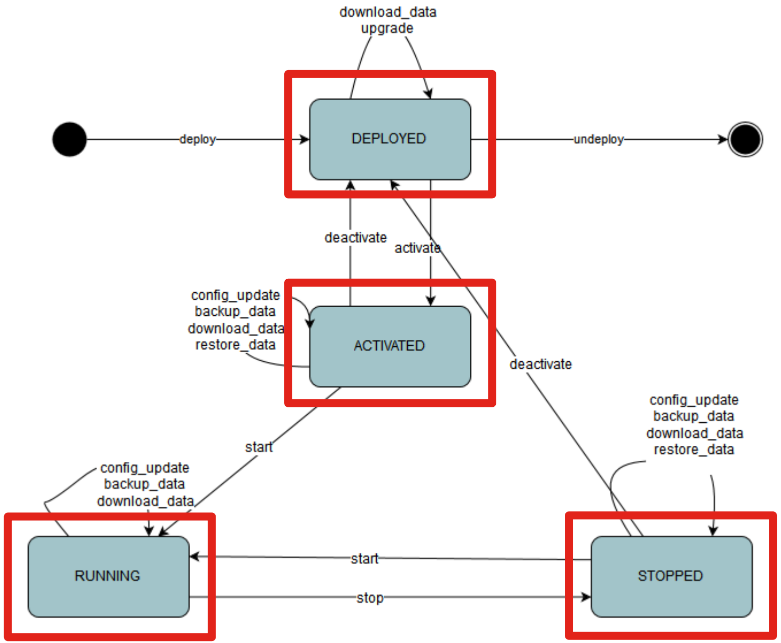
Deploying

Activating

Running

Monitoring

- container management
- cloud
- on premise
- autonomous



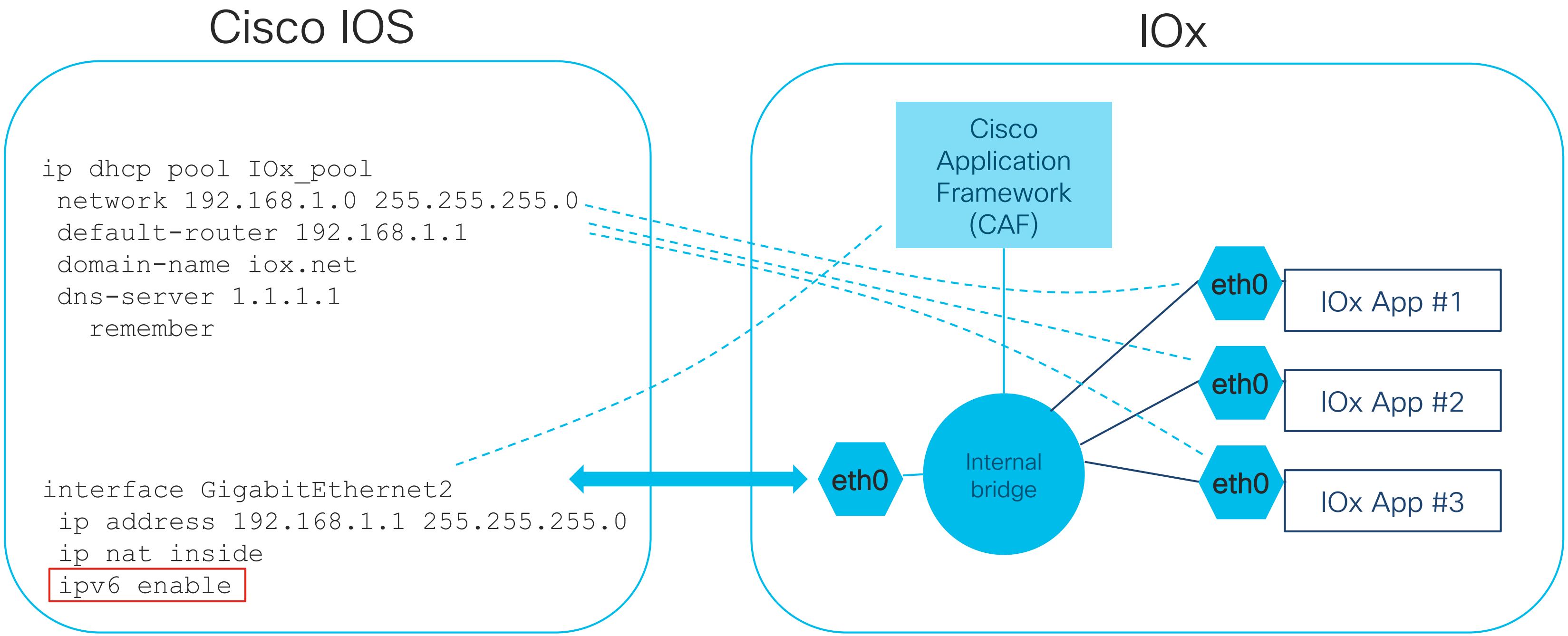
Agenda

- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

IOx focus Platforms (for IIoT)

	IR1101	Modular IOS-XE Cellular router	arm64
	IR8x9	IOS Cellular router	x64
	IC3000	Compute Appliance	x64
	IE3400	IOS-XE based Industrial Ethernet Switch	arm64

Networking with IOx (Example: IR809, Bridging)



```
ip dhcp pool IOx_pool
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
 domain-name iox.net
 dns-server 1.1.1.1
   remember
```

```
interface GigabitEthernet2
 ip address 192.168.1.1 255.255.255.0
 ip nat inside
 ipv6 enable
```

Agenda

- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

IOx Applications Language Support

- Can be written in **Any Language**
- Containers packaged with **libraries, interpreters, etc…**
- IOx supports different CPU architectures:
  - PowerPC, ARM, Intel x86
- Compiled Languages (C, C++, Go,…):
  - **Cross compiling might be required**
- Interpreted languages (Python, Perl,…):
  - Are platform independent

Cisco Toolkit for IOx

Cisco provides:

- IOx client tools
- DevNet Support Community
- DevNet Practice Sandbox
- Software to deploy and manage IOx apps
- Application templates in multiple languages [1]
- Interoperability Verification Testing (IVT) Certification

Developer provides:

- Language, compilers, IDE
- Non IOx Container Toolchain (Docker)
- Container OS (such as Alpine Linux, or Busybox)

[1] https://github.com/CiscoDevNet/iox-app-template

Packaging

IOx Application types (Overview)

Container apps

Contains:

- application code
- libraries
- native binaries
- entire root file system

No Operating System

Docker tooling

VM packaged apps

Same as container app, plus a complete OS

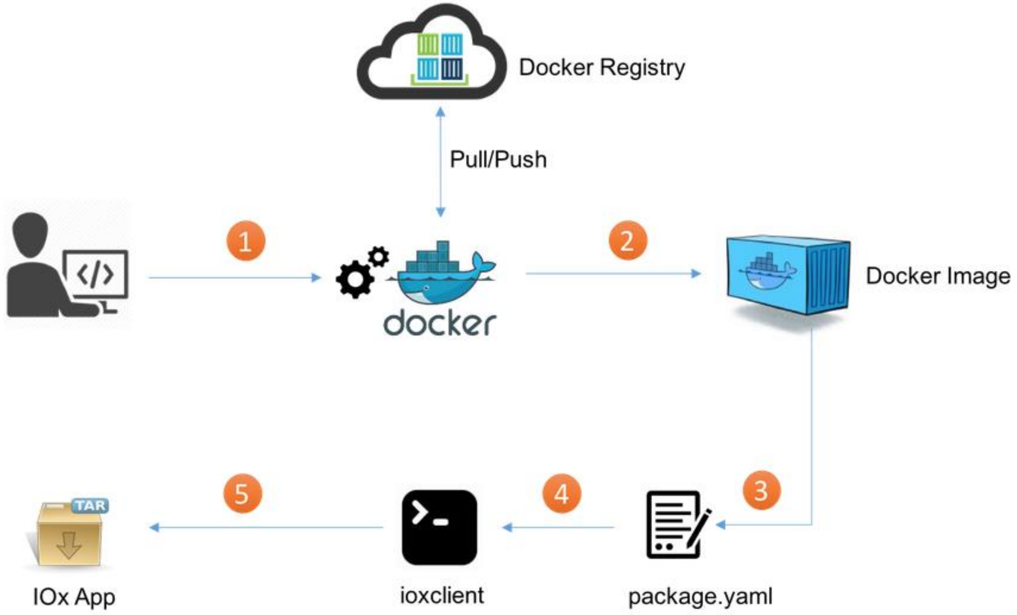
.vmdk format (found in .ova)

Docker Style and Container Applications

Docker style applications

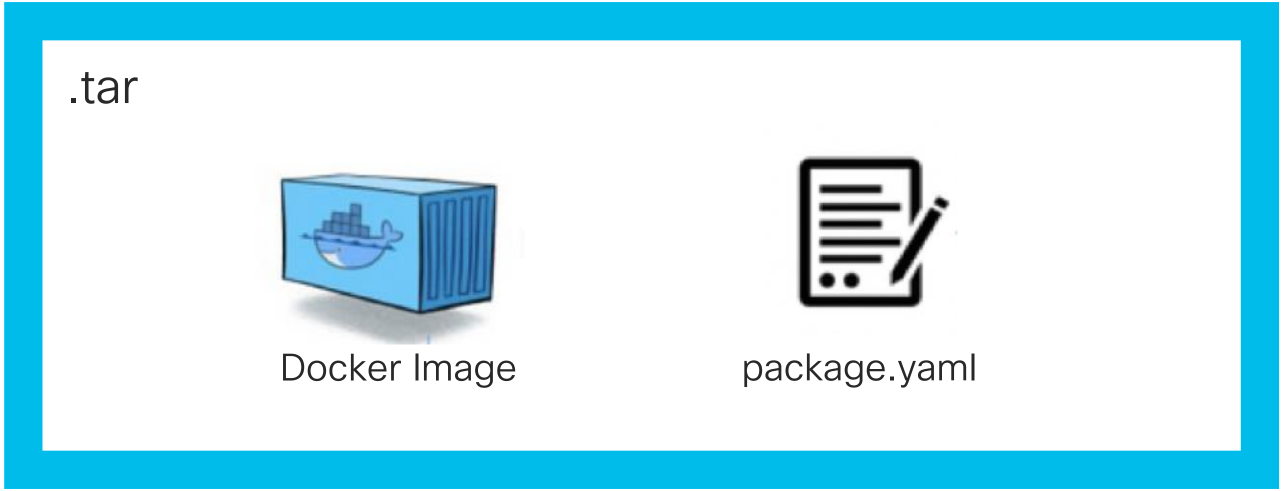
- Uses existing ecosystem and skills base
- Leverages expertise in DC containerized applications
- Pull prebuilt binaries from a software repository vs. compile from source code for the entire file system.
- End result: Dramatic time savings over an IOx SDK build

Using the Docker tool chain to generate IOx applications



1. Use docker tools and images
2. Generate required docker image
3. Write suitable package descriptor file
4. Use ioxclient wrapper command and point it to generated docker image and package.yaml
5. Generates IOx compatible app

Docker Application Anatomy for IOx



.tar

Docker Image

package.yaml

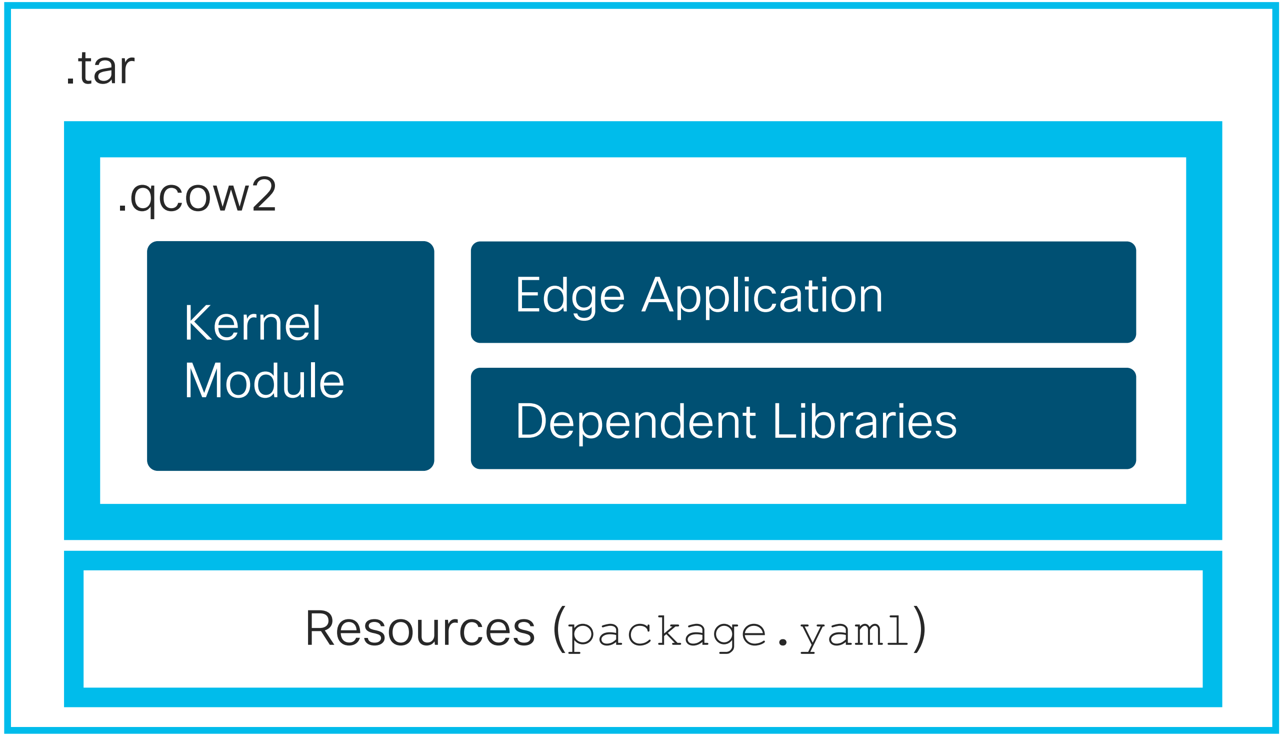
- Cross compilation for different platforms is still needed

VM Packaged Applications

VM Packaged applications

- Self contained & Independent
- Bigger in size
- Limited visibility into the VM
- Management and packaging at scale is not easy
- VMs run on hypervisor Kernel-based Virtual Machine (KVM) using Quick Emulator (QEMU)
- Only supported on IC3000 and CGR compute module

VM Packaged Applications - Anatomy



.tar

.qcow2

Kernel Module

Edge Application

Dependent Libraries

Resources (`package.yaml`)

Agenda

- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

What are we going to do now?

- Create a package with a web server
- Package it to run on IOx
- Deploy the package
- Validate if it is running

Prerequisites not Covered

- Docker installed: https://www.docker.com/get-started
- `ioxclient` installed: https://developer.cisco.com/docs/iox/#!iox-resource-downloads
- Can be done on Windows, Linux, MacOS

Create a simple file structure

- Create a directory to hold the files
- Then create the base files themselves:

```
Dockerfile
main.py
package.yaml
```

Package Anatomy

IOx application package is a tarball containing the following files:

File	Description
package.yaml	Application Descriptor
package.mf	Manifest file containing the checksum of the other files at this level. Automatically generated by ioxclient
artifacts.tar.gz	Compressed envelope containing a tar ball of docker image

Define the Dockerfile

```
FROM python:3-alpine
```

tells Docker to build a container image based on the publicly-available Alpine Linux 3.9 image

```
RUN apk add --update \
  python3
RUN pip3 install bottle
```

RUN instruction installs Python3, then uses the pip3 tool to install the bottle web framework.

```
EXPOSE 8000
```

EXPOSE instruction configures the created container to listen on port 8000.

```
COPY main.py /main.py
```

COPY instruction copies the main.py file to the root of the container filesystem.

```
CMD python3 /main.py
```

CMD instruction executes the main.py file using the Python 3 interpreter. This instruction is necessary only when running the container locally for testing.

Create your code (main.py)

- Uses the “bottle” framework to create a web server
- Binds the root URL to a message
- Listens to connections on port 8000

```
from bottle import route, run

@route('/’)
  def hello():
    return '<b>Hello Cisco Live</b>!'

run(host='0.0.0.0', port=8000)
```

package.yaml

```
descriptor-schema-version: "2.2”
info:
  name: iox_docker_python_ll
  description: "IOx Docker HelloWorld”
  version: "1.0”
  author-link: http://www.cisco.com
  author-name: "Cisco Systems”
app:
  cpuarch: "x86_64”
  type: docker
  resources:
    profile: c1.small
    network:
      -
        interface-name: eth0
        ports:
          tcp:
            - 8000
  startup:
    rootfs: rootfs.tar
    target: ["/usr/local/bin/python3", "main.py"]
```

- Contains the configuration information needed to package and run the IOx application
- YAML is a markup language that in IOx uses to store configuration information about the application package.

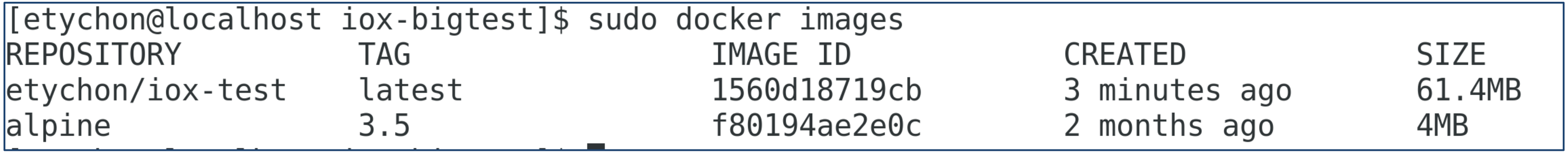
Build the Docker image

- Build docker image

```
docker build -t etychon/iox-test .
```

- Check build success

```
docker images
```



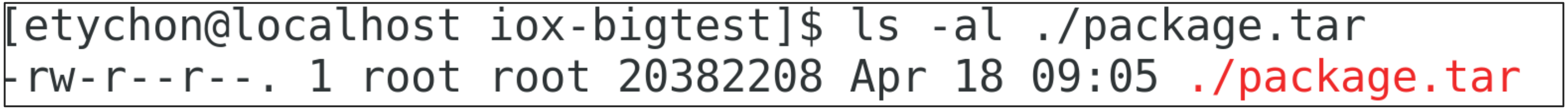
```
[etychon@localhost iox-bigtest]$ sudo docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
etychon/iox-test    latest              1560d18719cb        3 minutes ago       61.4MB
alpine              3.5                 f80194ae2e0c        2 months ago        4MB
```

Create a package IOx will accept

- Package the IOx Application with the ioxclient tool:

```
ioxclient docker package etychon/iox-test:latest .
```

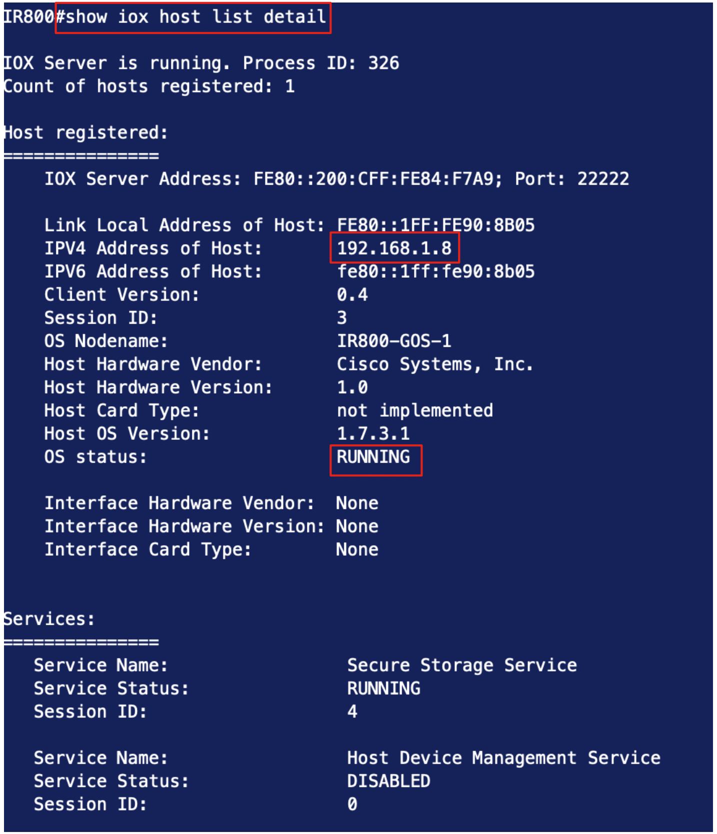
- Verify the package has been created:



```
[etychon@localhost iox-bigtest]$ ls -al ./package.tar
-rw-r--r--. 1 root root 20382208 Apr 18 09:05 ./package.tar
```

Verify IOx runs on Gateway

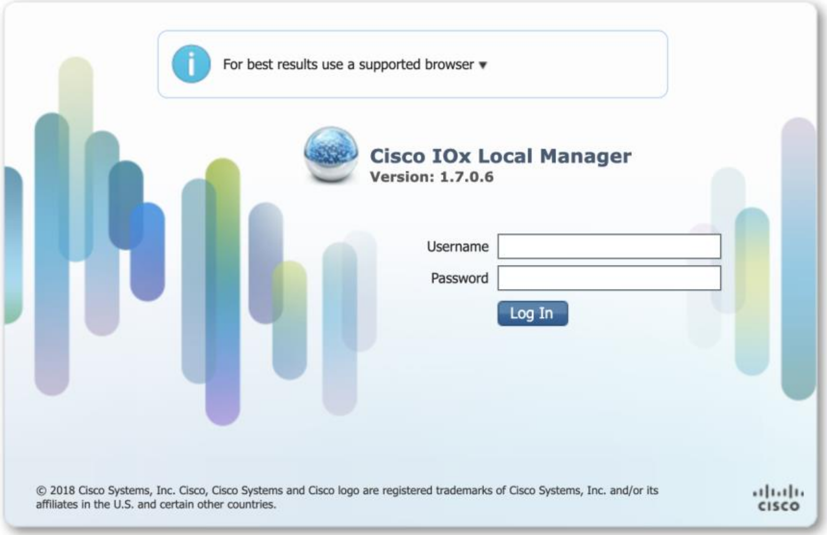
- IOx config varies per platform, check Cisco DevNet for details
- Check if IOx running with:
  `show iox host list details`



```
IR800#show iox host list detail

IOX Server is running. Process ID: 326
Count of hosts registered: 1

Host registered:
===============
    IOX Server Address: FE80::200:CFF:FE84:F7A9; Port: 22222

    Link Local Address of Host: FE80::1FF:FE90:8B05
    IPV4 Address of Host:       192.168.1.8
    IPV6 Address of Host:       fe80::1ff:fe90:8b05
    Client Version:             0.4
    Session ID:                 3
    OS Nodename:                IR800-GOS-1
    Host Hardware Vendor:       Cisco Systems, Inc.
    Host Hardware Version:      1.0
    Host Card Type:             not implemented
    Host OS Version:            1.7.3.1
    OS status:                  RUNNING

    Interface Hardware Vendor:  None
    Interface Hardware Version: None
    Interface Card Type:        None


Services:
===============
   Service Name:                 Secure Storage Service
   Service Status:               RUNNING
   Session ID:                   4

   Service Name:                 Host Device Management Service
   Service Status:               DISABLED
   Session ID:                   0
```

Log on to Local Manager to upload package

- Log-in to IOx Local Manager: https://10.0.0.1:8443/admin
- Default credentials: cisco/cisco



For best results use a supported browser ▾

Cisco IOx Local Manager
Version: 1.7.0.6

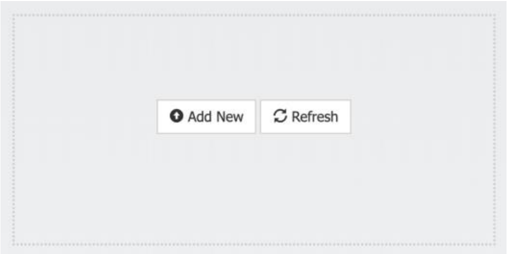
Username
Password

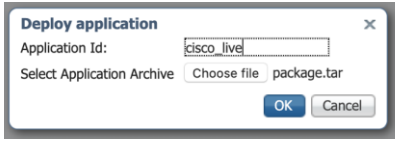
Log In

© 2018 Cisco Systems, Inc. Cisco, Cisco Systems and Cisco logo are registered trademarks of Cisco Systems, Inc. and/or its affiliates in the U.S. and certain other countries.

IOx Application Deployment

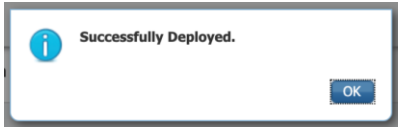
- Select ”Add New” in “Applications” tab
- Choose the “package.tar” built previously
- Wait a couple of minutes
- Application deployed
- Deployed but still needs to be activated!

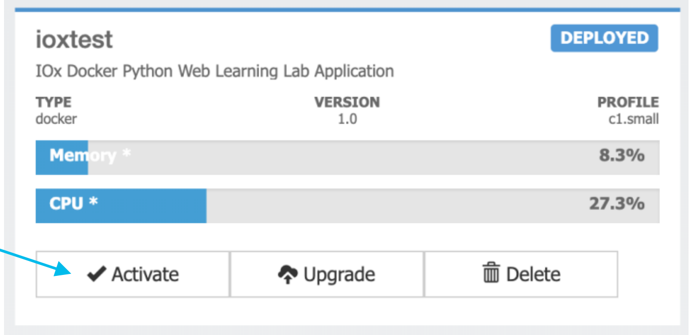



Deploy application

Application Id: cisco_live

Select Application Archive: package.tar


Successfully Deployed.


ioxtest — DEPLOYED

IOx Docker Python Web Learning Lab Application

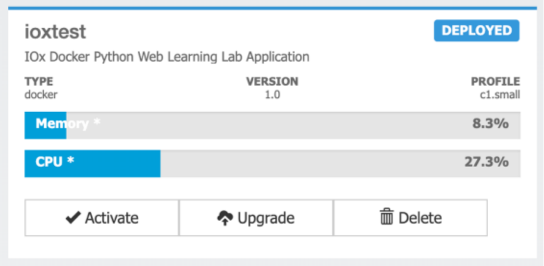
TYPE docker — VERSION 1.0 — PROFILE c1.small

Memory * 8.3%

CPU * 27.3%

IOx Application Activation

- Click “Activate”
- Because we want TCP/8000 to be mapped, select ”iox-nat0” as Network Configuration
- Configure “Port Mapping” to custom 8000 internal and external
- Select ”Ok”, then “Activate”



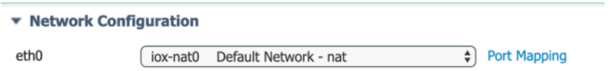
ioxtest DEPLOYED

IOx Docker Python Web Learning Lab Application

TYPE docker | VERSION 1.0 | PROFILE c1.small

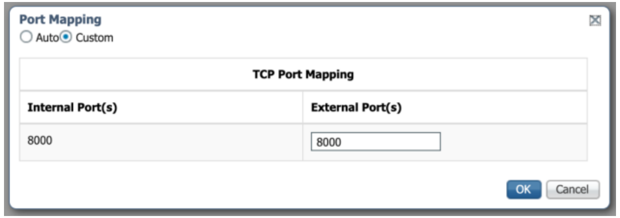
Memory * 8.3%

CPU * 27.3%



Network Configuration

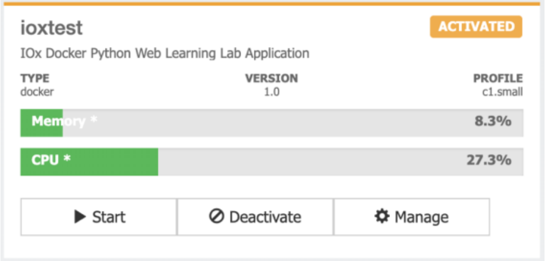
eth0 iox-nat0 Default Network - nat



Port Mapping

○ Auto ● Custom

TCP Port Mapping	
Internal Port(s)	External Port(s)
8000	8000



ioxtest ACTIVATED

IOx Docker Python Web Learning Lab Application

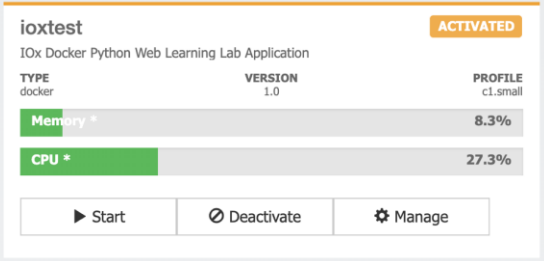
TYPE docker | VERSION 1.0 | PROFILE c1.small

Memory * 8.3%

CPU * 27.3%

IOx Application Running

- When the container is "Activated", click "Start"
- Container is now running.



ioxtest ACTIVATED

IOx Docker Python Web Learning Lab Application

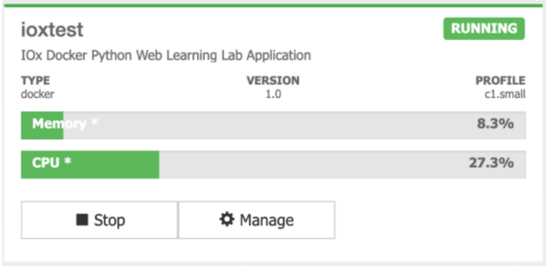
TYPE docker

VERSION 1.0

PROFILE c1.small

Memory * 8.3%

CPU * 27.3%



ioxtest RUNNING

IOx Docker Python Web Learning Lab Application

TYPE docker

VERSION 1.0

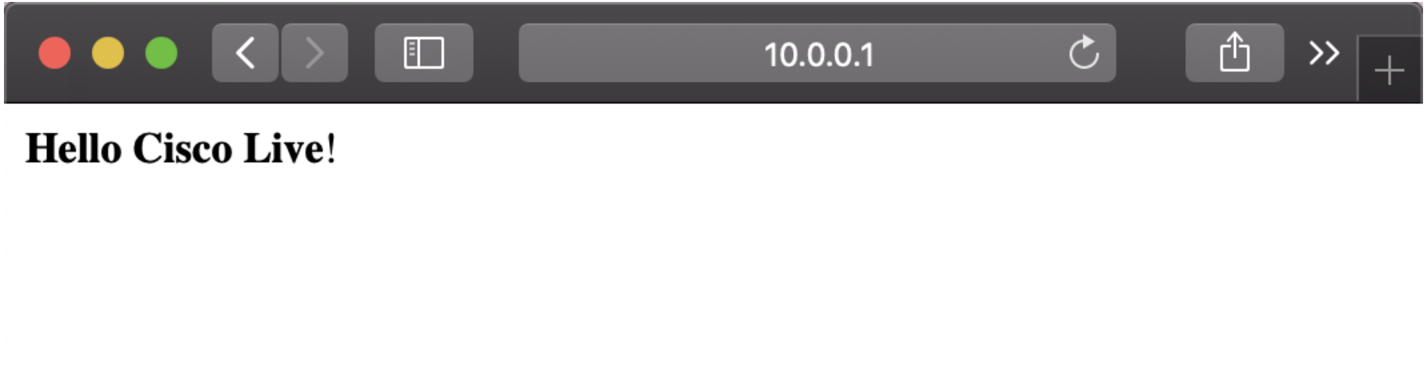
PROFILE c1.small

Memory * 8.3%

CPU * 27.3%

Verify!

- Point browser to http://10.0.0.1:8000/
- Note: this is the router's external NAT interface, because we have configured a NAT static mapping.



Hello Cisco Live!

Agenda

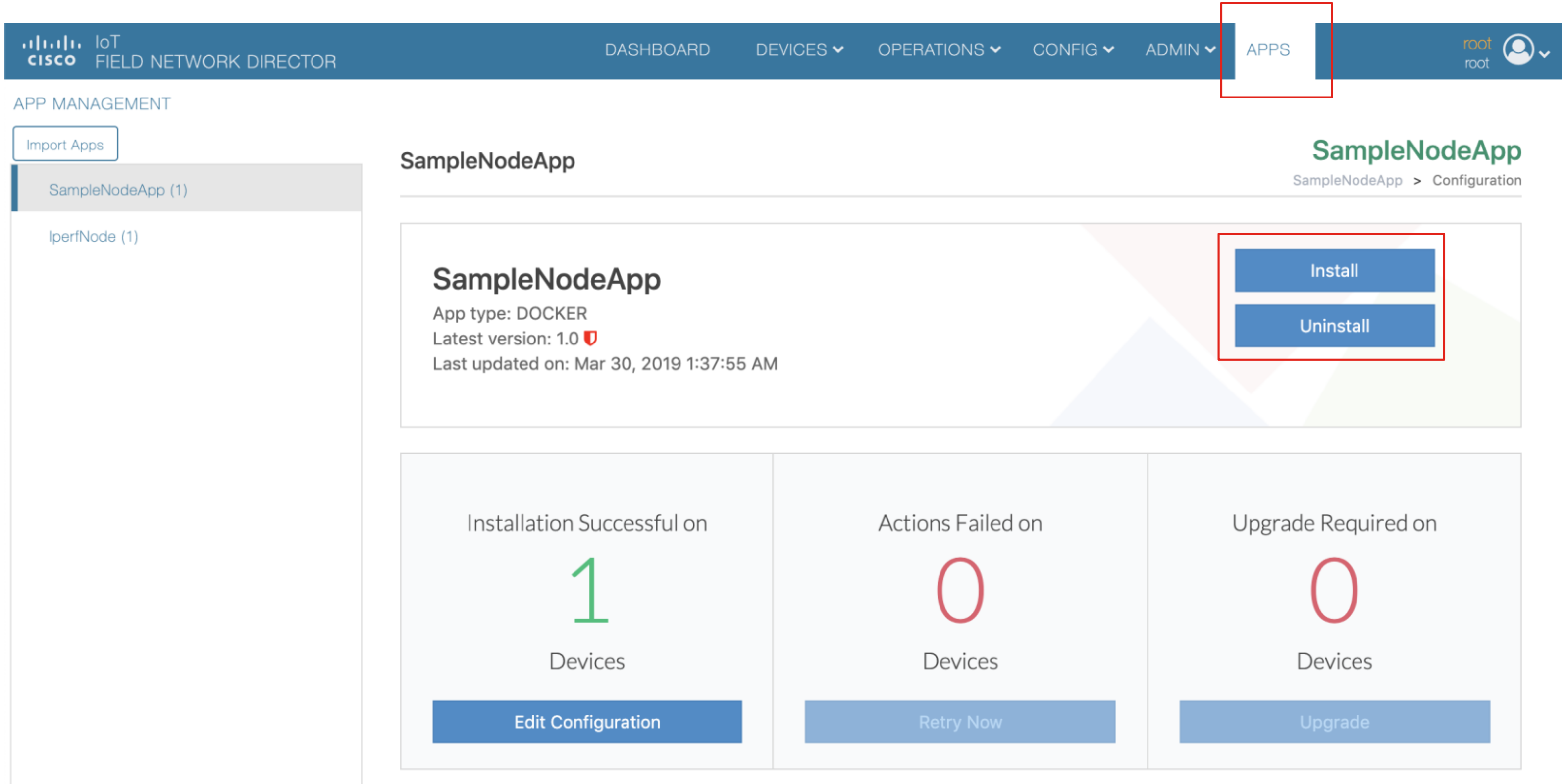
- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

Deploying and Monitoring with Field Network Director (FND)

Field Network Director – Overview

- Network Management platform specifically for industrial routers (IR), industrial switches (IE), industrial compute (IC), and gateways (LoRA IXM)
- Automatically provision field area routers and tunnel routers with CLI configuration (for tunnels, mesh interface, etc) (“ZTD”)
- Give operators visibility into network status, events, issues, metrics
- Update firmware / IOS on endpoints
- *Installs and maintains IOx applications on edge devices*

Field Network Director (Upload)



SampleNodeApp

SampleNodeApp

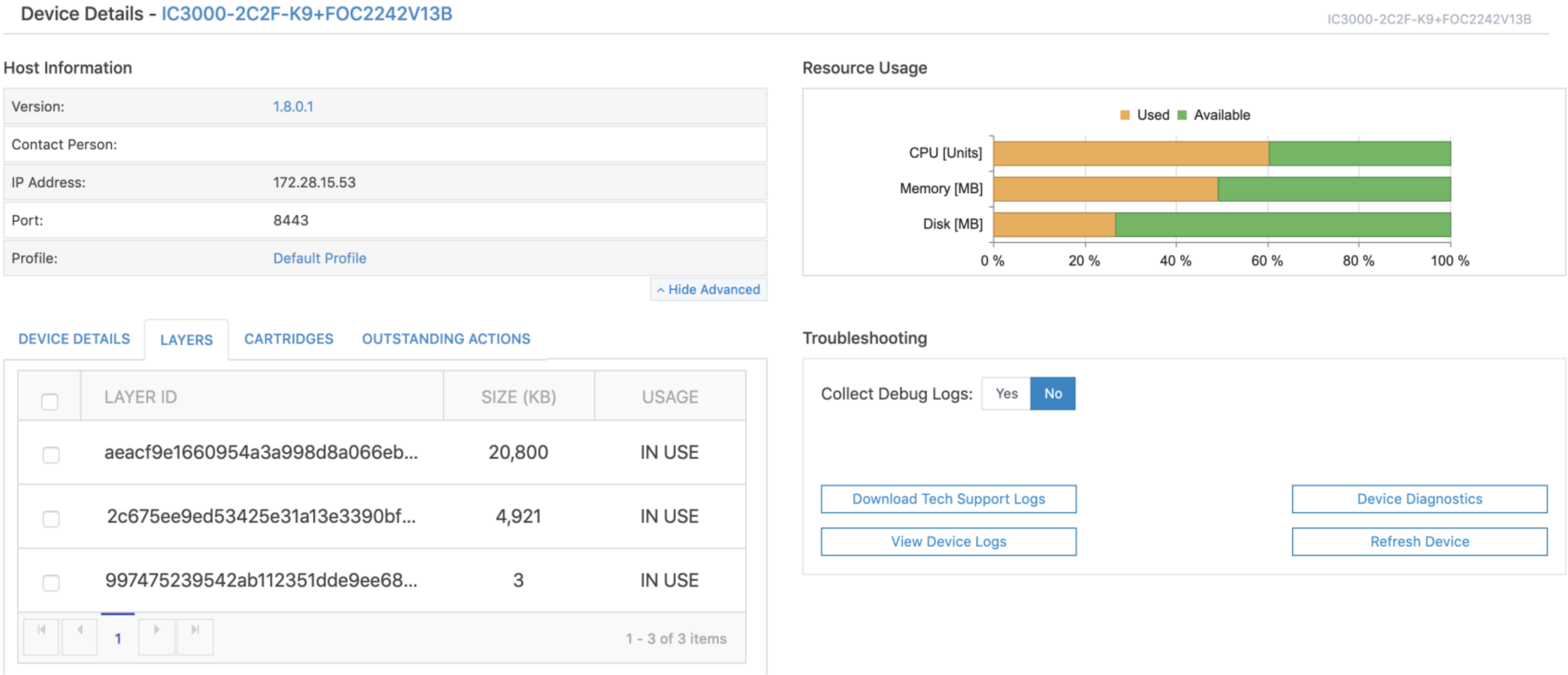
App type: DOCKER

Latest version: 1.0

Last updated on: Mar 30, 2019 1:37:55 AM

Installation Successful on	Actions Failed on	Upgrade Required on
1	0	0
Devices	Devices	Devices

FND - Monitoring Status



Device Details - IC3000-2C2F-K9+FOC2242V13B

IC3000-2C2F-K9+FOC2242V13B

Host Information

Version:	1.8.0.1
Contact Person:	
IP Address:	172.28.15.53
Port:	8443
Profile:	Default Profile

^ Hide Advanced

Resource Usage

DEVICE DETAILS | LAYERS | CARTRIDGES | OUTSTANDING ACTIONS

□	LAYER ID	SIZE (KB)	USAGE
□	aeacf9e1660954a3a998d8a066eb...	20,800	IN USE
□	2c675ee9ed53425e31a13e3390bf...	4,921	IN USE
□	997475239542ab112351dde9ee68...	3	IN USE

1

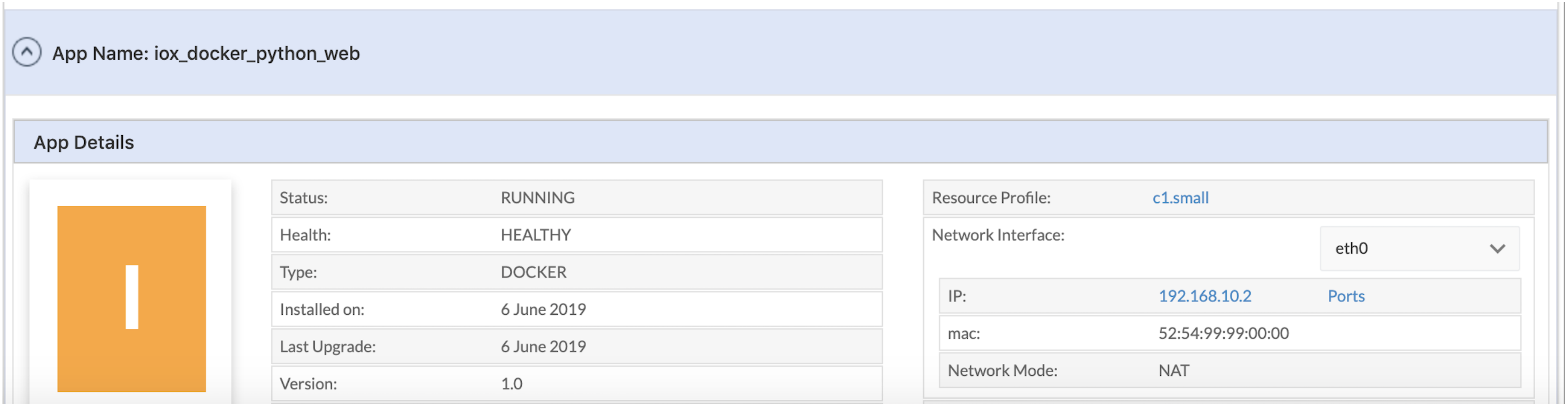
1 - 3 of 3 items

Troubleshooting

Collect Debug Logs: Yes [✓ No]

Device Health, Logs and usage displayed by FND

FND - Monitoring Status



App Name: iox_docker_python_web

App Details

Status:	RUNNING
Health:	HEALTHY
Type:	DOCKER
Installed on:	6 June 2019
Last Upgrade:	6 June 2019
Version:	1.0

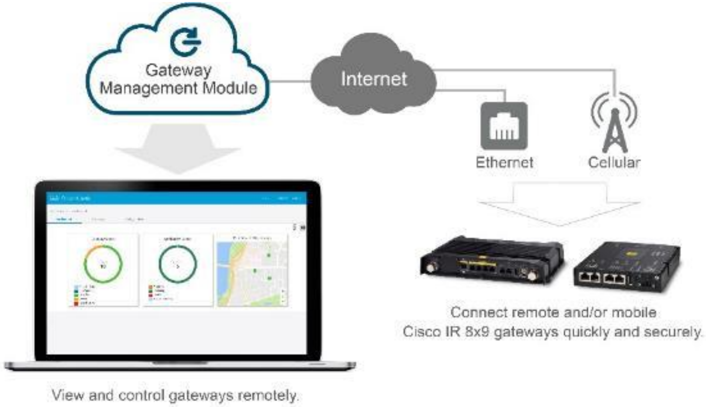
Resource Profile: c1.small

Network Interface: eth0

IP:	192.168.10.2	Ports
mac:	52:54:99:99:00:00	
Network Mode:	NAT	

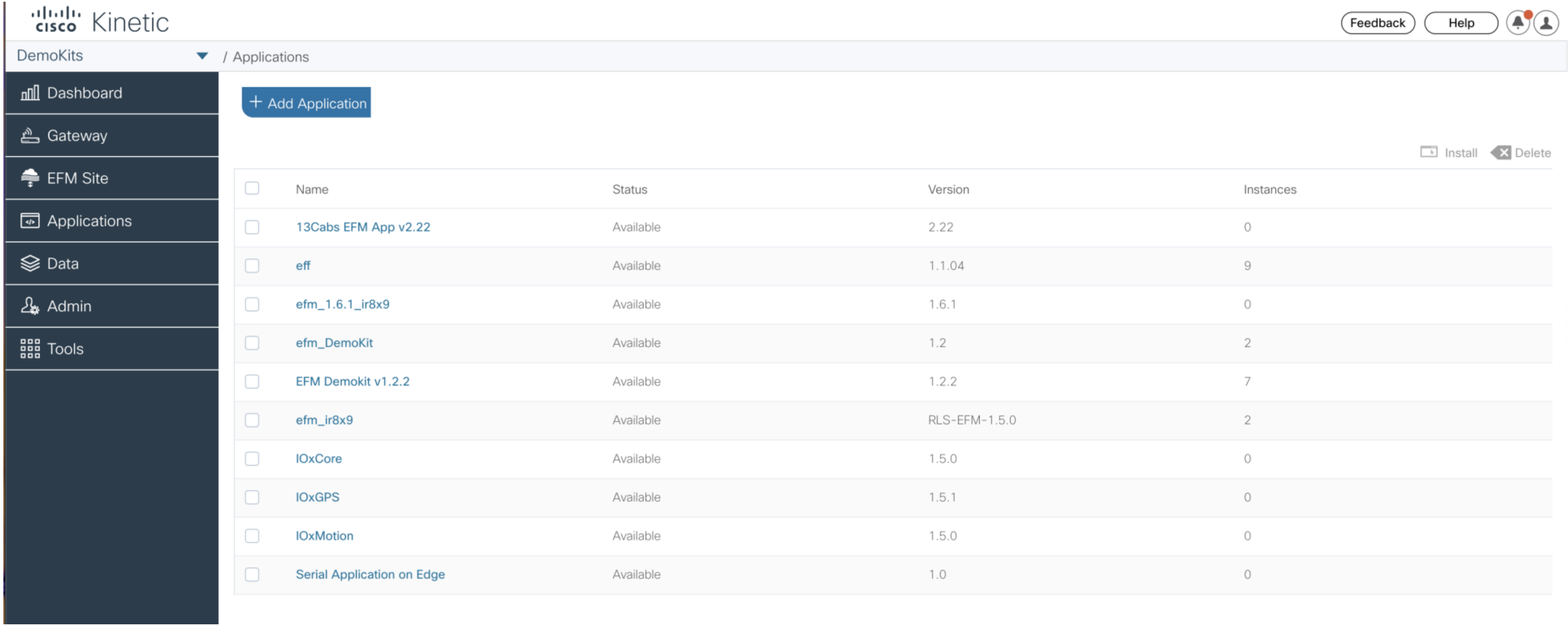
Deploying and Monitoring with **Kinetic Gateway Management Module (GMM)**

Gateway Management Module (GMM) Overview


Gateway
Management Module
Internet
Ethernet
Cellular
Connect remote and/or mobile
Cisco IR 8x9 gateways quickly and securely.
View and control gateways remotely.

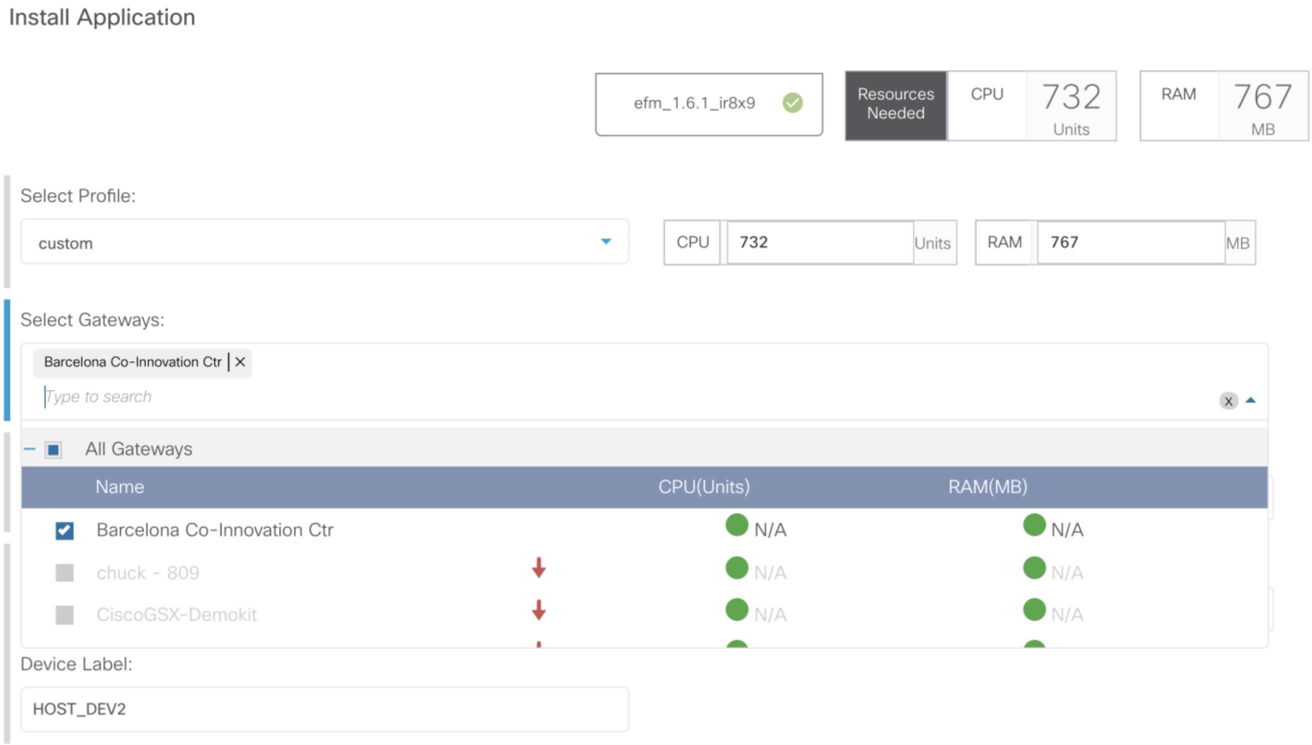
- Cloud-only platform to manage IR gateways
- Configure, view and control gateways remotely
- Deploy, operate and debug IOx applications from the Cloud

GMM – Application Upload



□	Name	Status	Version	Instances
□	13Cabs EFM App v2.22	Available	2.22	0
□	eff	Available	1.1.04	9
□	efm_1.6.1_ir8x9	Available	1.6.1	0
□	efm_DemoKit	Available	1.2	2
□	EFM Demokit v1.2.2	Available	1.2.2	7
□	efm_ir8x9	Available	RLS-EFM-1.5.0	2
□	IOxCore	Available	1.5.0	0
□	IOxGPS	Available	1.5.1	0
□	IOxMotion	Available	1.5.0	0
□	Serial Application on Edge	Available	1.0	0

GMM – Application Installation



Install Application

efm_1.6.1_ir8x9 ✓

Resources Needed	CPU	732 Units	RAM	767 MB

Select Profile: custom

CPU 732 Units

RAM 767 MB

Select Gateways: Barcelona Co-Innovation Ctr ✕

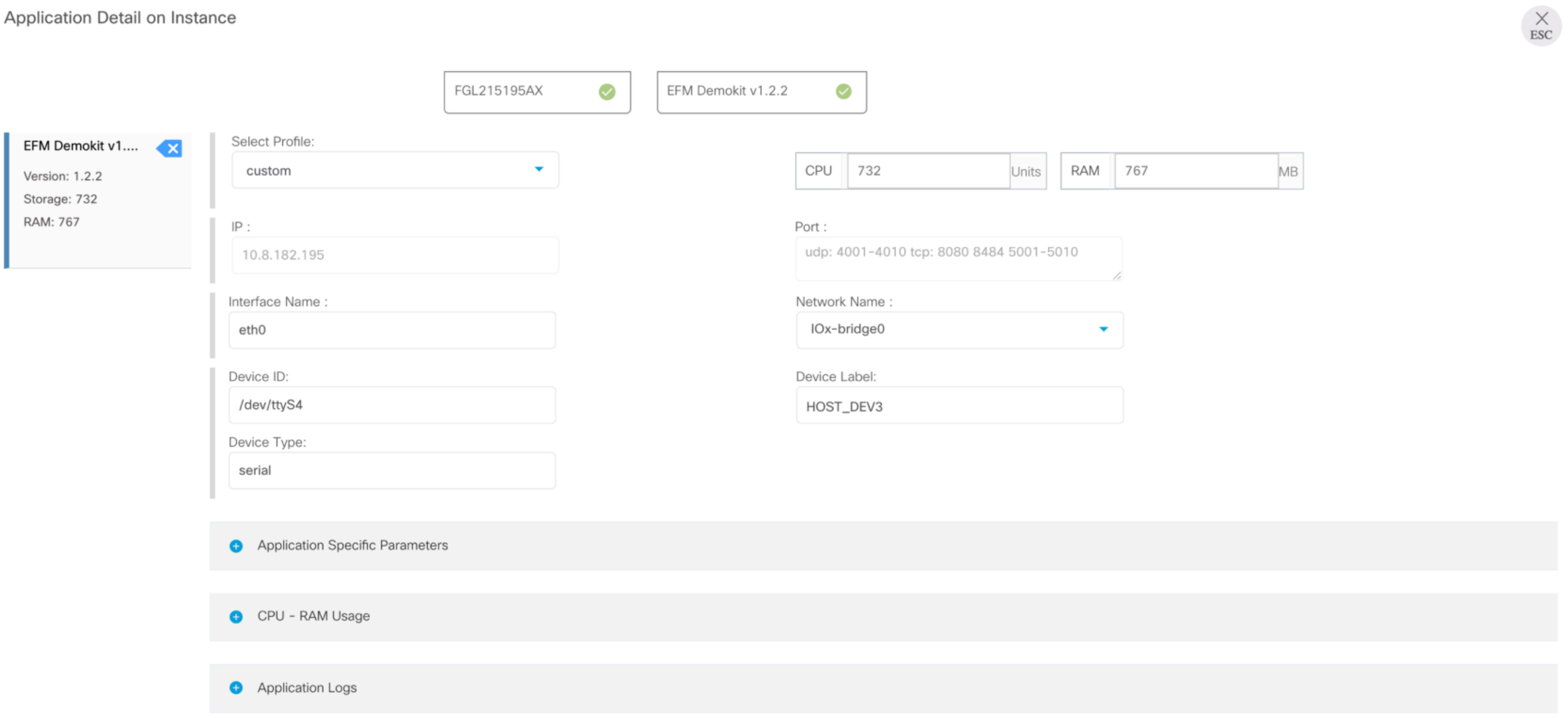
Type to search

– ■ All Gateways

	Name		CPU(Units)	RAM(MB)
☑	Barcelona Co-Innovation Ctr		● N/A	● N/A
□	chuck - 809	↓	● N/A	● N/A
□	CiscoGSX-Demokit	↓	● N/A	● N/A

Device Label: HOST_DEV2

GMM – Monitoring



Application Detail on Instance

FGL215195AX ✓

EFM Demokit v1.2.2 ✓

EFM Demokit v1....

Version: 1.2.2

Storage: 732

RAM: 767

Select Profile: custom

CPU 732 Units

RAM 767 MB

IP : 10.8.182.195

Port : udp: 4001-4010 tcp: 8080 8484 5001-5010

Interface Name : eth0

Network Name : IOx-bridge0

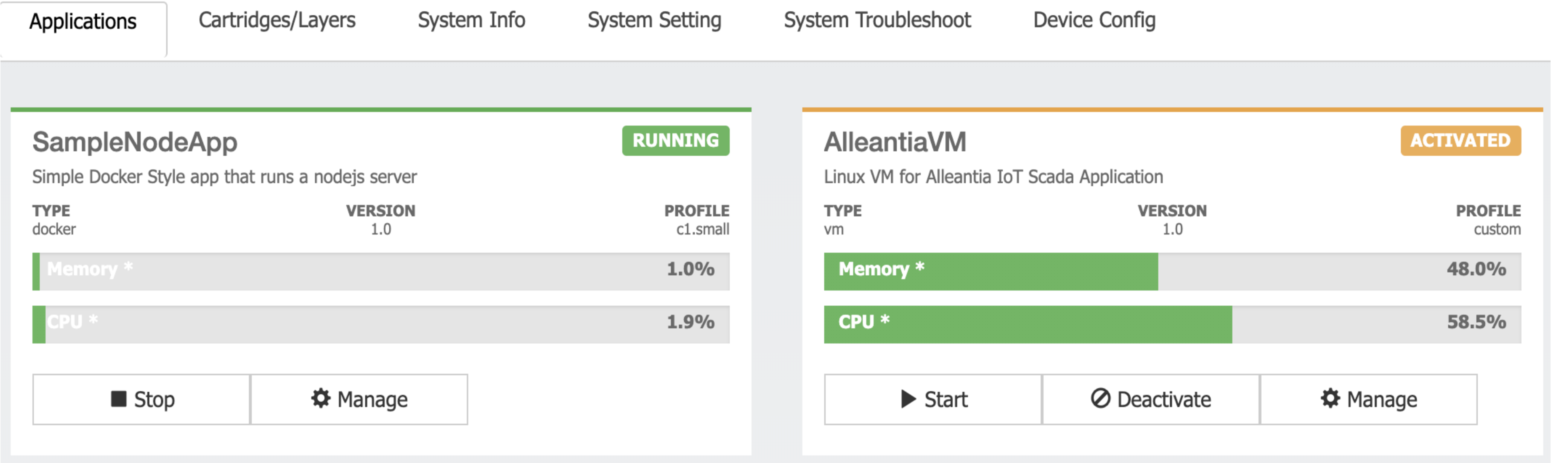
Device ID: /dev/ttyS4

Device Label: HOST_DEV3

Device Type: serial

Monitoring with Local Manager

Local Manager - Monitoring Status



SampleNodeApp RUNNING

Simple Docker Style app that runs a nodejs server

TYPE	VERSION	PROFILE
docker	1.0	c1.small

Memory * 1.0%

CPU * 1.9%

AlleantiaVM ACTIVATED

Linux VM for Alleantia IoT Scada Application

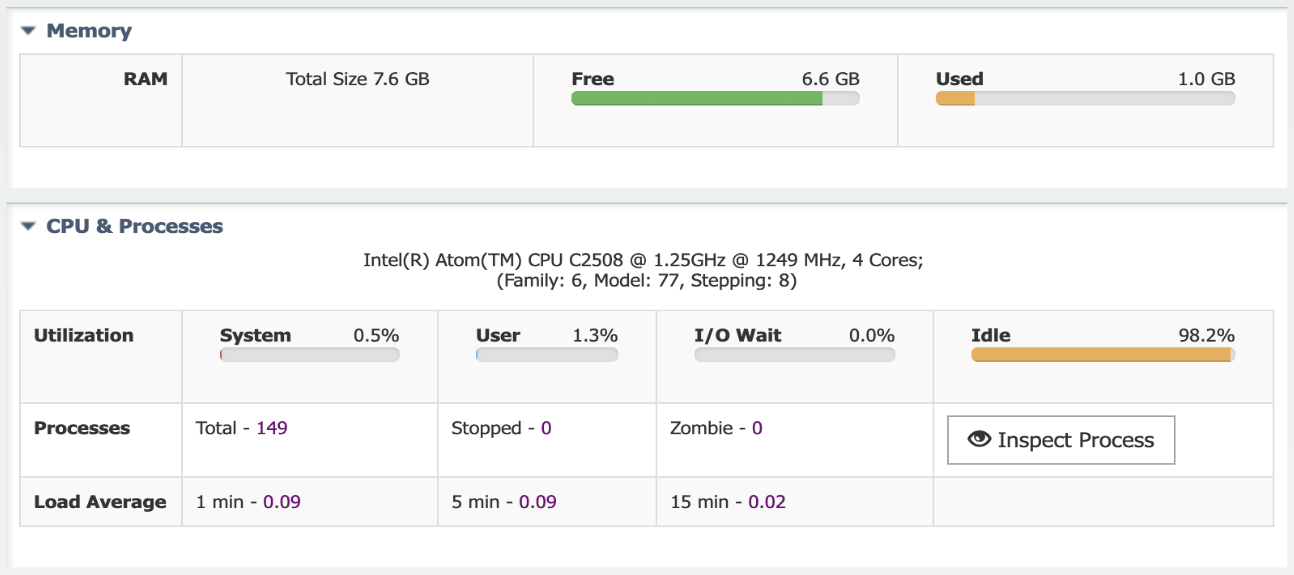
TYPE	VERSION	PROFILE
vm	1.0	custom

Memory * 48.0%

CPU * 58.5%

Application Status displayed by Local Manager

Local Manager - Monitoring Status



▾ **Memory**

RAM	Total Size 7.6 GB	**Free** 6.6 GB	**Used** 1.0 GB

▾ **CPU & Processes**

Intel(R) Atom(TM) CPU C2508 @ 1.25GHz @ 1249 MHz, 4 Cores;
(Family: 6, Model: 77, Stepping: 8)

Utilization	**System** 0.5%	**User** 1.3%	**I/O Wait** 0.0%	**Idle** 98.2%
Processes	Total - 149	Stopped - 0	Zombie - 0	Inspect Process
Load Average	1 min - 0.09	5 min - 0.09	15 min - 0.02	

Memory & CPU usage displayed by Local Manager

Agenda

- Introduction to IOx
- Supported Platforms
- Development and Packaging
- Demo
- Deploying and Monitoring
- Conclusions and Next Steps

What you've learned

- IOx is an application execution environment
- IOx runs alongside IOS on selected Cisco platforms
- How to build your own application and container
- How to deploy and monitor container

You are now an IOx Hero!

Next Steps on IoT Technologies

- DEVNET-1712: Docker+VM+LXC = IOx?
- DEVNET-2529: IOx 2.0 - Docker all the way
- DEVNET-2560: Managing IOx app deployment & connectivity for IR829/IC3000 using Cisco Field Network Director
- DEVNET-1560: ML Applications in IoT/Edge applications
- DEVNET-1559: CICD Pipelines for Cisco's IoT Edge compute platforms
- BRKIOT-2225: IoT gateway scalable deployment with Cisco Kinetic Gateway Management Module (GMM)

- DevNet Learning Labs: https://developer.cisco.com/learning/tracks/iot

Complete your online session survey

- Please complete your session survey after each session. Your feedback is very important.
- Complete a minimum of 4 session surveys and the Overall Conference survey (starting on Thursday) to receive your Cisco Live t-shirt.
- All surveys can be taken in the Cisco Events Mobile App or by logging in to the Content Catalog on ciscolive.com/emea.

Cisco Live sessions will be available for viewing on demand after the event at ciscolive.com.

Continue your education

- Demos in the Cisco campus
- Walk-in labs
- Meet the engineer 1:1 meetings
- Related sessions

Thank you

You make **possible**