
cisco Live!
Let's go

The bridge to possible

All You Need To Know About App Hosting on Catalyst

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cisco Live!

BRKOPS-2490

About Me

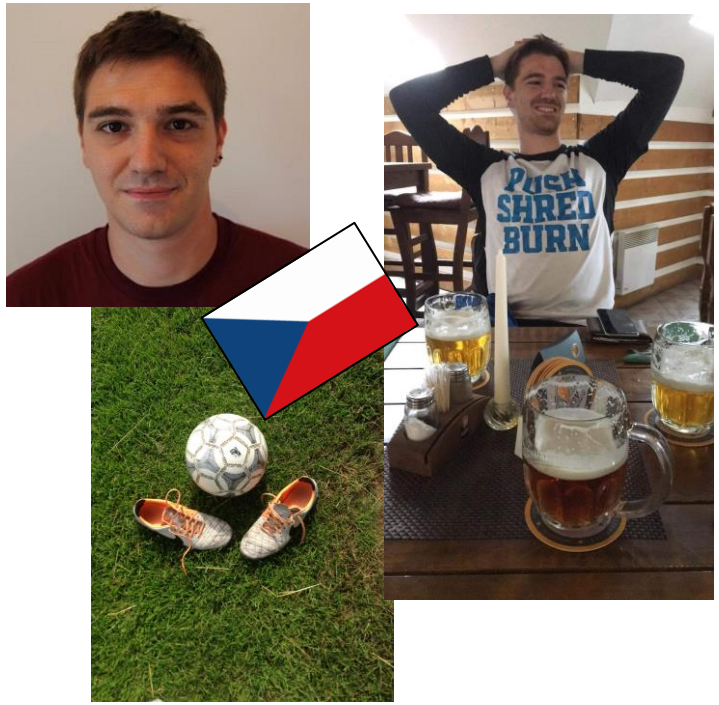
Dominik Soukup

- Solutions Engineer For Wireless
- CCIEW# 68153

Milestones past year

- First CCIE
- First Cisco Live!
- First time dad
- Season 8 in Cisco family

Competitive Sports & Beer Tasting



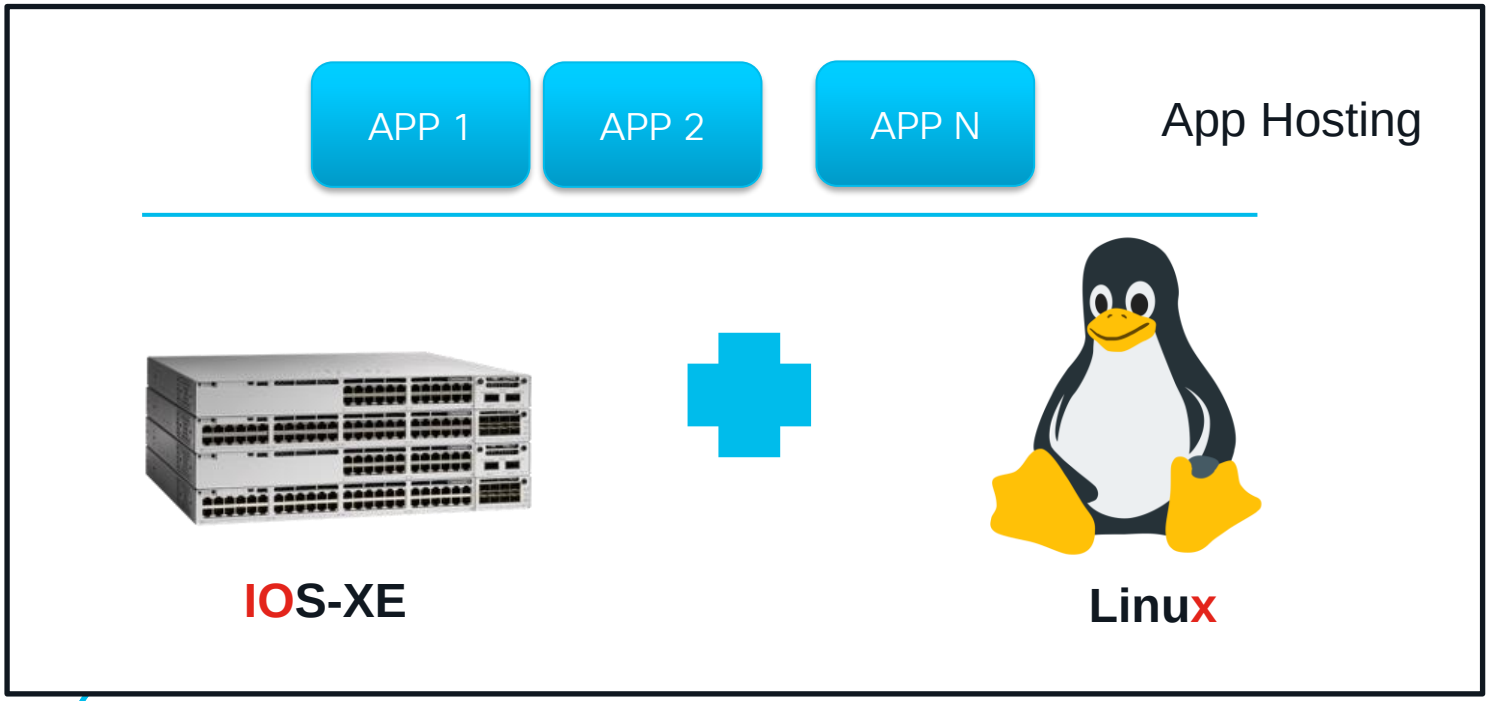
Agenda

- Motivation
- Design and Constraints
- Step-by-step Development
- Real Use Cases
- Conclusion

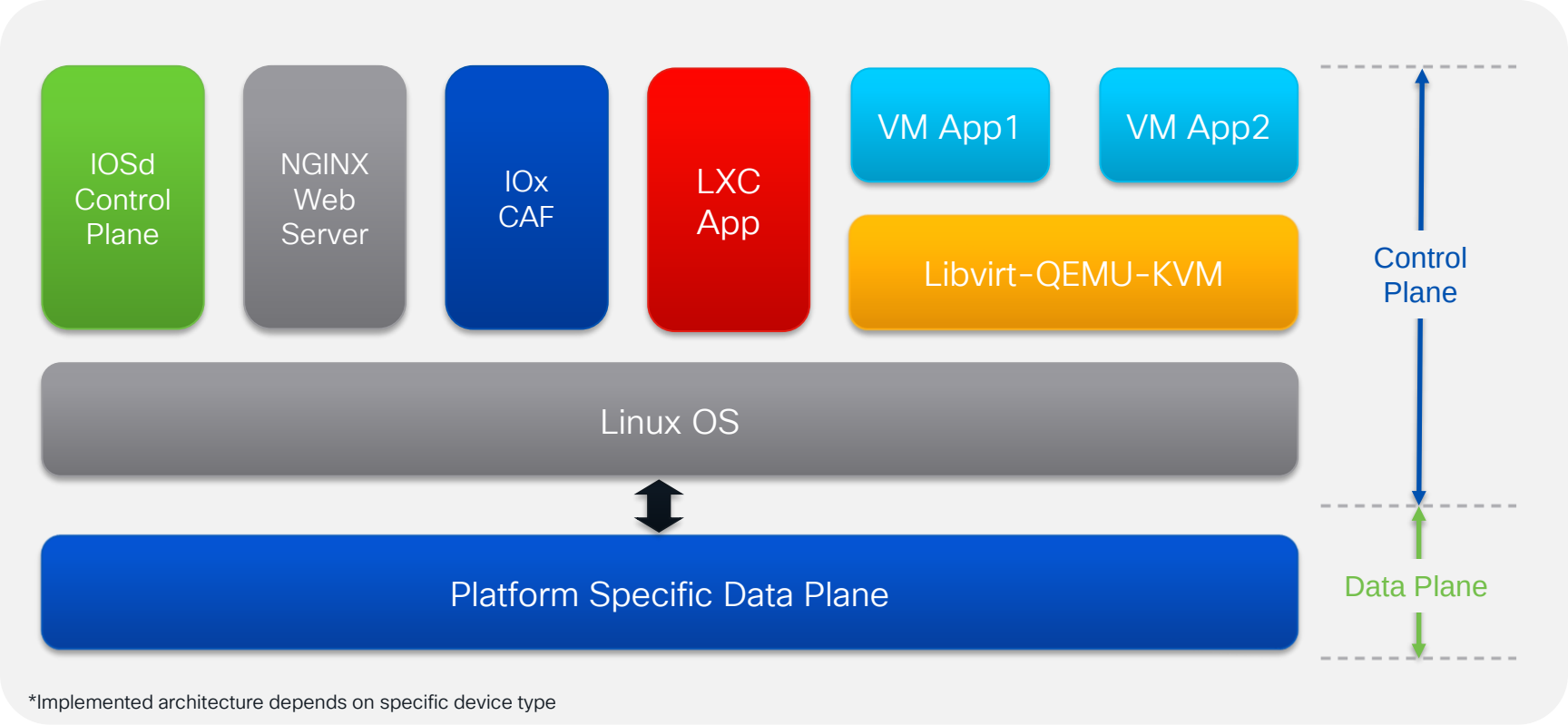
Edge Compute Evolution

Growing with increase in Data Processing across Industries

What is Cisco IOx?



App-hosting Architecture Overview



*Implemented architecture depends on specific device type

What Platform Can Host An Application?

Catalyst 9{3,4,5}00 Family

IE Family

Catalyst 9100 Family

IW Family

ISR 4000 | ASR 1000 | Catalyst 8000 Family

IR Family

HW resources for App Hosting

	Resource type	Catalyst 9300	Catalyst 9300-X	Catalyst 9400	Catalyst 9400-X	Catalyst 9500	Catalyst 9500-X	Catalyst 9600	Catalyst 9600-X
Networking	AppGig Port	1x1G	2x10G	1x1G	2x10G	Mgmt Port*	2x10G	Mgmt Port*	Mgmt Port* (2x10G CPU ports)
Resources	Memory	2GB	8GB	8GB	8GB	8GB	8GB	8GB	8GB
	CPU	1 core	2 core	1 core	1 core	1 core	1 core	1 core	1 core
	Storage	240GB (USB3.0/SSD)	240GB (USB3.0/SSD)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)

* Using loopback with any external ports

** This overview is not a complete list of Cisco App Hosting resources for all platforms

HW resources for App Hosting

	Resource type	Catalyst 9600	Catalyst 9600-X
Networking	AppGi	Mgmt Port*	Mgmt Port* (2x10G CPU ports)
Resources	Mem	8GB	8GB
	CPU	1 core	1 core
	Storage	480-960GB (SATA)	480-960GB (SATA)

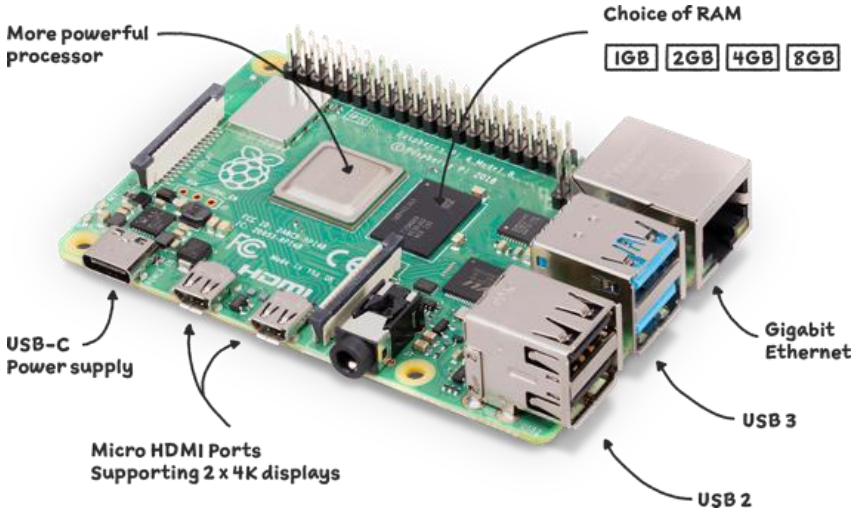
* Using loopback with any external ports

Source: Reddit

HW resources for App Hosting

	Resource type	Catalyst 9300	Catalyst 9300-X	Catalyst 9400	Catalyst 9400-X	Catalyst 9500	Catalyst 9500-X	Catalyst 9600	Catalyst 9600-X
Networking	AppGig Port	1x1G	2x10G	1x1G	2x10G	Mgmt Port*	2x10G	Mgmt Port*	Mgmt Port* (2x10G CPU ports)
Resources	Memory	2GB	8GB	8GB	8GB	8GB	8GB	8GB	8GB
	CPU	1 core	2 core	1 core	1 core	1 core	1 core	1 core	1 core
	Storage	240GB (USB3.0/SSD)	240GB (USB3.0/SSD)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)	480-960GB (SATA)

* Using loopback with any external ports



Source: raspberrypi.com

IOx Hardware Platforms Summary*

X86_64,
Docker Native

ARM
Docker Compatible

X86_64,
Docker Compatible | Native

ARM
Docker Native

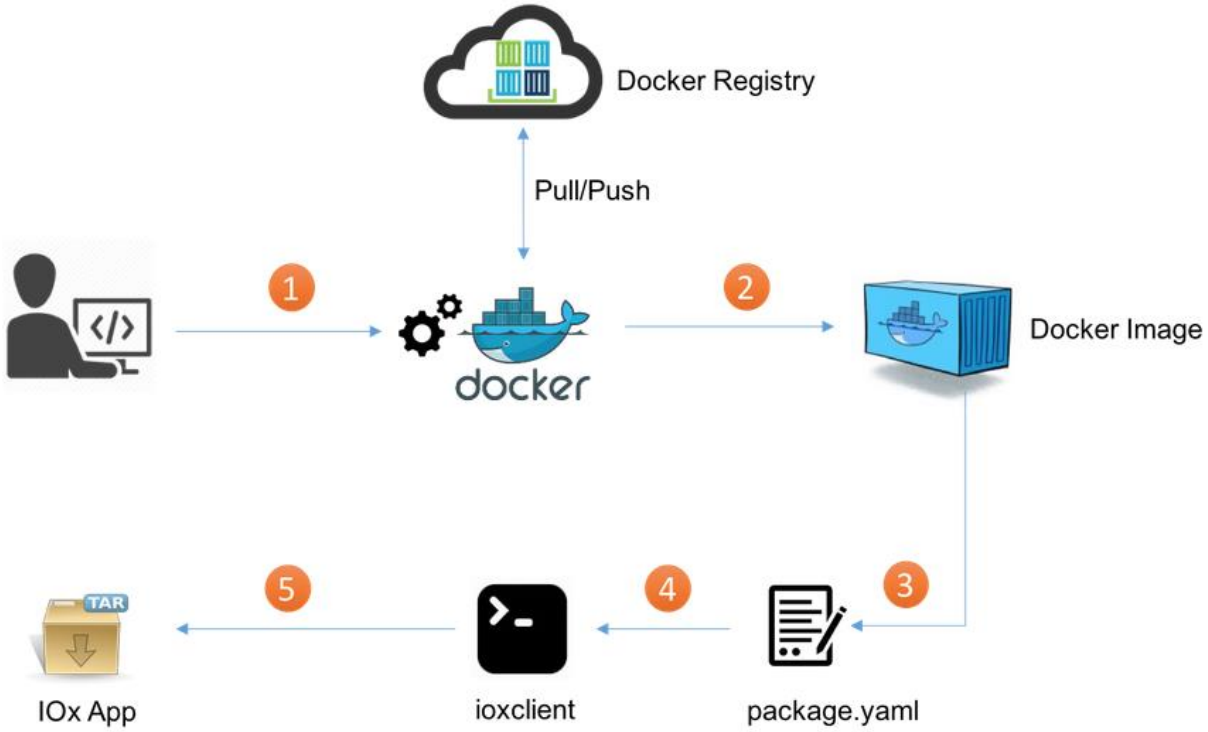
ARM
Docker Compatible

ARM | X86_64,
Docker Compatible
SSD optional

*This is high-level summary info. Always check recent details per device

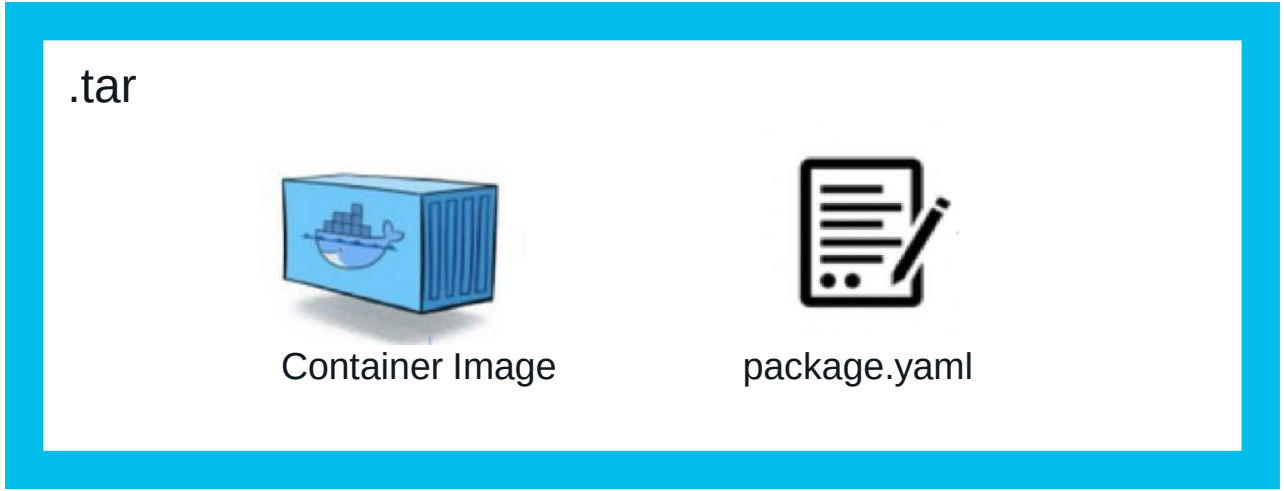
App Design Steps

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

Application Anatomy for IOx



- Cross compilation for different platforms is still needed

Tools To Deploy/Manage The App

APP

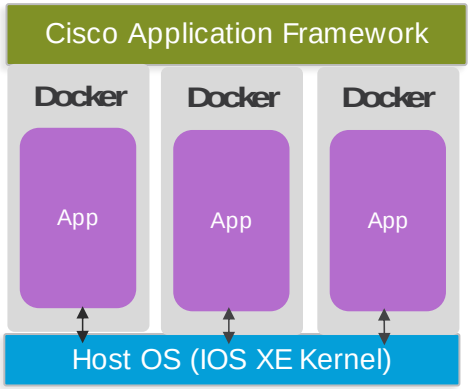
CLI

YANG

Local Manager (WebGUI)

IOxclient

Catalyst Center



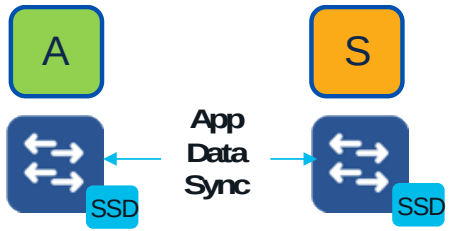
Design FAQ

FAQ

Q: What if the APP crashes?
A: Memory, CPU and storage are isolated from networking fuctions.

Q: What if my device restarts?
A: The APP will come back to original state.

Q: How does it work with switching stack?
A: Cold restart. Retain the last configured operational state of app*.



*Majority of Catalyst 9000 since 17.5=>

FAQ

Q: Do I need SSD disk for all APPs?
A: Internal flash is not supported for third-party applications except for Industrial devices and devices without SSD storage option. Internal flash can be used for Cisco some signed APPs.

Q: What are CPU Units?
A: Based on the benchmarking results, x86 based 64 bit Intel Xeon processor with one core of CPU @ 2GHz will have 10000 CPU units.

Q: How is data security handled?
A: Cisco provides the platform infrastructure not data level security.

FAQ

Q: What docker base image should I use?
A: The smaller the better. Some examples:

- Alpine Linux -> 5.61MB (alpine:3.14)
- Oracle Linux -> 116MB (oraclelinux:8-slim)

Q: How can I connect to the containers?
A: You can leverage CLI or API capabilities.

Q: Is application development limited?
A: No, you are free in your development.

Q: What license level is needed?
A: DNA Advantage for Enterprise Catalyst 9000 switching and wireless.
No license for Industrial routing and switching

App Development Example

DIY App For Cat9k

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)
```

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.

Build the Docker image

- Build docker image

```
docker build -t cleu24-app .
```

- Check build success

```
docker images
```

```
dosoukup@DOSOUKUP-M-21HW cleu24 % docker images
REPOSITORY     TAG       IMAGE ID       CREATED              SIZE
cleu24-app     latest    72ff90d2d5d6   About an hour ago    104MB
```

(Optional) Test Docker image

- Run docker image

```
docker run -d -p 8000:8000 cleu24-app
```

- Check running containers

```
docker ps
```

```
dosoukup@DOSOUKUP-M-21HW cleu24 % docker ps
CONTAINER ID   IMAGE         COMMAND
315171f5ce0f   cleu24-app    "/bin/sh -c 'python3…"
```

- Connect to docker container

```
docker exec -it <container-id> /bin/sh
```

- Stop docker container

```
docker stop <container-id>
```

Save Docker image

- Save docker image

```
docker save cleu24-app:latest -o demo.tar
```

- Check success

```
ls -lt
```

```
dosoukup@DOSOUKUP-M-21HW cleu24 % ls -lt
total 231248
-rw-------  1 dosoukup  staff  108777472 Dec 16 12:00 demo.tar
```

Get Ready Your Device

Verify DNA Advatage License

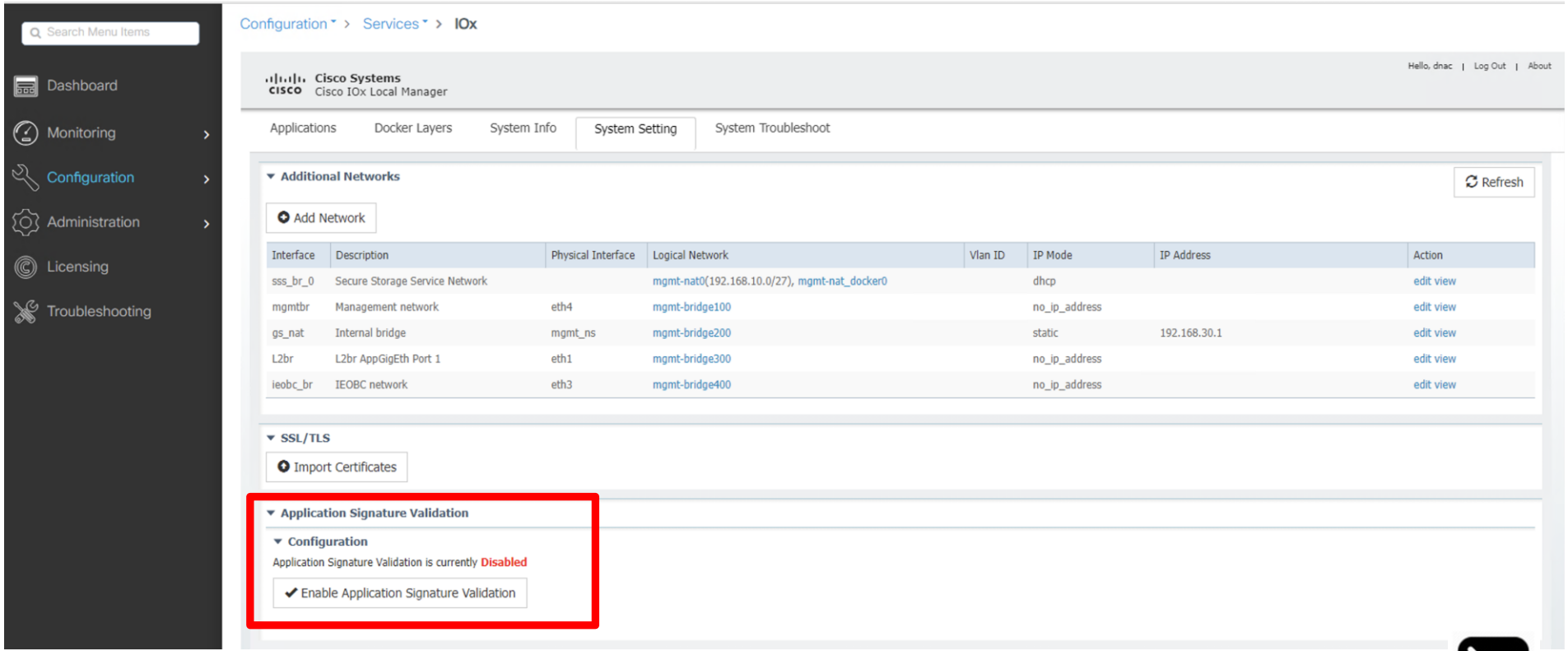
```
Switch# show version
Technology Package License Information:
------------------------------------------
Technology-package
Current                    …
------------------------------------------
network-advantage …
dna-advantage …
```

Enable & Verify IOx Framework

```
Switch(config)# iox
Switch# show iox-service
IOx Infrastructure Summary:
---------------------------
IOx service (CAF)          : Running
IOx service (HA)           : Running
IOx service (IOxman)       : Running
IOx service (Sec storage)  : Running
Libvirta 5.5.0             : Running
Dockerd v19.03.13-ce       : Running
Sync Status                : Disabled
```

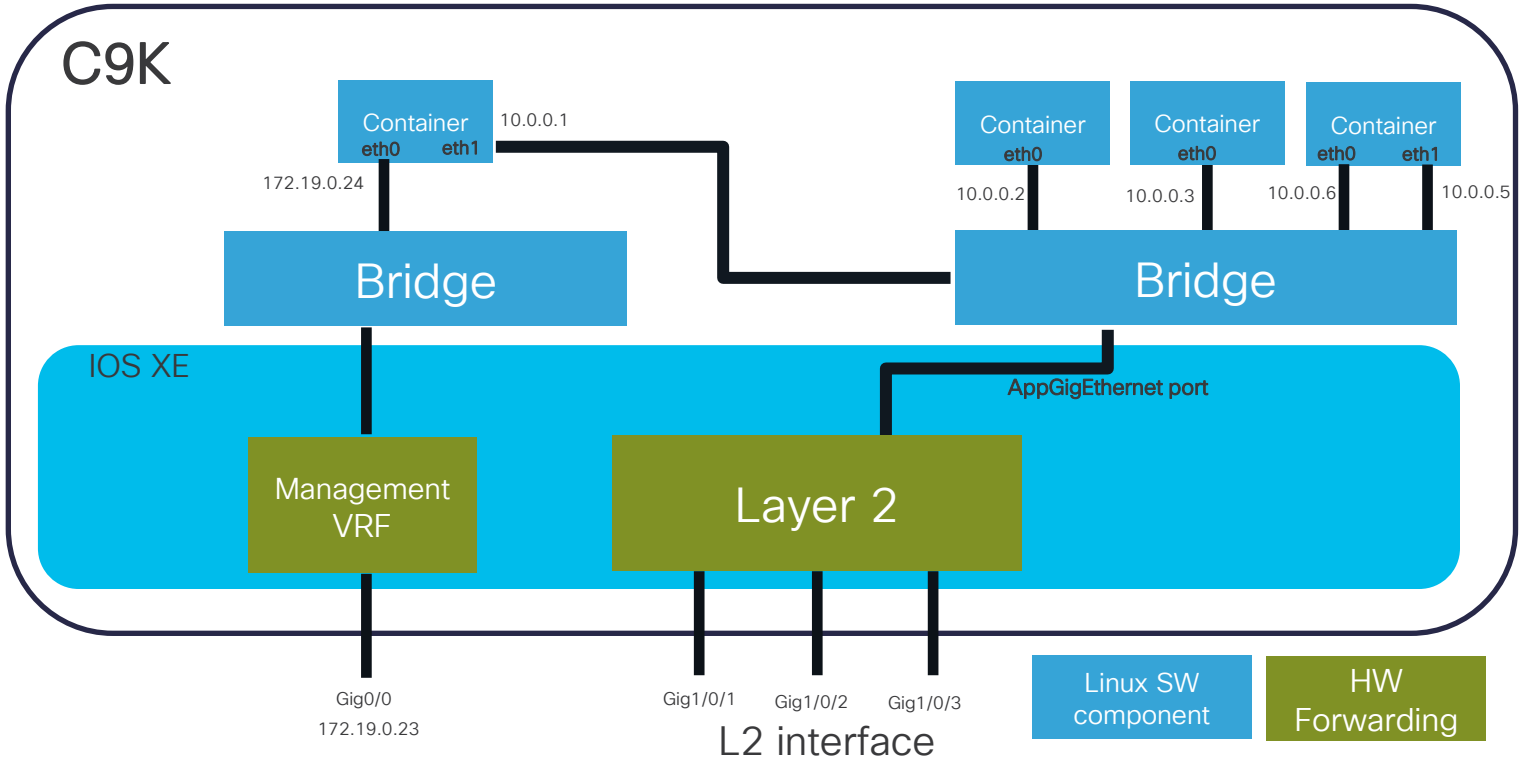
IOS-XE

Check Application Signature Validation



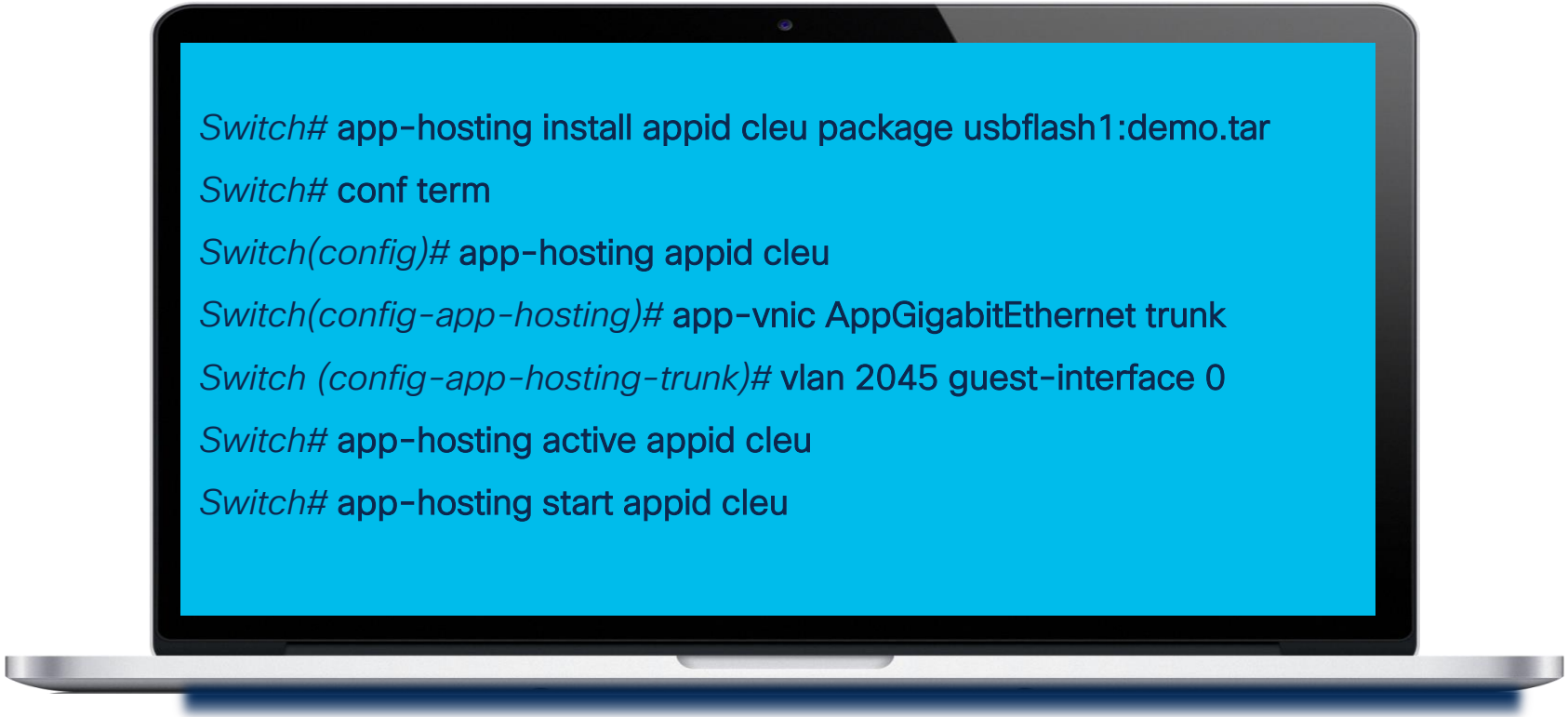
IOS-XE

IOx Networking



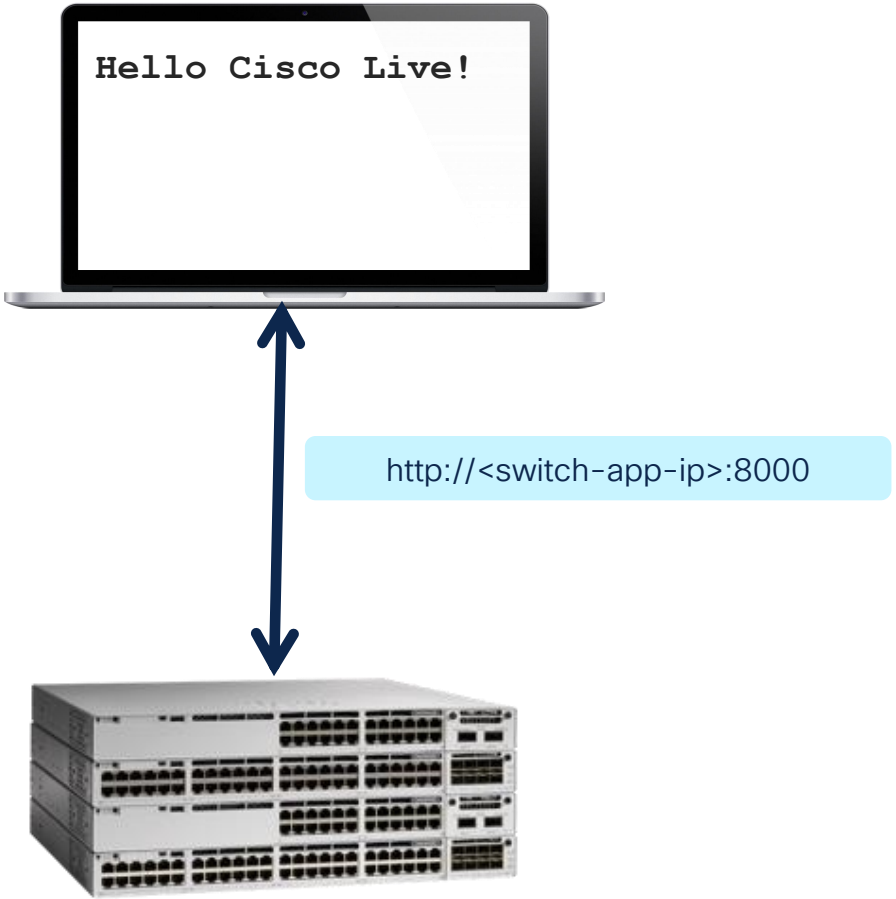
IOS-XE

CLI Level Deployment



IOS-XE

App Is Running!

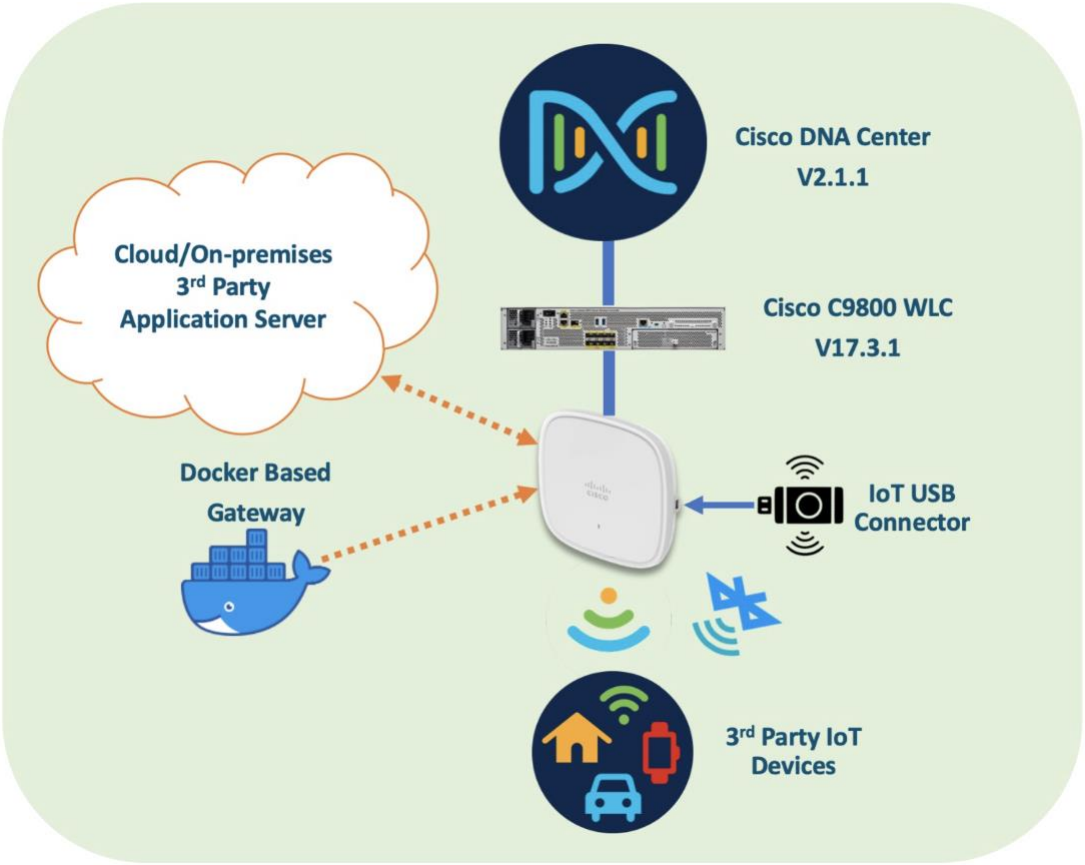


DevNet Eco System Exchange

Reference Link

- Cisco will not provide any support to third-party apps and open source apps unless specifically called out.
- Such apps, however, will be validated for compatibility on Cisco® Catalyst® 9000 switches.
- DevNet ecosystem will indicate the partners who have worked on Cisco Catalyst 9000 switches.

Not All Platforms Are Equal



More Details on DevNet

The Same Development Workflow Style

Define the Dockerfile

```
FROM arm64v8/alpine:latest

RUN apk add python3

... Same as before ...
```

Define the Dockerfile on x86

```
FROM multiarch/qemu-user-static:x86_64-aarch64 as qemu
FROM arm64v8/alpine:latest
```

```
RUN apk add python3 py3-pip py3-bottle dhclient
```

```
... Same as before ...
```

Build the Docker image

- Build docker image

```
docker build -t cleu-ap-app .
```

- Check build success

```
docker images
```

```
dosoukup@DOSOUKUP-M-21HW 9130-ap-app % docker images
REPOSITORY      TAG       IMAGE ID       CREATED              SIZE
cleu-ap-app     latest    47a2817f0e79   About a minute ago   56.3MB
```

package.yaml

```
descriptor-schema-version: "2.10"
info:
  name: ”CLEU-AP-APP”
  description: ”CLEU24 AP APP"
  version: "1.0"
  author-link: "http://www.cisco.com"
  author-name: "Cisco Systems”
app:
  cpuarch: aarch64
  type: docker
  resources:
    profile: c1.small
    network:
      -
        interface-name: eth0
        ports:
            tcp: [8000]
            udp: [8000]
  startup:
    rootfs: rootfs.img
    target: “/bin/sh /init.sh“
```

- 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.
- Always check descriptor-schema-version for the proper format

Save Docker image

- Save docker image and create IOx package

```
ioxclient docker package -p ext2 cleu-ap-app ./conf
```

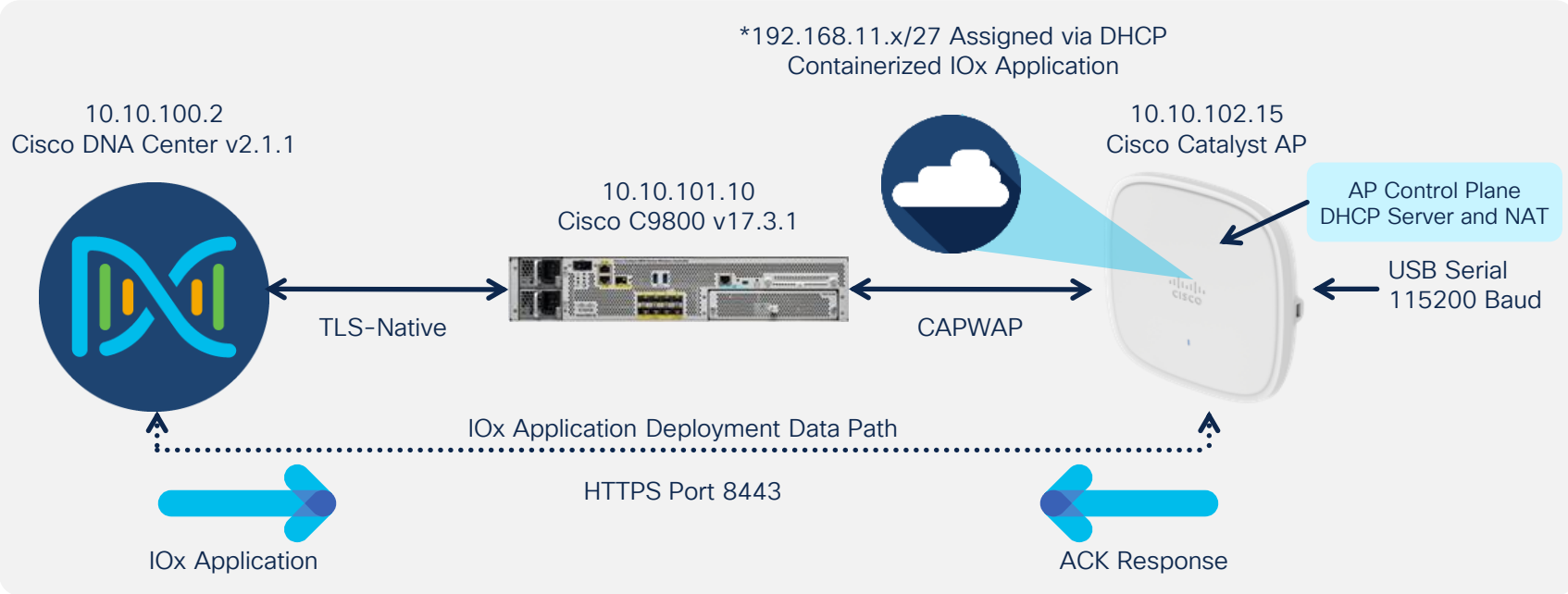
- Check success

```
ls -lr
```

```
dosoukup@DOSOUKUP-M-21HW 9130-ap-app % ls -lt conf
total 8264
-rw-r--r--  1 dosoukup  staff  3375104 Dec 16 23:27 package.tar
-rw-r--r--@ 1 dosoukup  staff      843 Dec 16 22:39 package.yaml
```

- Deploy *package.tar* using *Catalyst Center* or *ioxclient*

Application Hosting Network topology



*The IOx Application's traffic is locally switched and communicates to external sources through NATTing the AP's IP

Partner Solution Use Case Segments

Electronic Shelf Label
Retail Management

- LCD price tags that can be updated remotely.

Asset Tracking
Building Management

- Sensors that track, movement, temperature, humidity, location, and many more.

Patient Tracking
Medical Management

- Sensor that track location, human vitals and many more for efficient medical operations.

App Hosting Use Cases

Packet Capture++

Packet Capture Challenge

Embedded
Packet Caputre

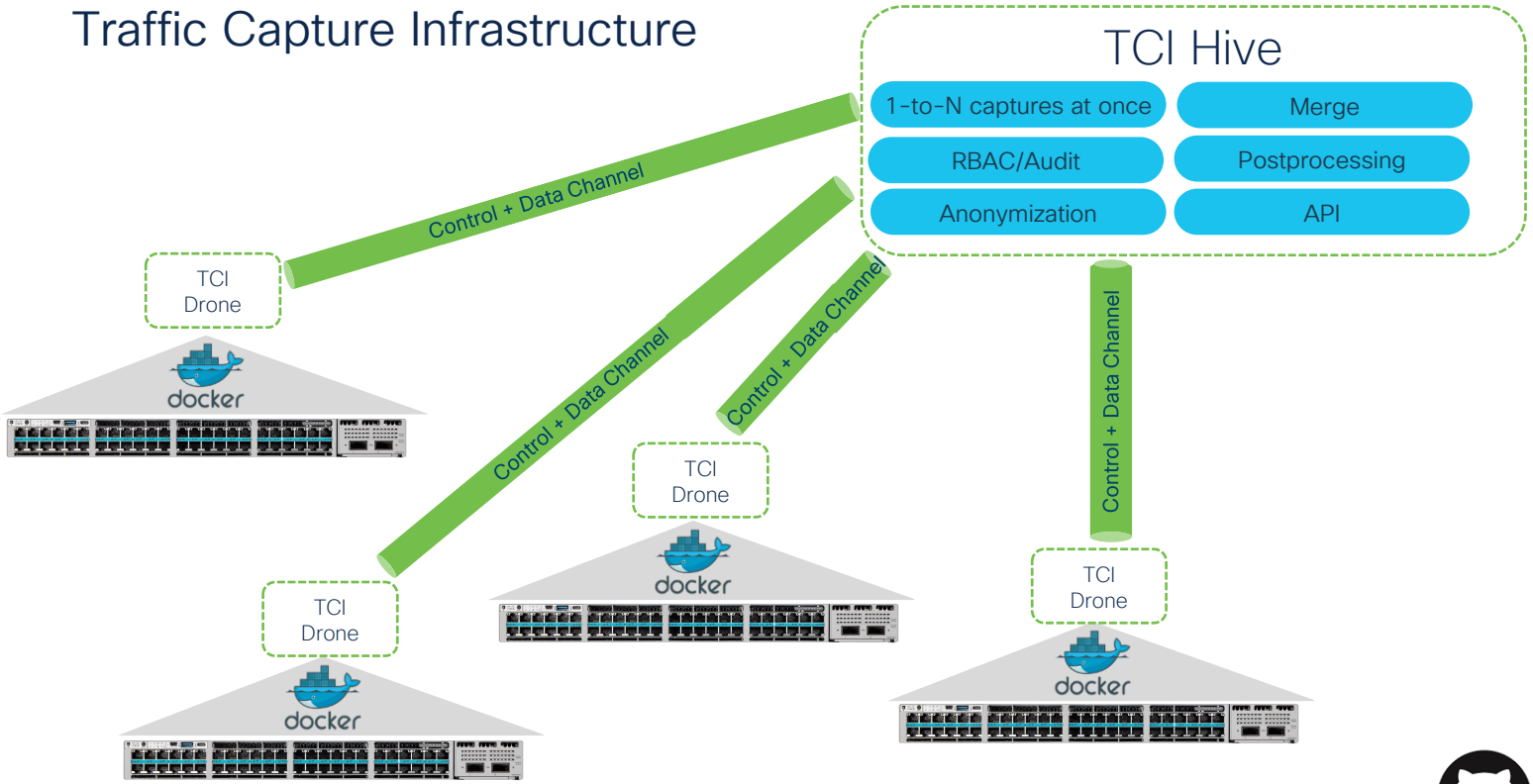
E|R|SPAN

Wireshark

Easy with one switch but what about about distributed environment?

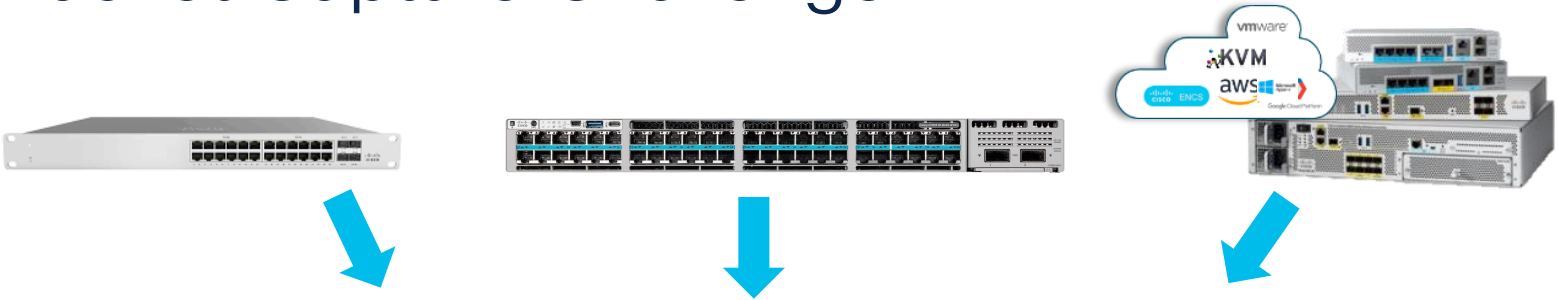
Packet Capture Challenge

Traffic Capture Infrastructure



Reference

Packet Capture Challenge

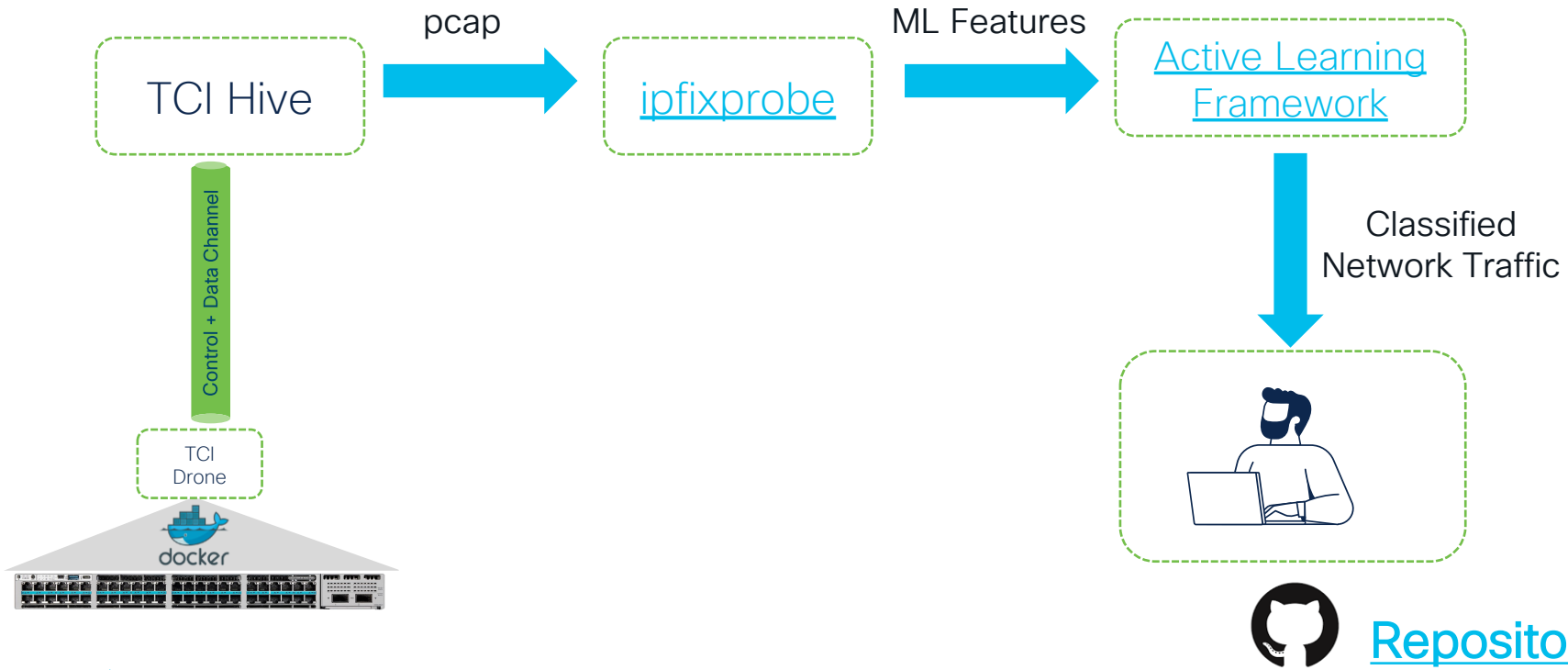


146	2.433166	170.72.231.0	192.168.20.3	TCP	66 443 → 50760 [ACK] Seq=1 Ack=518 Win=1536 Len=0 TSval=
147	2.436640	170.72.231.0	192.168.20.3	TLSv1.3	1314 Server Hello, Change Cipher Spec, Application Data
148	2.436647	170.72.231.0	192.168.20.3	TCP	1314 443 → 50760 [ACK] Seq=1249 Ack=518 Win=1536 Len=1248
149	2.436648	170.72.231.0	192.168.20.3	TCP	1314 443 → 50760 [ACK] Seq=2497 Ack=518 Win=1536 Len=1248
150	2.436650	170.72.231.0	192.168.20.3	TCP	418 443 → 50760 [PSH, ACK] Seq=3745 Ack=518 Win=1536 Len=
151	2.436651	170.72.231.0	192.168.20.3	TLSv1.3	1314 Application Data
152	2.436652	170.72.231.0	192.168.20.3	TLSv1.3	385 Application Data, Application Data
153	2.436765	192.168.20.3	170.72.231.0	TCP	66 50760 → 443 [ACK] Seq=518 Ack=5664 Win=126592 Len=0 T
154	2.436865	192.168.20.3	170.72.231.0	TCP	66 [TCP Window Update] 50760 → 443 [ACK] Seq=518 Ack=566
155	2.446964	192.168.20.3	170.72.231.0	TLSv1.3	146 Change Cipher Spec, Application Data
156	2.447069	192.168.20.3	170.72.231.0	TCP	1314 50760 → 443 [ACK] Seq=598 Ack=5664 Win=131072 Len=124
157	2.587375	170.72.231.0	192.168.20.3	TLSv1.3	145 Application Data
158	2.587380	170.72.231.0	192.168.20.3	TLSv1.3	145 Application Data

What is inside TLS traffic?

Packet Capture Challenge

Machine Learning Classification



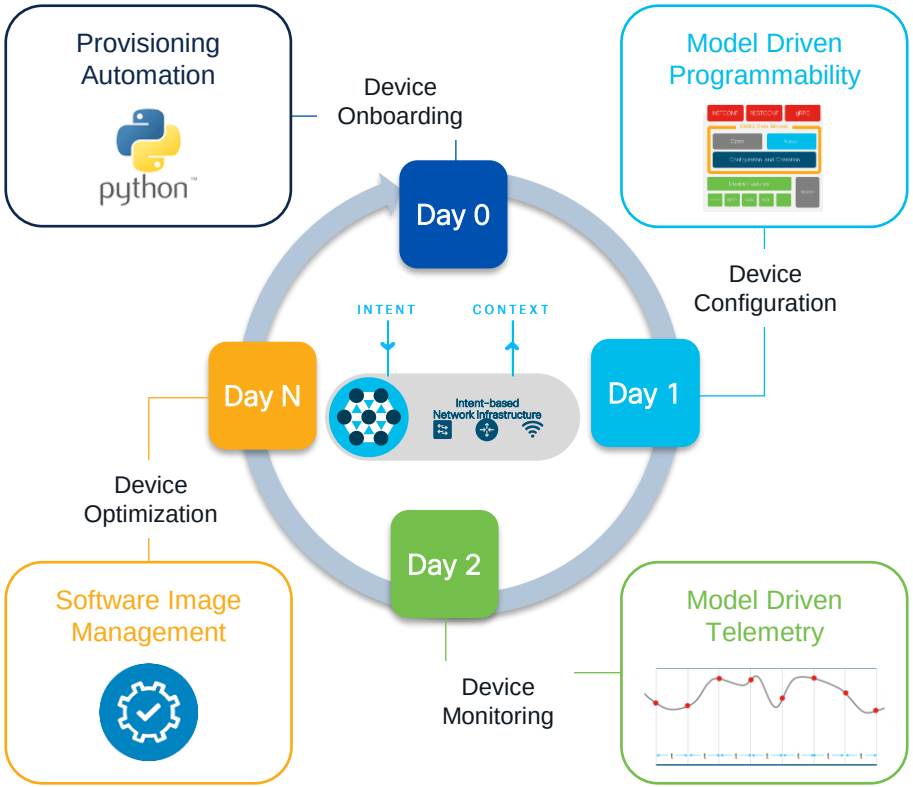
Monitoring and Troubleshooting

IOS XE Programmability

Pre-boot Execution Environment

Zero Touch Provisioning

Plug and Play



Network Configuration Protocol (NETCONF)

RESTCONF

YANG Data Models

gNMI + OpenConfig

Guest Shell

On-Box Python

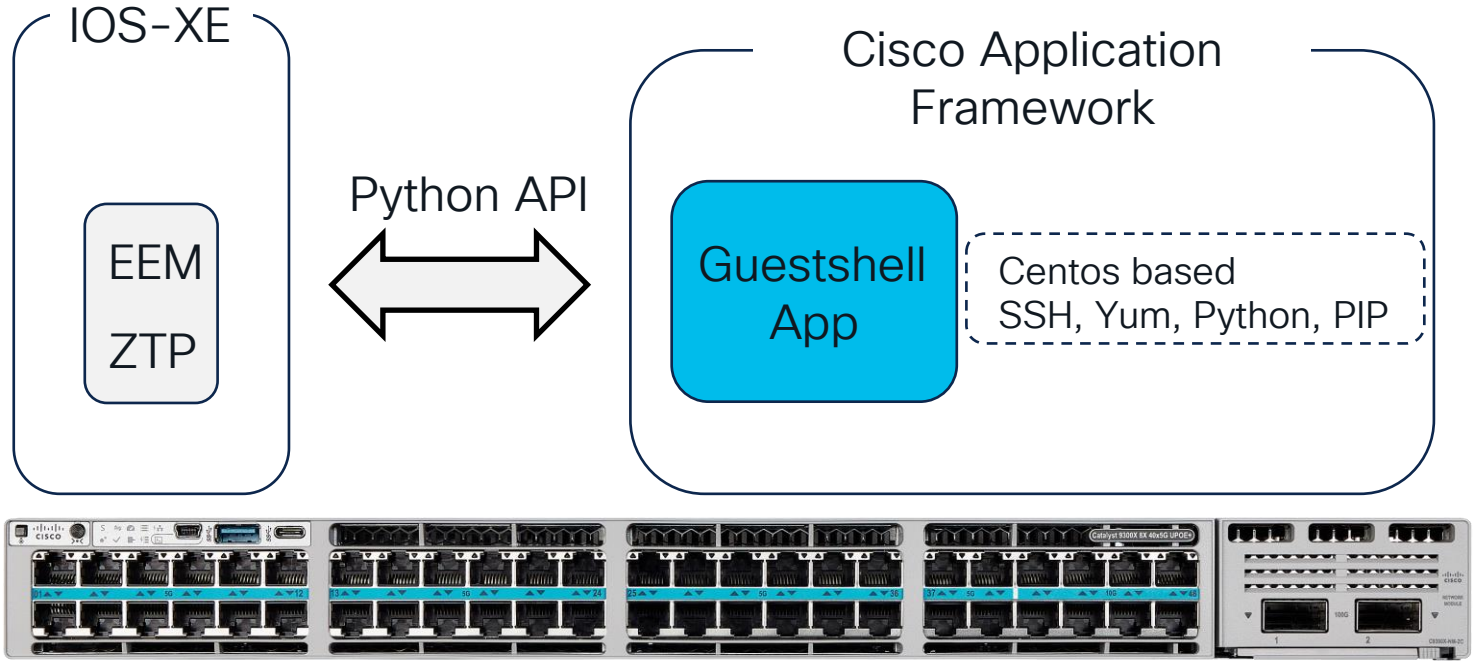
Application Hosting

gNMI Dial-In

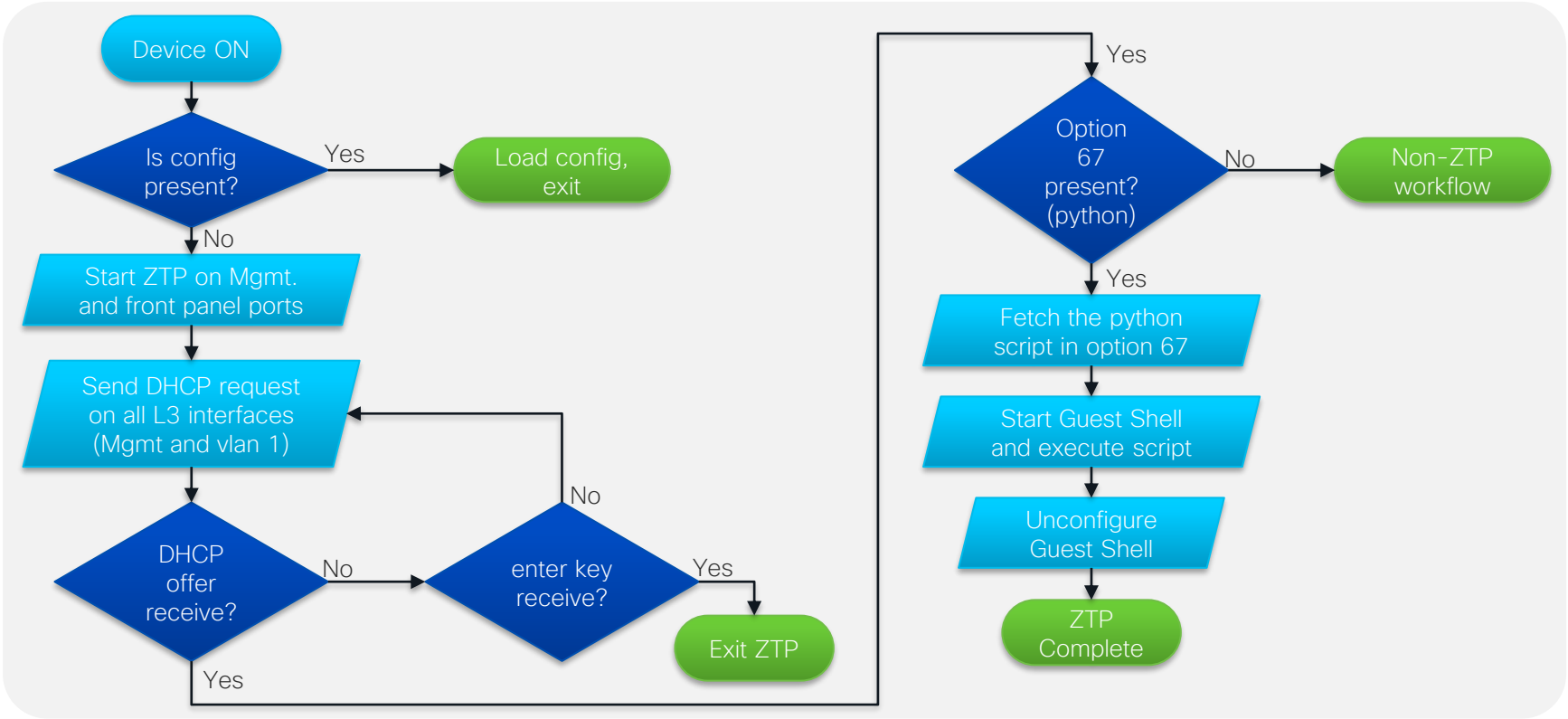
gRPC Dial-Out

NETCONF Dial-Out

Guestshell Overview



ZTP Workflow using Guestshell

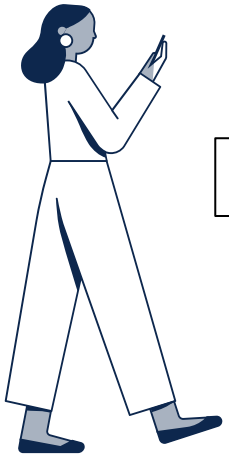


Wireless Troubleshooting Automation

Configuration Debug

RA Trace

OTA Capture



How to react faster?

How to analyze debugs?

How to parse collected data?

Wireless Troubleshooting Automation

Configuration Debug

NEW

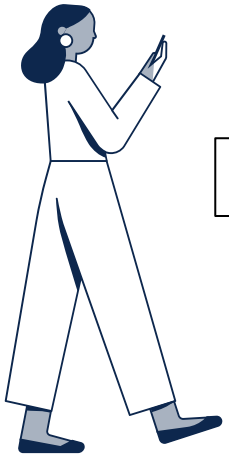
Wireless Config Analyzer Express

RA Trace

Wireless Debug Analyzer

OTA Capture

WiFi HAWK



9800 Guestshell/EEM scripts

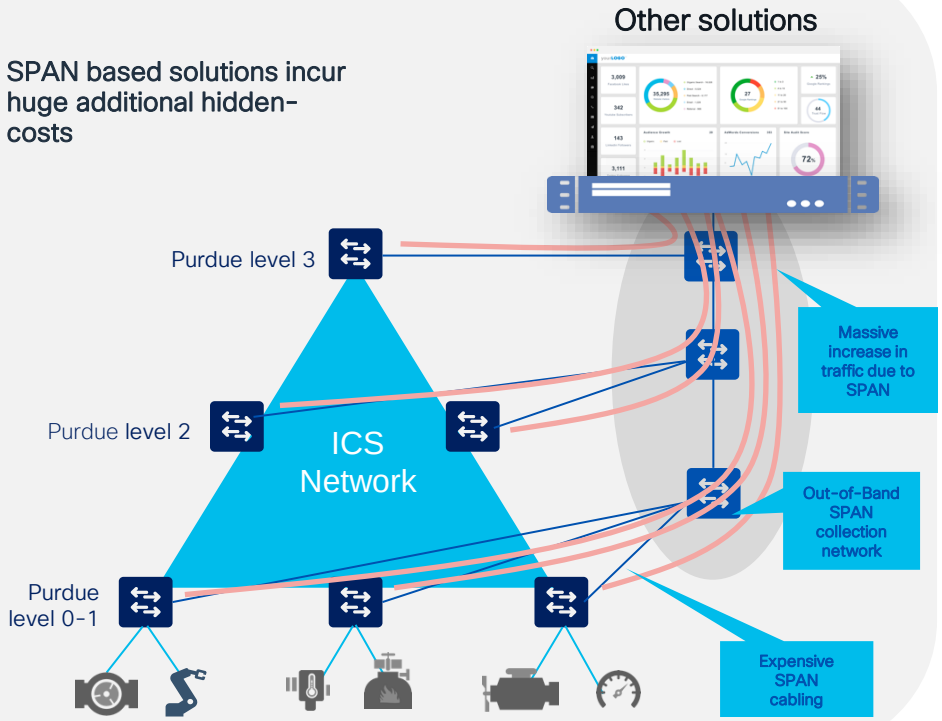
Wireless Troubleshooting Automation

Why?	What?
Efficient Client Troubleshooting Wireless client troubleshooting requires lots of iterations to collect right information. This tool will help us to do all those steps in one shot, saving time and ensuring we get correlated logs and captures from 9800 WLC using Guestshell & Python Innovation.	▪ Automatic client RA traces, Packet Captures, & Summary of events using Guestshell python scripts ▪ Enabled on Multiple WLCs to capture IRCM ▪ DNAC : MRE workflow integration completed by Eng
Uninterrupted Embedded Packet Capture This tool will help to export packet capture buffer to a server without having to start and stop the capture, allowing to have continuous packet capture stored in server with different filenames to do forensic analysis with all the packets.	▪ Configure & Export rotatory packet capture on 9800 using Guestshell ▪ Continuous captures help when issue is random & Sporadic in nature ▪ MRE Workflow integration work in progress
Automated Archive request and export Based on recent learnings we need to enable verbose traces for complete 9800. This tool will help us to automate periodical archive traces and exports without requiring customer intervention.	▪ Configure & Export Archive traces from 9800 using EEM ▪ Periodical & timed log capture for efficient troubleshooting ▪ MRE Workflow integration work in progress
KPI Collector This tool will help to automate data collection (KPI or Action Plan), ensures we have the right data collected	▪ Run a set of commands and store info in the file using Python & Guestshell ▪ Tool will be able to collect outputs several times to monitor counter & Other KPI stats ▪ MRE Workflow integration work in progress

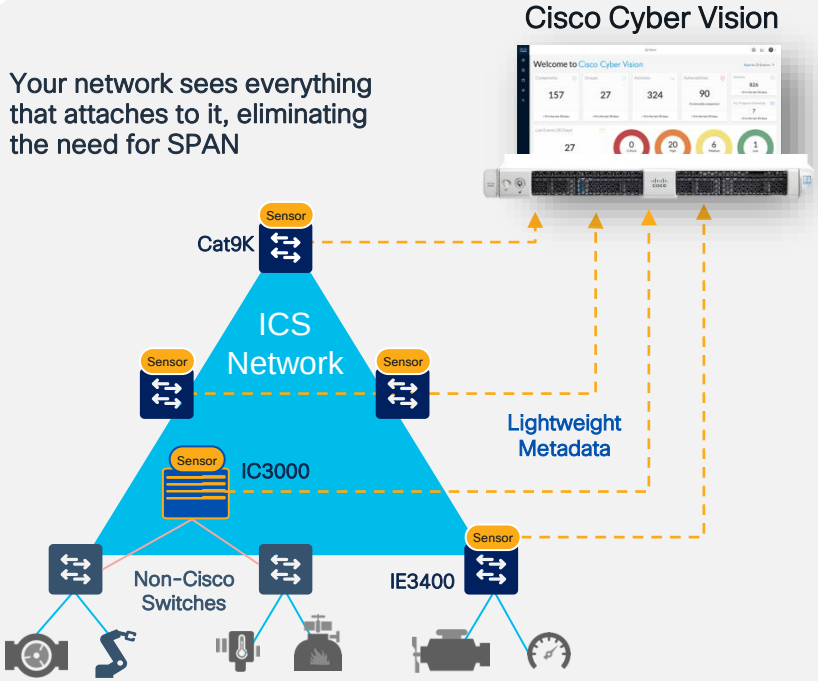
Cisco APPs

Building a **scalable** IoT/OT security architecture

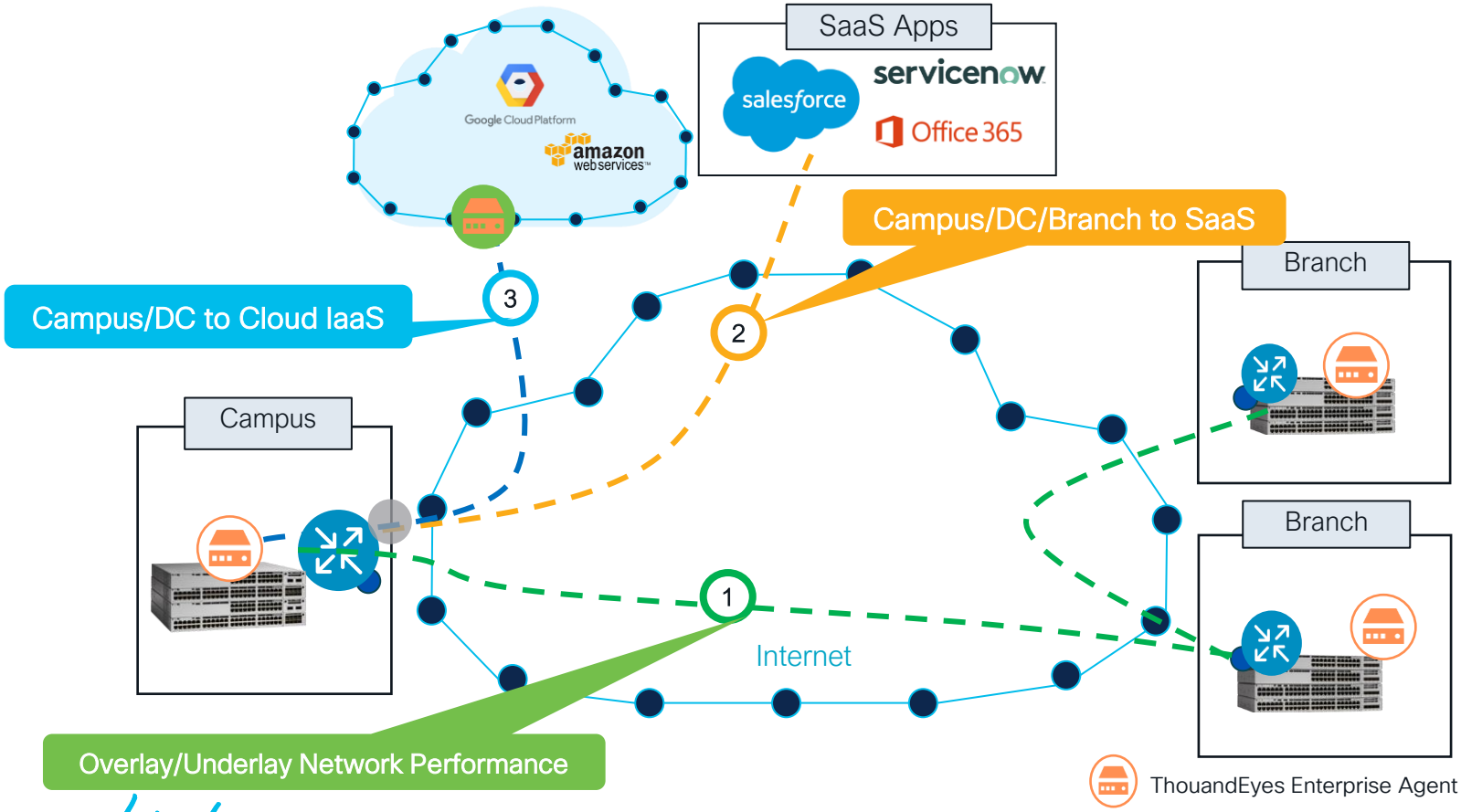
SPAN based solutions incur huge additional hidden-costs



Your network sees everything that attaches to it, eliminating the need for SPAN



Service Assurance with ThousandEyes



Wired IoT unifies visibility for common outcomes

Unified Middleware Layer

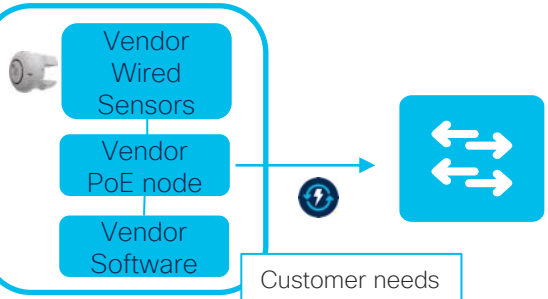
Deliver consistent outcome irrespective of sensor type

Opens some outcomes for traditional WLCs

Occupancy Example

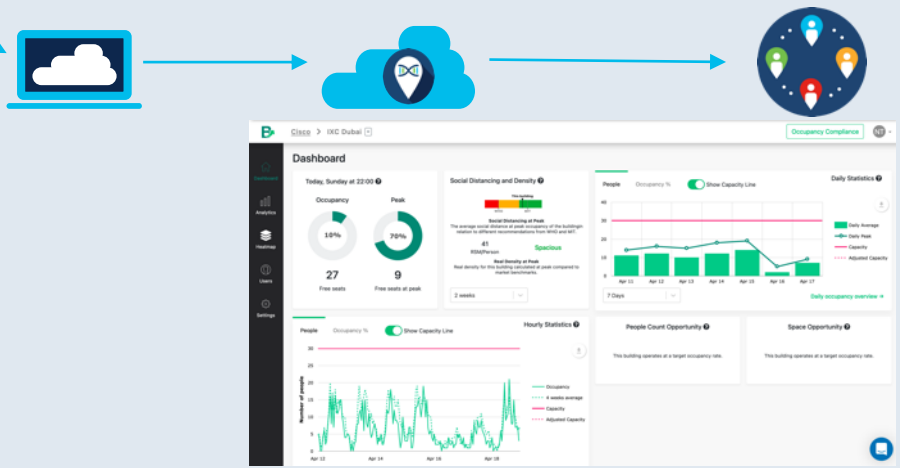
Wireless PIR sensors in open areas

Wired PIR sensors for conference rooms



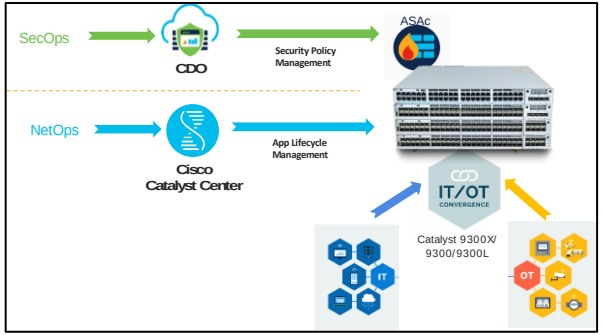
Customer needs to set this up anyways

Common language and consistent APIs

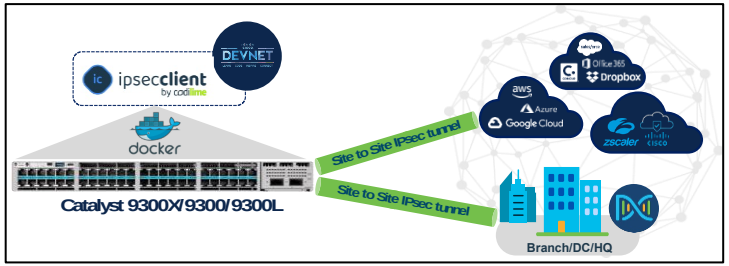


cisco Live!

And many more!

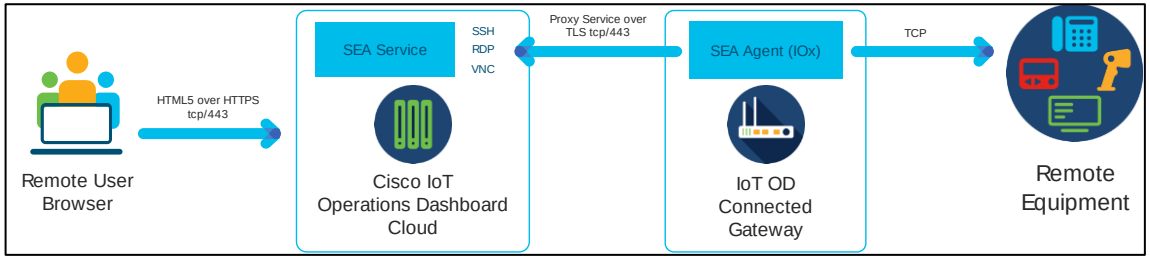


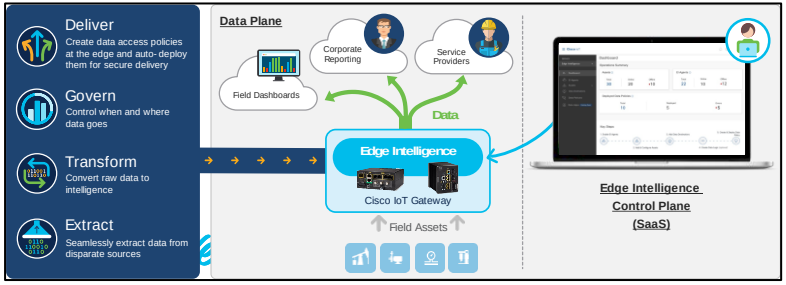
ASAc Firewall



SW-Based IPSec

Secure Equipment Access





Edge Intelligence

Conclusion

Conclusion

- More Data and less work with App Hosting
- App Hosting leverages the Power of the platform
- Easy to start and continue with publicly available resources
- Ask for help from Cisco team, even for prototypes

Resources

- Introduction to IOx
- Devnet Application Hosting Overview
- Application Hosting on Catalyst Switches
- Application Hosting on Catalyst Access Points
- Application Hosting on Catalyst Access Points Deployment Guide
- IOx Troubleshooting
- Guestshell
- Github With Sample IOx Apps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The bridge to possible
Thank you
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Let's go