Getting Started with Network Automation using IOS-XR7

End-to-End CI/CD Ops with XR7

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@irakshat   https://github.com/akshshar
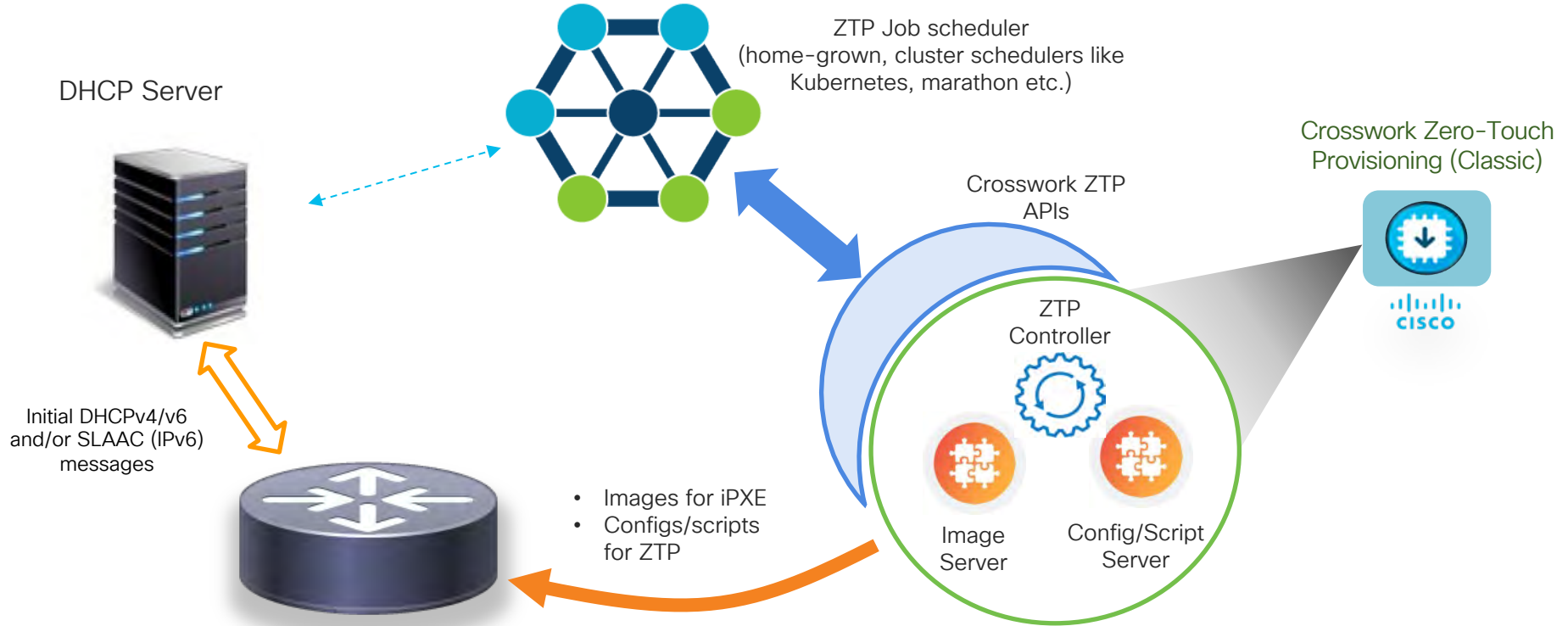
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Agenda

- IOS-XR7 ZTP and Cisco Crosswork

- IOS-XR7 Install: Based on DNF

- IOS-XR7 API architecture

- Cisco Crosswork

- Enabling Network CI/CD with IOS-XR7
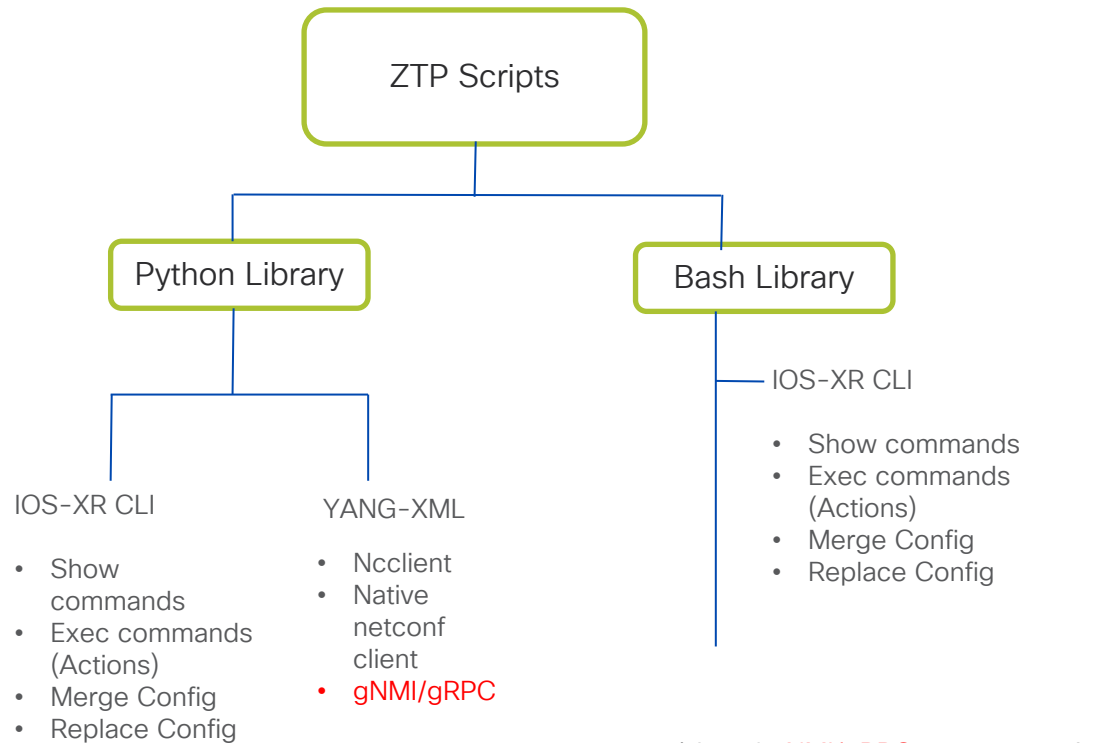
- Demo!

- Learn More!

IOS-XR7 ZTP and Cisco Crosswork

IOS-XR7 ZTP with Cisco Crosswork

DHCP Server

ZTP Job scheduler
(home-grown, cluster schedulers like
Kubernetes, marathon etc.)

Crosswork Zero-Touch
Provisioning (Classic)

Crosswork ZTP
APIs

ZTP
Controller

Initial DHCPv4/v6
and/or SLAAC (IPv6)
messages

- Images for iPXE
- Configs/scripts
  for ZTP

Image
Server

Config/Script
Server

ZTP Scripts: On-Box APIs for complete automation

```
ZTP Scripts
├── Python Library
│   ├── IOS-XR CLI
│   │   • Show commands
│   │   • Exec commands (Actions)
│   │   • Merge Config
│   │   • Replace Config
│   └── YANG-XML
│       • Ncclient
│       • Native netconf client
│       • gNMI/gRPC
└── Bash Library
    └── IOS-XR CLI
        • Show commands
        • Exec commands (Actions)
        • Merge Config
        • Replace Config
```

* Local gNMI/gRPC support coming soon.
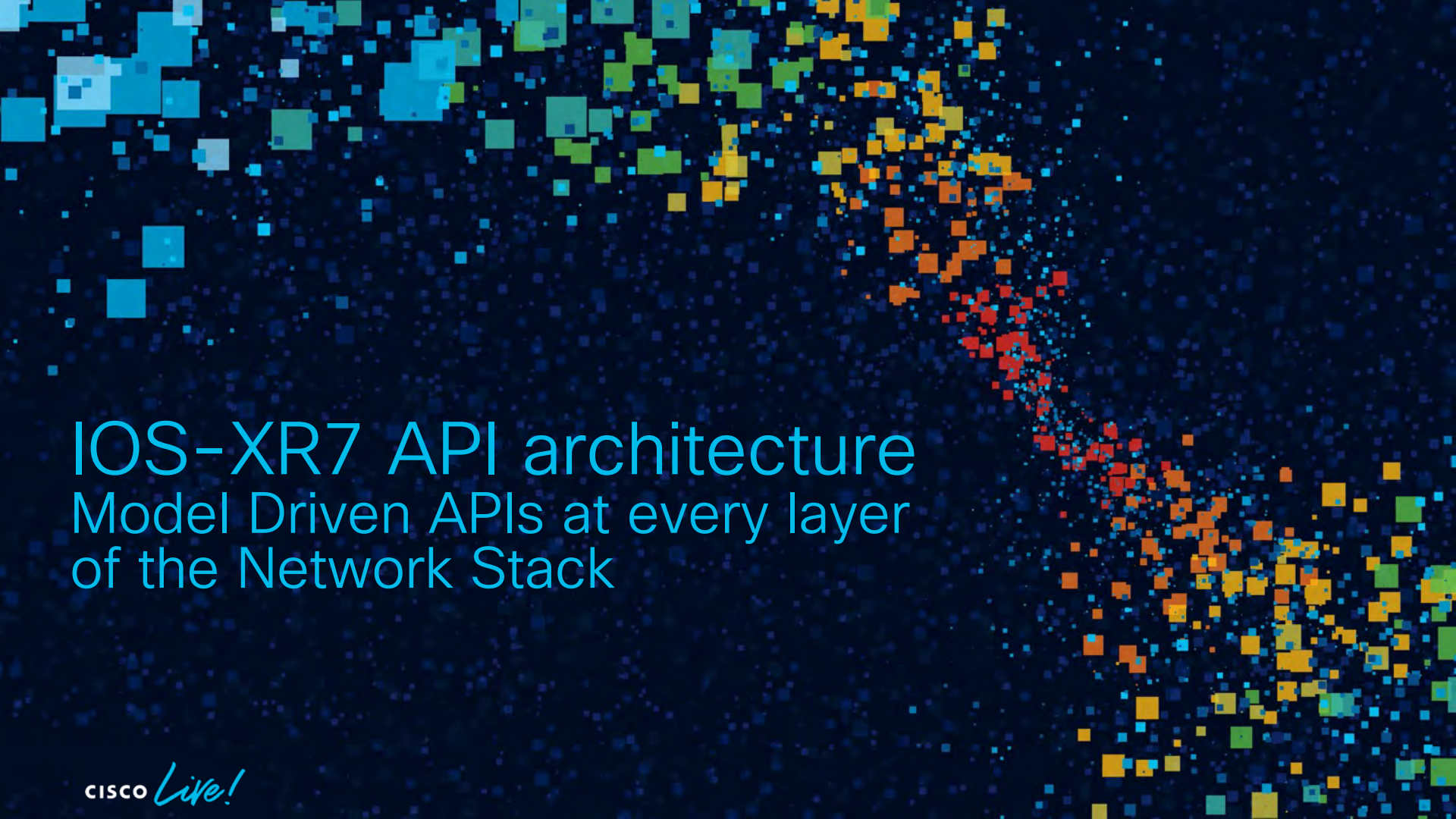
IOS-XR7 Install:
Based on DNF, Built for automation

CISCO *Live!*

IOS XR7 Install Workflows

DNF / RPM repository

- xr-eigrp rpms
- xr-telnet rpms
- xr-rip rpms
- xr-k9sec rpms
- xr-cdp rpms

No more SMUs! All bug fixes are a set of upgraded RPMs!

Optional RPMs can be upgraded without any Reload!

Structured Syslog events (Event Driven Telemetry) for every install operation over gRPC

GRPC

IOSXR7

DNF

- New XR7 Install built on top of **DNF (Dandified yum)!**

- Installs IOS-XR RPM packages and third-party applications packages compiled for WRL9

- XR RPMs with structured dependencies and metadata

- Use off-box rpm, dnf tools to analyze packages

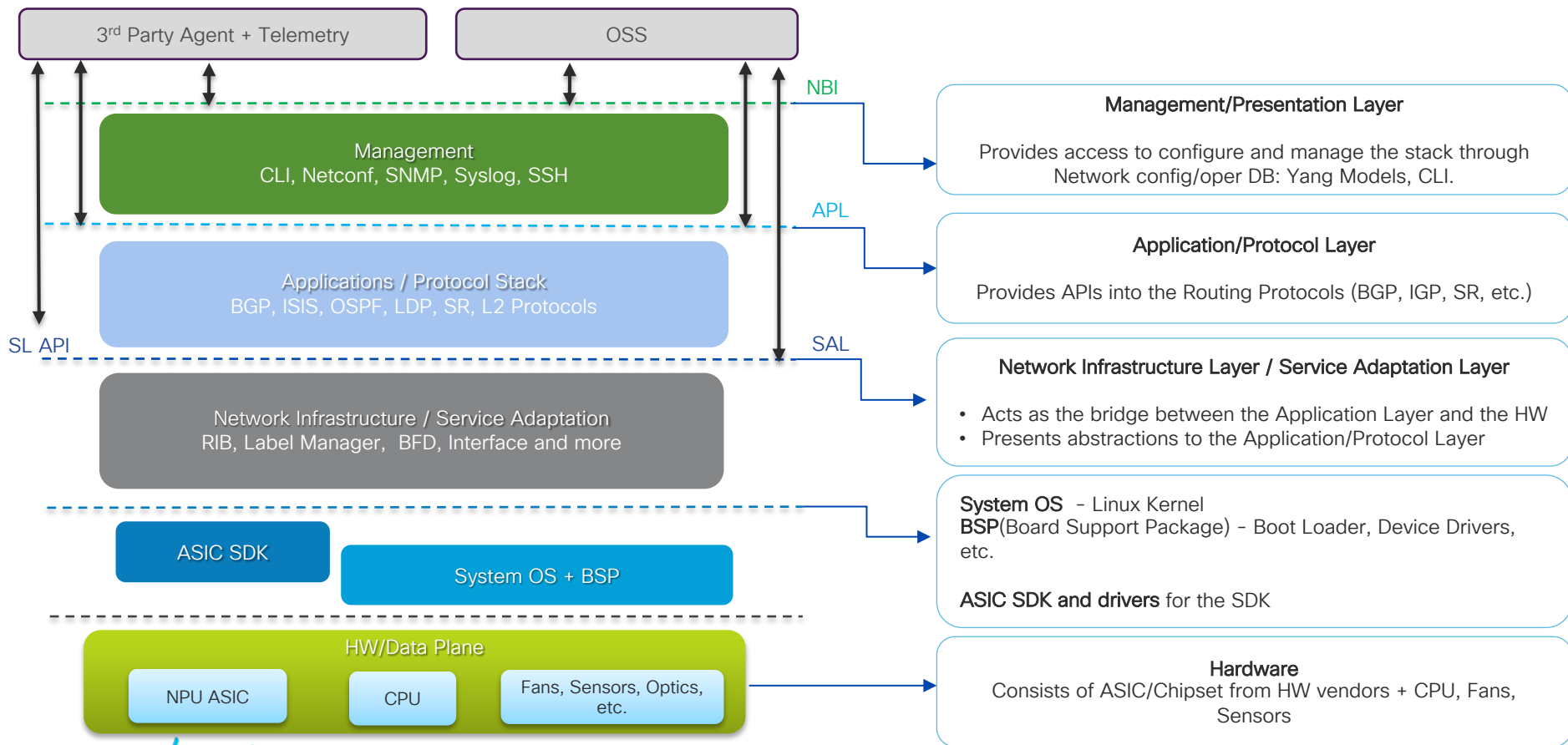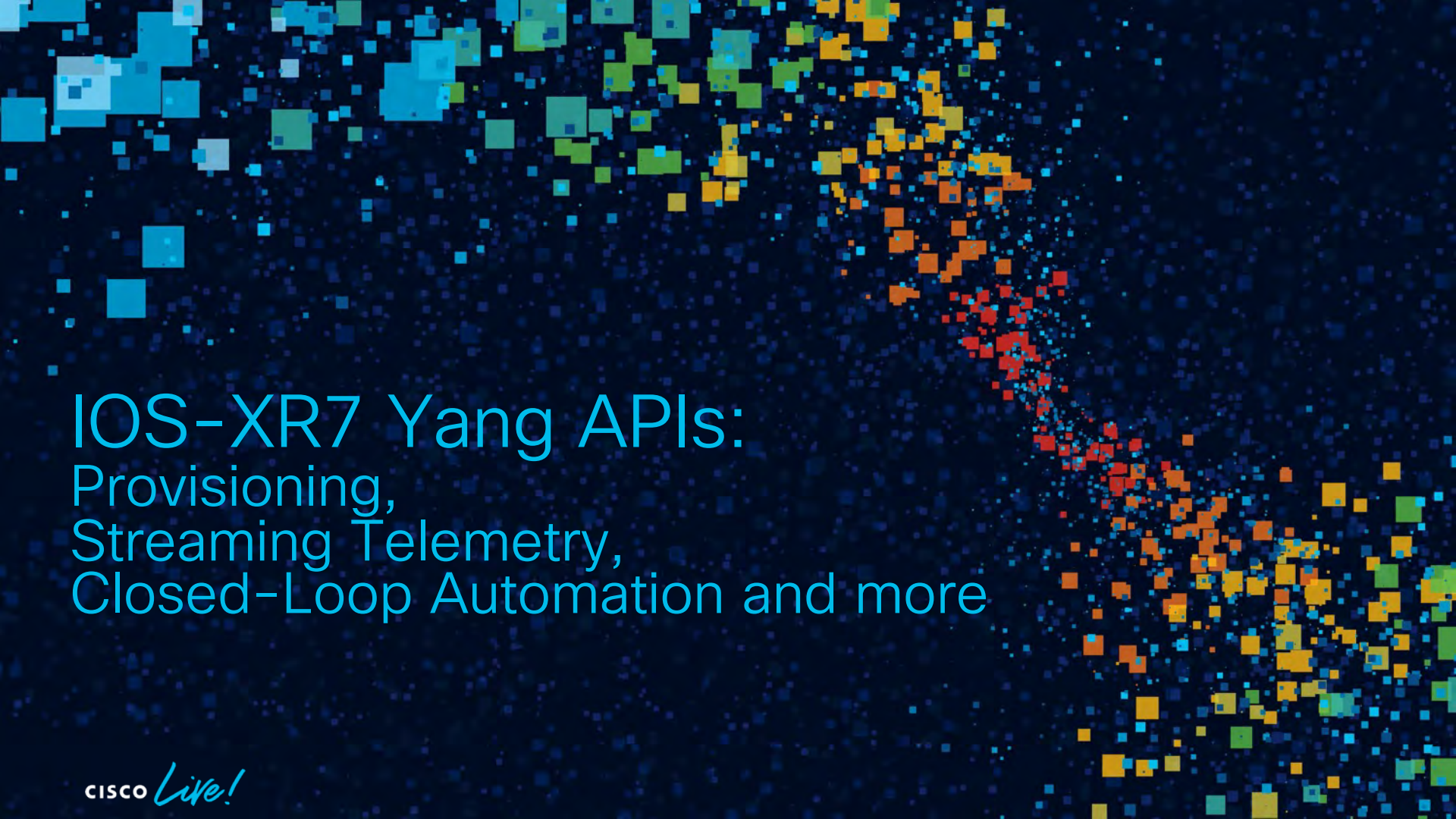- Don't want a remote repo? Create a local dnf repo on the router!

IOS-XR7 API architecture
Model Driven APIs at every layer of the Network Stack

API-Driven, Layered SW Architecture

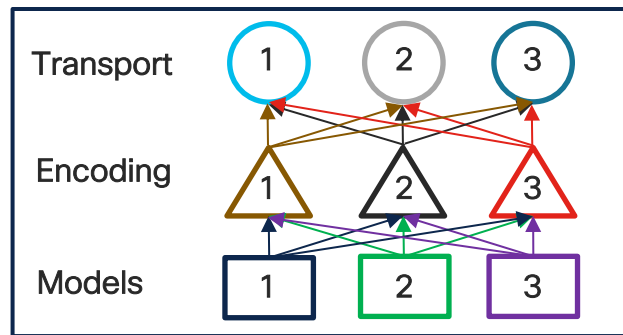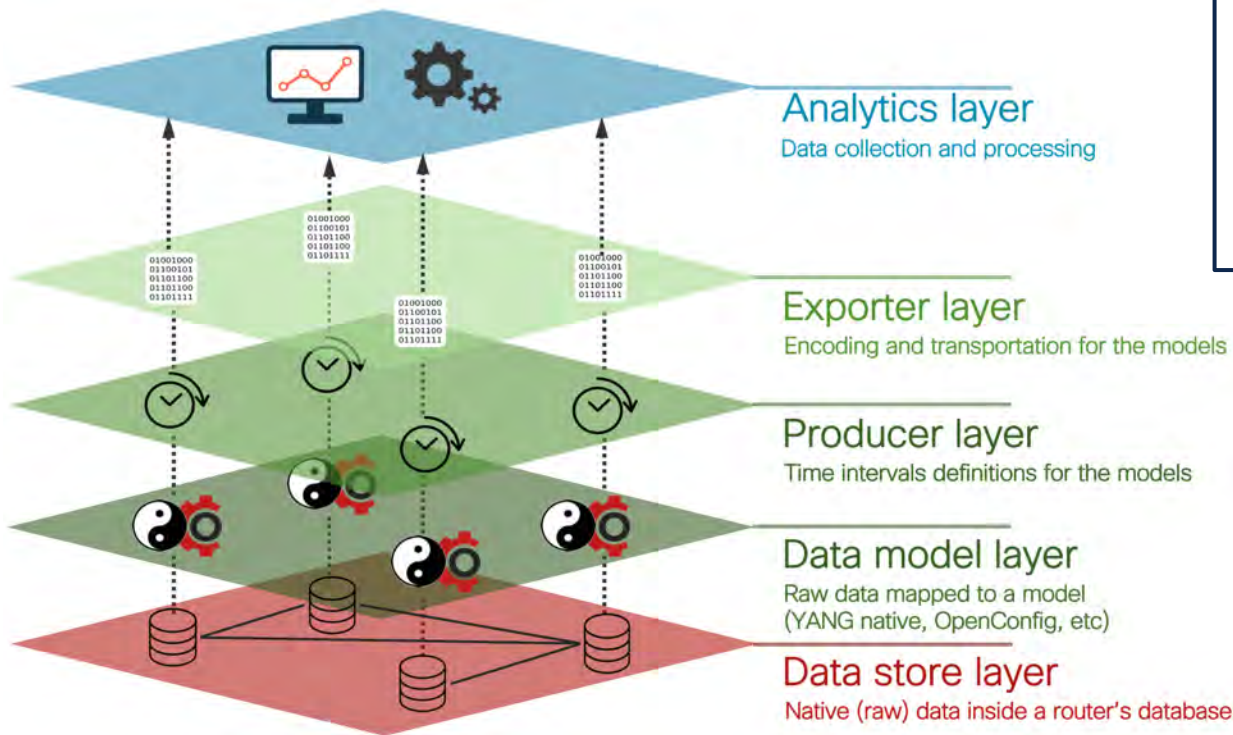| 3rd Party Agent + Telemetry	OSS

NBI

Management
CLI, Netconf, SNMP, Syslog, SSH

APL

Applications / Protocol Stack
BGP, ISIS, OSPF, LDP, SR, L2 Protocols

SL API

SAL

Network Infrastructure / Service Adaptation
RIB, Label Manager, BFD, Interface and more

ASIC SDK

System OS + BSP

HW/Data Plane
- NPU ASIC
- CPU
- Fans, Sensors, Optics, etc.

Management/Presentation Layer

Provides access to configure and manage the stack through Network config/oper DB: Yang Models, CLI.

Application/Protocol Layer

Provides APIs into the Routing Protocols (BGP, IGP, SR, etc.)

Network Infrastructure Layer / Service Adaptation Layer

- Acts as the bridge between the Application Layer and the HW
- Presents abstractions to the Application/Protocol Layer

System OS – Linux Kernel
BSP (Board Support Package) – Boot Loader, Device Drivers, etc.

ASIC SDK and drivers for the SDK

Hardware
Consists of ASIC/Chipset from HW vendors + CPU, Fans, Sensors

Model-Driven Manageability

Controller Orchestrator

Apps

| App | App | App |

SDK

Model-Driven SDKs
YANG Development Kit (YDK)

Model-Driven Telemetry

Protocol

| NETCONF | gRPC |

Closed-loop automation

Encoding

| XML | JSON | GPB |

Model-Driven Configuration

Transport

| SSH | TCP | HTTP |

Network Device

Models

YANG Models
(native, open)

IOS-XR Streaming Telemetry

Transport 1 2 3

Encoding 1 2 3

Models 1 2 3

Analytics layer
Data collection and processing

Exporter layer
Encoding and transportation for the models

Producer layer
Time intervals definitions for the models

Data model layer
Raw data mapped to a model
(YANG native, OpenConfig, etc)

Data store layer
Native (raw) data inside a router's database

Find tons of Content on Streaming Telemetry with IOS-XR on:

https://xrdocs.io/telemetry/

IOS-XR Service Layer APIs

CLI, Yang Models, Streaming Telemetry

Manageability Layer

SYSDB

Service Layer API

Network Infrastructure Layer (Service Layer)

Service-Layer APIs bypass SysDB giving higher performance

Off-Box Client

gRPC stub

Python, C++, go

Request   Response

On-Box Client

gRPC stub

Python, C++, go

gRPC Server (Router)

Protobuf Schema/Model

| Initialization RPCs | RIB RPCs | MPLS RPCs | Interface RPCs | BFD RPCs | ...... |

SL-API Functionality Verticals
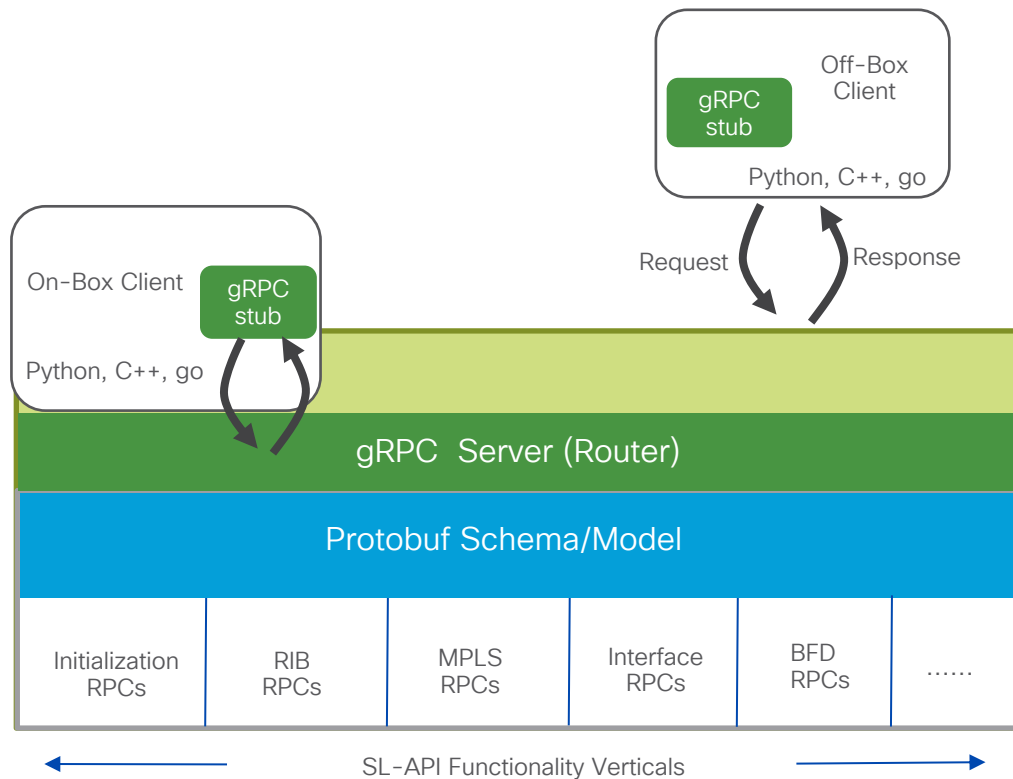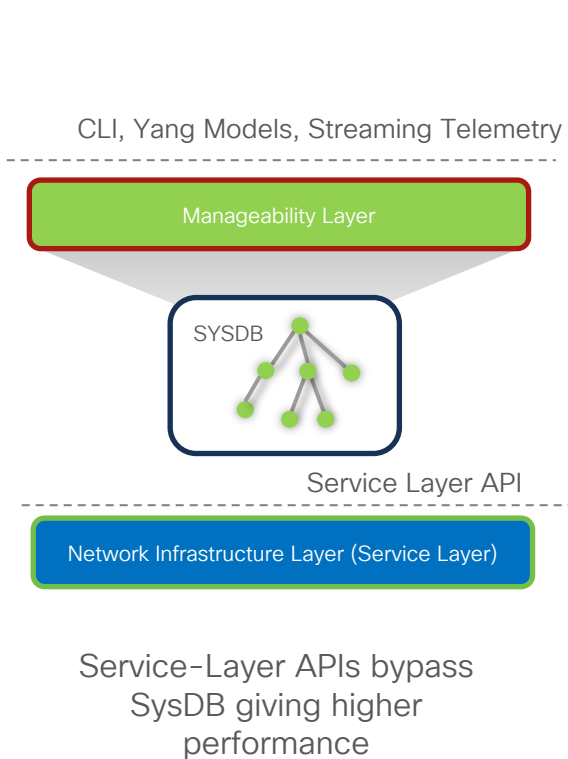
Cisco Crosswork:
Bringing Network Automation, Operations, Telemetry, Analytics and Trust under one roof

Cisco Crosswork

Health Insights   **Change Automation**   **Data Gateway**   **Situation Manager**   **Network Insights**
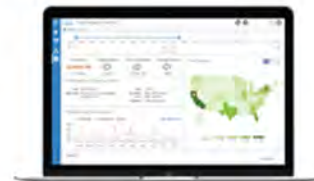
Cisco Crosswork on DevNet

[Cisco Crosswork API, Getting Started and more](#)

Cisco Crosswork Installation Guides:
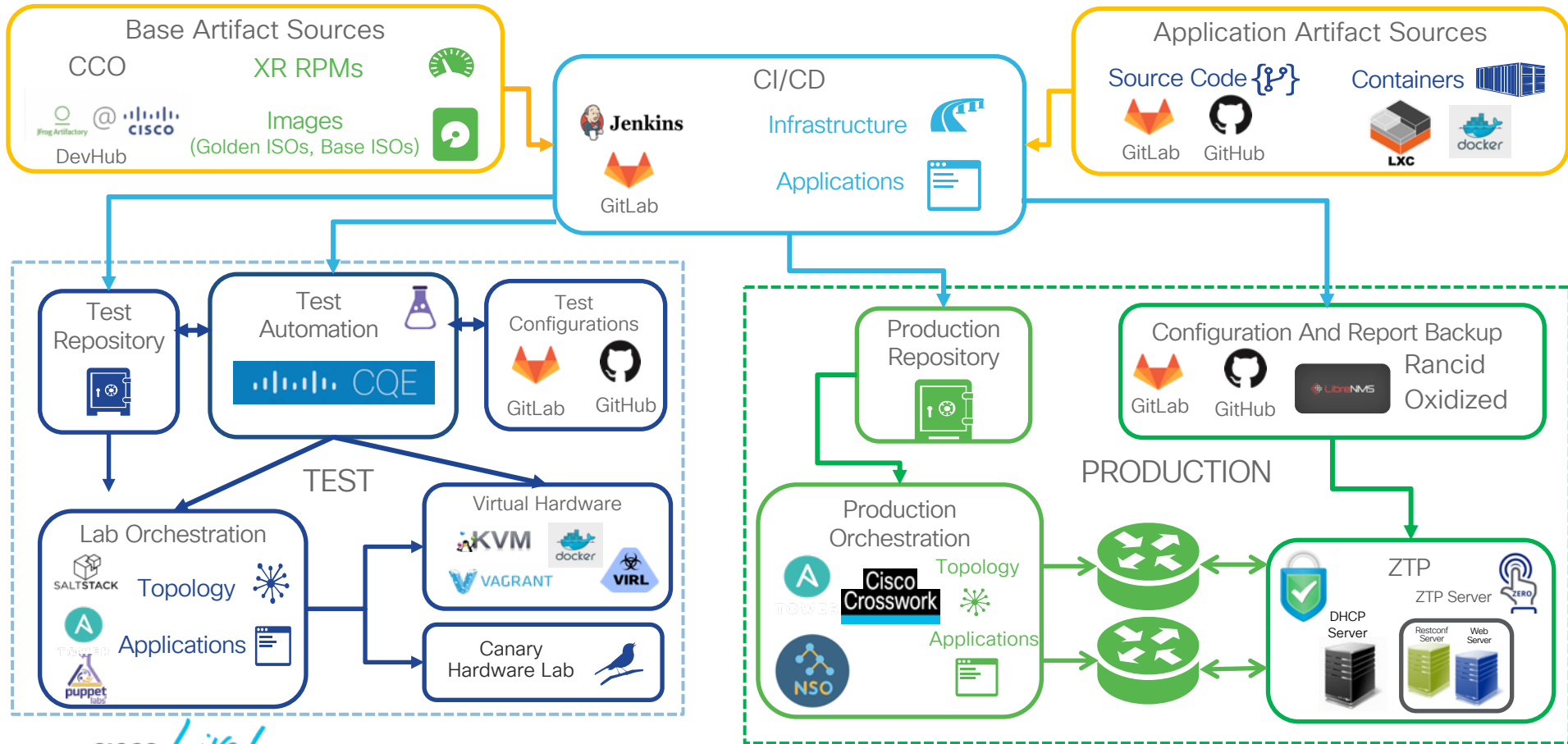https://www.cisco.com/c/en/us/support/cloud-systems-management/crosswork-network-automation/products-installation-guides-list.html

Enabling Network CI/CD with IOS-XR7 and its ecosystem

Enabling Network CI/CD with IOS-XR7

Base Artifact Sources

CCO — XR RPMs

iFrog Artifactory @ CISCO

DevHub — Images (Golden ISOs, Base ISOs)

CI/CD

Jenkins — Infrastructure

GitLab — Applications

Application Artifact Sources

Source Code {} — Containers

GitLab · GitHub · LXC · docker

TEST

Test Repository

Test Automation — CQE

Test Configurations — GitLab · GitHub

Lab Orchestration — Topology — Applications

SALTSTACK · TOWER · puppet labs

Virtual Hardware — KVM · docker · VAGRANT · VIRL

Canary Hardware Lab

PRODUCTION

Production Repository

Configuration And Report Backup — GitLab · GitHub · LibreNMS — Rancid Oxidized

Production Orchestration — Topology — Applications

TOWER · Cisco Crosswork · NSO

ZTP — ZTP Server

DHCP Server · Restconf Server · Web Server

Demo:
Using Gitlab CI/CD to deploy Artifacts and Apps on IOS-XR7 in production

Demo: Continuous Deployment with XR7 using GitLab CI/CD

Base Artifact Sources

CCO

JFrog Artifactory @ cisco

DevHub

BGP RPM

XR RPMs

Continuous Integration

GitLab

Infrastructure

Applications

Application Artifact Sources

GitLab

Open/R

docker

PRODUCTION

Production Repository

rpm

docker

Configurations, Scheduler Code, Playbooks

GitLab

Streaming Telemetry

Cisco Crosswork

Production Orchestration

Cisco Crosswork

A

ydk

Topology

Applications

ZTP

DHCP Server

Cisco Crosswork

cisco

Demo: Continuous Deployment with XR7 using GitLab CI/CD

- Demo Code:
  https://gitlab.com/akshshar/xr7-netops

- The entire automation workflow spans ZTP, XR install, Telemetry, YDK and Open/R bring-up (which uses IOS-XR Service Layer APIs).

- This automation workflow leverages 5 GitLab CI/CD pipelines with the following trigger order:

Postman → ztp (Set up Crosswork and start hook server)

→ install_telemetry_rtr1 (install BGP RPM on rtr1 and monitor install events)

→ install_telemetry_rtr2 (install BGP RPM on rtr2 and monitor install events)

→ ydk (Configure BGP on rtr1 and rtr2)

→ openr (Bring-up Open/R as IGP to establish BGP neighbors)
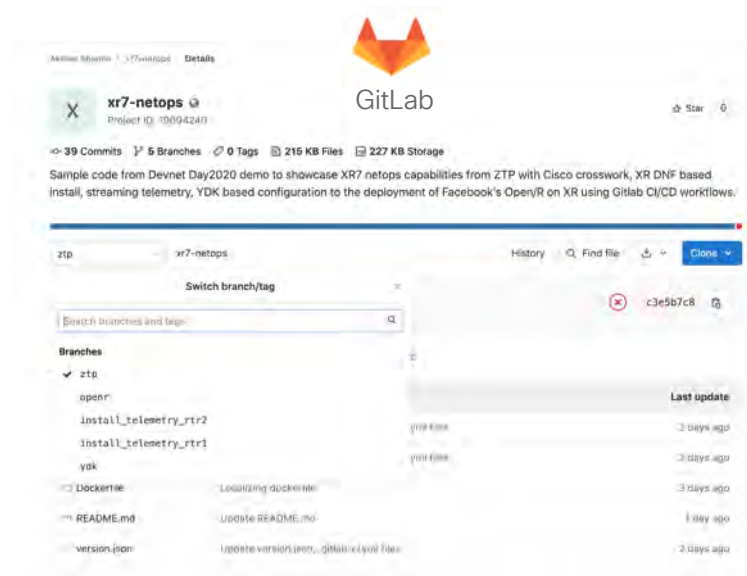
Learn more!

Explore More on IOS-XR ZTP

- Blogs on xrdocs:

  https://xrdocs.io/device-lifecycle/
  - IOS-XR ZTP: Learning through Packet Captures
  - Working with Zero Touch Provisioning
  - iPXE Deep Dive

- IOS-XR ZTP APIs (Bash and Python):
  - DevNet Sandbox based Learning Labs

- IOS-XR ZTP on Github
  - IOS-XR ZTP Python library, sample scripts
  - xr-restztp (ZTP hook server used in the demo)
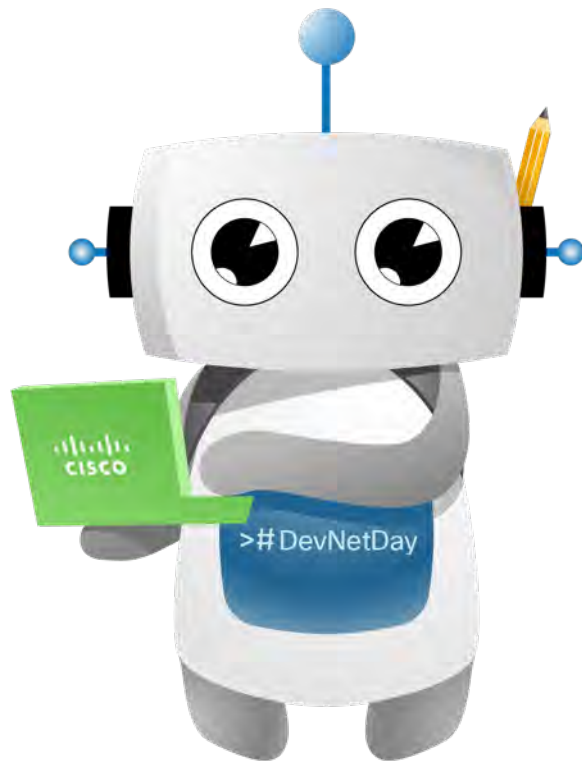
Explore More on IOS-XR Yang Capabilities

- Cisco NSO
  https://developer.cisco.com/docs/nso/

- IOS-XR Yang Models per release
  IOS-XR Yang models on GitHub

- Yang Development Kit (YDK)
  Website: ydk.io
  YDK-Py Library
  Sample Python YDK apps
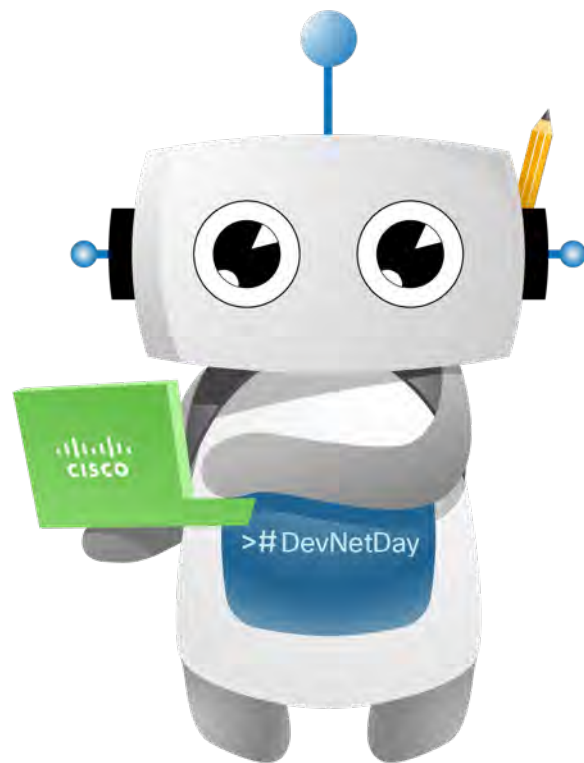
Support for Config-Management Tools

IOS-XR

Ansible Core:
http://docs.ansible.com/ansible/latest/list_of_network_modules.html#iosxr

Ansible NSO modules:
https://docs.ansible.com/ansible/latest/modules/nso_config_module.html

https://docs.ansible.com/ansible/latest/modules/nso_show_module.html

https://docs.ansible.com/ansible/latest/modules/nso_verify_module.html

Proxy Minion interface module :
https://docs.saltstack.com/en/latest/ref/proxy/all/salt.proxy.cisconso.html

Execution module for Cisco NSO Proxy minions:
https://docs.saltstack.com/en/latest/ref/modules/all/salt.modules.cisconso.html

https://github.com/cisco/cisco-yang-puppet-module

Explore More on IOS-XR Telemetry
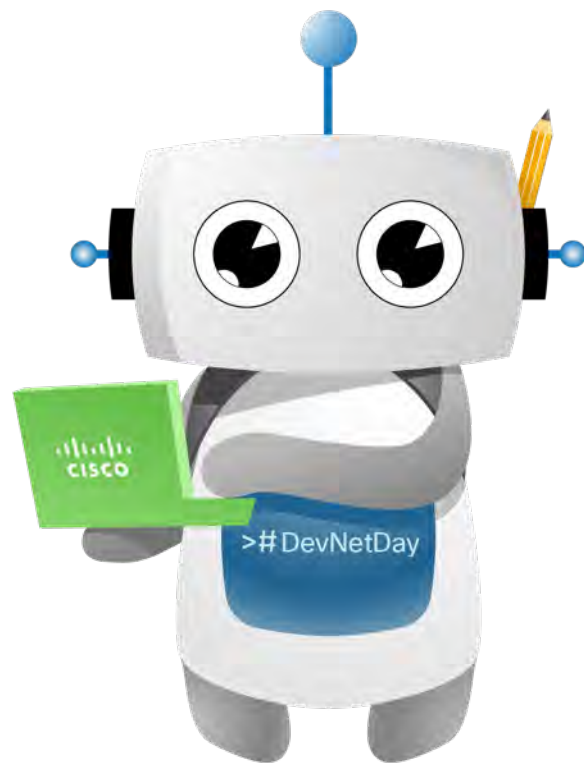
- Blogs on xrdocs:
  https://xrdocs.io/telemetry/

- IOS-XR Telemetry Learning Labs:
  DevNet Sandbox based Learning Labs

- IOS-XR Telemetry on Github
  IOS-XR Telemetry Proto Files

Explore More on IOS-XR Service Layer APIs

- Blogs on xrdocs:

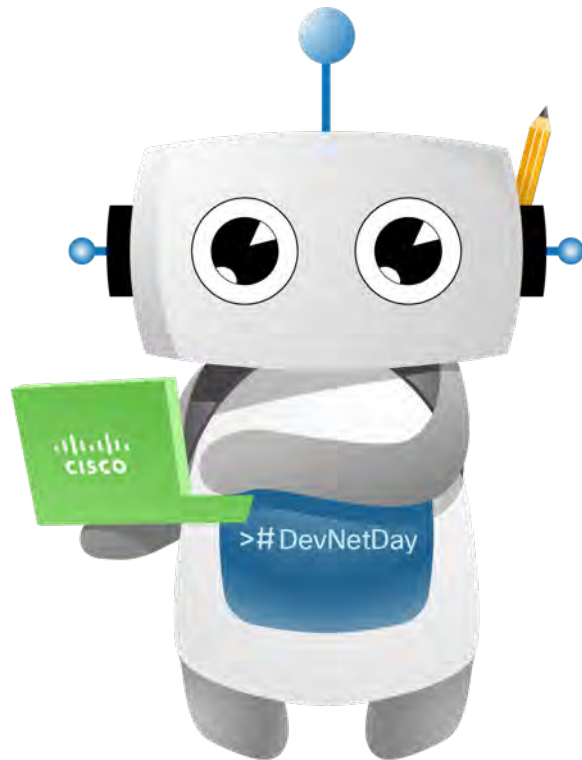 https://xrdocs.io/cisco-service-layer/

- IOS-XR Service Layer API Crash Course:
  - DevNet Sandbox based Learning Labs

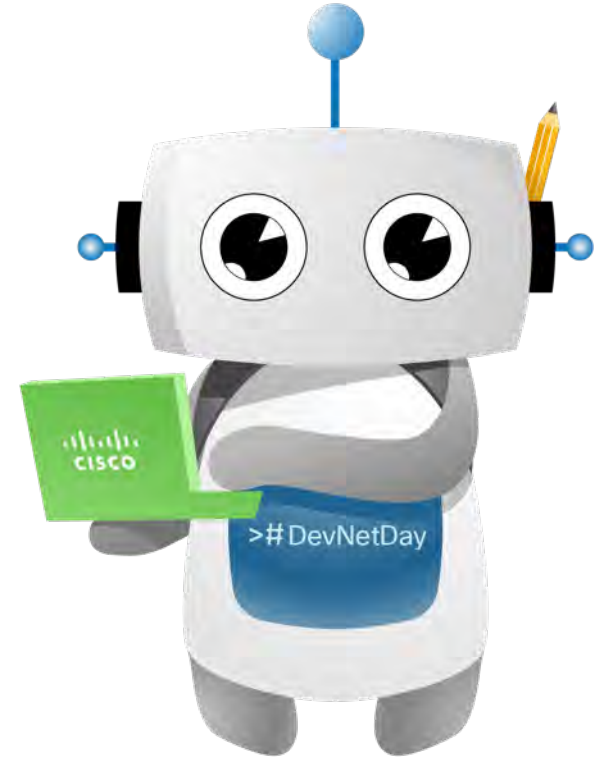- IOS-XR Service Layer APIs on GitHub
  - IOS-XR Service Layer

Explore More on Cisco Crosswork

- Cisco Crosswork on Devnet
  - [Cisco Crosswork API, Getting Started and more](#)

- Cisco Crosswork Installation Guides:
  - https://www.cisco.com/c/en/us/support/cloud-systems-management/crosswork-network-automation/products-installation-guides-list.html

Thank you

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