



You make **possible**



Programmability with IOS-XR Platforms

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BRKOPS-2285

CISCO *Live!*

Barcelona | January 27-31, 2020



Cisco Webex Teams

Questions?

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

How

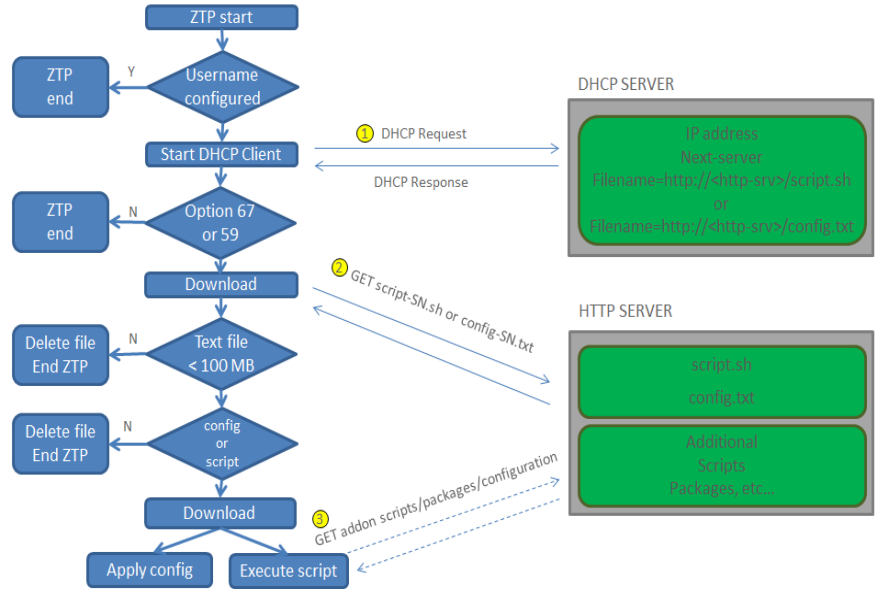
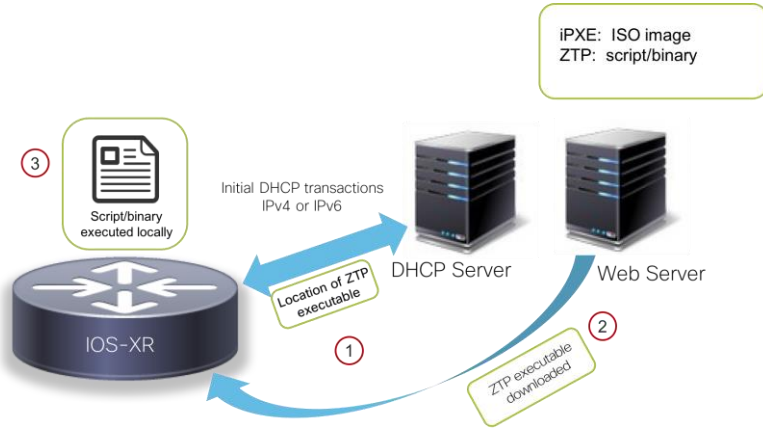
- 1 Find this session in the Cisco Events Mobile App
- 2 Click “Join the Discussion”
- 3 Install Webex Teams or go directly to the team space
- 4 Enter messages/questions in the team space



Agenda

- Cisco ZTP (Bringing up automation)
- Model Driven Manageability
- Streaming Telemetry
- Service layer API
- App Hosting
- Demo

ZTP



Ref : <https://developer.cisco.com/learning/lab/01-iosxr-02-cli-automation-python/step/1>

ZTP helper Libraries

```
RP/0/RP0/CPU0:r1#bash Sat Sep 8 18:53:22.730 UTC  
[r1:~]$ python
```

```
Python 2.7.3 (default, Dec 12 2017, 08:22:03)  
[GCC 4.9.1] on linux2  
Type "help", "copyright", "credits" or "license" for more information.
```

```
>>> import sys  
>>> sys.path.append("/pkg/bin")  
>>> from ztp_helper import ZtpHelpers  
>>> from pprint import pprint
```

```
>>> ztp_obj=ZtpHelpers()  
>>> cmd={"exec_cmd": "show running-config"}  
>>> ztp_obj.xrcmd(cmd)  
>>> pprint(ztp_obj.xrcmd(cmd))
```

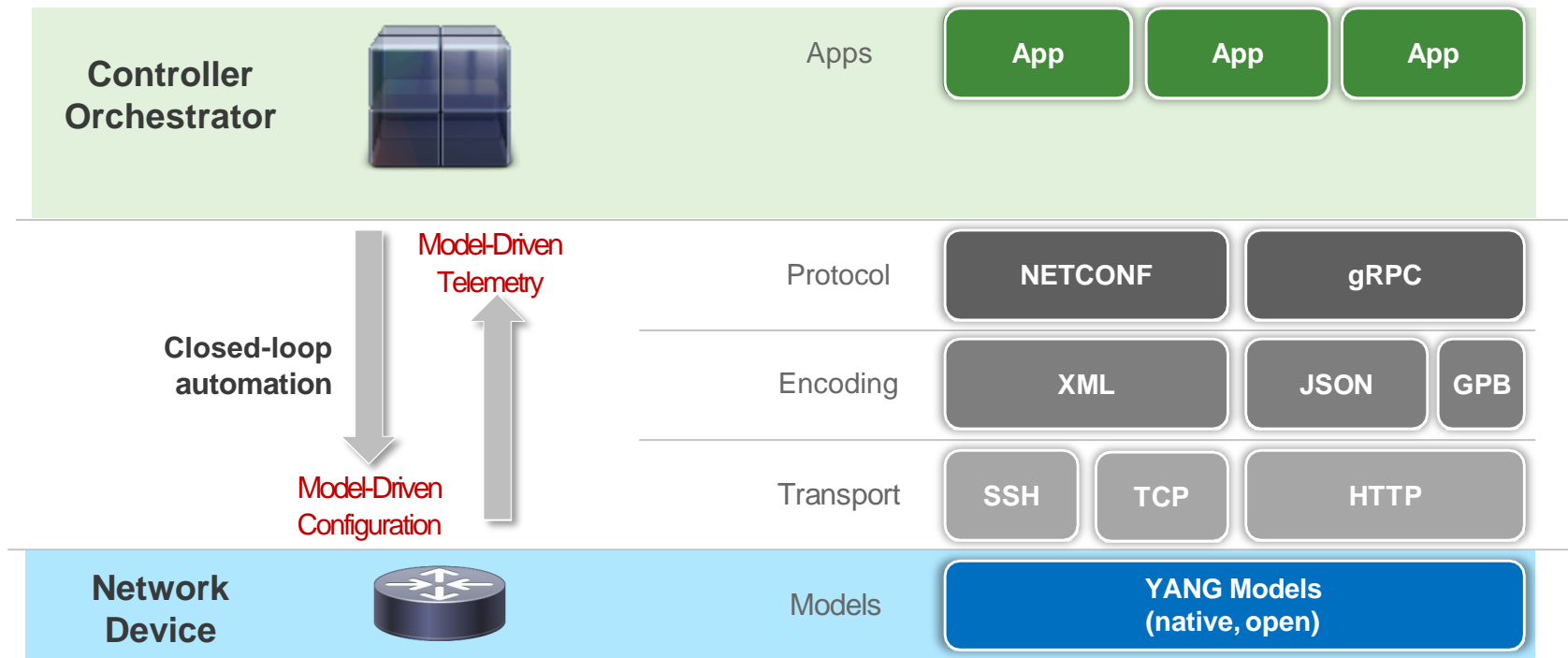
Output

xrapply(), xrapply_string(), xrreplace()

```
Building configuration...  
{'output': ['!!! IOS XR Configuration version = 6.4.1',  
            '!!! Last configuration change at Sat Sep 8 19:07:36 2018 by ZTP',  
            '',  
            'hostname r1',  
            'banner motd ;',  
            '-----',  
            'Router 1 (Cisco IOS XR Sandbox)',  
            '-----',  
            '',  
            'logging console debugging',  
            'service timestamps log datetime msec',  
            'service timestamps debug datetime msec',  
            'username admin',  
            'group root-lr',  
            'group cisco-support',  
            'secret 5 $1$A4C9$oaNorr6BXDrUE4gDd086L.',  
            '',  
            'line console',  
            'timestamp disable',  
            'exec-timeout 0 0',  
            '',  
            'vty-pool default 0 4 line-template VTY-TEMPLATE',  
            'call-home',  
            'service active',  
            'contact smart-licensing',  
            'profile CiscoTAC-1',  
            'active',  
            'destination transport-method http',  
            '',  
            '']}]
```

Model Driven Automation(NETCONF,gRPC,gNMI)–ANX

Model-Driven Manageability

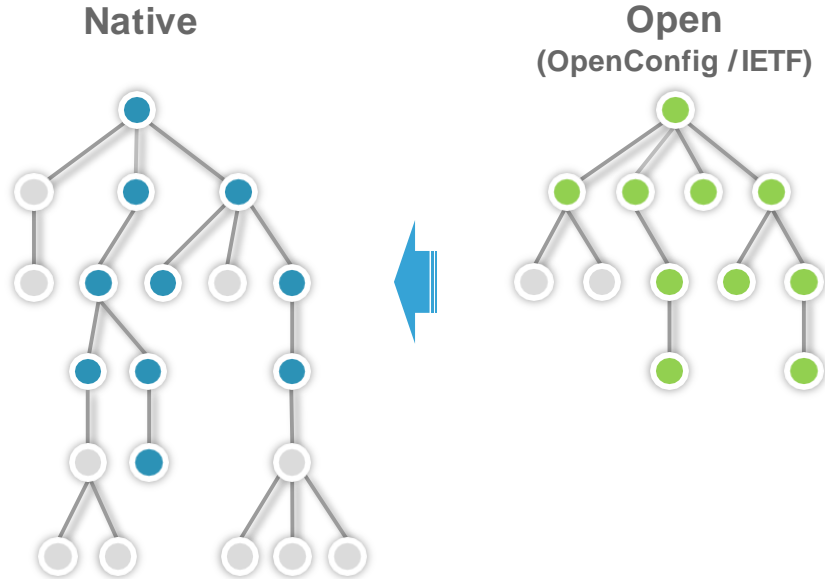


Benefits of Model-Driven Manageability

- Model based, structured, computer friendly
- Multiple model types (native, OpenConfig, IETF, etc.)
- Models decoupled from transport, protocol and encoding
- Choice of transport, protocol and encoding
- Model-driven SDKs for abstraction and simplification
- Wide standard support while leveraging open source



Data Models in Cisco IOS XR



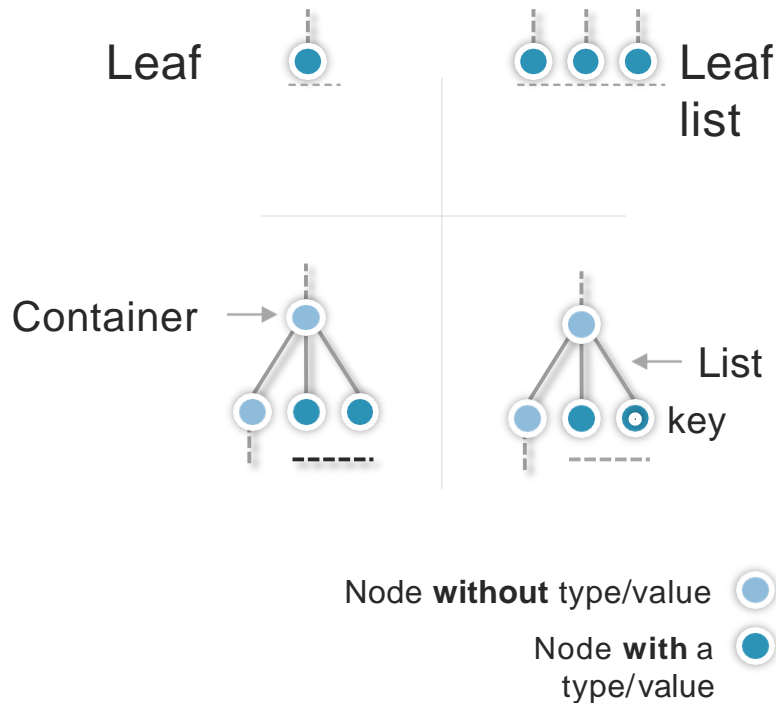
- Data (config and operational) and actions/commands (RPCs) in a tree structure
- Self-documented and shipped with devices
- Native (XR specific) and open (vendor neutral) models
- Native models provide most coverage
- Open (OpenConfig and IETF) provide reduced coverage
- Open models internally mapped to native models

Cisco IOS XR Native Data Models

- Provide most comprehensive coverage for device functionality
- Approximately ~385 models in XR 6.5.1 (800+ YANG files)
- A single model defines either configuration (cfg), operational state (oper) or an action/command (act)
 - Cisco-IOS-XR-ipv4-bgp-**cfg**
 - Cisco-IOS-XR-ipv4-bgp-**oper**
 - Cisco-IOS-XR-ipv4-bgp-**act**
- Models posted at
 - <https://github.com/YangModels/yang/tree/master/vendor/cisco/xr>



YANG



- Modeling language for networking
- Defines data hierarchy (config or oper), RPCs and notifications
- Main node types
 - Leaf – node with name, type and value (no children)
 - Leaf list – sequence of leafs (no children)
 - Container – node that groups nodes and has no type or value
 - List – Series of data instances generally with one or more keys
- Models extended through augmentations
- Unsupported nodes specified as deviations

YANG Model Example

YANG

```
container community-sets {  
  description "Container for community sets";  
  list community-set {  
    key community-set-name;  
    description "Definitions for community sets";  
    leaf community-set-name {  
      type string;  
      description "name of the community set";  
    }  
    leaf-list community-member {  
      type string {  
        pattern '([0-9]+:[0-9]+)';  
      }  
      description "members of the community set";  
    }  
  }  
}
```

CLI

```
community-sets  
  community-set C-SET1  
    65172:1,  
    65172:2,  
    65172:3  
  !  
  community-set C-SET10  
    65172:10,  
    65172:20,  
    65172:30  
  !  
!
```

Model Data Example

XML

```
<community-sets>
  <community-set>
    <community-set-name>C-SET1</community-set-name>
    <community-member>65172:1</community-member>
    <community-member>65172:2</community-member>
    <community-member>65172:3</community-member>
  </community-set>
  <community-set>
    <community-set-name>C-SET10</community-set-name>
    <community-member>65172:10</community-member>
    <community-member>65172:20</community-member>
    <community-member>65172:30</community-member>
  </community-set>
</community-sets>
```

CLI

```
community-sets
  community-set C-SET1
    65172:1,
    65172:2,
    65172:3
  !
  community-set C-SET10
    65172:10,
    65172:20,
    65172:30
  !
!
```

Model Data Example

JSON

```
{  "community-sets": {
    "community-set": [
      {  "community-set-name": "CSET1",
        "community-member": [
          "65172:1",
          "65172:2",
          "65172:3" ]
      },
      {  "community-set-name": "CSET10",
        "community-member": [
          "65172:10",
          "65172:20",
          "65172:30" ]
      }
    ]
  }
}
```

CLI

```
community-sets
  community-set C-SET1
    65172:1,
    65172:2,
    65172:3
  !
  community-set C-SET10
    65172:10,
    65172:20,
    65172:30
  !
!
```

Look for your Yang-Model...

<https://www.yangcatalog.org/yang-search/>

YANG DB Search

Enter your search term(s) below:

mpls

Search Options

☐ Case-Sensitive ☐ Regular Expression ☐ Include MIBs ☒ Only Show Latest Revisions

Search Fields

☒ All

☒ Module Name ☒ Node Description ☒ Node Name

YANG Versions

☒ 1.0 ☒ 1.1

Schema Types

☒ All

☒ Typedef ☒ Grouping ☒ Feature

☒ Extension ☒ Identity ☒ RPC

☒ Container ☒ List ☒ Leaf-List

☒ Action ☒ Leaf ☒ Notification

Screenshot

YANG DB Search Results for 'mpls'

Show 10 entries

Name	Revision	Schema Type	Path	Module	Origin	Organization
affinity-action-type	2014-11-05	typedef	/mpls-te-types:affinity-action-type?typedef	ietf-mpls-te-types (Module Details) (Tree View) (Impact Analysis)	Industry Standard	ietf
allow-reverse-lsp	2015-11-09	leaf	/mpls-oam-cfg:mpls-oam?container=mpls-oam-cfg:reply-mode?container=mpls-oam-cfg:control-channel?container=mpls-oam-cfg:allow-reverse-lsp?leaf	Cisco-IOS-XR-mpls-oam-cfg (Module Details) (Tree View) (Impact Analysis)	Vendor-Specific	cisco

Where can I download Yang-models

<https://github.com/YangModels/yang/tree/master/vendor/cisco>

The screenshot shows the GitHub repository page for **YangModels / yang**. The repository has 198 watches, 719 stars, and 608 forks. The navigation bar includes links for Code, Issues (34), Pull requests (2), Actions, Projects (0), Wiki, Security, and Insights. The current view is the file structure for the **yang / vendor / cisco /** branch. The file list includes:

File/Folder	Description	Last Commit
..		
nx	added models for 9.3-3 (#736)	last month
xe	Added Cisco-IOS-XE-17.1.1 Release Yang Models (#726)	2 months ago
xr	Added Available-Content.md for complete listing of the models for bet... (6 hours ago
README.md	Update README.md	16 days ago
check.sh	Improved model check times for Cisco models (#147)	3 years ago

NETCONF Protocol Overview

- Rich functionality to manage configuration and operational (state) data
- Operations defined as RPCs (request / reply) in XML
- Client/app initiate request towards server/device
- Supports running, candidate and startup configurations
- Capability exchange during session initiation



Main NETCONF Protocol Operations

Operation	Description
get-config	Retrieve all or part of a specified configuration
edit-config	Loads all or part of a specified configuration (merge, replace, create, delete, remove)
copy-config	Create or replace an entire configuration datastore
get	Retrieve all or part of running configuration and device operational data
get-schema	Retrieve device schema (model)
lock	Lock entire configuration datastore (e.g. candidate)
unlock	Remove lock on entire configuration datastore (e.g. candidate)
close-session	Request graceful session termination

NETCONF Edit-Config Operations

Operation	Description
Merge	Merge configuration with existing configuration (default)
Replace	Replace configuration with existing configuration
Create	Create configuration if non-existent. Otherwise, return error. (non-idempotent*)
Delete	Delete configuration if non-existent. Otherwise, return error. (non-idempotent)
Remove	Remove configuration. Ignore if configuration non-existent.

* Cannot be applied multiple times without changing the result beyond the initial application

Overview of gRPC on Cisco IOS XR

- Google RPC provides a general (open source) RPC framework
- Interface definition in Cisco IOS XR specifies device operations
- Functional subset of NETCONF
- Simple client development
- High performance



Protocol Operations in Cisco IOS XR Interface

Operation	Description
GetConfig	Retrieve configuration
MergeConfig	Merge configuration
DeleteConfig	Delete configuration
ReplaceConfig	Replace configuration
CommitReplace	Replace entire configuration
GetOper	Retrieve operational data
CliConfig	Merge configuration data in CLI format
ShowCmdTextOutput	Retrieves CLI show-command output data

Protocol Operations in OpenConfig gNMI Interface

Operation	Description
capabilities	Discover device capabilities (models, encodings, version, extensions)
get	Retrieve device state
set	Modify device state (delete, replace, update)
subscribe	Subscribe to device update

gNMI Implementation in Cisco IOS XR

- Based on gNMI v0.4.0
- Introduced in release 6.5.1
- **Set** and **Get** RPCs use JSON_IETF (RFC 7951) and ASCII (CLI) encoding
- **Subscribe** RPC
 - Paths must consider data aggregation points (no arbitrary paths)
 - No aliases

ANX(Advanced NETCONF Explorer)

<https://github.com/cisco-ie/anx>

✓ Clone this Git

git clone <https://github.com/cisco-ie/anx.git>

✓ Change to the anx directory

#docker-compose up -d



```
shambhu@shambhu-virtual-machine:/$ docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
anx_anx              latest             8e95e943ed19       2 days ago         165MB
```

cisco-ie / anx

Watch 19 Star 67 Fork 12

Code Issues 6 Pull requests 1 Actions Projects 6 Wiki Security Insights

Advanced NETCONF Explorer: Graphical Explorer for NETCONF / YANG and GNM/GRPC Telemetry & Java NETCONF 1.1 client library

netconf yang-model netconf-explorer orchestrator netconf-client telemetry yang-nodes gnm gnm-protocol

40 commits 1 branch 0 packages 0 releases 1 contributor Apache-2.0

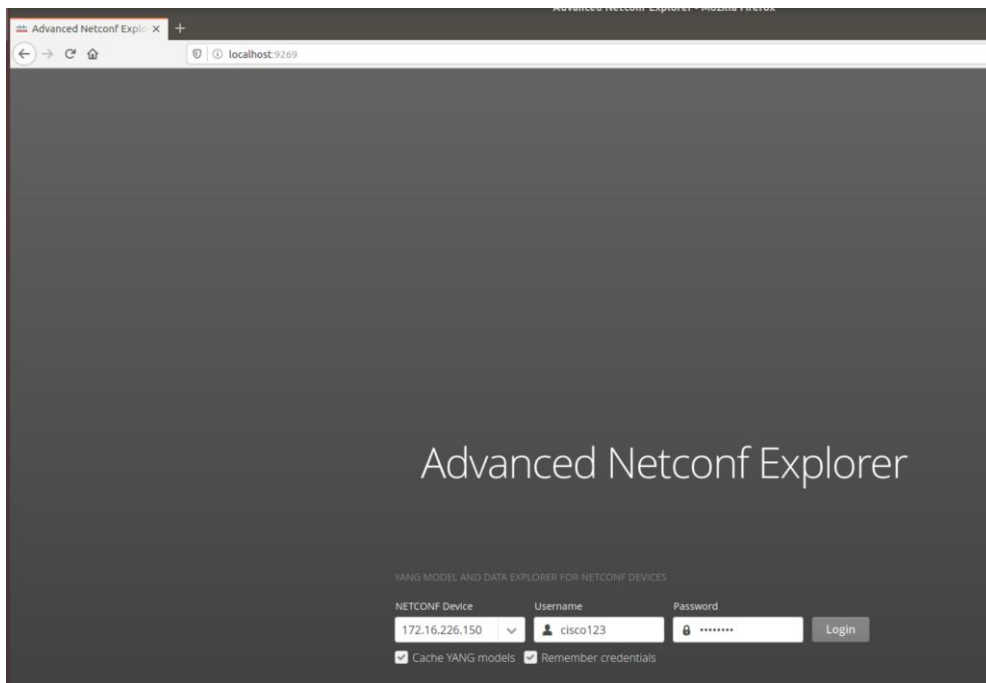
Branch: master New pull request Create new file Upload files Find file Clone or download

sbryx Update dependencies Latest commit ee3ef3 on Jun 25, 2019

anc	Update dependencies	7 months ago
explorer	Update dependencies	7 months ago
grpc	Update dependencies	7 months ago
Dockerfile	Add credential saving, add YANG model cache & fix port probing	15 months ago
LICENSE	Initial commit	2 years ago
README.md	Update maven instructions	13 months ago
docker-compose.yml	Initial commit	2 years ago
pom.xml	Switch to tomcat Docker as base	2 years ago
test.sh	Initial commit	2 years ago

ANX(Advanced NETCONF Explorer)

```
shambhu@shambhu-virtual-machine:/$ docker images | grep anx
anx_anx      latest      8e95e943ed19    2 days ago      165MB
shambhu@shambhu-virtual-machine:/$ docker start anx_anx_1
anx_anx_1
shambhu@shambhu-virtual-machine:/$ docker ps | grep anx
836484db6531    anx_anx      "catalina.sh run"    2 days ago      Up 4 minutes      0.0.0.0:9269->8080/tcp    anx_anx_1
shambhu@shambhu-virtual-machine:/$
```



ANX(Advanced NETCONF Explorer)

Netconf: 172.16.226.150 x +

localhost:9269

Advanced Netconf Explorer

Device 172.16.226.150 (603 YANG models)

Start NETCONF console

YANG Models

View Download all

NETCONF Capabilities

Telemetry Tools

Select or input sensor group name Edit Live data CLI to YANG

GNMI Subscribe Interval GNMI Port

change 57400 GNMI Subscribe

Parser Warnings

Search models Search nodes

Apply Clear Show Data v

- CISCO-ENTITY-FRU-CONTROL-MIB (<http://tail-f.com/ns/mibs/CISCO-ENTITY-FRU-CONTROL-MIB/200311240000Z>)
- CISCO-ENTITY-SENSOR-MIB (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-entity-sensor-mib>)
- ENTITY-MIB (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-entity-mib>)
- ENTITY-STATE-MIB (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-entity-state-mib>)
- RVM (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-rvm-mgr>)
- SNMP-COMMUNITY-MIB (<http://tail-f.com/ns/mibs/SNMP-COMMUNITY-MIB/200308060000Z>)
- SNMP-FRAMEWORK-MIB (<http://tail-f.com/ns/mibs/SNMP-FRAMEWORK-MIB/200210140000Z>)
- SNMP-MPD-MIB (<http://tail-f.com/ns/mibs/SNMP-MPD-MIB/200210140000Z>)
- SNMP-NOTIFICATION-MIB (<http://tail-f.com/ns/mibs/SNMP-NOTIFICATION-MIB/200210140000Z>)
- SNMP-TARGET-MIB (<http://tail-f.com/ns/mibs/SNMP-TARGET-MIB/200210140000Z>)
- SNMP-USER-BASED-SM-MIB (<http://tail-f.com/ns/mibs/SNMP-USER-BASED-SM-MIB/200210160000Z>)
- SNMP-VIEW-BASED-ACM-MIB (<http://tail-f.com/ns/mibs/SNMP-VIEW-BASED-ACM-MIB/200210160000Z>)
- SNMPv2-MIB (<http://tail-f.com/ns/mibs/SNMPv2-MIB/200210160000Z>)
- ShowMedia (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-show-media>)
- VM (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-vm-mgr>)
- aaa (<http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-lib-cfg>)
- aaa (<http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-locald-admin-cfg>)
- aaa (<http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-locald-oper>)
- aaa (<http://tail-f.com/ns/aaa/1.1>)
- aaa-nacm (<http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-nacm-oper>)
- accounting (<http://cisco.com/ns/yang/Cisco-IOS-XR-accounting-cfg>)
- acl (<http://openconfig.net/yang/acl>)
- actions (<http://www.cisco.com/ns/yang/Cisco-IOS-XR-sysadmin-sm>)
- actions (<http://www.cisco.com/panini/calvados/opertest1>)
- active-nodes (<http://cisco.com/ns/yang/Cisco-IOS-XR-config-mdm-cfg>)
- address-family (<http://cisco.com/ns/yang/Cisco-IOS-XR-um-vrf-cfg>)
- address-pool-service (<http://cisco.com/ns/yang/Cisco-IOS-XR-ip-daps-cfg>)

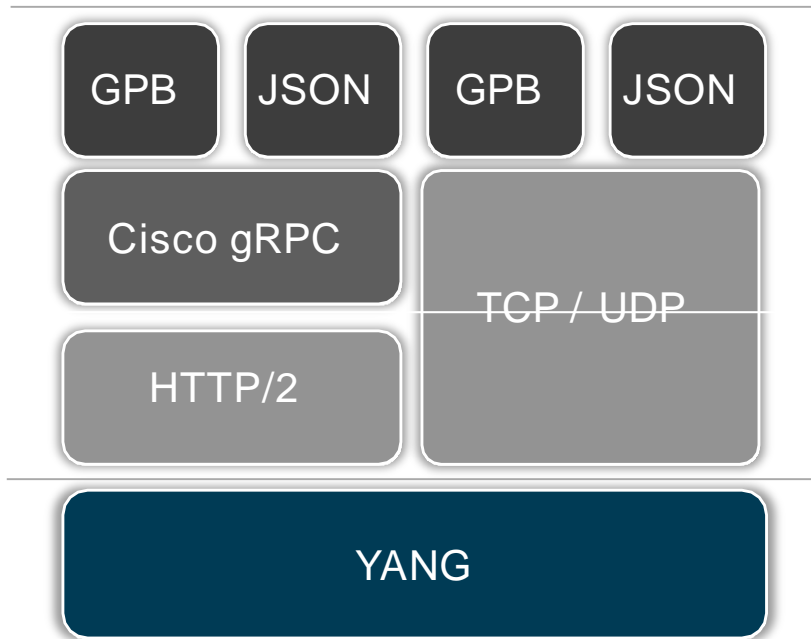
Streaming Telemetry— ANX, Pipeline (architecture and operation)

Telemetry



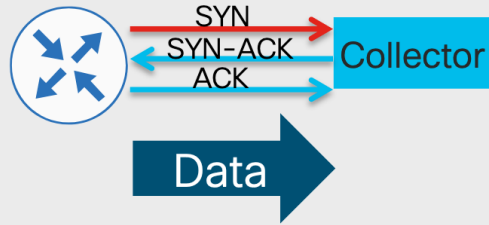
Overview of Telemetry on Cisco IOS XR

- Loosely-coupled stack
 - Data encoding (JSON vs GPB)
 - Transport (HTTPv2 vs TCP vs UDP)
 - Data model (native vs open)
- Session initiation
 - Dial-in (transient destination)
 - Dial-out (persistent destination)
- Flexible data streaming modes (frequency vs event driven)



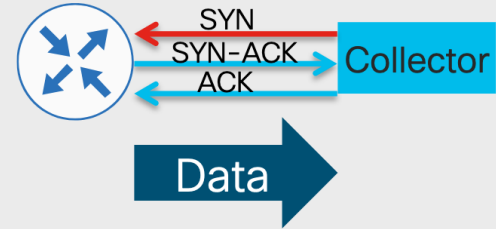
MDT Modes...

Dial-Out



- TCP & gRPC (from 6.1.1)
- UDP (from 6.2.1)

Dial-In



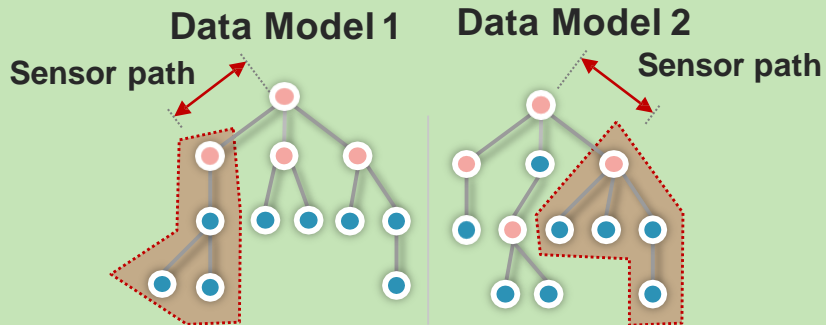
- gRPC only (from 6.1.1)

Telemetry Subscriptions

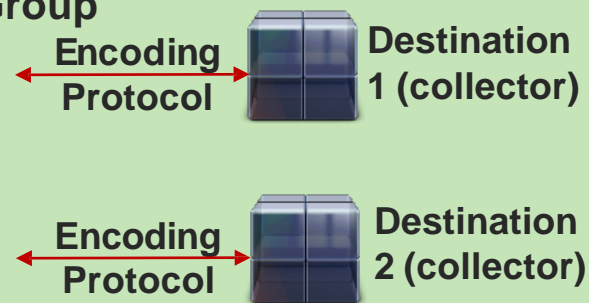
```
sensor-group memory
sensor-path Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/generic-counters
!
```

Subscription

Sensor Group

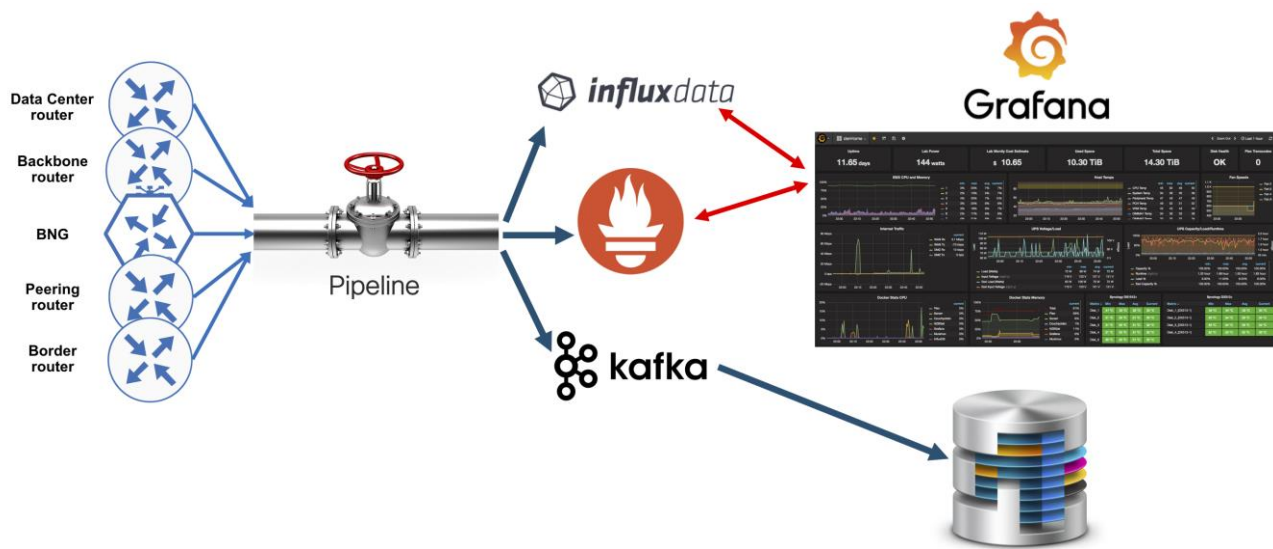


Destination Group



● Aggregation point

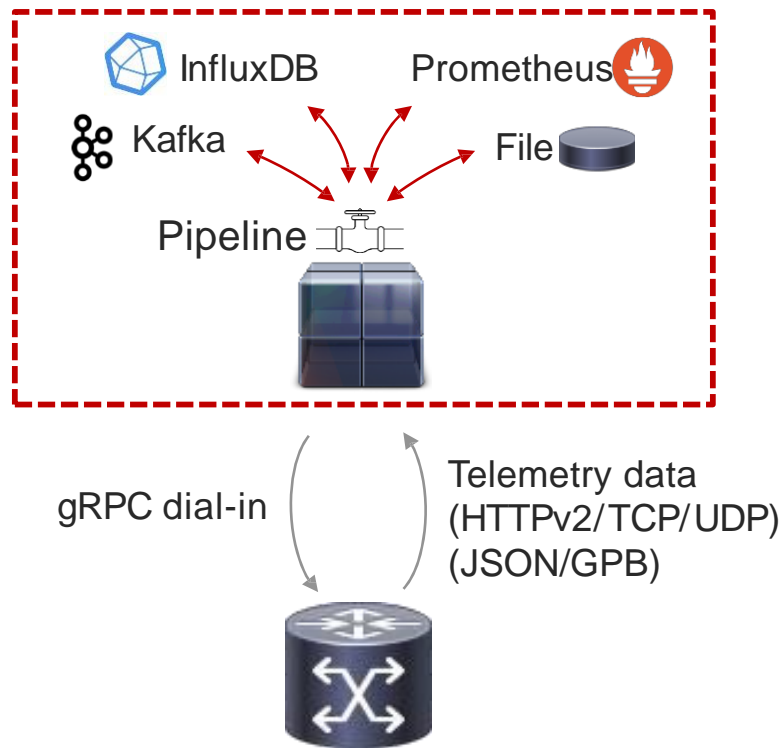
Telemetry tool (Pipeline)



<https://github.com/cisco/bigmuddy-network-telemetry-pipeline>

Pipeline – An Open-Source Telemetry Collector

- Collector for telemetry data
- Performs basic encoding transformation
- Data producer for Kafka, InfluxDB, Prometheus, etc.
- Supports dial-in and dial-out sessions



XR config

```
telemetry model-driven
destination-group DG1
address-family ipv4 172.16.226.132 port 5432
encoding self-describing-gpb
protocol tcp
!
!
sensor-group memory
sensor-path Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring/cpu-utilization
sensor-path Cisco-IOS-XR-nto-misc-oper:memory-summary/nodes/node/summary
sensor-path Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/data-rate
sensor-path Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/generic-counters
!
subscription SUB
sensor-group-id memory sample-interval 5000
destination-id DG1
```

Pipeline Config

Input from device

```
[default]
id = pipeline

[fromRouters]
stage = xport_input
type = tcp
encap = st
listen = :5432
logdata = off
keepalive_seconds = 3

[toInflux]
stage = xport_output
type = metrics
file = metrics.json
output = influx
influx = http://localhost:8086
database = mddtb
```

Metric.json

Output to Influxdb

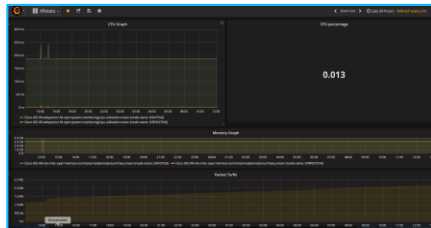
InfluxDB



InfluxDB

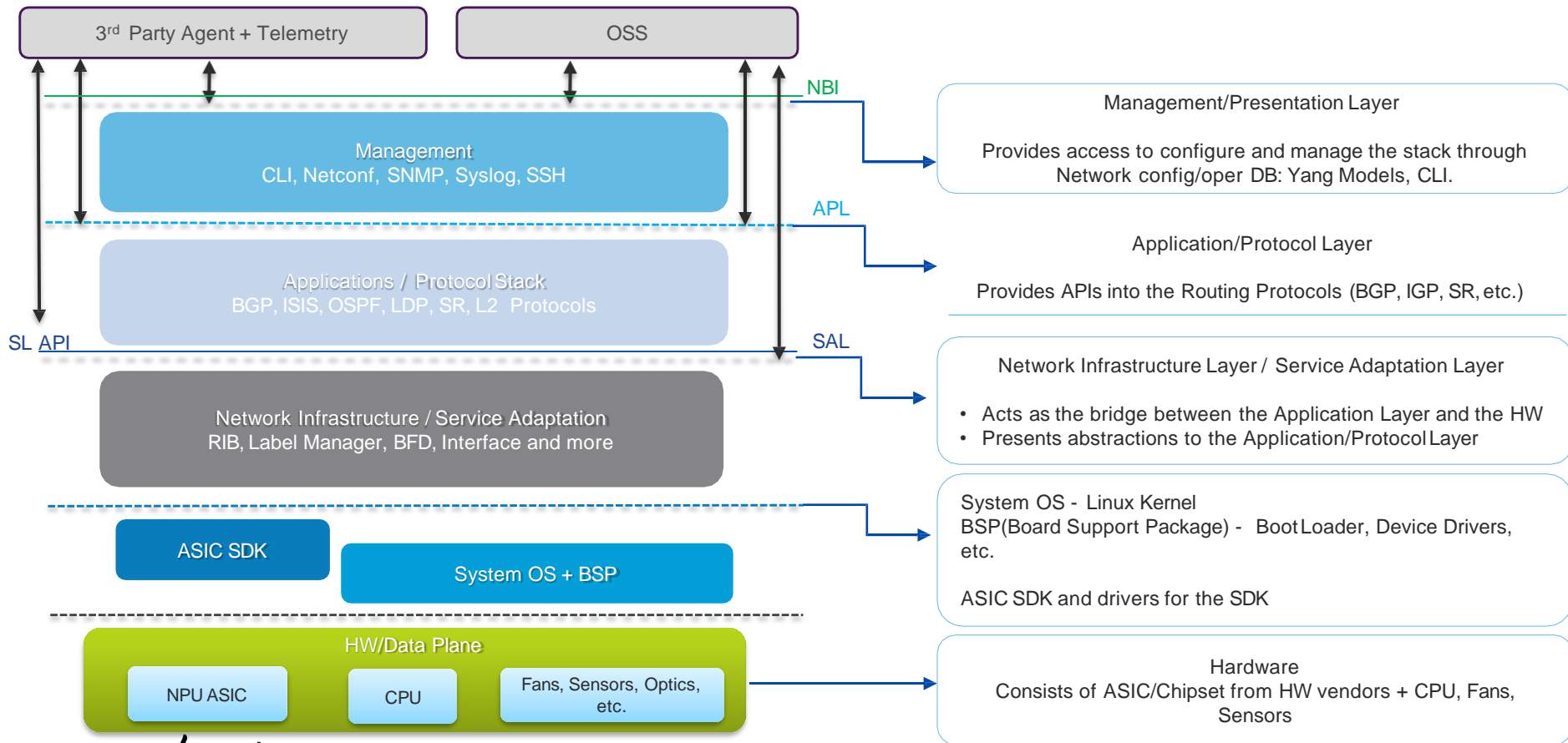


Query

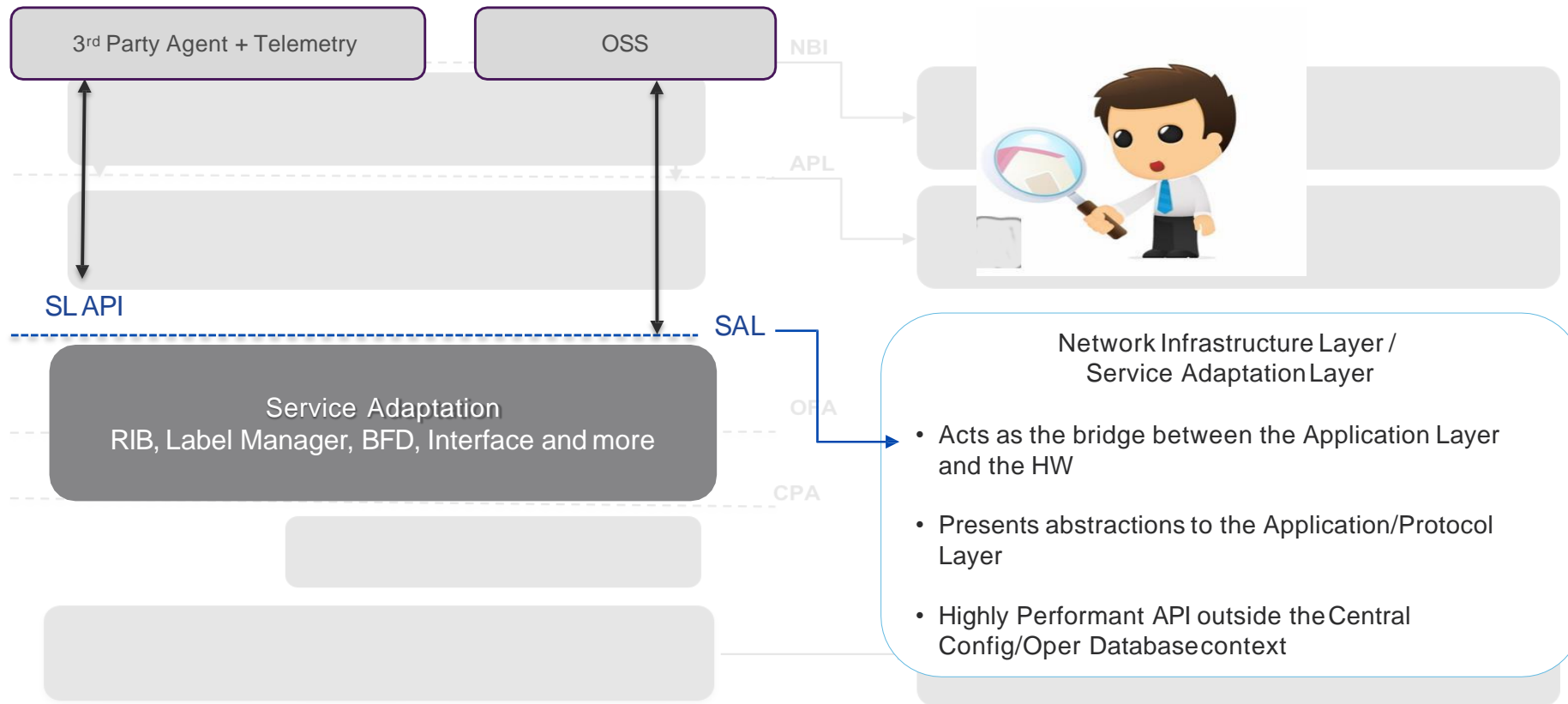


Service Layer API

De-Layering The Network Stack



Zooming in



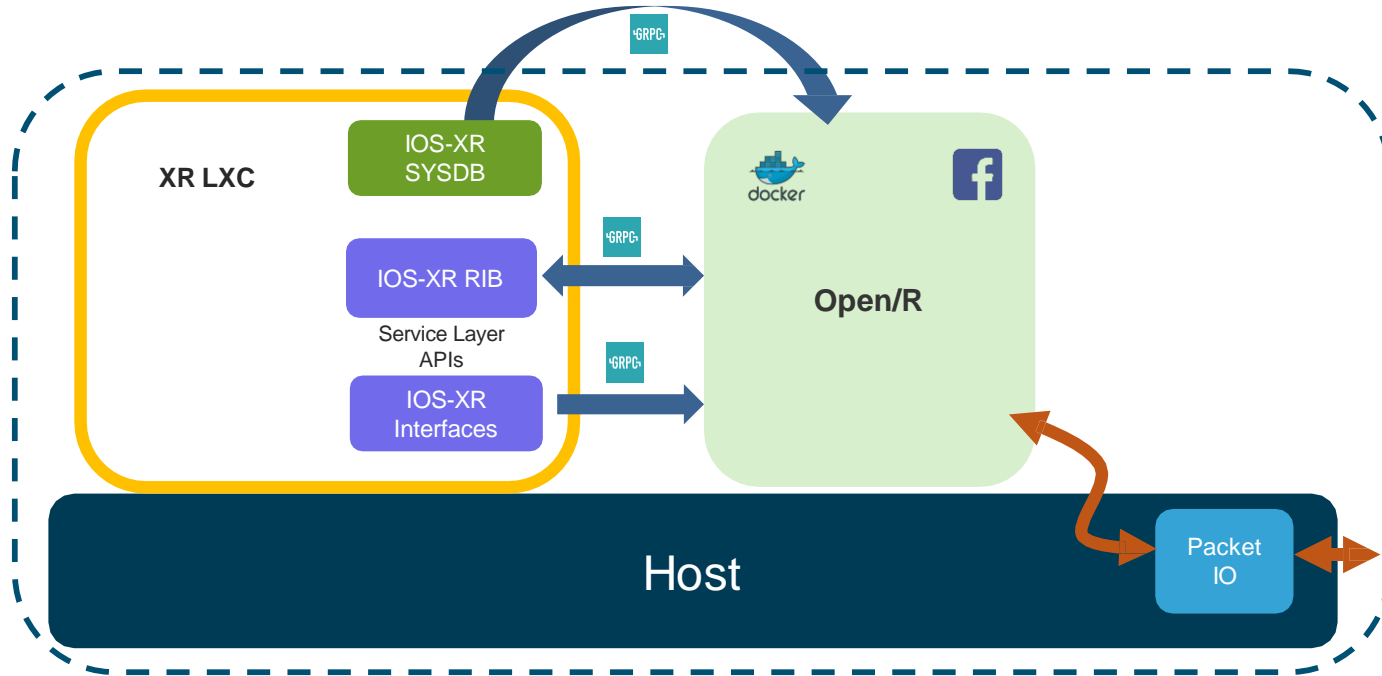
Bring your own Protocol/Agent

On-box agents and custom protocols that co-exist with standard protocols to influence routing.



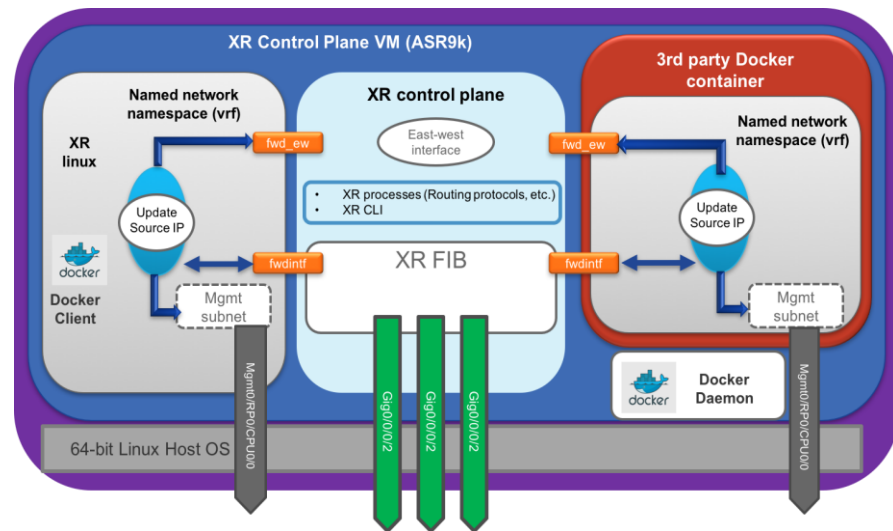
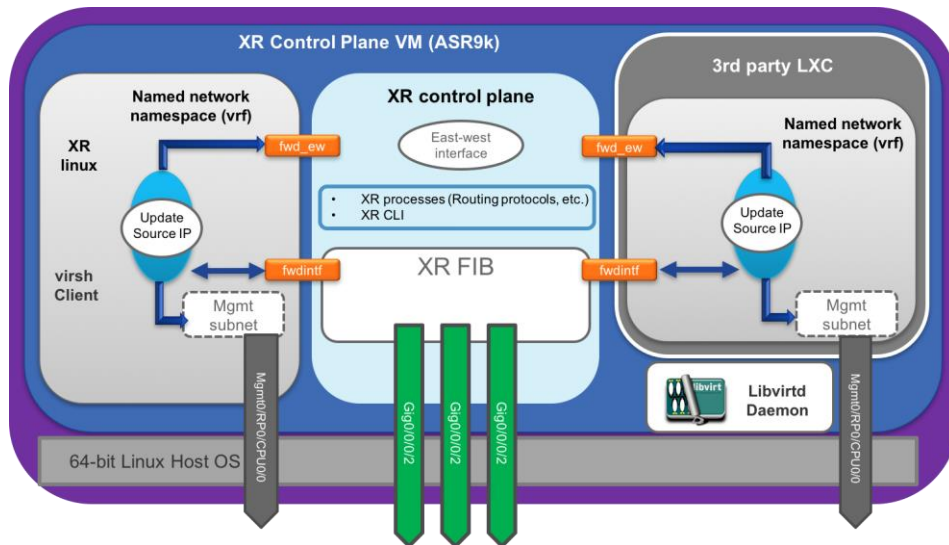
Running Open/R on XR

<https://github.com/akshshar/openr-xr>



APP Hosting

App Hosting Architecture



App Hosting

Open/R

```
RP/0/RP0/CPU0:rtr1#bash
Fri Feb 16 22:46:52.944 UTC
```

```
[rtr1:~]$ docker images
```

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
11.11.11.2:5000/openr	latest	fdddb43d9600	33 seconds ago	1.829 GB

```
[rtr1:~]$
```

```
[[host:~]$ docker version
```

Client:

```
Version:      1.10.0
API version:   1.22
Go version:    go1.4.2
Git commit:    abaf4ef
Built:         Mon Apr 25 14:00:32 2016
OS/Arch:       linux/amd64
```

Server:

```
Version:      1.10.0
API version:   1.22
Go version:    go1.4.2
Git commit:    cb6da92
Built:         Tue Aug 8 22:08:35 2017
OS/Arch:       linux/amd64
```

Demo

Further Readings...

- Advanced Topics in Cisco IOS Telemetry : BRKSPG-2503
- Advanced IOS-XR Programmability Using Service Layer APIs: BRKSPG-3000
- ZTP : <https://xrdocs.io/device-lifecycle/tutorials/2016-08-26-working-with-ztp/>

Stay Subscribed
<https://xrdocs.io/>

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Thank you





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