OPEN SOURCE 101 @ THE LINUX FOUNDATION OPEN SOURCE SUMMIT EUROPE

Data Networks Neutrality with OpenConfig

Unveiling Challenges & Practical Insights

Who is this?

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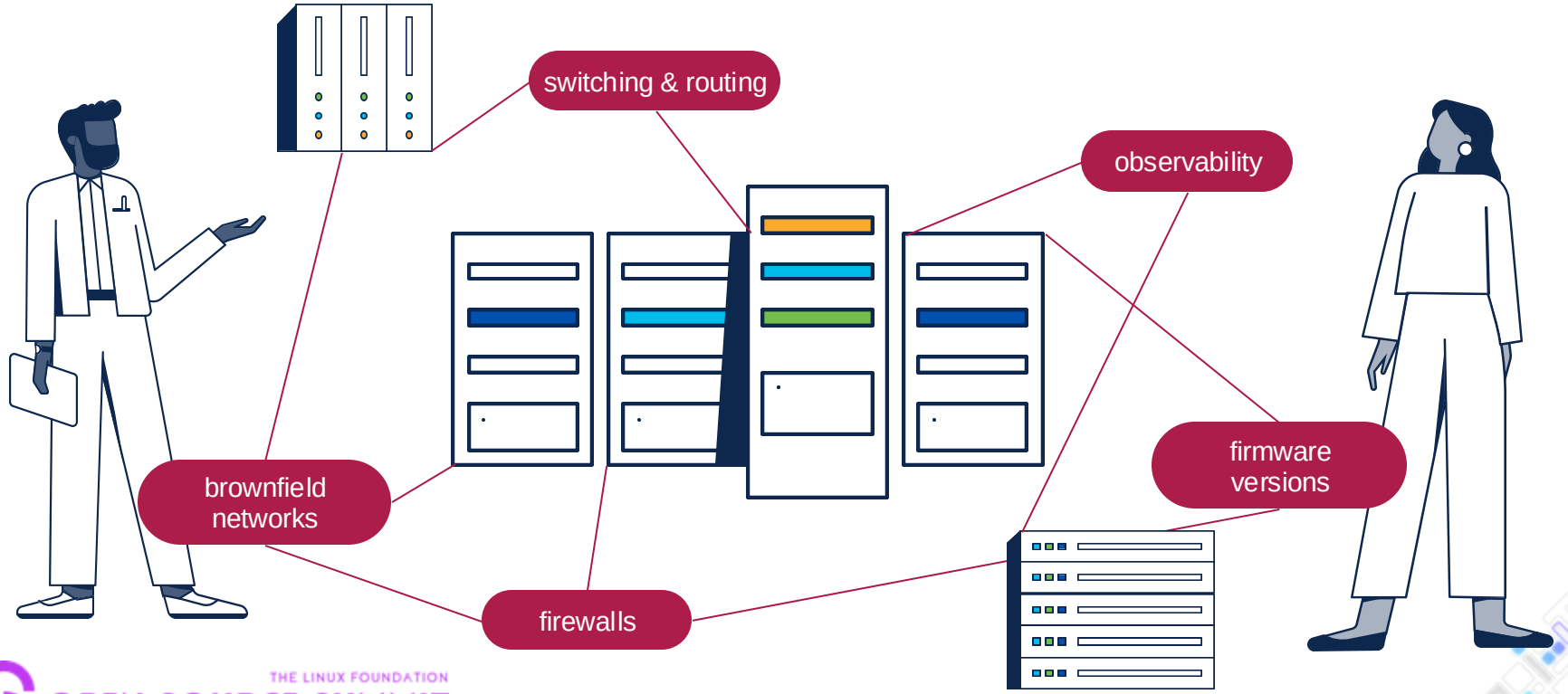
POV: You are the IT admin of a big scale data network (amid COVID)



My SSH console just won’t do right now …

Operations Team

- Spreadsheet-based (99% of the times …)
- Manual CLI copy/paste
- Lots of time and rework due to errors

What tends to go wrong

- Error-prone massive configurations
- Configuration consistency
- Monitoring across network domains
- Integration with the business

Yes, we built a script. However …

Quick workaround is to emulate CLI (console) commands pushing via SSH

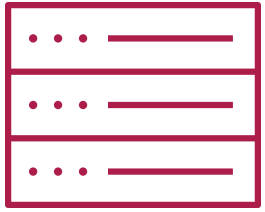
No commit error control (invalid configs, healthchecks, inconsistent states)

After the first firmware upgrade, some parts of the scripts stopped working (the CLI commands had changed!)

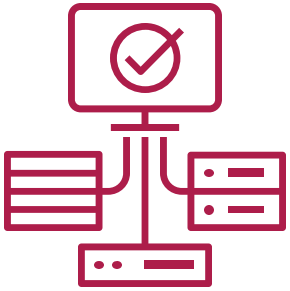
CLI is intended for human use only! Not for automation

So, what if we could …. ?

Do tracking & versioning of our devices config mechanisms as code (via git)



Interact with our devices in a consistent & automated way



Talk to our devices the same, regardless of the vendor

Today’s agenda

Model-driven programmability

OpenConfig: One model to rule them all

The nooks and crannies

Tips & tricks

This session is about

- Network programmability 101
- YANG modelling essentials
- OpenConfig overview

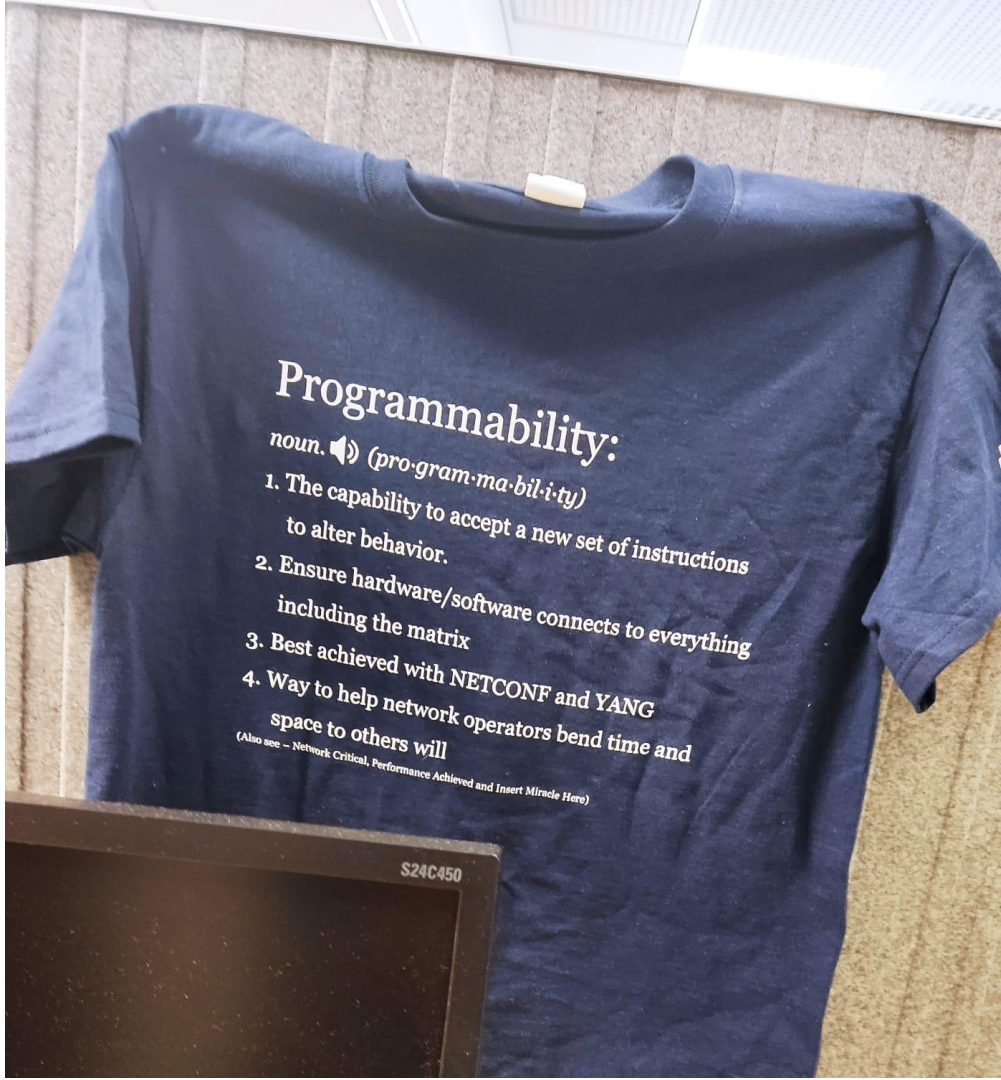
This session is not about

- Data networks in-depth config
- Network vendor specifics
- Advanced YANG modelling

Model-driven programmability

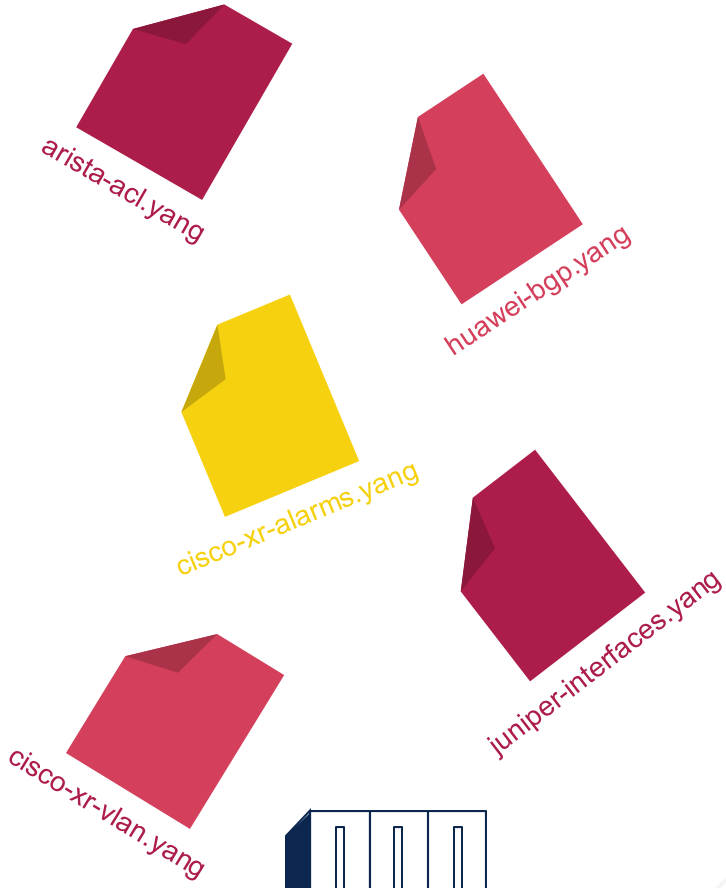
Model-driven programmability

- Going beyond mimicking CLI or operating with SNMP
- In-built mechanisms for altering network devices behavior using protocols and standards
- Consistent states
- IETF RFCs



YANG data models

- RFC 6020
- Data modelling language
- Models configurations and state data of a device or service
- Organized in nodes with data types
- Device Data Models (Interface, VLAN, etc)
- Service Data Models (L3VPN, VRF, etc)
- Industry Standard vs. Vendor Specific



YANG data models

Leaf

```
leaf hostname {
  type string;
  description "The name of the device.";
}
```

A leaf represents a single data element, which is a scalar value

YANG data models

Leaf-list

```
leaf-list dns-servers {
  type string;
  description "List of DNS server IP addresses.";
}
```

A leaf-list represents an ordered collection of leaf elements

YANG data models

List

```
list interface {
  key "name";
  leaf name {
    type string;
    description "The name of the interface.";
  }
  leaf mtu {
    type uint32;
    description "MTU size of the interface.";
  }
}
```

A list represents a sequence of data elements, each potentially containing multiple child elements under a key-value format

YANG data models

Container

```
container system {
  leaf hostname {
    type string;
    description "The hostname of the device.";
  }
  leaf timezone {
    type string;
    description "The timezone of the device.";
  }
}
```

A container groups related data elements together

NETCONF protocol

- RFC 6241
- Commit, edit and delete configurations on network devices
- Successor of SNMP, but for config and monitoring
- Based on XML for encoding
- Comms via RPCs (Remote Procedure Calls)
- YANG models are used to operate the device's config

1. hello message over a established SSH session to get the device's data models

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability> … :base:1.0</capability>
    <capability> … :base:1.1</capability>
    <capability> … :writable-running:1.0</capability>
    <capability> … :xpath:1.0</capability> …
```

2. RPC request / RPC reply

```
<?xml version="1.0" encoding="utf-8"?>
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <netconf-yang xmlns="http://cisco.com/yang/cisco-self-mgmt">
        <cisco-ia xmlns="http://cisco.com/yang/cisco-ia">
          <snmp-trap-control>
            <trap-list>
              <trap-oid>1.3.6.1.4.1.9.9.41.2.0.1</trap-oid>
            </trap-list>
          </snmp-trap-control>
        </cisco-ia>
      </netconf-yang>
    </config>
  </edit-config>
</rpc>
```

message

operations

model-based content

RESTCONF protocol

- RFC 8040
- Based on XML or JSON for data encoding
- RESTful-style interaction with network devices
- Also based on YANG data models
- GET, POST, PUT, PATCH, DELETE
- HTTPS transport

```
curl -k -u "your_username:your_password" \
  -H "Accept: application/yang-data+json" \
  -H "Content-Type: application/yang-data+json" \
  -X GET \
  "https://<device_ip>/restconf/data/ietf-
   interfaces:interfaces?depth=unbounded"
```

OpenConfig

model model

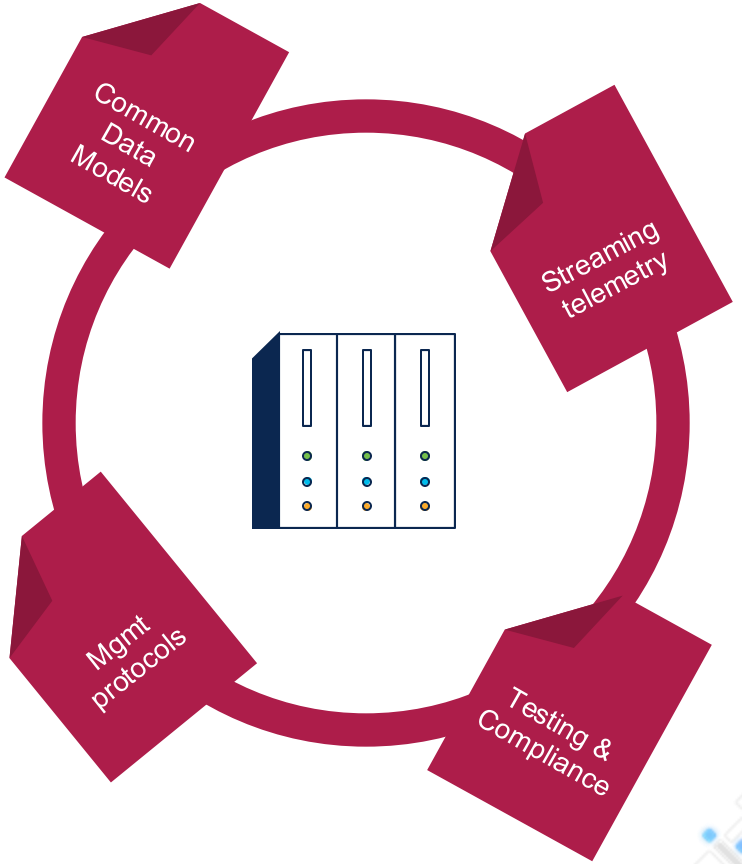
"One ~~Ring~~ to rule them all, One ~~Ring~~ to find them,
One ~~Ring~~ to bring them all and in the ~~darkness~~ bind them."

model network

"The Lord of the Rings - The Fellowship of the Ring" J.R.R. Tolkien

OPENCONFIG

- Initiative driven by network operators to develop vendor-agnostic data models for network management
- Providing a common, open, and standardized way to manage network devices



OpenConfig's Data Models

github.com/openconfig/public/

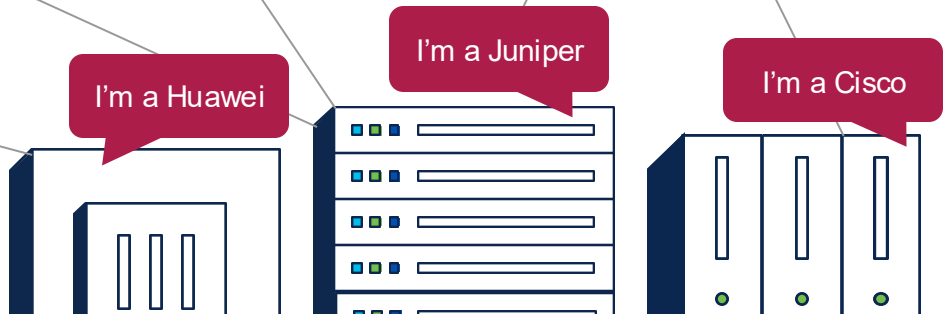
Atomic consistency
(all committed / none committed)

Models available on public repositories

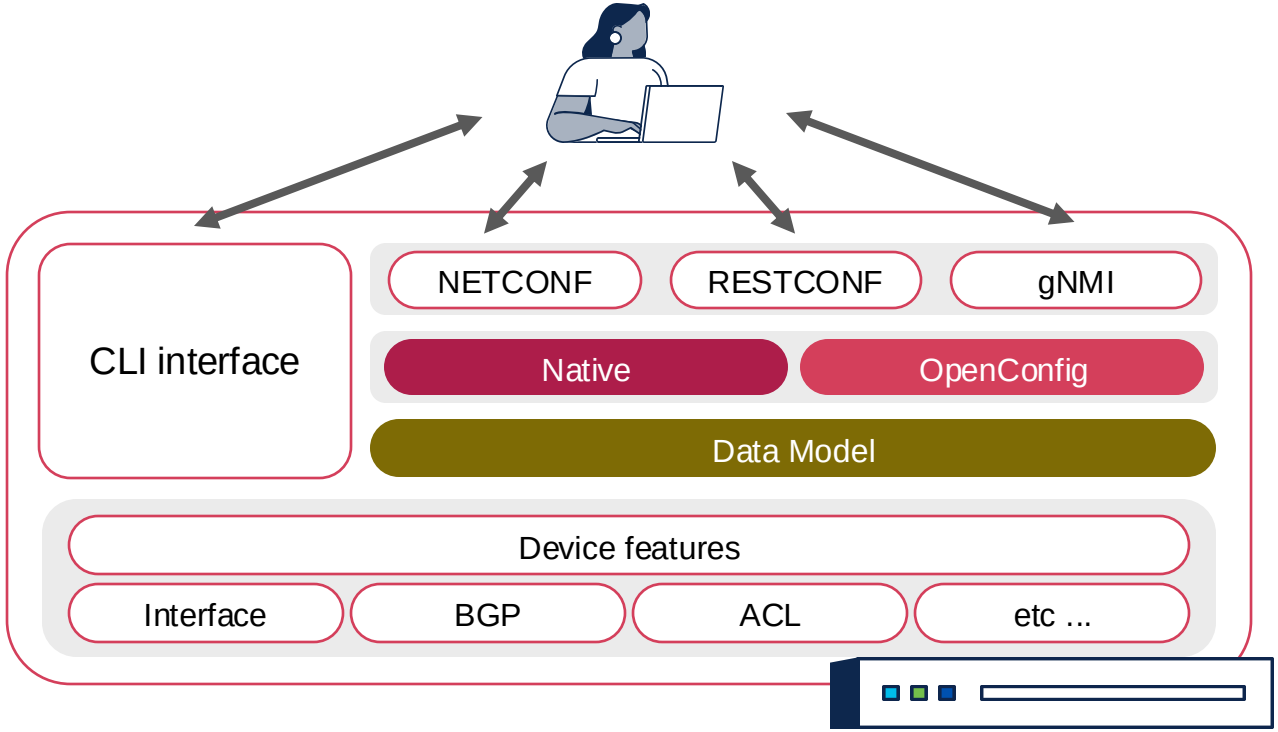
Based on YANG v1.0
(IETF standard)

Configuration & operational data models

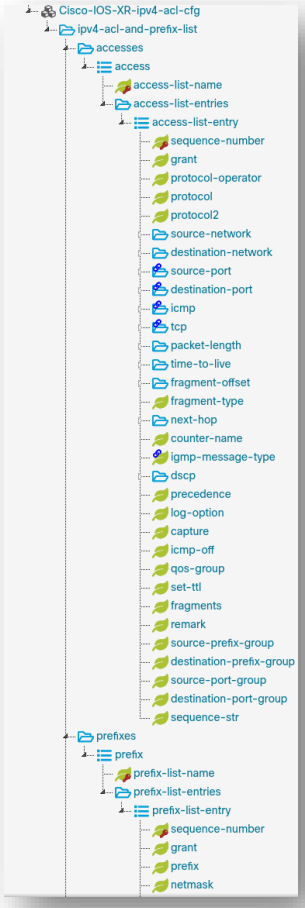
Vendor-neutral



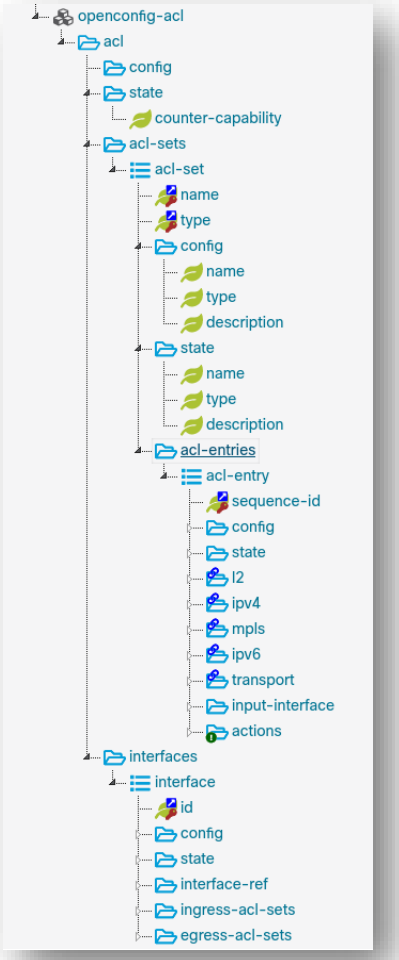
Simplified view of a device's programmable APIs*



* generalizing various vendors



ACL IOSXR Native model



ACL OC model

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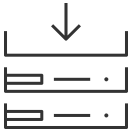
The nooks and crannies

Open Models

Vendor-specific Models

Open Models		Vendor-specific Models
Faster innovation by operator's contributions to new features		Innovation is often tied to the vendor's release cycle
Potential cost reduction by minimizing the need for vendor-specific training & tools		May incur higher costs due to the need for specialized knowledge and tools
Only cover the most widely used features and protocols across vendors		Cover almost all the features and protocols of the specific vendor

Deviations

Mechanisms used by vendors to indicate how their implementation of a model differs from the standard OpenConfig model

Deviations are defined as separate modules that are used in addition to the core OpenConfig model

As a result, the standardized model can be used even if a device does not fully comply with it

Deviations

```
module device-deviations {
  namespace "http://example.com/device-deviations";
  prefix "dev-dev";

  import openconfig-interfaces {
    prefix "oc-if";
  }

  deviation /oc-if:interfaces/oc-if:interface/oc-if:config/oc-if:mtu {
    deviate not-supported;
  }
}
```

not-supported

A particular feature or node is not supported by the device

Deviations

```
module device-deviations {
  namespace "http://example.com/device-deviations";
  prefix "dev-dev";

  import openconfig-interfaces {
    prefix "oc-if";
  }

  deviation /oc-if:interfaces/oc-if:interface/oc-if:config/oc-if:mtu {
    deviate replace {
      type uint32;
    }
}
```

replace

Replace a node's definition with a different one
(data type, constraints, etc)

Deviations

```
module device-deviations {
 namespace "http://example.com/device-deviations";
 prefix "dev-dev";


 import openconfig-interfaces {
  prefix "oc-if";
 }


 deviation /oc-if:interfaces/oc-if:interface/oc-if:config/oc-if:mtu {
  deviate add {
   must ". >= 1280 and . <= 9216" {
    error-message "MTU must be in the range 1280-9216";
   }
```

add

Add new constraints or features to the existing model for a specific device

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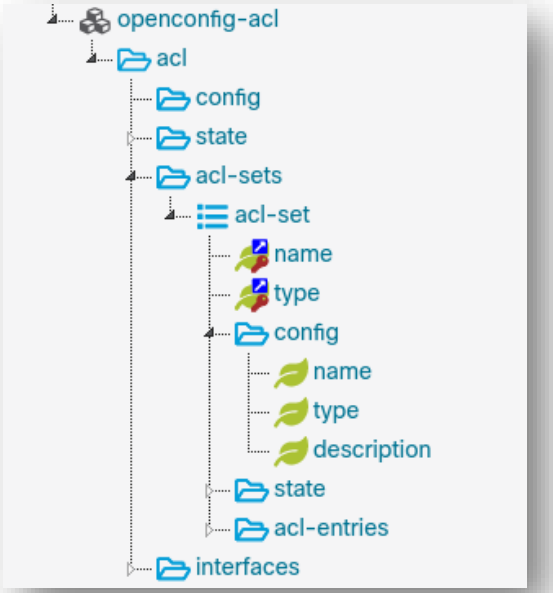
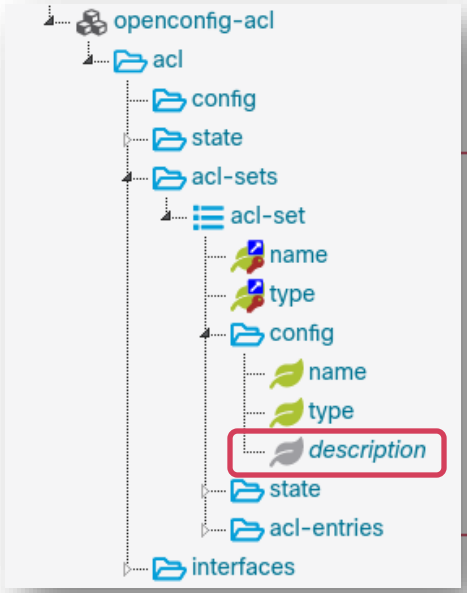


ACL OC model

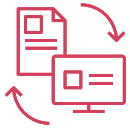


IOSXR ACL OC model deviation

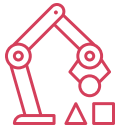
```
deviation "/oc-acl:acl/oc-acl:acl-sets/oc-acl:acl-set/oc-acl:config/oc-acl:description"
{
   deviate not-supported;
}
```

Tips& tricks

Tips & tricks



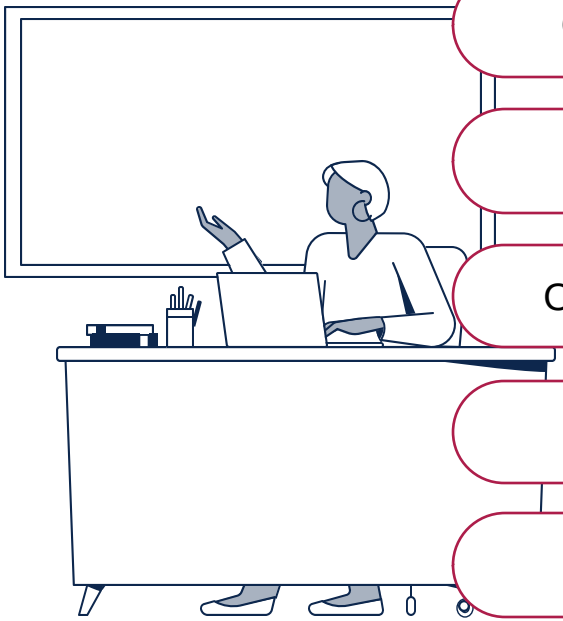
Deviation deltas can be versioned based on the vendor and platform



Create-once-use-many approach, where choices for vendors can be made based on deviations rather than CLI commands

Design your systems to be modular. This way, you can integrate deviations as needed without tightly coupling to any particular vendor

References and tooling



- OpenConfig YANG models repository - github.com/openconfig/public
- OpenConfig schema paths - openconfig.net/projects/models/paths/
- OpenConfig schema docs - openconfig.net/projects/models/schemadocs/
- YANG suite tool - developer.cisco.com/yangsuite/
- Our demo repository

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