You make **possible**

Unleash the Power of OpenConfig

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Sr. Network Test Engineer

DEVLIT-4014

Barcelona | January 27-31, 2020

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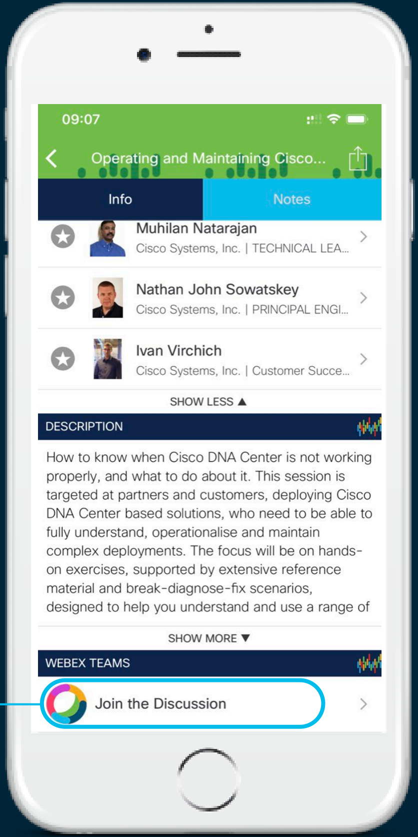
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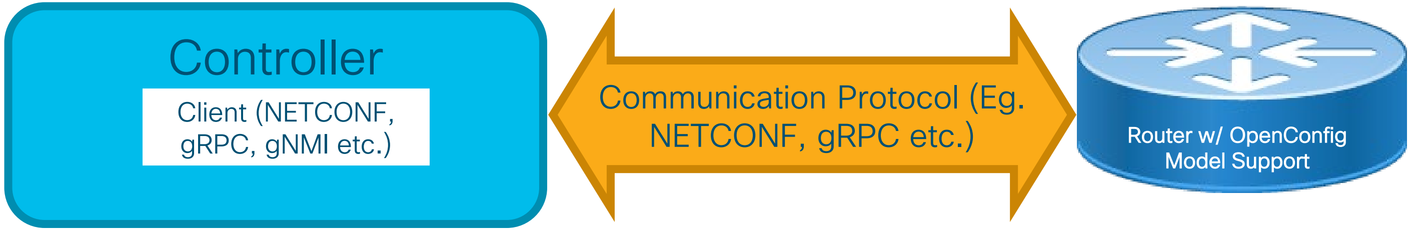
WEBEX TEAMS
Join the Discussion

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

Goals

- Understand Today’s Network Challenges
- Road to Model driven Programmability
- Introduction to OpenConfig for Network Provisioning & Operations.


Controller
Client (NETCONF, gRPC, gNMI etc.)
Communication Protocol (Eg. NETCONF, gRPC etc.)
Router w/ OpenConfig Model Support

Today’s Network Challenges

Todays Network is Open, and accessed by not just Network Engineer but by API developers.

- Overview of the 2002 IAB Network Management Workshop
  - Need for user-friendly Network Configuration protocol
  - Programmatic interface for device configuration.
  - Ability to Configure Services and not just devices.
  - SNMP is not optimized enough for Configuration & DevOps and is not transaction based.

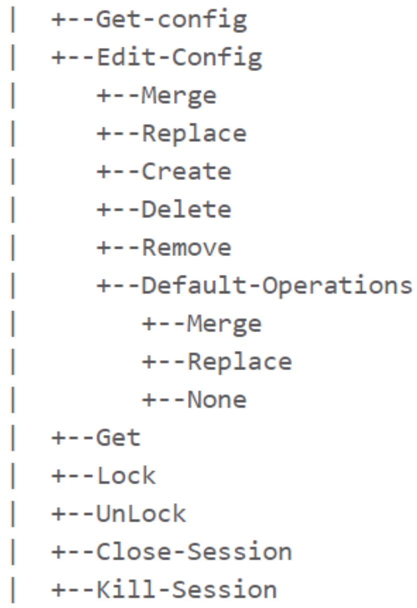
More details : https://tools.ietf.org/html/rfc3535

NETCONF & Yang

NETCONF

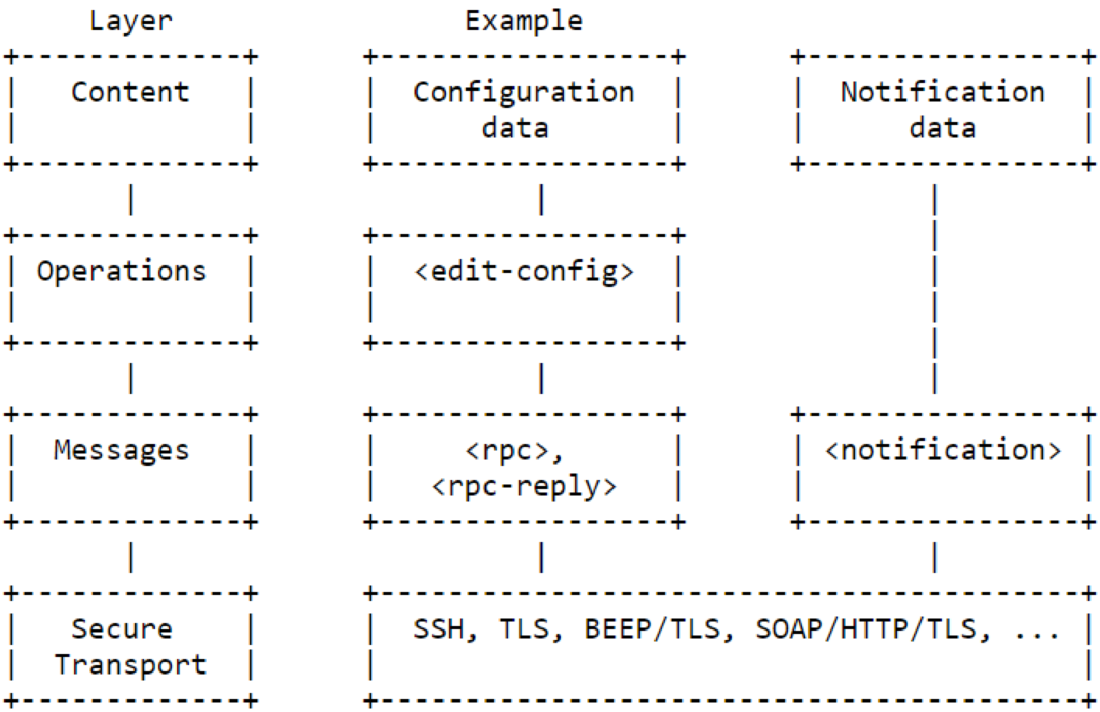
NETwork CONFiguration protocol

- IETF Standard [rfc6241, rfc6242]
  - Transaction based
  - Configure, manipulate & delete the config. [get-config, edit-config & delete-config]
  - Query Operational data [get]
- Operations are realized on top of RPC [remote procedure calls]
  - Uses XML data encoding



```
|   +--Get-config
|   +--Edit-Config
|      +--Merge
|      +--Replace
|      +--Create
|      +--Delete
|      +--Remove
|      +--Default-Operations
|         +--Merge
|         +--Replace
|         +--None
|   +--Get
|   +--Lock
|   +--UnLock
|   +--Close-Session
|   +--Kill-Session
```

NETCONF Protocol Layers



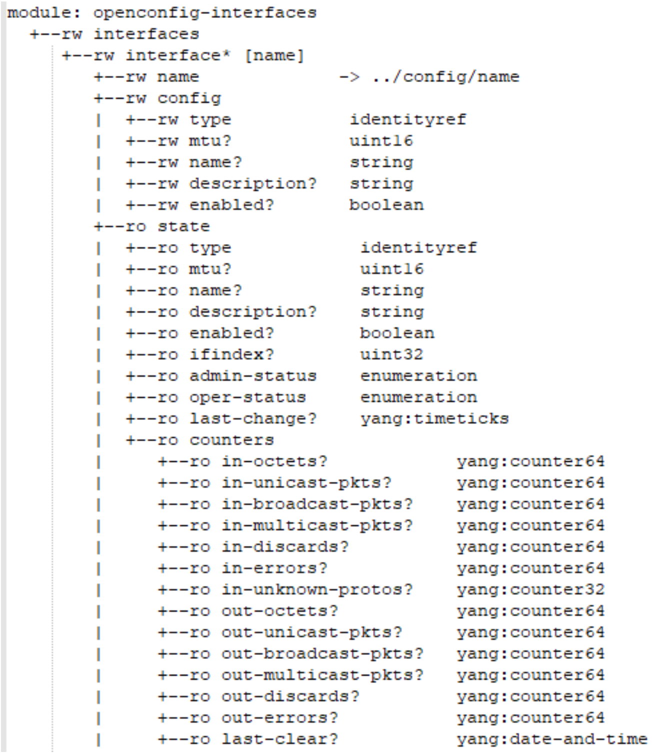
```
         Layer                 Example
    +-------------+      +-----------------+      +----------------+
    |   Content   |      |  Configuration  |      |  Notification  |
    |             |      |      data       |      |      data      |
    +-------------+      +-----------------+      +----------------+
           |                       |                      |
    +-------------+      +-----------------+              |
    | Operations  |      |  <edit-config>  |              |
    |             |      |                 |              |
    +-------------+      +-----------------+              |
           |                       |                      |
    +-------------+      +-----------------+      +----------------+
    |  Messages   |      |     <rpc>,      |      | <notification> |
    |             |      |   <rpc-reply>   |      |                |
    +-------------+      +-----------------+      +----------------+
           |                       |                      |
    +-------------+      +-----------------------------------------+
    |   Secure    |      |  SSH, TLS, BEEP/TLS, SOAP/HTTP/TLS, ... |
    |  Transport  |      |                                         |
    +-------------+      +-----------------------------------------+
```

Source : https://tools.ietf.org/html/rfc6241

YANG

Yet Another Next Generation

- YANG is a data modeling language used to model configuration and state data manipulated by the NETCONF protocol
- IETF Standard [rfc6020]
  - specifically targeted to the needs of configuration management
  - Easy to read, to promote adoption.
  - Provides mechanisms to validate models of configuration data for semantics and syntax.



```
module: openconfig-interfaces
  +--rw interfaces
     +--rw interface* [name]
        +--rw name             -> ../config/name
        +--rw config
        |  +--rw type           identityref
        |  +--rw mtu?           uint16
        |  +--rw name?          string
        |  +--rw description?   string
        |  +--rw enabled?       boolean
        +--ro state
        |  +--ro type            identityref
        |  +--ro mtu?            uint16
        |  +--ro name?           string
        |  +--ro description?    string
        |  +--ro enabled?        boolean
        |  +--ro ifindex?        uint32
        |  +--ro admin-status    enumeration
        |  +--ro oper-status     enumeration
        |  +--ro last-change?    yang:timeticks
        |  +--ro counters
        |     +--ro in-octets?            yang:counter64
        |     +--ro in-unicast-pkts?      yang:counter64
        |     +--ro in-broadcast-pkts?    yang:counter64
        |     +--ro in-multicast-pkts?    yang:counter64
        |     +--ro in-discards?          yang:counter64
        |     +--ro in-errors?            yang:counter64
        |     +--ro in-unknown-protos?    yang:counter32
        |     +--ro out-octets?           yang:counter64
        |     +--ro out-unicast-pkts?     yang:counter64
        |     +--ro out-broadcast-pkts?   yang:counter64
        |     +--ro out-multicast-pkts?   yang:counter64
        |     +--ro out-discards?         yang:counter64
        |     +--ro out-errors?           yang:counter64
        |     +--ro last-clear?           yang:date-and-time
```

NETCONF Client

- Satisfies the prerequisites for an SSH/TLS connection
- Opens/Ends a NETCONF session
- Sends NETCONF RPCs requesting/changing configuration / Operation data
- (Optional)Syntax and Semantics Verification.
- (Optional)locks/unlocks the candidate configuration
- Open source clients:
  - libnetconf: NETCONF library in C
  - ncclient: Python library for NETCONF clients

NETCONF Session

SSH & NETCONF configuration

- Connection-Oriented
  - Transport : SSH [default 830], TLS
- Netconf Client establishes session with server
- Session Establishment
  - Hello message
  - Exchanges capabilities, modules and features
- Session-termination : close/kill

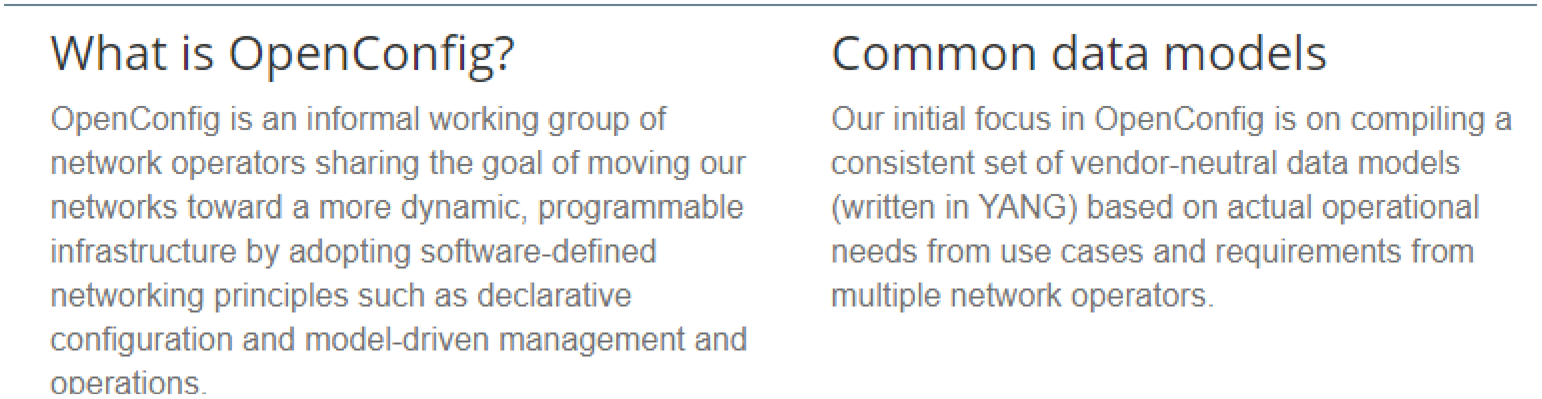
```
!
ssh server v2
ssh server vrf default
ssh server netconf vrf default
!
```

```
!
netconf agent tty
!
netconf-yang agent
 ssh
!
```

OpenConfig Models

What is it ?

http://www.openconfig.net/

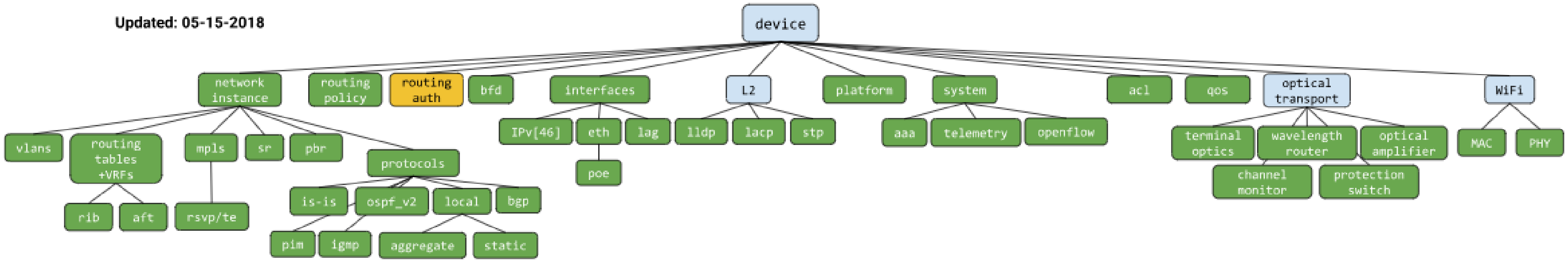


What is OpenConfig?

OpenConfig is an informal working group of network operators sharing the goal of moving our networks toward a more dynamic, programmable infrastructure by adopting software-defined networking principles such as declarative configuration and model-driven management and operations.

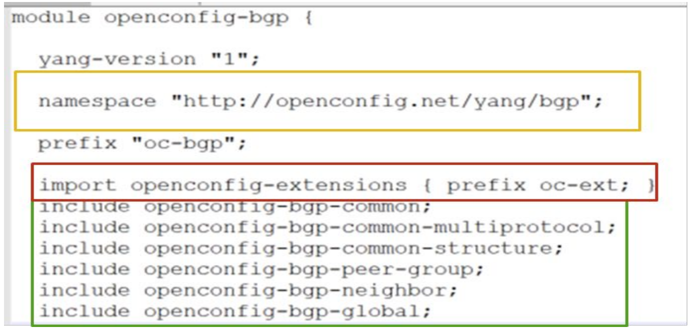
Common data models

Our initial focus in OpenConfig is on compiling a consistent set of vendor-neutral data models (written in YANG) based on actual operational needs from use cases and requirements from multiple network operators.



Updated: 05-15-2018

OpenConfig Models



```
module openconfig-bgp {

  yang-version "1";

  namespace "http://openconfig.net/yang/bgp";

  prefix "oc-bgp";

  import openconfig-extensions { prefix oc-ext; }
  include openconfig-bgp-common;
  include openconfig-bgp-common-multiprotocol;
  include openconfig-bgp-common-structure;
  include openconfig-bgp-peer-group;
  include openconfig-bgp-neighbor;
  include openconfig-bgp-global;
```

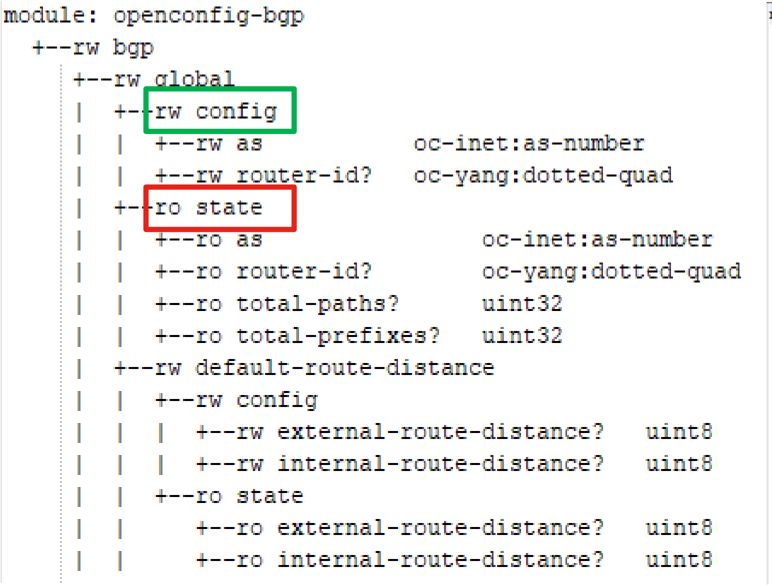
Unique name

External modules with a local prefix

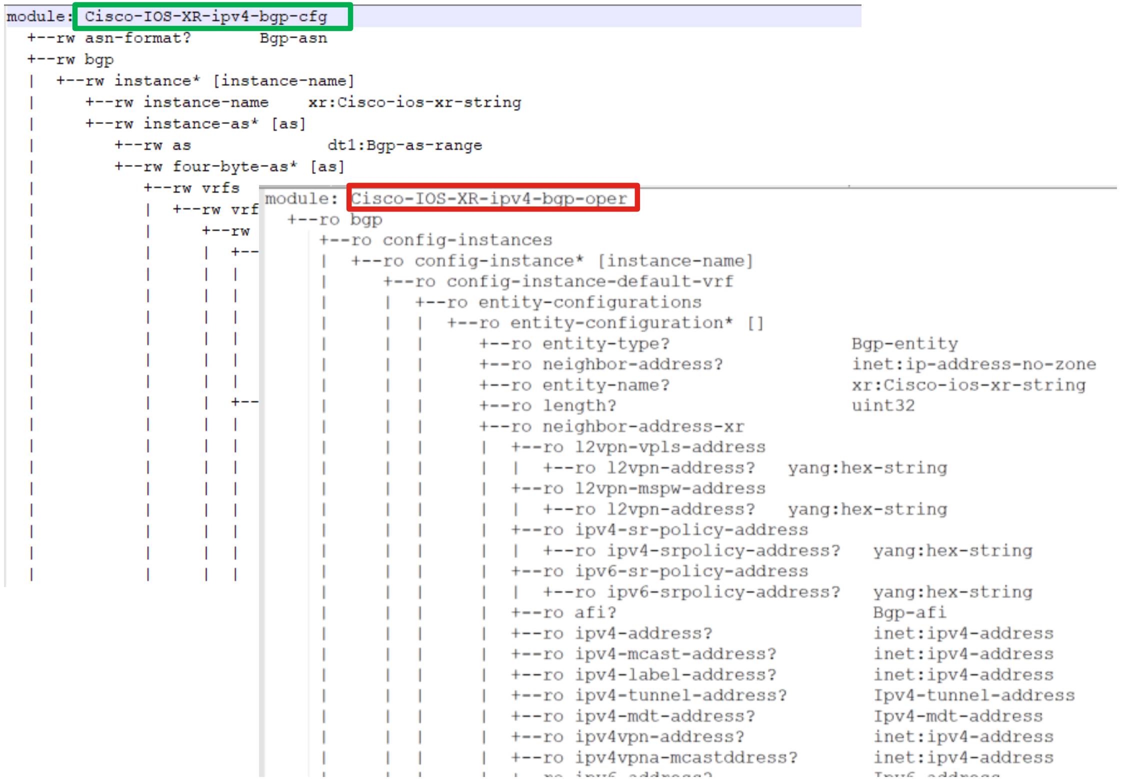
Sub-modules

- Module is the base unit of definition in YANG for eg. openconfig-bgp.yang
- YANG models can augment an existing data model with additional nodes
- "include" statement to include submodules
- "import" statement to reference external modules
- When a definition in an external module is referenced, a locally defined prefix MUST be used, followed by “:”

OpenConfig vs Cisco-defined Model : BGP



```
module: openconfig-bgp
  +--rw bgp
     +--rw global
     |  +--rw config
     |  |  +--rw as              oc-inet:as-number
     |  |  +--rw router-id?      oc-yang:dotted-quad
     |  +--ro state
     |  |  +--ro as                    oc-inet:as-number
     |  |  +--ro router-id?            oc-yang:dotted-quad
     |  |  +--ro total-paths?          uint32
     |  |  +--ro total-prefixes?       uint32
     |  +--rw default-route-distance
     |  |  +--rw config
     |  |  |  +--rw external-route-distance?   uint8
     |  |  |  +--rw internal-route-distance?   uint8
     |  |  +--ro state
     |  |     +--ro external-route-distance?   uint8
     |  |     +--ro internal-route-distance?   uint8
```



```
module: Cisco-IOS-XR-ipv4-bgp-cfg
  +--rw asn-format?          Bgp-asn
  +--rw bgp
  |  +--rw instance* [instance-name]
  |     +--rw instance-name     xr:Cisco-ios-xr-string
  |     +--rw instance-as* [as]
  |        +--rw as                dt1:Bgp-as-range
  |        +--rw four-byte-as* [as]
  |           +--rw vrfs
  |           |  +--rw vrf
  |           |     +--rw
  |           |     |  +--
  |           |     |  |
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  |           |     |  |
  |           |     |  |
```
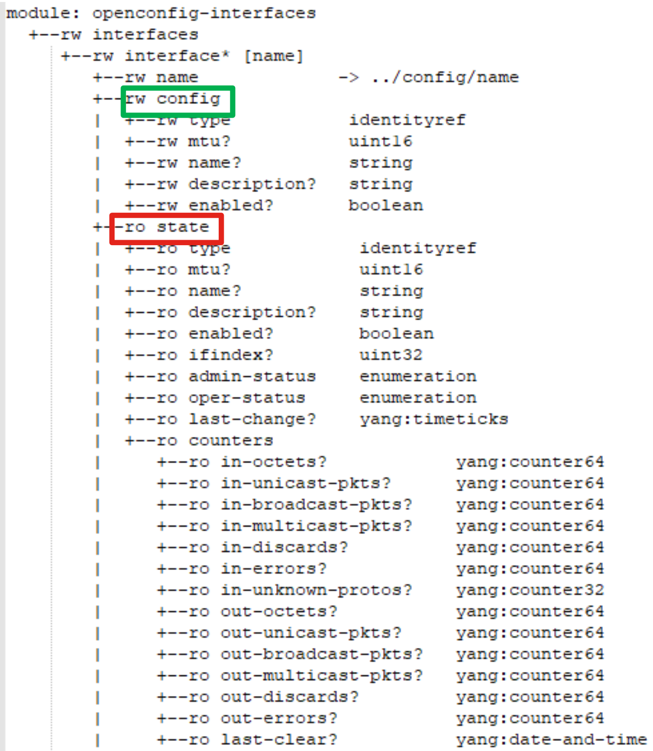
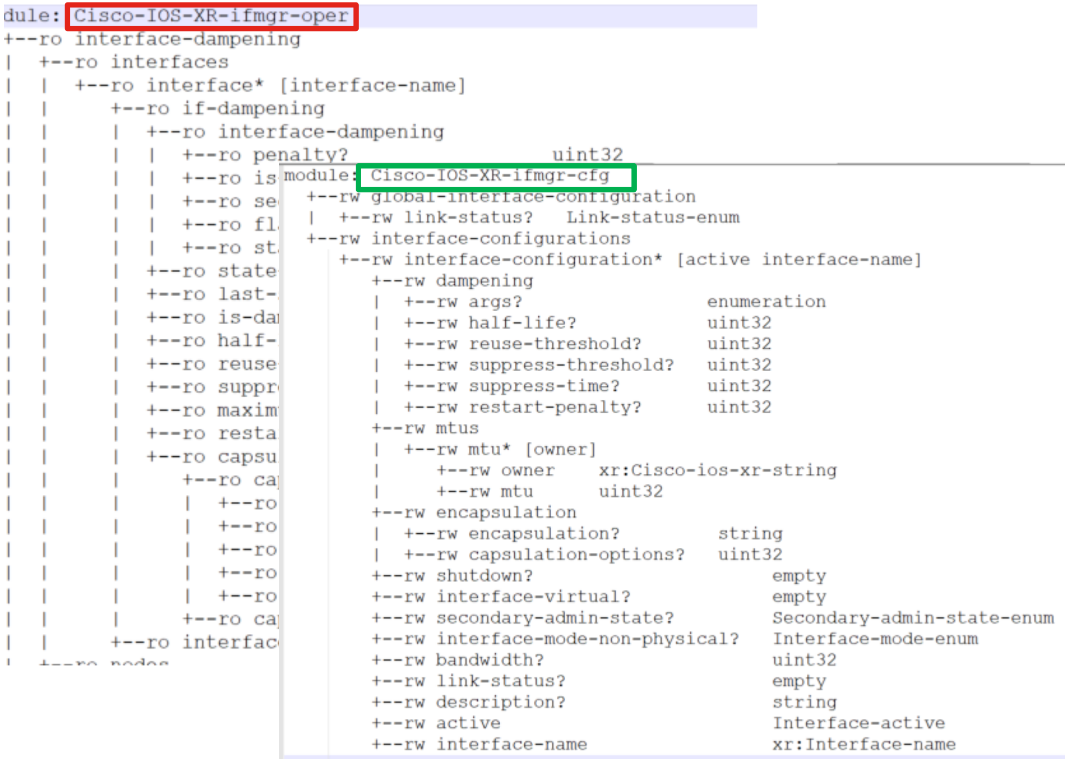

```
module: Cisco-IOS-XR-ipv4-bgp-oper
  +--ro bgp
     +--ro config-instances
     |  +--ro config-instance* [instance-name]
     |     +--ro config-instance-default-vrf
     |     |  +--ro entity-configurations
     |     |  |  +--ro entity-configuration* []
     |     |  |     +--ro entity-type?              Bgp-entity
     |     |  |     +--ro neighbor-address?         inet:ip-address-no-zone
     |     |  |     +--ro entity-name?              xr:Cisco-ios-xr-string
     |     |  |     +--ro length?                   uint32
     |     |  |     +--ro neighbor-address-xr
     |     |  |     |  +--ro l2vpn-vpls-address
     |     |  |     |  |  +--ro l2vpn-address?    yang:hex-string
     |     |  |     |  +--ro l2vpn-mspw-address
     |     |  |     |  |  +--ro l2vpn-address?    yang:hex-string
     |     |  |     |  +--ro ipv4-sr-policy-address
     |     |  |     |  |  +--ro ipv4-srpolicy-address?   yang:hex-string
     |     |  |     |  +--ro ipv6-sr-policy-address
     |     |  |     |  |  +--ro ipv6-srpolicy-address?   yang:hex-string
     |     |  |     |  +--ro afi?                        Bgp-afi
     |     |  |     |  +--ro ipv4-address?               inet:ipv4-address
     |     |  |     |  +--ro ipv4-mcast-address?         inet:ipv4-address
     |     |  |     |  +--ro ipv4-label-address?         inet:ipv4-address
     |     |  |     |  +--ro ipv4-tunnel-address?        Ipv4-tunnel-address
     |     |  |     |  +--ro ipv4-mdt-address?           Ipv4-mdt-address
     |     |  |     |  +--ro ipv4vpn-address?            inet:ipv4-address
     |     |  |     |  +--ro ipv4vpna-mcastddress?       inet:ipv4-address
```

Model Snipped for representation on slide

OpenConfig vs Cisco-defined Model : Interface



```
module: openconfig-interfaces
   +--rw interfaces
      +--rw interface* [name]
         +--rw name                  -> ../config/name
         +--rw config
         |  +--rw type              identityref
         |  +--rw mtu?              uint16
         |  +--rw name?             string
         |  +--rw description?      string
         |  +--rw enabled?          boolean
         +--ro state
         |  +--ro type               identityref
         |  +--ro mtu?               uint16
         |  +--ro name?              string
         |  +--ro description?       string
         |  +--ro enabled?           boolean
         |  +--ro ifindex?           uint32
         |  +--ro admin-status       enumeration
         |  +--ro oper-status        enumeration
         |  +--ro last-change?       yang:timeticks
         |  +--ro counters
         |     +--ro in-octets?             yang:counter64
         |     +--ro in-unicast-pkts?       yang:counter64
         |     +--ro in-broadcast-pkts?     yang:counter64
         |     +--ro in-multicast-pkts?     yang:counter64
         |     +--ro in-discards?           yang:counter64
         |     +--ro in-errors?             yang:counter64
         |     +--ro in-unknown-protos?     yang:counter32
         |     +--ro out-octets?            yang:counter64
         |     +--ro out-unicast-pkts?      yang:counter64
         |     +--ro out-broadcast-pkts?    yang:counter64
         |     +--ro out-multicast-pkts?    yang:counter64
         |     +--ro out-discards?          yang:counter64
         |     +--ro out-errors?            yang:counter64
         |     +--ro last-clear?            yang:date-and-time
```



```
dule: Cisco-IOS-XR-ifmgr-oper
+--ro interface-dampening
|  +--ro interfaces
|  |  +--ro interface* [interface-name]
|  |     +--ro if-dampening
|  |     |  +--ro interface-dampening
|  |     |  |  +--ro penalty?                 uint32
|  |     |  |  +--ro is
|  |     |  |  +--ro se
|  |     |  |  +--ro fl
|  |     |  |  +--ro st
|  |     |  +--ro state
|  |     |  +--ro last-
|  |     |  +--ro is-da
|  |     |  +--ro half-
|  |     |  +--ro reuse
|  |     |  +--ro suppr
|  |     |  +--ro maxim
|  |     |  +--ro resta
|  |     |  +--ro capsu
|  |     |     +--ro ca
|  |     |     |  +--ro
|  |     |     |  +--ro
|  |     |     |  +--ro
|  |     |     |  +--ro
|  |     |     |  +--ro
|  |     |     +--ro ca
|  |     +--ro interfac
|  +--ro nodes
```

```
module: Cisco-IOS-XR-ifmgr-cfg
  +--rw global-interface-configuration
  |  +--rw link-status?    Link-status-enum
  +--rw interface-configurations
     +--rw interface-configuration* [active interface-name]
        +--rw dampening
        |  +--rw args?                   enumeration
        |  +--rw half-life?              uint32
        |  +--rw reuse-threshold?        uint32
        |  +--rw suppress-threshold?     uint32
        |  +--rw suppress-time?          uint32
        |  +--rw restart-penalty?        uint32
        +--rw mtus
        |  +--rw mtu* [owner]
        |     +--rw owner      xr:Cisco-ios-xr-string
        |     +--rw mtu        uint32
        +--rw encapsulation
        |  +--rw encapsulation?          string
        |  +--rw capsulation-options?    uint32
        +--rw shutdown?                            empty
        +--rw interface-virtual?                   empty
        +--rw secondary-admin-state?               Secondary-admin-state-enum
        +--rw interface-mode-non-physical?         Interface-mode-enum
        +--rw bandwidth?                           uint32
        +--rw link-status?                         empty
        +--rw description?                         string
        +--rw active                               Interface-active
        +--rw interface-name                       xr:Interface-name
```

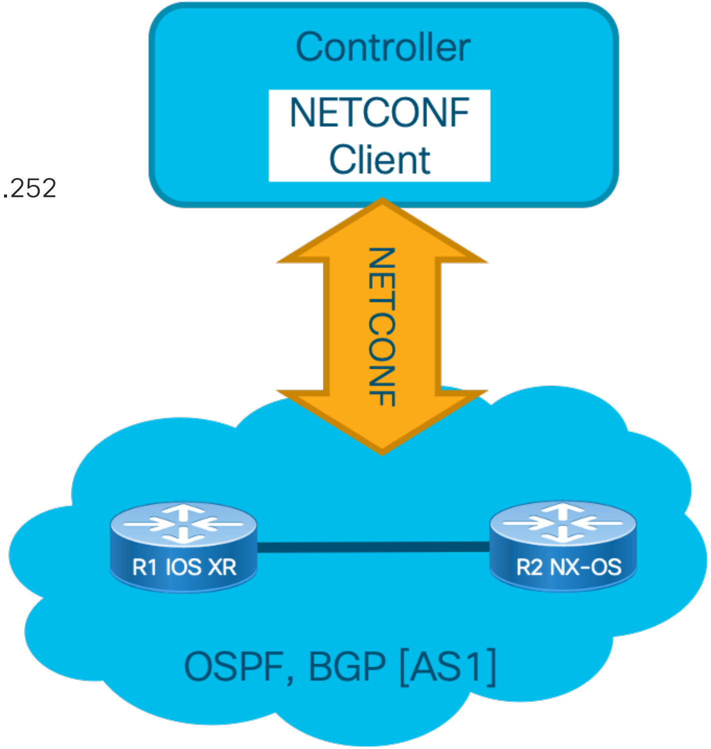
Model Snipped for representation on slide

pYANG Demo

OpenConfig Demo

R1 IOS XR Config

```
interface GigabitEthernet0/0/0/0
ipv4 address 100.1.2.1 255.255.255.252
!
router bgp 1
bgp router-id 1.1.1.1
address-family ipv4 unicast
!
neighbor 100.1.2.2
 remote-as 1
 address-family ipv4 unicast
```



R2 NX OS Config

```
interface Ethernet1/1
 ip address 100.1.2.2/30
!
router bgp 1
 router-id 2.2.2.2
 address-family ipv4 unicast
 neighbor 100.1.2.1
  remote-as 1
  address-family ipv4 unicast
```

Referred Sessions & Further Reading

- DEVWKS-1644 - Building IP Core Network with OpenConfig
- DEVWKS-1381 - Introduction to Using gRPC-based Protocol for Model-Driven Management of IOS-XR
- LTRSPG-2601 - Cisco IOS XR Programmability
- OpenConfig references
  - http://www.openconfig.net/
  - https://github.com/openconfig
- pYANG : https://github.com/mbj4668/pyang
- NETCONF & YANG RFCs
  - RFC 3535 : Overview of the 2002 IAB Network Management Workshop
  - RFC 6241 : Network Configuration Protocol
  - RFC 6242 : Using the NETCONF Protocol over Secure Shell
  - RFC 6020 : YANG - A Data Modeling Language for the Network Configuration Protocol
- Open Source Netconf Client :
  - libnetconf: NETCONF library in C intended for building NETCONF clients and servers.
  - ncclient: Python library for NETCONF clients

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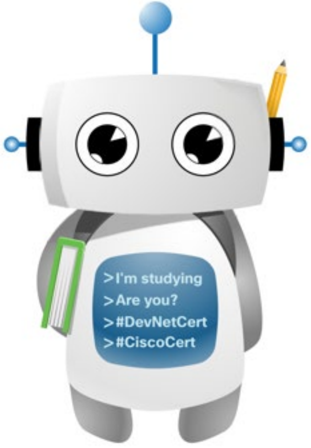

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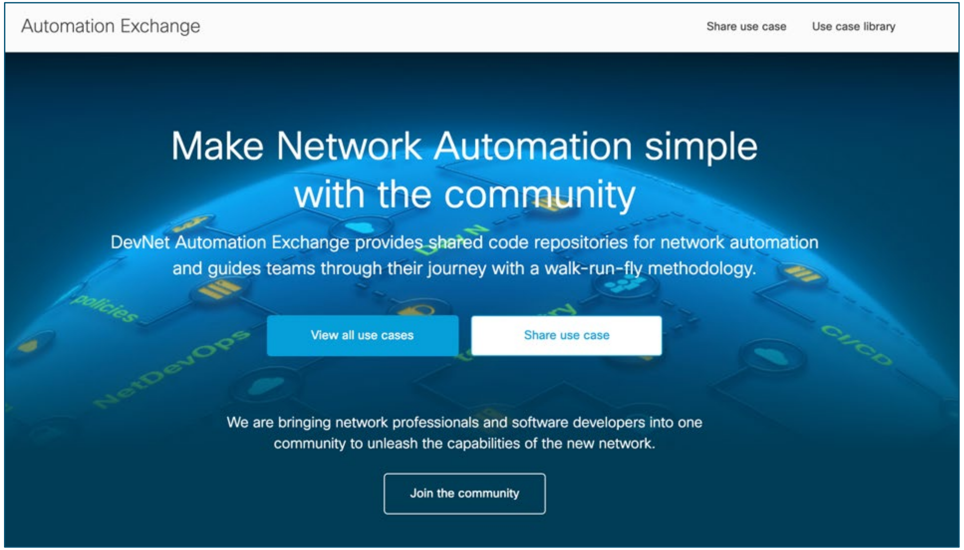

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