Exploring YANG Data Modeling

A Guided Session using NSO

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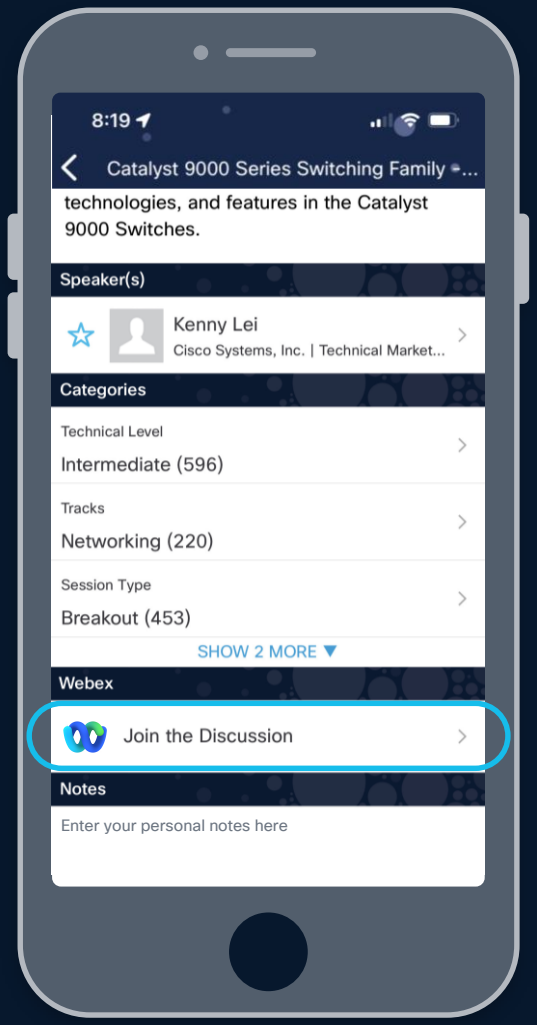

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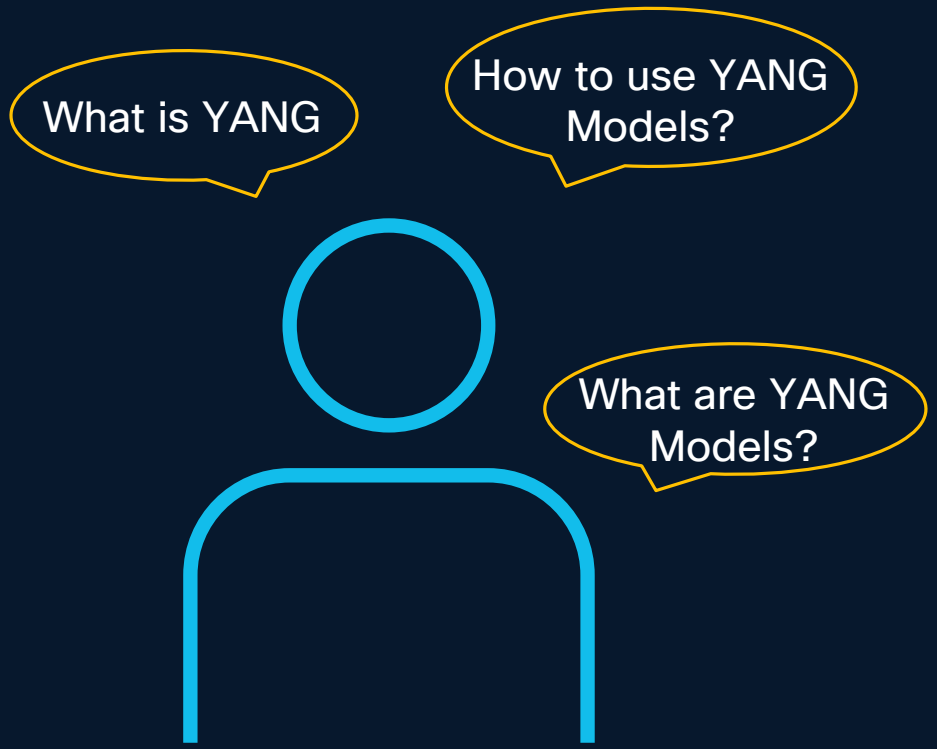
Agenda



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02 What is YANG

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04 Components & Data Types in YANG

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Need for Data Modeling

Unstructured Data: Not Always Easy to Read

```
Router Re1-BGL-12-3 1.2.3.4 down GigabitEthernet 0/0/2 enable
```

What do these commands mean?

```
person Jacob 27 hawai vegan
```

How would a machine know the datatypes and relationships between them?

Structured Data

```
<config xmlns="http://tail-f.com/ns/config/1.0">
  <person xmlns="http://com/example/userinfo">
    <name>Aayushi</name>
    <age>26</age>
    <favorite-holiday-destinations>San Diego</favorite-holiday-destinations>
    <food-choice>vegetarian</food-choice>
  </person>
</config>
```

Example 1

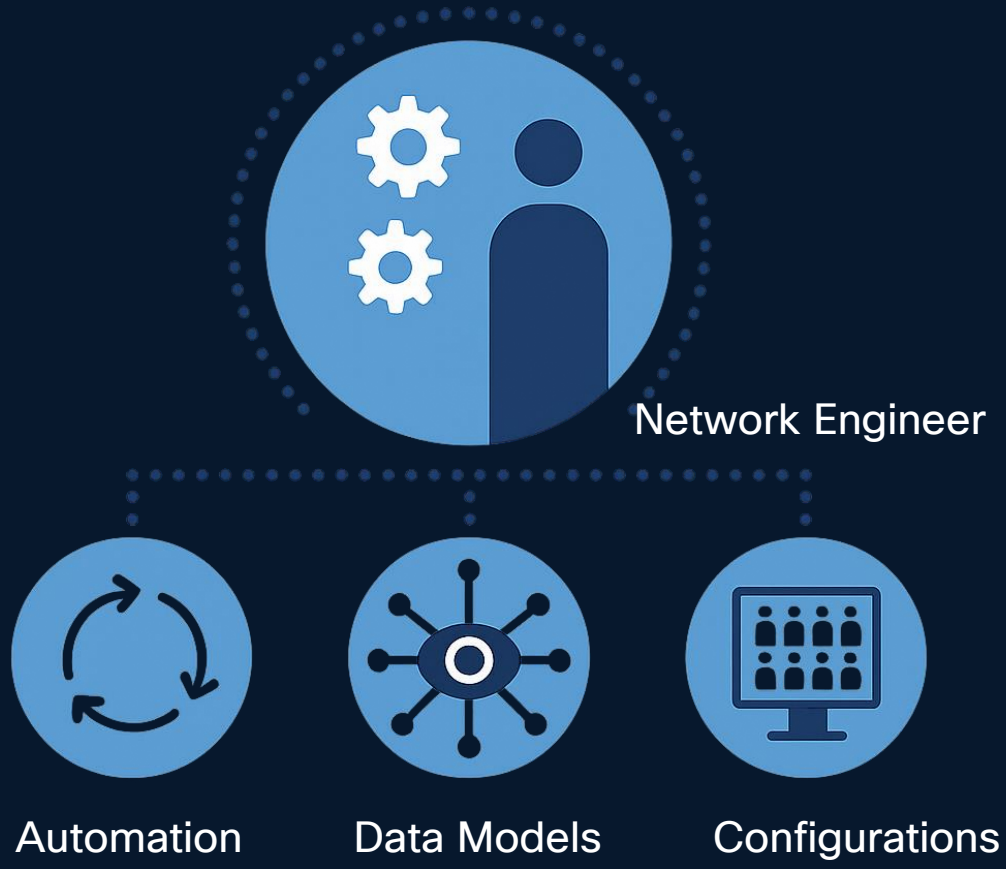
Example 2

```
<config xmlns="http://tail-f.com/ns/config/1.0">
  <router xmlns="http://com/example/routermodel">
    <name>rno1-BGL-16-1</name>
    <address>10.20.30.40</address>
    <operational-status>up</operational-status>
    <interface>
      <type>GigabitEthernet</type>
      <enabled>true</enabled>
      <interface-id>1/1</interface-id>
    </interface>
  </router>
</config>
```

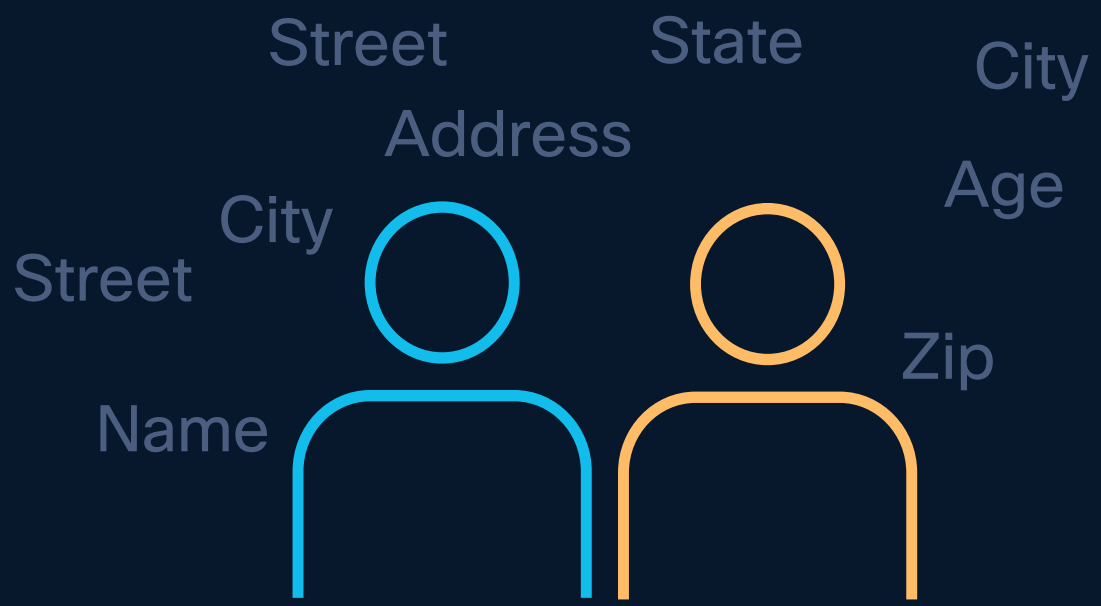
Who defines the STRUCTURE?

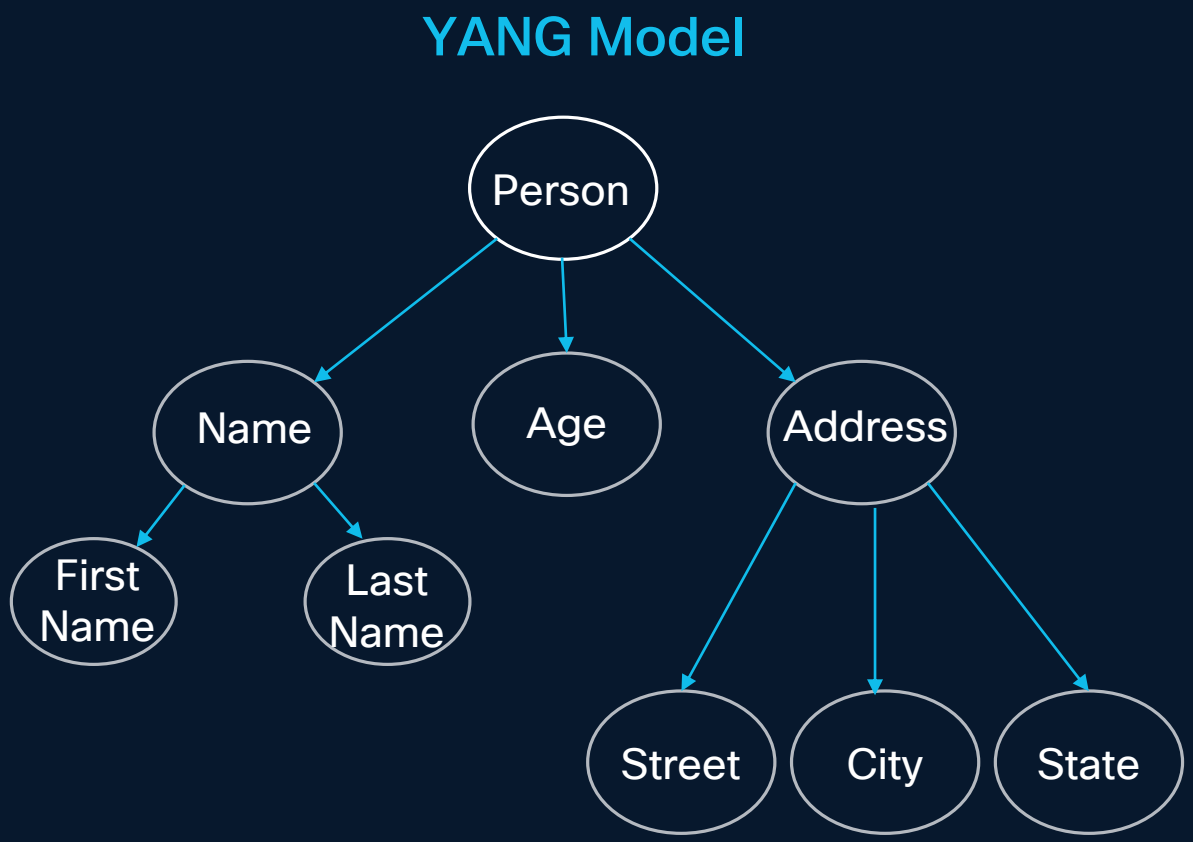
YANG

Yet Another Next Generation



Blueprint for network configuration





Why YANG?

Yang is the key to automating, scaling, and future-proofing your network

AI generated image

Features of YANG

1. Yang is a tree hierarchy
   - Starts at the root (top)
2. Defines the structure
3. Modularity
4. YANG supports different encoding formats (e.g. XML, JSON).
5. Helps automation tooling know:
   - What features are available
   - Expected Input/Output data constraints

Criteria	YANG	XML Schema / JSON Schema
Designed for networking	✅ Purpose-built for modeling config/state data in network devices	❌ Generic structure validation, not network-aware
Human-readable & concise	✅ Tree-structured, easy to read and maintain	⚠️ Verbose (XML), less intuitive
Standardized by IETF	✅ Widely adopted in RFCs (RFC 6020/7950)	❌ Not designed for network standards
Supports modularity & reuse	✅ Uses import, include, grouping	⚠️ Limited or verbose reuse
Integration with protocols	✅ Works seamlessly with NETCONF, RESTCONF	❌ Doesn't integrate directly

XML Schema

```
<config xmlns="http://tail-f.com/ns/config/1.0">
  <router xmlns="http://com/example/routermodel">
    <name>rno1-BGL-16-1</name>
    <address>10.20.30.40</address>
    <operational-status>up</operational-status>
    <interface>
      <type>GigabitEthernet</type>
      <enabled>true</enabled>
      <interface-id>1/1</interface-id>
    </interface>
  </router>
</config>
```

YANG Model

```
container router {
  leaf name {
    type string;
  }
  leaf address {
    type inet:ipv4-address;
  }
  leaf operational-status {
    type enumeration {
      enum up;
      enum down;
    }
  }
  list interface {
    key "type";

    description
      "The list of interfaces on the device.";

    leaf type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigE;
      }
    }
    leaf enabled {
      type boolean;
      default "true";
      description "This leaf contains the configured, desired state of the interface.";
    }
    leaf interface-id {
      tailf:info "X.X or X/X";
      type union {
        type string{
          pattern '(\d+)(.)(\d+)';
        }
        type string {
          pattern '(\d+/)+\d+';
        }
      }
```

```
<config xmlns="http://tail-f.com/ns/config/1.0">
  <router xmlns="http://com/example/routermodel">
    <name>rno1-BGL-16-1</name>
    <address>10.20.30.40</address>
    <operational-status>up</operational-status>
    <interface>
      <type>GigabitEthernet</type>
      <enabled>true</enabled>
      <interface-id>1/1</interface-id>
    </interface>
  </router>
</config>
```

Components & Data Types in YANG

Components of YANG – Modules, Namespaces & Imports

Module:

- Defines data model structure
- Identified by a unique namespace URI
- Represents a single data model

```
module router-model {
  namespace "http://com/example/routermodel";
  prefix router-model;
  import ietf-inet-types {
    prefix inet;
  }
```

Namespace:

- Uniquely identifies a YANG module
- Prevents naming conflicts across modules
- Typically written as a URI (e.g., http://example.com/ns/module)

```
module router-model {
  namespace "http://com/example/routermodel";
  prefix router-model;
  import ietf-inet-types {
    prefix inet;
  }
```

Import Statement:

- Allows modular design & code reuse
- Uses prefix to refer to imported items
- Enables integration of external types and groupings

```
module router-model {
  namespace "http://com/example/routermodel";
  prefix router-model;
  import ietf-inet-types {
    prefix inet;
  }
```

The Basic Building Blocks of YANG: Node Types

```
container person {
  leaf name {
    type string;
    }
  leaf age {
    type uint32;
  }
  leaf-list favorite-holiday-destinations {
    type string;
  }
  leaf food-choice {
    type enumeration {
      enum vegan;
      enum vegetarian;
      enum non-vegetarian;
    }
    mandatory true;
  }
}
```

CONTAINER

Group nodes together (no data)

LEAF

A single unit of data

LEAF-LIST

Multiple units of one data

LIST

Collection of nodes (leaves & leaf-lists)

```
container router {
  leaf name {
    type string;
  }
  leaf address {
    type inet:ipv4-address;
  }
  leaf operational-status {
    type enumeration {
      enum up;
      enum down;
    }
  }
  list interface {
    key "type";

    description
      "The list of interfaces on the device.";

    leaf type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigE;
      }
    }
    leaf enabled {
      type boolean;
      default "true";
      description "This leaf contains the configured, desired state of the interface.";
    }
    leaf interface-id {
      tailf:info "X.X or X/X";
      type union {
        type string{
          pattern '(\d+)(.)(\d+)';
        }
        type string {
          pattern '(\d+/)+\d+';
```

Some Basic YANG Data Types

Type	Description
int8/16/32/64	Integer
uint8/16/32/64	Unsigned integer
decimal64	Decimal floating-point format
string	Unicode string
enumeration	Set of alternatives
boolean	True or false
bits	Boolean array
binary	Binary BLOB
leafref	Reference "pointer"

```
container router {
  leaf name {
    type string;
  }
  leaf address {
    type inet:ipv4-address;
  }
  leaf operational-status {
    type enumeration {
      enum up;
      enum down;
    }
  }
  list interface {
    key "type";

    description
      "The list of interfaces on the device.";

    leaf type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigE;
      }
    }
    leaf enabled {
      type boolean;
      default "true";
      description "This leaf contains the configured, desired state of the interface.";
    }
    leaf interface-id {
      tailf:info "X.X or X/X";
      type union {
        type string{
          pattern '(\d+)(.)(\d+)';
        }
        type string {
          pattern '(\d+/)+\d+';
        }
      }
```

String: A flexible mix of numbers, letters & punctation

Custom Imported Types:

- Hidden regular expressions enforcing ipv4 syntax

Enumeration:

- Choose one from pre-defined set of value
- Has additional enum for each value

Boolean: Whether a value is either True or False

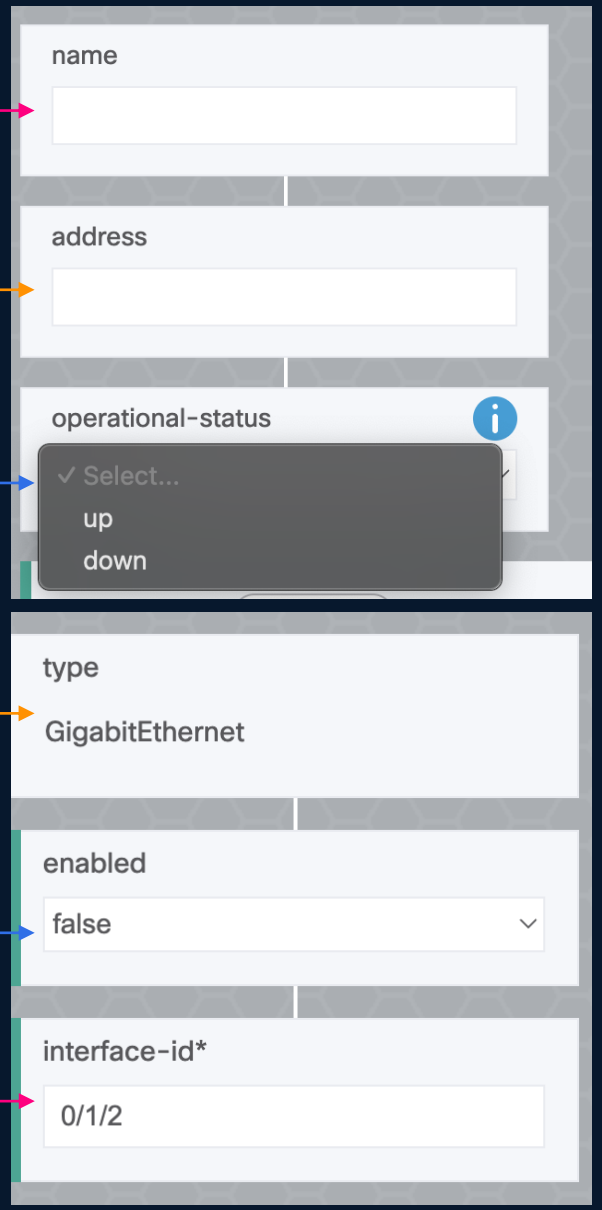
Union: The value should correspond to one of its member types

YANG Statements Visualized: NSO GUI

```
container router {
  leaf name {
    type string;
  }
  leaf address {
    type inet:ipv4-address;
  }
  leaf operational-status {
    type enumeration {
      enum up;
      enum down;
    }
  }
  list interface {
    key "type";

    description
      "The list of interfaces on the device.";

    leaf type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigE;
      }
    }
    leaf enabled {
      type boolean;
      default "true";
      description "This leaf contains the configured, desired state of the interface.";
    }
    leaf interface-id {
      tailf:info "X.X or X/X";
      type union {
        type string{
          pattern '(\d+)(.)(\d+)';
        }
        type string {
          pattern '(\d+/)+\d+';
        }
      }
```



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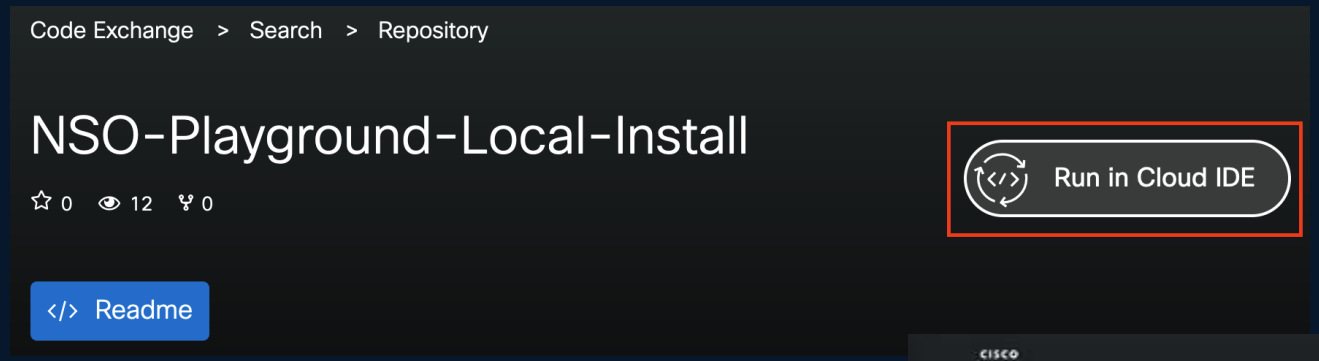
YANG Statements Visualized: NSO CLI

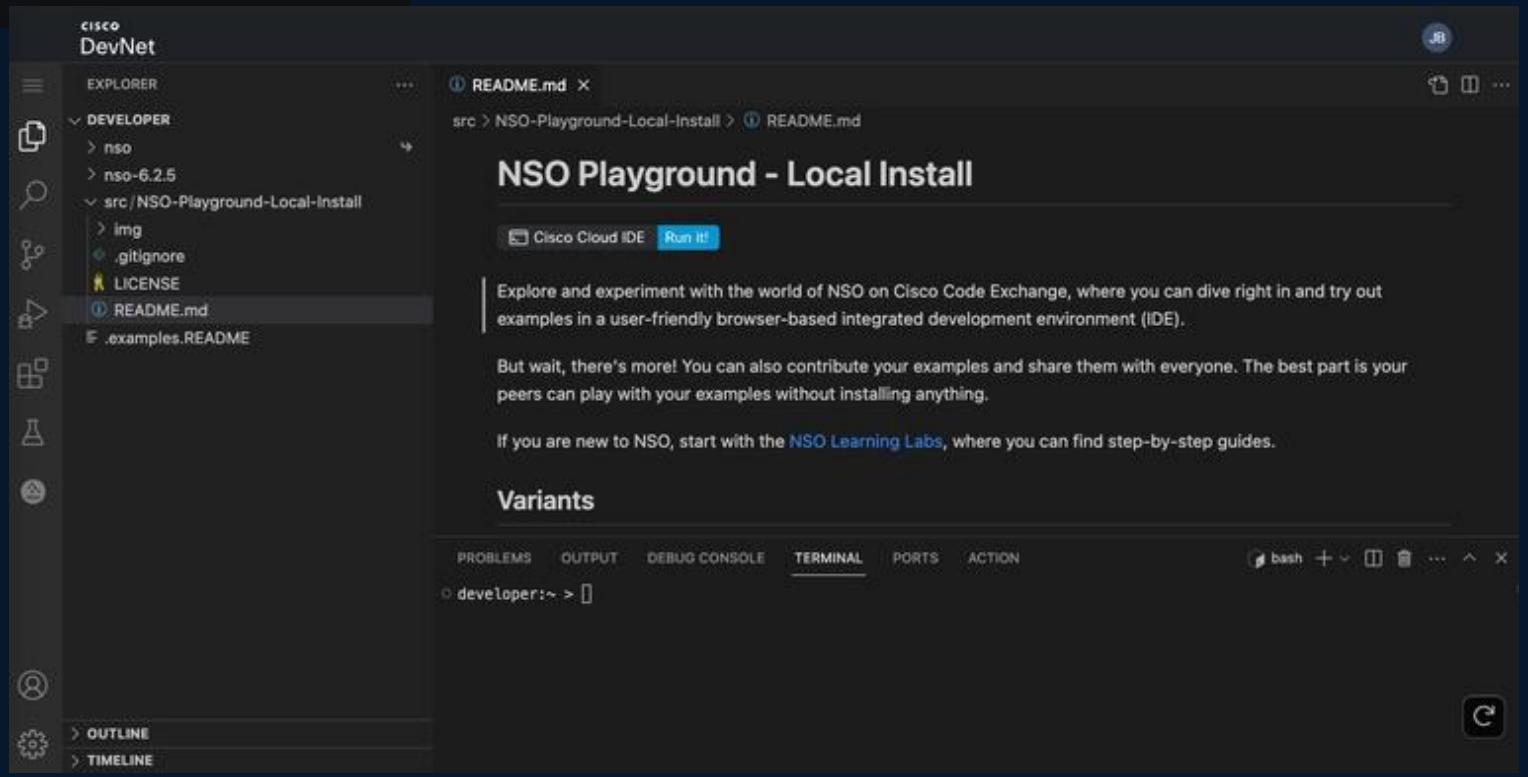
```
container router {
  leaf name {
    type string;
  }
  leaf address {
    type inet:ipv4-address;
  }
  leaf operational-status {
    type enumeration {
      enum up;
      enum down;
    }
  }
  list interface {
    key "type";

    description
      "The list of interfaces on the device.";

    leaf type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigE;
      }
    }
    leaf enabled {
      type boolean;
      default "true";
      description "This leaf contains the configured, desired state of the interface.";
    }
    leaf interface-id {
      tailf:info "X.X or X/X";
      type union {
        type string{
          pattern '(\d+)(.)(\d+)';
        }
        type string {
          pattern '(\d+/)+\d+';
        }
      }
```

```
admin@ncs(config)# router ?
Possible completions:
  address  interface  name  operational-status
admin@ncs(config)# router operational-status ?
Possible completions:
  down  up
admin@ncs(config)# router interface
Possible completions:
  GigabitEthernet  TenGigE
admin@ncs(config)# router interface TenGigE ?
Possible completions:
  disabled
  enabled
  interface-id   X.X or X/X
  <cr>
```

Cisco NSO Playground Overview

Getting started with NSO Playground





Creating an NSO Instance

Step 1: Prepare NSO

```
source $NCS_DIR/ncsrc
```

Step 2: Setup your NSO instance

```
ncs-setup --dest ~/nso-instance
```

Step 3: Go to the ~/nso-instance directory

```
cd ~/nso-instance
```

Step 4: Start the NSO server

```
ncs
```

Compile / Install YANG Packages

Step 1: Prepare NSO

```
source $NCS_DIR/ncsrc
```

Step 2: Copy the package directories into ~/nso-instance/packages by:

- Cloning the packages using git clone into your home directory, then moving or soft-linking them into the packages
- Dragging and dropping the folders via the VS Code GUI

```
git clone https://github.com/aaymahaj/DEVNET-1882

cd ~/nso-instance/packages

# Move the directories from DEVNET-1882 to the packages directory
mv ~/DEVNET-1882/user-info ~/nso-instance/packages/
mv ~/DEVNET-1882/router-model ~/nso-instance/packages/
```

Step 3: Re-compile the packages

```
cd ~/nso-instance/packages/user-info/src
make clean all
cd ~/nso-instance/packages/router-model/src
make clean all
```

Step 4: Reload the packages

```
packages reload force
exit
```

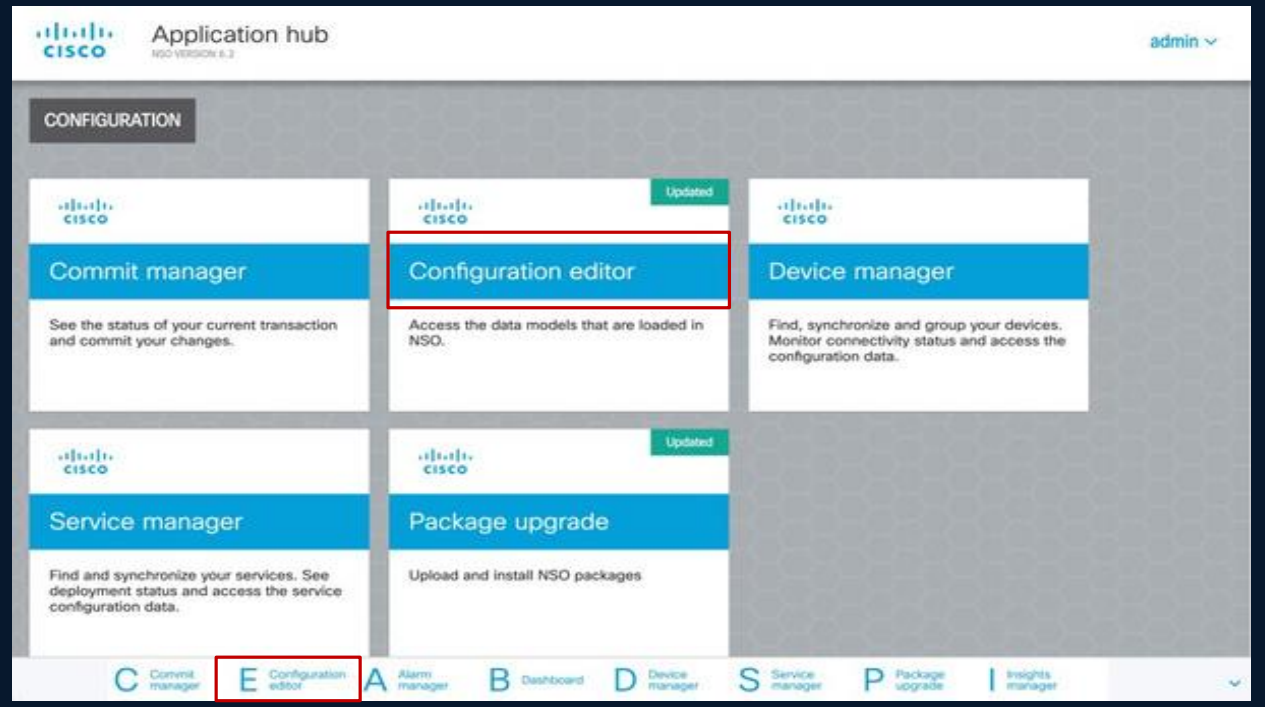
Accessing the NSO GUI

Step 1: echo NSO GUI URL

```
echo $DEVENV_APP_8080_URL
```

Step 2: Open the above URL in a browser
The credentials are ”admin” / “admin”

Step 3: Click on the “E – Configuration Editor” on the bottom left
(Or on the button in the middle of the screen}

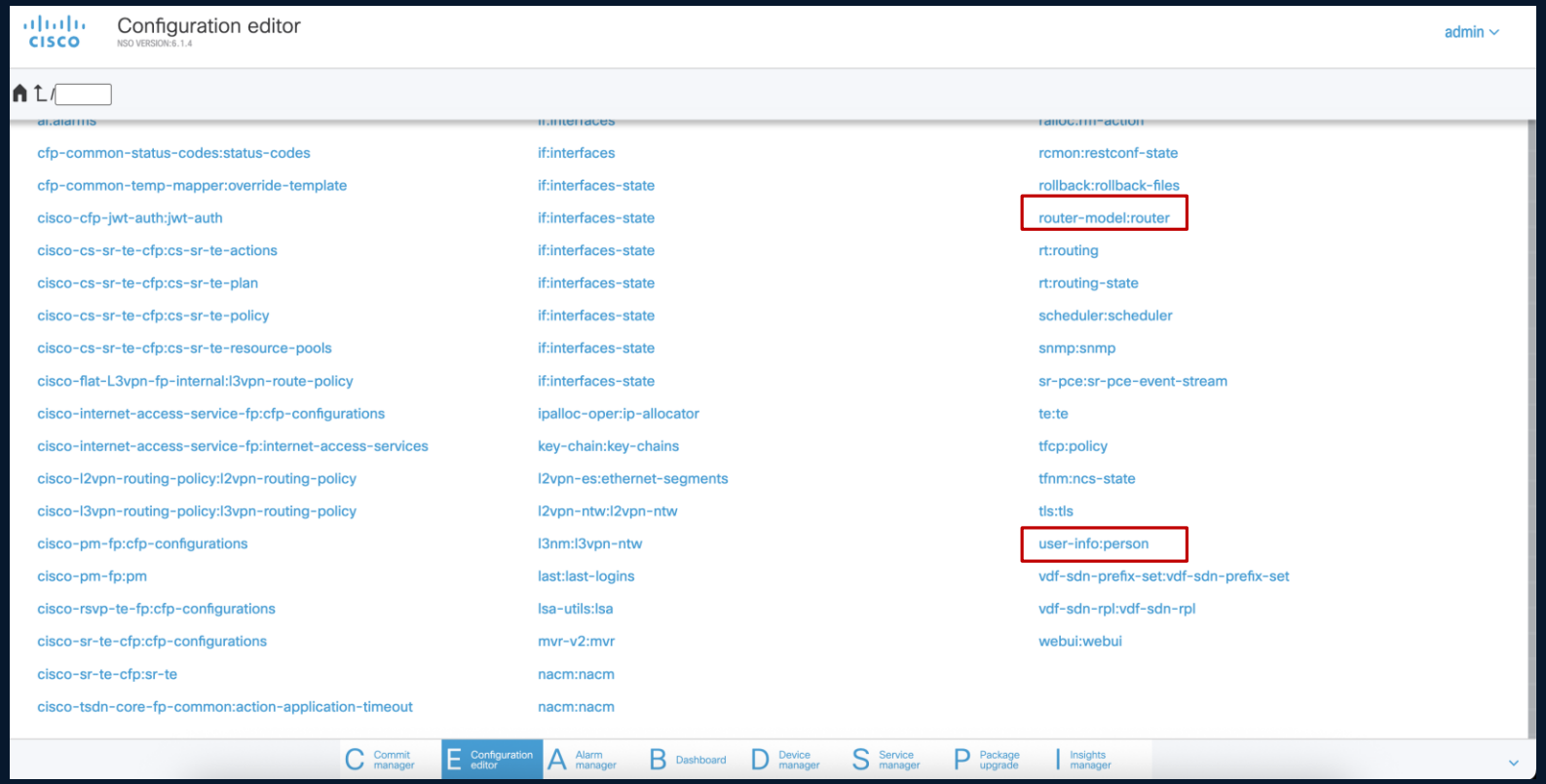


Accessing the Packages on GUI

Step 1: Each package is assigned a unique namespace prefix in the format:

<namespace>:<package_name>

Step 2: Select a custom package to edit its configurations.
By default, no values are pre-populated—configurations start as blank.

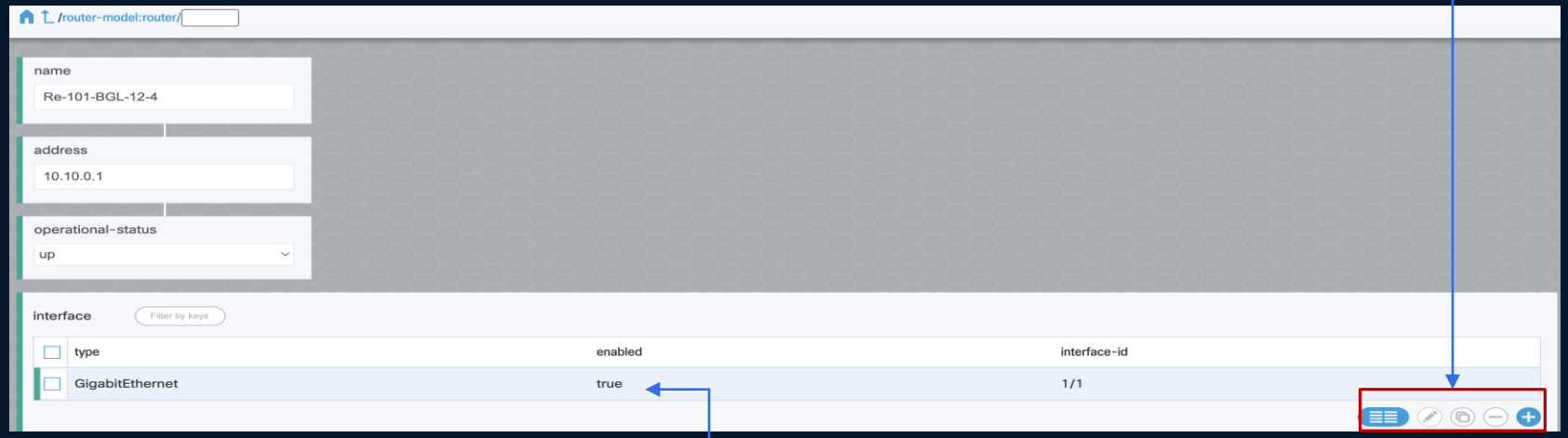


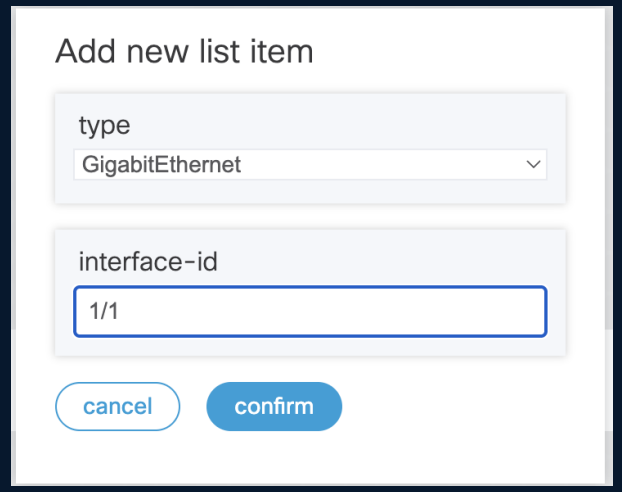
Adding Configurations to our custom fields via GUI

Step 1: Enter a values in the respective fields.

Step 2: Provide a valid IP address in the “address” field.

Step 3: Click on “+” to add list items in list “Interface”





Step 4: The value for “enabled” is “True” by default and can be updated by clicking on it.

Note: The data model uses a custom data type for IP address validation. A regular expression (RegEx) ensures that only properly formatted IP addresses are accepted.

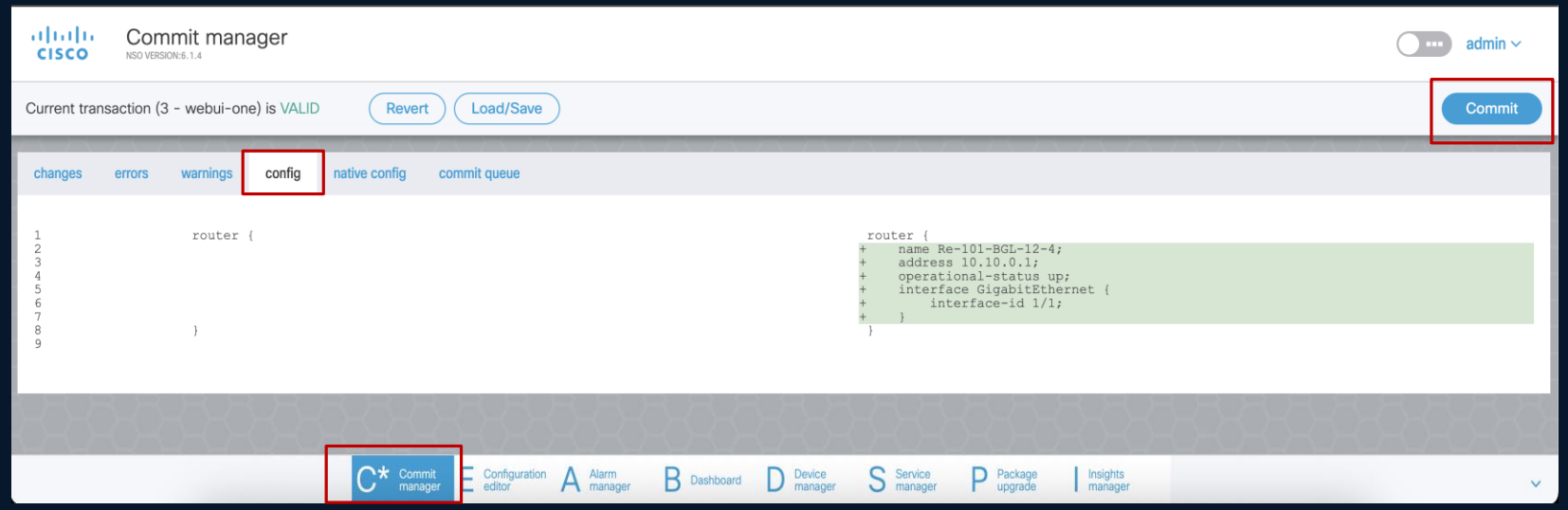
Saving the Data (commit) to NSO

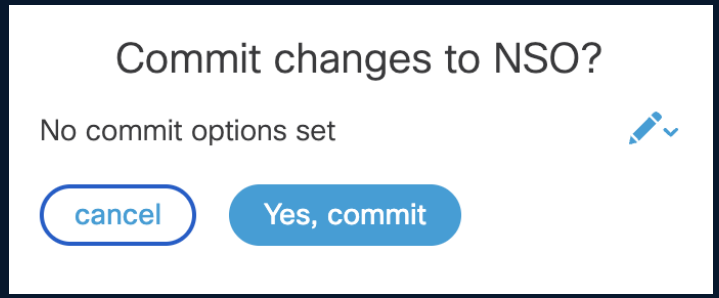
Step 1: Click on the “C – Commit Manager” on the bottom left

Step 2: Make sure you have entered the right values by clicking on “Config” to see the dry-run

Step 3: Click on “Commit” button

Step 4: Click on “Yes, commit” button

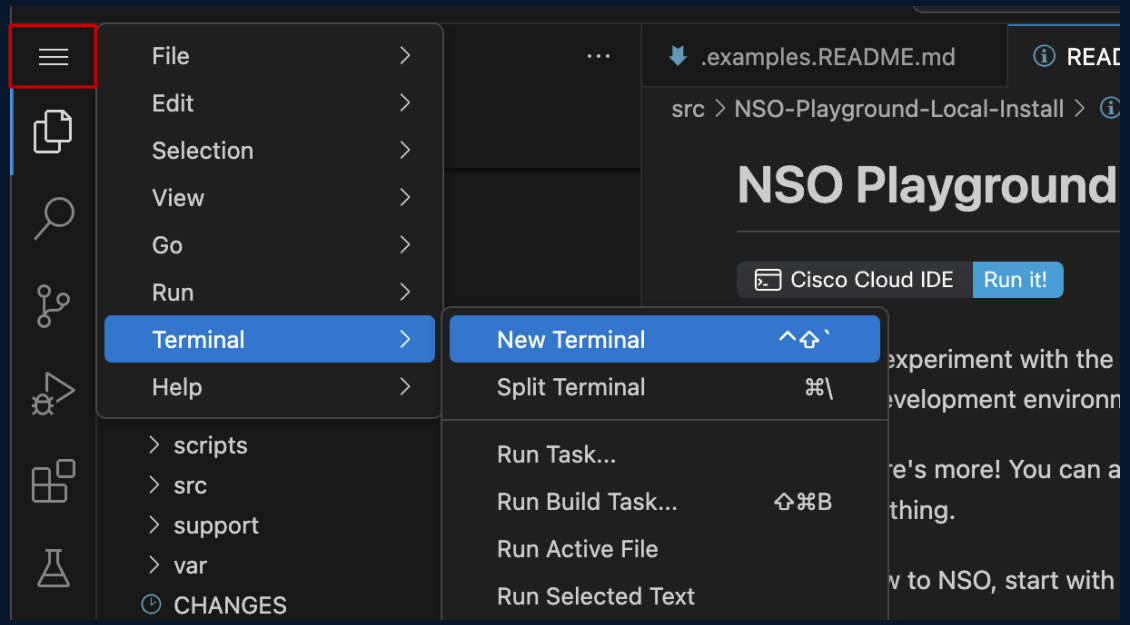




Accessing the NSO CLI from Terminal in the Browser

Step 1: If a terminal is already visible at the bottom of the screen, use it directly.

Step 2: If not, open a new terminal by clicking on the **Terminal** icon in the left-side navigation bar.



Adding Configurations to our custom fields via CLI

Step 1: Prepare NSO

```
source $NCS_DIR/ncsrc
```

Step 2: Enter in NSO CLI

```
ncs_cli -C -u admin
```

Step 3: To view the configurations, we committed in the cli, run the below commands

```
show running-config router
show running-config router | display json
show running-config router | display xml
```

Step 4: Enter "**config**" mode to start configuring, follow these steps as shown in the adjacent image

```
admin@ncs# config
Entering configuration mode terminal
admin@ncs(config)# router name re-demo-CLUS address 4.5.6.7 ?
Possible completions:
  interface  operational-status  <cr>
admin@ncs(config)# router name re-demo-CLUS address 4.5.6.7 operational-status up interface ?
Possible completions:
  GigabitEthernet  TenGigE
admin@ncs(config)# router name re-demo-CLUS address 4.5.6.7 operational-status up interface TenGigE ?
Possible completions:
  disabled
  enabled
  interface-id   X.X or X/X
  <cr>
admin@ncs(config)# router name re-demo-CLUS address 4.5.6.7 operational-status up interface TenGigE interface-id 1.4 ?
Possible completions:
  disabled  enabled  <cr>
admin@ncs(config)# router name re-demo-CLUS address 4.5.6.7 operational-status up interface TenGigE interface-id 1.4 disabled
admin@ncs(config-interface-TenGigE)# commit
Commit complete.
admin@ncs(config)# show full-configuration router
router name        re-demo-CLUS
router address     4.5.6.7
router operational-status up
router interface TenGigE
 disabled
 interface-id 1.4
!
```

View Configurations in CLI

Step 1: Prepare NSO

```
source $NCS_DIR/ncsrc
```

Step 2: Enter in nso cli

```
ncs_cli -C -u admin
```

Step 3: To view the configurations, we committed in the cli, run the below commands

```
show running-config router
show running-config router | display json
show running-config router | display xml
```

output

```
admin@ncs# show running-config router
router name        Re-101-BGL-12-4
router address     10.10.0.1
router operational-status up
router interface GigabitEthernet
 interface-id 1/1
!
admin@ncs# show running-config router | display json
{
  "data": {
    "router-model:router": {
      "name": "Re-101-BGL-12-4",
      "address": "10.10.0.1",
      "operational-status": "up",
      "interface": [
        {
          "type": "GigabitEthernet",
          "interface-id": "1/1"
        }
      ]
    }
  }
}
admin@ncs# show running-config router | display xml
<config xmlns="http://tail-f.com/ns/config/1.0">
  <router xmlns="http://com/example/routermodel">
    <name>Re-101-BGL-12-4</name>
    <address>10.10.0.1</address>
    <operational-status>up</operational-status>
    <interface>
      <type>GigabitEthernet</type>
      <interface-id>1/1</interface-id>
    </interface>
  </router>
</config>
```

Live Demo

Recap & Takeaways

Recap & Takeaways

What You Learned:

- Why structured data modeling is essential in networking
- The fundamentals and components of YANG
- How YANG fits into the Cisco NSO ecosystem
- How to visualize and deploy YANG models using NSO (GUI + CLI)

Key Takeaways:

- YANG simplifies data structure definitions for automation
- NSO + YANG enables scalable, modular network config management
- Start small—experiment with basic modules in the NSO Playground
- Use YANG models to bridge human readability and machine automation

Slido Quiz

Join at slido.com
#DEVNET-1882

Which of the following is a valid YANG node type?

In YANG, what is a 'leaf' used for?

What is the primary purpose of YANG in network automation?

Q & A

Appendix

Appendix

GitHub Repo: https://github.com/aaymahaj/DEVNET-1882

NSO Playground: https://developer.cisco.com/codeexchange/github/repo/CiscoDevNet/NSO-Playground-Local-Install/

YANG Documentation: https://developer.cisco.com/docs/nso-guides-6.3/the-yang-data-modeling-language/#yang-introduction

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Contact me at: aaymahaj@cisco.com

Thank you


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