cisco Live!

Let's go

The bridge to possible

Advanced YANG Data Modeling for Cisco NSO

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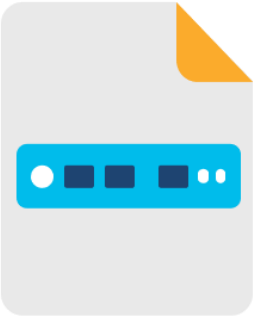
Agenda

- YANG - Introduction
- Path Navigation & Constraints
- Leaf
- Container
- List
- Use Cases
- NSO Developer Studio (YANG)
- Summary

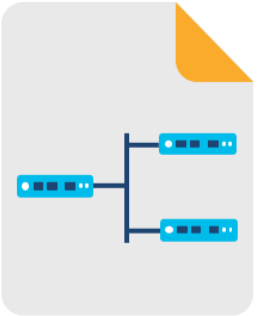
YANG Introduction

YANG in NSO: Devices & Services



<u>Device Data Models</u>

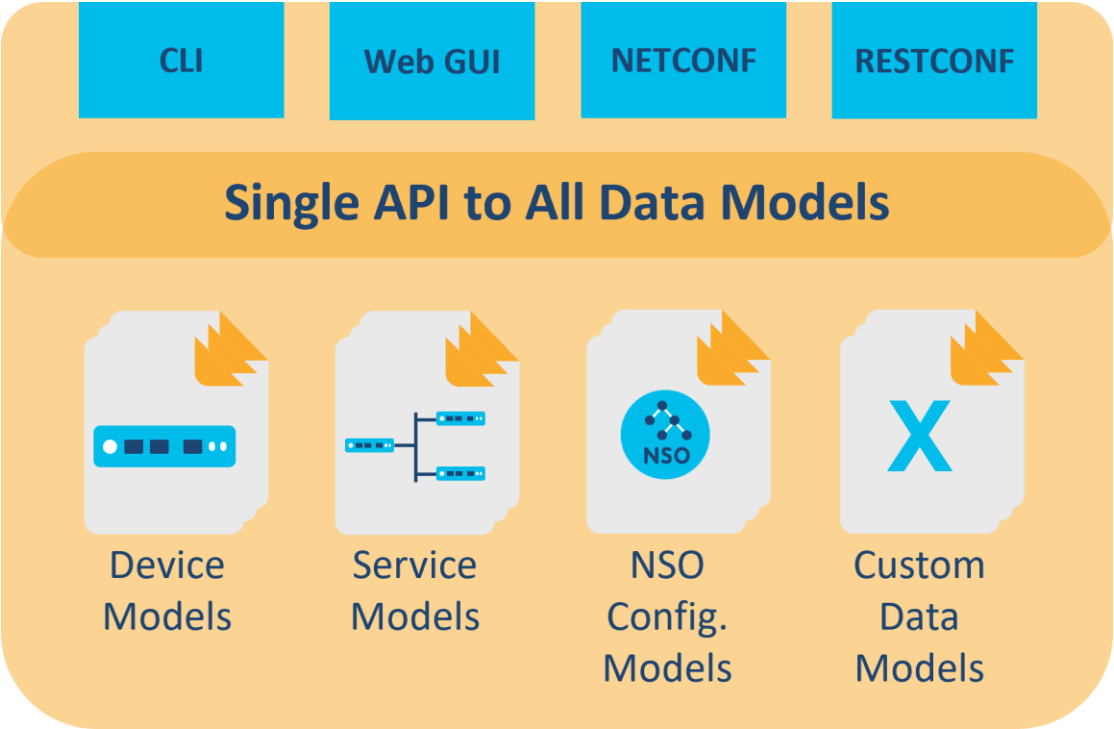
- Interface
- VLAN
- Device ACL
- Tunnel
- OSPF
- Etc.



<u>Service Data Models</u>

- Layer 3 MPLS VPN
- MP-BGP
- VRF
- Network ACL
- System Management
- Network Faults
- Etc.

YANG is everywhere



Path Navigation & Constraints

Access the YANG

How to get path for a specific resource in the Configuration Database (CDB) ?

```
admin@ncs# show running-config devices device IOS0 | display xpath
```

```
/devices/device[name='IOS0']/config/ios:interface/GigabitEthernet
[name='0/0']/ip/address/primary/address 1.1.1.1
/devices/device[name='IOS0']/config/ios:interface/GigabitEthernet
[name='0/0']/ip/address/primary/mask 255.255.255.0
...
```

path()

XPath uses path expressions to select nodes and also this expression can be used to return a collection of nodes, rather than a unique node.

```
list interface {
  key "name";
  leaf name {
    type string;
  }
}
leaf mgmt-interface {
  type leafref {
    path "../interface/name";
  }
}
```

current()

Starting point for an XPath location path.

```
leaf phase {
  type enumeration {
    enum Telnet;
    enum SSH;
  }
}
leaf mgmtVLAN {
  when "current()/../phase = 'SSH'";
  type string;
}
```

when()

Allows to expose node under given condition only.

```
leaf device {
    type leafref {
        path "/ncs:devices/ncs:device/ncs:name";
    }
}
container ios {
    when "/ncs:devices/ncs:device[ncs:name=current()/../device]/
           ncs:platform/ncs:name = 'ios'";
    leaf device-description {
        tailf:info "device description";
        type string;
    }
}
```

must()

Constraint used to restrict and ensure that configuration meets the condition. It is using an XPath expression that must evaluate to true.

```
leaf device {
    tailf:info "PE Router";
    type leafref {
        path "/ncs:devices/ncs:device/ncs:name";
    }
    must "starts-with(current(),'PE')" {
        error-message
        "Only PE devices can be selected.";
    }
}
```

deref()

Follows the reference defined by the first node in document order in the argument node-set, and returns the nodes it refers to.

WITH

```
leaf my-ip {
  type leafref {
    path "/server/ip";
  }
}
leaf my-port {
  type leafref {
    path "deref(../my-ip)/../port";
  }
}
```

WITHOUT

```
leaf my-ip {
  type leafref {
    path "/server/ip";
  }
}
leaf my-port {
  type leafref {
    path "/server[ip = current()/../my-ip]/port";
  }
}
```

SAME RESULT

contains()

Evaluates if referenced leaf value in the model **contains** given string.

```
leaf port {
    type string;
}
container encapsulation {
    when "contains(current()/../port,'.')" {
        tailf:dependency "../port";
    }
}
```

starts-with()

Evaluates if referenced leaf value in the model **starts with** given string.

```
leaf type {
  type enumeration {
    enum test;
    enum isp;
    enum mobile_4G;
    enum mobile_5G;
  }
}
container classifier {
  when "starts-with(current()/../type,'mobile')";
  presence true;
  leaf name {
    type string;
  }
}
```

But we have way more...

* last
* position
* count
* id
* local-name
* namespace-uri
* name
* string
* concat
* starts-with
* contains
* substring-before
* substring-after
* substring

* string-length
* normalize-space
* translate
* boolean
* nodeset-as-boolean
* false
* true
* not
* number
* sum
* floor
* ceiling
* round
* re-match

* string-compare
* compare
* current
* deref
* sort-by
* enum-value
* bit-is-set
* min
* max
* avg
* band
* bor
* bxor
* bnot

Evaluate your XPath in NSO

Enable Devtools:

```
admin@ncs# devtools true

admin@ncs# config
```

Evaluate Xpath:

```
admin@ncs(config)# xpath eval "/devices/device[contains(name, 'a') or
contains(name, 'i')]"

/devices/device[name='ios0']
```

Evaluate your XPath in NSO

String Examples:

```
admin@ncs(config)# xpath eval normalize-space(' test')
test
```

```
admin@ncs(config)# xpath eval translate('test_xyz', '_', '-')
test-xyz
```

```
admin@ncs(config)# xpath eval compare('abc','abc')
0
```

```
admin@ncs(config)# xpath eval string-length('test')
4
```

Evaluate your XPath in NSO

String Examples:

```
admin@ncs(config)# xpath eval substring('test_xyz', 2, 2)

es
```

```
admin@ncs(config)# xpath eval substring-before('aa-bb','-')
aa
admin@ncs(config)# xpath eval substring-after('aa-bb','-')
bb
```

```
admin@ncs(config)#
xpath eval re-match('1.22.333', '\\d{1,3}\\.\\d{1,3}\\.\\d{1,3}')

true
```

```
admin@ncs(config)# xpath eval concat('area','-SW')

area-SW
```

Evaluate your XPath in NSO

Node-Set Examples:

```
admin@ncs(config)# xpath eval count(devices/device)
3
```

```
admin@ncs(config)# xpath eval "devices/device[last()]"
/devices/device[name='JUN0']
```

```
admin@ncs(config)# xpath eval devices/device[position()=2]
/devices/device[name='IOSXR0']
```

```
admin@ncs(config)# xpath eval name(devices/device)
ncs:device
```

Evaluate your XPath in NSO

Numeric Examples:

```
admin@ncs(config)# xpath eval floor(4.69)
4
```

```
admin@ncs(config)# xpath eval ceiling(4.69)
5
```

```
admin@ncs(config)# xpath eval "10 div 5"
2
```

```
admin@ncs(config)# xpath eval 2*2
4
```

Evaluate your XPath in NSO

Boolean Examples:

```
admin@ncs(config)# xpath eval boolean(0)
false
```

```
admin@ncs(config)# xpath eval not(0)
true
```

```
admin@ncs(config)# xpath eval true()
true
```

```
admin@ncs(config)# xpath eval false()
false
```

Leaf

leafref

Hint to values for the leaf existing somewhere in the model.
It **enforces** data validation.

```
leaf vrf-name {
  type leafref {
    path "/ncs:devices/ncs:device[ncs:name=current()/../device]/
           ncs:config/iosxr:vrf/iosxr:vrf-list/iosxr:name";
  }
}
```

```
admin@ncs(config)# SERVICE vrf-name ?
Possible completions:
  VRF1  VRF2
admin@ncs(config)# SERVICE vrf-name VRF3 ?
Possible completions:
  Error: "VRF3" is an invalid value.
```

tailf:non-strict-leafref

Hint to values for the leaf existing in the model but **without enforcing** any data validation nor evaluation logic.

```
leaf vrf-name {
  tailf:non-strict-leafref {
    path "/ncs:devices/ncs:device[ncs:name=current()/../device]/
           ncs:config/iosxr:vrf/iosxr:vrf-list/iosxr:name";
  }
  type string;
}
```

```
admin@ncs(config)# SERVICE vrf-name VRF3 ?
```

YANG will accept value that is not existing under referenced leaf.

tailf:default-ref

Sets a leaf to the value of another leaf unless it is explicitly set.

```
leaf BVI {
  type uint16 {
    range 1..4094;
  }
}
container encapsulation {
  choice encapsulation-choice {
    container dot1q {
      presence true;
      leaf tag {
        type uint16 {
          range 1..4094;
        }
        tailf:default-ref "../../../BVI";
      }
    }
  }
}
```

tailf:cli-show-with-default

Allows to display leaf in configuration even if it is set to the default value.

```
leaf mtu-size {
  tailf:cli-show-with-default;
  type uint16;
  default 1500;
}
```

```
admin@ncs# show run SERVICE
SERVICE
 interface GigabitEthernet 0/0
  mtu-size    1500
  !
 !
```

WITH

```
admin@ncs# show run SERVICE
SERVICE
 interface GigabitEthernet 0/0
 !
!
```

WITHOUT

tailf:cli-expose-key-name

By default when inputting a list element - key name doesn't appear in the CLI. We can expose it.

```
list SERVICE {
    key "device";
    leaf device {
        tailf:cli-expose-key-name;
        type string;
    }
}
```

WITHOUT

```
admin@ncs(config)# SERVICE IOS1
```

WITH

```
admin@ncs(config)# SERVICE device IOS1
```

tailf:hidden

This statement can be used to hide a node from some, or all, northbound interfaces (CLI and Web UI).

```
leaf calculated-lsps {
  tailf:hidden true;
  type string;
}
```

Use it as a storage!

Container

presence

If you want to make container optional (where you have mandatory leaf elements). If anything is configured under container – the container will be true, if nothing is configured under the container – then it is absent (false).

```
container routing-protocol {
  container bgp {
    presence true;
    // MANDATORY LEAF elements
  }
  container ospf {
    presence true;
    // MANDATORY LEAF elements
  }
}
```

tailf:cli-flatten-container

```
container customer {
  tailf:cli-flatten-container;
  leaf name {
    type string;
  }
  leaf address {
    type string;
  }
}
container interface {
  leaf int-type {
    type string;
  }
  leaf int-id {
    type string;
  }
}
```

Allows the CLI to exit the container and continue to input from the parent container when all leaf elements in the current container has been set.

```
admin@ncs(config)# SERVICE customer name
CLIENT address KRK interface int-type GE
int-id 0/1
```

WITH

```
admin@ncs(config)# SERVICE customer name
CLIENT address KRK
admin@ncs(config)# exit
admin@ncs(config)# interface int-type GE
int-id 0/1
```

WITHOUT

tailf:cli-add-mode

Creates a mode of the container. It can be used in config nodes only.

```
container vrf-config {
  tailf:cli-add-mode;
  leaf vrf-name {
    type string;
  }
  leaf local-as-number {
    tailf:info "BGP AS";
    type enumeration {
      enum 12345;
      enum 23456;
     }
  }
}
```

```
admin@ncs(config)# SERVICE IOS0 vrf-config
<ENTER>
admin@ncs(config-vrf-config)# ?
Possible completions:
  local-as-number
  vrf-name
```

WITH

```
admin@ncs(config)# SERVICE IOS0 vrf-config
----------------------------------------^
syntax error: incomplete path
admin@ncs(config)# SERVICE IOS0 vrf-config ?
Possible completions:
  local-as-number
  vrf-name
```

WITHOUT

List

min-elements/max-elements

Specify minimum/maximum number of elements that have to occur in this list or leaf-list.

```
list FastEthernet {
    tailf:info "FastEthernet port";
    key port;
    max-elements 1;
    min-elements 1;
    leaf port {
        type string;
    }
}
```

tailf:cli-flat-list-syntax

Allow operators to enter the leaf-list values without the brackets.

```
leaf-list vrf-name {
    tailf:cli-flat-list-syntax;
    type string;
}
```

```
admin@ncs(config)# SERVICE vrf-name [ VRF1 VRF2 ]
```

WITHOUT

```
admin@ncs(config)# SERVICE vrf-name VRF1 VRF2
```

WITH

tailf:cli-compact-syntax

```
container vrf-config {
  tailf:cli-compact-syntax;
  leaf vrf {
     type string;
  }

  leaf local-as-number {
    tailf:info "AS Number";
    type enumeration {
      enum 12345;
      enum 23456;
    }
  }
}
```

Use the compact representation for this node in the 'show running-configuration' command (all leaf elements are shown in a single line).

```
admin@ncs# show running-config SERVICE
SERVICE service
 vrf-config vrf vrf1 local-as-number 12345
!
```

WITH

```
admin@ncs# show running-config SERVICE
SERVICE service
 vrf-config vrf vrf1
 vrf-config local-as-number 12345
!
```

WITHOUT

tailf:cli-sequence-commands

```
list link {
    tailf:cli-sequence-commands;
    key "id";
    leaf id {
        mandatory true;
        type string;
    }
    leaf source {
        type inet:ipv4-address;
    }
    leaf destination {
        type inet:ipv4-address;
    }
}
```

Enforces the exact order while inputting parameters. The order is the same as in the YANG model.

```
admin@ncs(config)# SERVICE link primary ?
Possible completions:
  source  <cr>
```

WITH

```
admin@ncs(config)# SERVICE link primary ?
Possible completions:
  destination  source  <cr>
```

WITHOUT

tailf:cli-incomplete-command

```
container dhcp {
  leaf port {
    tailf:cli-incomplete-command;
    type uint16;
  }
  leaf subnet {
    type inet:ipv4-prefix;
  }
}
```

Specifies that an auto-rendered command should be considered incomplete. Can be used to prevent "<cr>" from appearing in the completion list for optional internal nodes.

```
admin@ncs(config)# SERVICE dhcp port 12 ?
Possible completions:
  subnet
```

WITH

```
admin@ncs(config)# SERVICE dhcp port 12 ?
Possible completions:
  subnet  <cr>
```

WITHOUT

Use Cases

Vendor agnostic interfaces modelling

Vendor agnostic interfaces modelling

```
container ios-xr {
  tailf:cli-drop-node-name;
  when "/ncs:devices/ncs:device[ncs:name=current()/../hostname]/
         ncs:platform/ncs:name = 'ios-xr'";
  list interfaces {
    key "interface-type port";
    leaf interface-type {
      type enumeration {
        enum GigabitEthernet;
        enum TenGigabitEthernet;
        enum BundleEthernet;
      }
    }
    leaf port {
      type string;
    }
  }
}
```

Vendor agnostic interfaces modelling

```
container junos {
  tailf:cli-drop-node-name;
  when "/ncs:devices/ncs:device[ncs:name=current()/../hostname]/
         ncs:platform/ncs:name = 'junos'";
  list interfaces {
    key "interface-type port";
    leaf interface-type {
      mandatory true;
      type enumeration {
        enum xe-;
        enum ge-;
        enum ae-;
      }
    }
    leaf port {
      type string;
    }
  }
}
```

CLI Autocomplete Action

```
list l3vpn-service {
    key "device";
    leaf device {
      type string;
    }
    list interface {
      key "interface-type port";
      uses ncs:service-data;
      ncs:servicepoint l3vpn-servicepoint;
      leaf interface-type {
        type enumeration {
          enum GigabitEthernet;
          enum TenGigE;
        }
      }
      leaf port {
        type string;
        tailf:cli-completion-actionpoint "l3vpn-cli-completion-action";
      }
    }
  }
```

YANG

Python

```python
from _ncs.dp import action_reply_completion

## ACTION

def cb_completion(self, uinfo, cli_style, token, completion_char, kp,
                  cmdpath, cmdparam_id, simpleType, extra):

  ## OPENED MAAPI TRANSACTION
  result_list = []
  strkp = str(kp)

  device_name = strkp.split("l3vpn{")[1].split(" ")[0]
  interface_type = strkp.split("interface")[1].split("{")[1].split("}")[0]
  interface_list = getattr(root.devices.device[device_name].config.cisco_ios
                           _xr__interface, interface_type)
  for interface in interface_list:
    result_list.append((0, interface.id, None))

  action_reply_completion(uinfo, result_list)
```

NSO Developer Studio (YANG)

NSO Developer Studio

```
lea
  leaf                                  NSO Yang Leaf
  leaf-list                             NSO Yang Leaf List
  tailf:action                          NSO tailf:actionpoint

leaf leaf-name {
    type ;
}
  ipv4-and-prefix
  binary
  bits
  boolean
  decimal64
  empty
  enumeration
  identityref
  instance-identifier
  int16
  int32
  int64
```

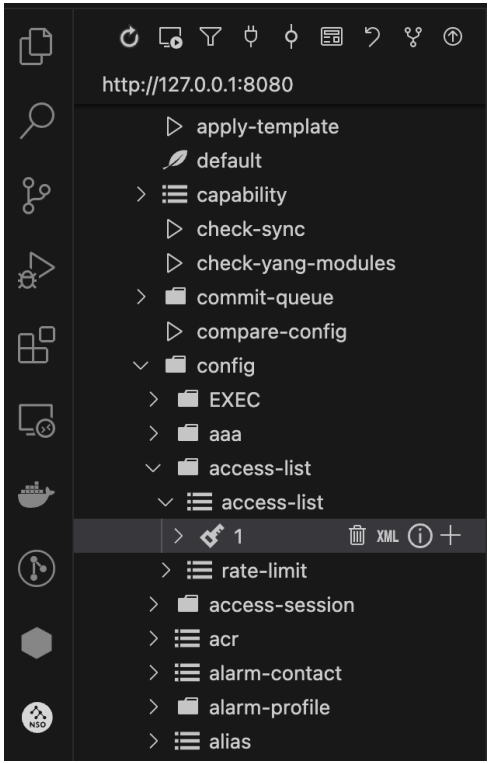
The 'leaf' statement is used to define a leaf node in the schema tree.It takes one argument, which is an identifier, followed by a block of substatements that holds detailed leaf information. RFC 7950, Section 7.6: https://tools.ietf.org/html/rfc7950#section-7.6 (NSO Developer Studio - Developer IDE)

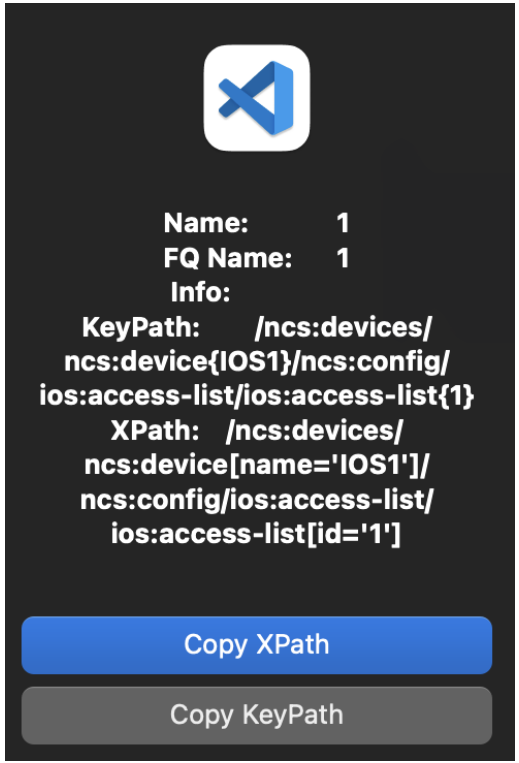
```
leaf leaf-name {
    description 'leaf-description';
    tailf:info 'leaf-info';
    type type-name {

    }
}
```

✓ Utilize YANG IDE

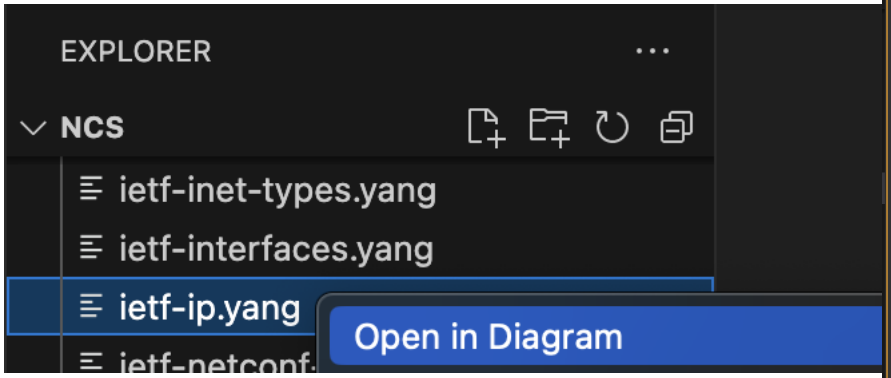
NSO Developer Studio

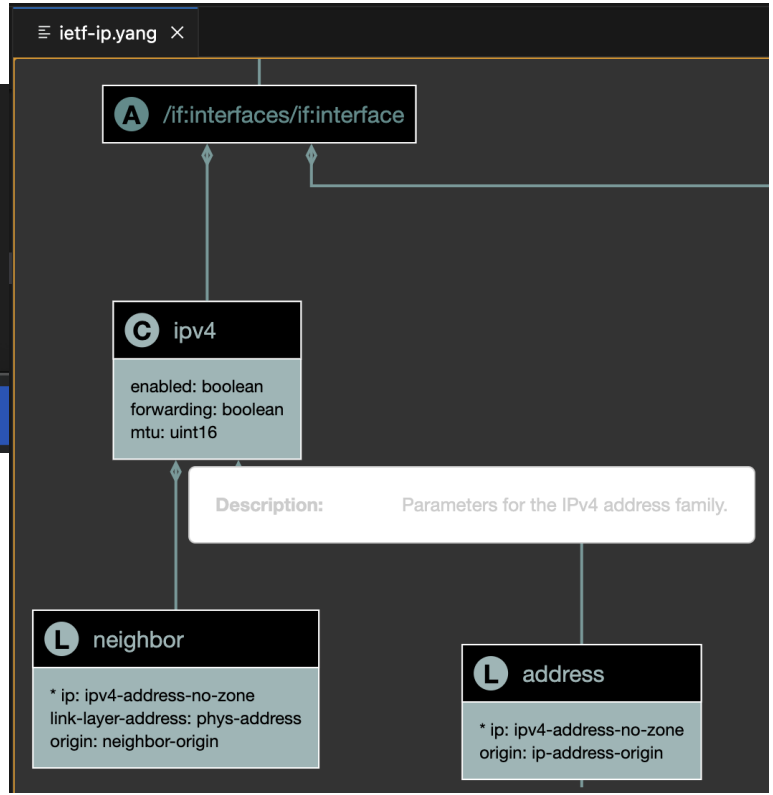




- ✓ Access CDB
- ✓ Copy XPath (or KeyPath)

NSO Developer Studio



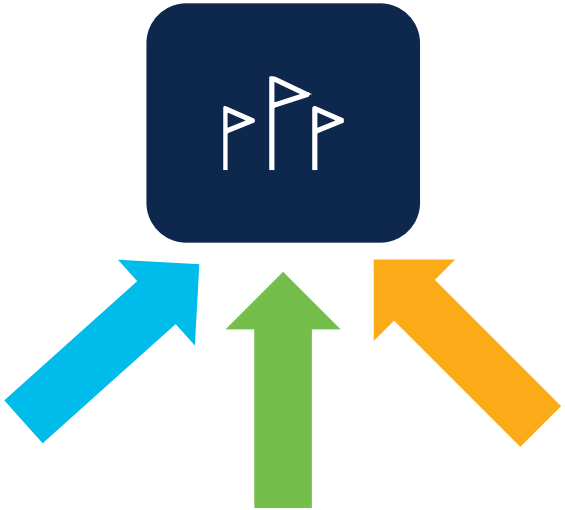


- ✓ View YANG models in diagram

Summary

Summary

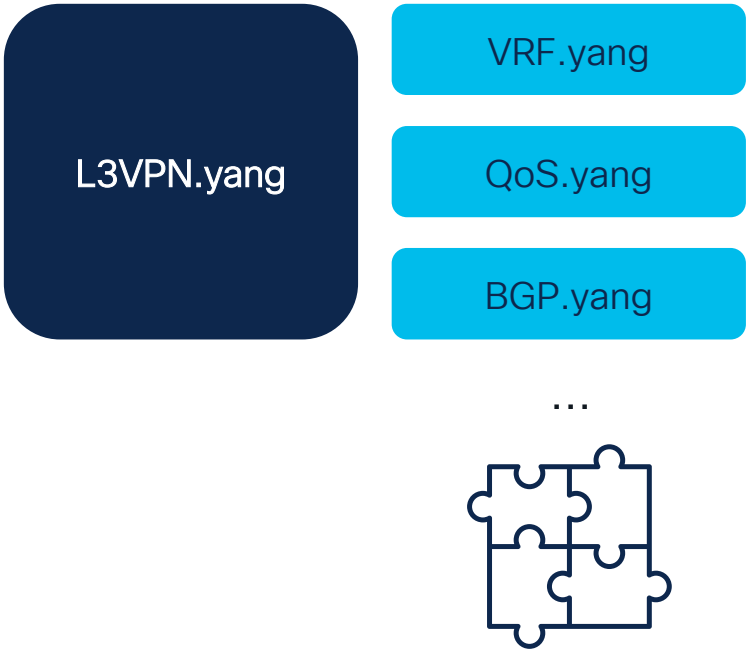
In YANG there are many different ways to accomplish the same goal.



But always follow the **3xM** rule ...

1. Be Modular

- ✓ Use groupings (e.g. interfaces)
- ✓ Decouple modules (e.g. separate VRF, QoS, Routing Protocol from L3VPN)
- ✓ Re-use modules across packages



2. Be Meticulous

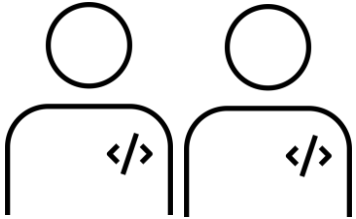
- ✓ Use range, length, pattern etc. to:
  - avoid inconsistency between Service model and NEDs
  - support future tooling around testing (payload generation)
- ✓ Get inspired from NEDs ... but do not copy-paste
- ✓ Declare your modules version

```
container acl { ...
  leaf acl-description {
    type string {
      length "0..64";
      pattern "[0-9a-zA-Z]*";
    }
    description "Purpose of ACL";
  }
```

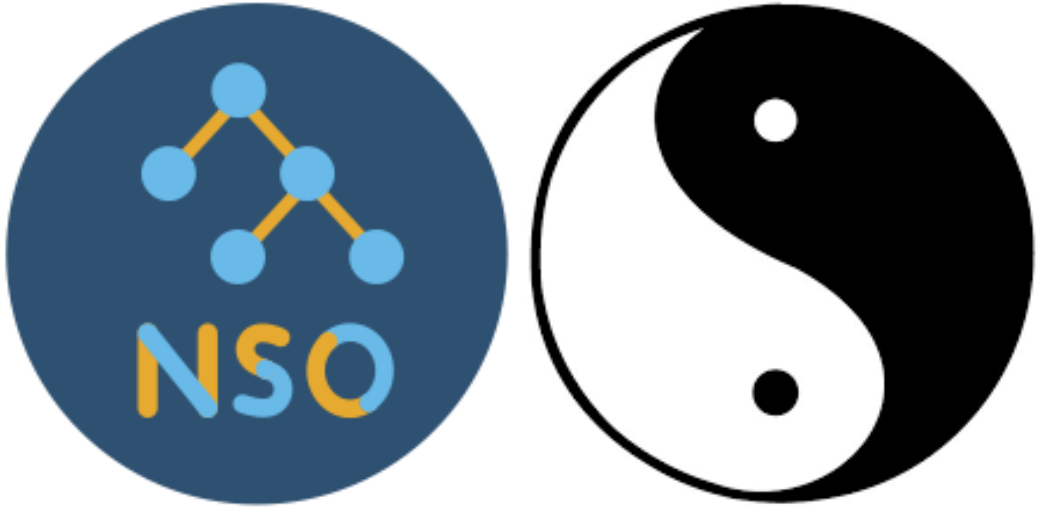
3. Be Mindful!

- ✓ **Keep it simple** for the Operator
  - test flow of the CLI
  - use learnt tricks:
    - containers with **tailf:cli-drop-node-name,** vendor-specific config
    - **tailf:cli-sequence-commands,** speed up operator input flow
    - **tailf:cli-completion-actionpoint,** complex leafref at runtime
    - And many more!

- ✓ Prevent Operator mistakes in Service inputs
  - use range, length, pattern etc.



YIN-YANG



“Automation is as good as the Data Models”

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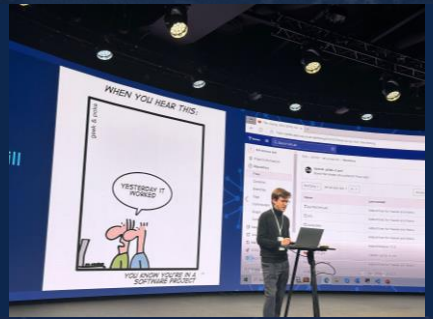

The bridge to possible

Thank you

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