



# IT – NSO Training

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# Agenda

- Day 1: What is NSO?
- Day 2: Using NSO
- Day 3: XML & Yang
- Day 4: Services
- Day 5: Complex Services and Python



# WELCOME TO DAY ONE!

# Agenda

- CONTEXT
- WHY AUTOMATE? WHY NSO?
- THE WHAT & WHY OF NSO
- NSO COMPONENTS
- BASH BASICS

# Training Expectations

- Learning is best when focused, laptops down
- Ask questions
- If unclear, please ask for clarification
- Spark room for question (1 trainer presenting, 1 on Spark)
- Labs are for learning, not merely tasks to be done

# Context

# Automation Maturity Model

NSO: Python API

Python Templates

Service Models

Ad-hoc /  
Scripting

Re-useable  
Frameworks

Orchestration



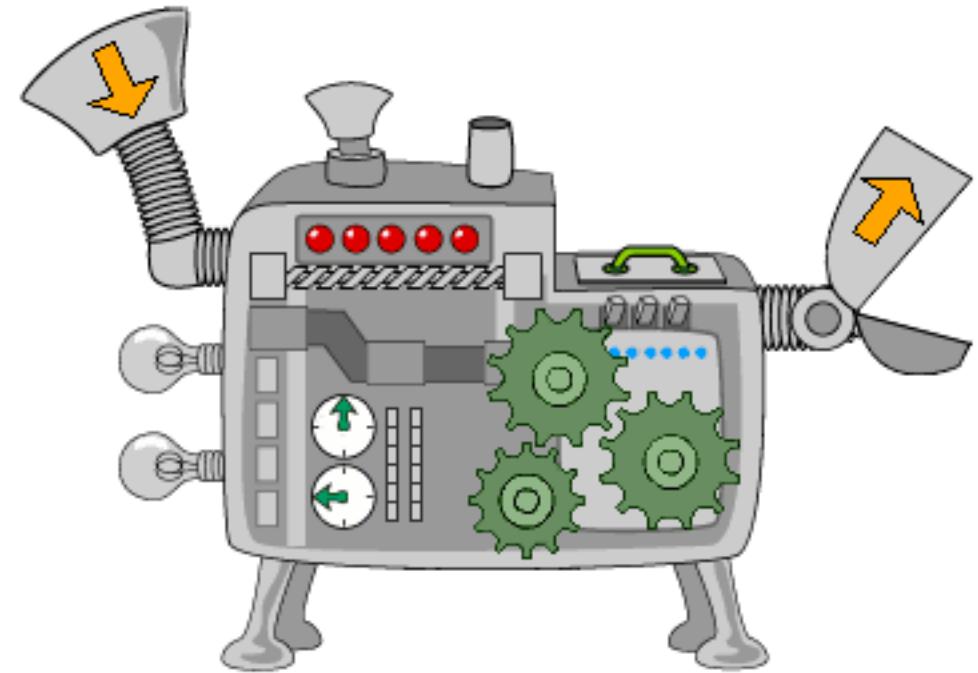
Engineer run  
one-off scripts  
and tools

Centrally managed  
frameworks & templates  
for faster development

Automated configuration lifecycle.  
Creation, Modification and Removal  
automated in one place

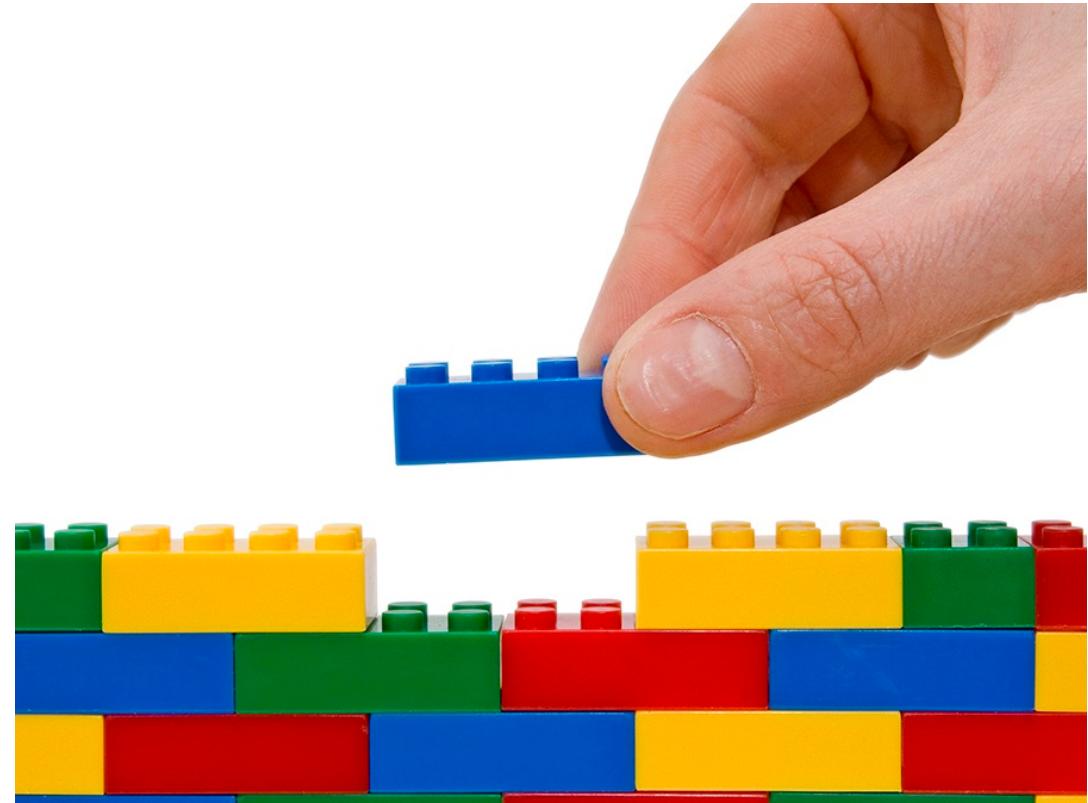
# Automation Maturity Model – Ad Hoc / Scripting

- 1 slide ad-hoc slide example
- 802.1X Script used for EM/MM rollout, generating config
- N2i script
- Most python scripts (using Paramiko, Netmiko, Cisco-Connect)
- Built for a specific purpose, with some minor variations.



# Automation Maturity Model – Re-Usable Frameworks

- Auto-config
- Templates
- Code scaffolds (insert your code here), N02 modules, Cisco-Connect
- Ansible



# Automation Maturity Model – Orchestration

- APIC-EM
- NSO
- ACI APIC



What is one example from each of the 3 categories in the Automation Maturity Model ?



# Demo – Script vs Orchestration

WHY AUTOMATE? WHY NSO?

# Why Automate?

- Changing Skillset of a Network Engineer (everyone automates, not just a dedicated automation engineer)
- Network Infrastructure moving to Software-Defined Everything (NFV, SDA, etc.)
- Maintain and Create a predictable and uniform network, making operations much easier
- Speed to delivery at scale (making changes to 100s of devices)

# Common Objections

- I am too busy to automate, or learn/practice automation skills
- I do not know where to start
- I get stuck setting up my environment
- I get interrupted when I finally get time to try
- I don't see how I can automate this task, it is just easier to do it manually, since I know that will work
- There seems to be too many competing platforms (ansible, NSO, python, NO2, etc.), I don't know which one to use
- I know how to use bash/SNMP/python/perl scripts, I don't need anything else

# Engineers getting started in automation

## **How to fail at network automation?**

1. Start with high-risk, difficult problems.
2. Assume an all-or-nothing mindset (everything has to be automated or nothing can be automated).
3. Try to reinvent everything yourself.
4. Superficially copy code and patterns without comprehension.
5. Fail to learn good debugging processes.
6. [Hugely] over-engineering the solution.

# Engineers getting started in automation

## **How to fail at network automation?**

7. Fail to apply things that you learned on a small scale.
8. Being too busy to automate.
9. Fail to learn how to reuse your code [longer term].
10. Fail to use available developer tools: Git, linters, unit-testing, CI-tools [longer term].

# How to Succeed at Network Automation

- Carve out time in your week where you can learn and practice the skills without interruption (no cell phone, no jabber/spark/email, etc.)
- Have a humble and teachable attitude, being patient while adjusting to the learning curve
- Teach others what you are learning to reinforce the concepts
- Pick a very small task to start with
- Read lots of examples and follow the logic
- Consider not only the problem at hand, but the business process around it
- Don't be afraid to ask others for help if you get stuck
- Use version control (git) and do not hard code passwords in code
- Actively seek to apply your skills to your daily job
- Write code / templates with readability and reusability in mind

# Every Network is Unique vs. Predictable



VS



# (at least) Two Types of Automation

Configuration Management  
(auto-config for example)

```
R1(config-ext-nacl)#do sh access-list OutBoundAccess
Extended IP access list OutBoundAccess
 10 permit ip 192.168.1.0 0.0.0.255 any
 11 deny tcp 192.168.2.0 0.0.0.127 any eq smtp
 12 deny tcp 192.168.2.0 0.0.0.127 any eq sunrpc
 13 deny tcp 192.168.2.0 0.0.0.127 any eq pop2
 14 deny tcp 192.168.2.0 0.0.0.127 any eq nntp
 15 deny tcp 192.168.2.0 0.0.0.127 any eq ftp
 16 deny tcp 192.168.2.0 0.0.0.127 any eq ftp-data
 17 deny tcp 192.168.2.0 0.0.0.127 any eq telnet
 18 deny tcp 192.168.2.0 0.0.0.127 any eq cmd
 19 deny tcp 192.168.2.0 0.0.0.127 any eq irc
 20 permit ip 192.168.2.0 0.0.0.255 any
 30 permit ip 192.168.3.0 0.0.0.255 any
 40 permit ip 192.168.4.0 0.0.0.255 any
 50 permit ip 192.168.5.0 0.0.0.255 any
R1(config-ext-nacl)#[
```

Operational Alerting  
(EMAN Monitoring, Science Logic, etc)



# WHAT IS NSO?

# The Flexibility of NSO

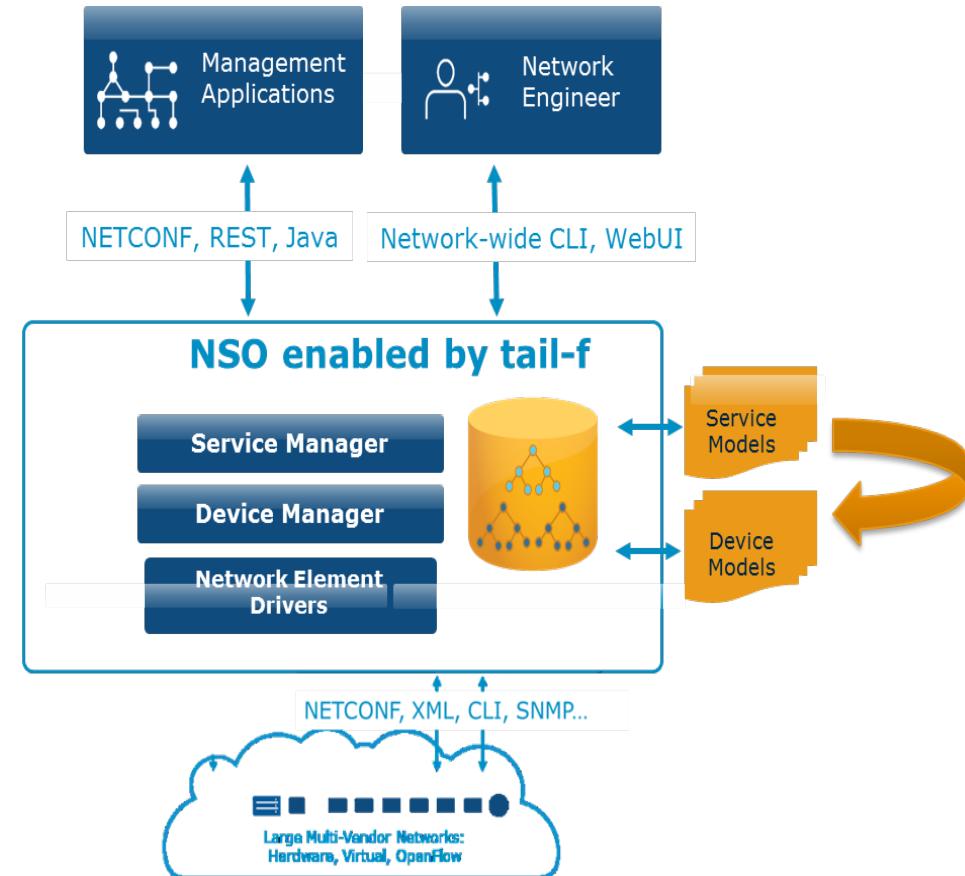
Do you want to build a house or a boat?

NSO gives the tools to do either (metaphorically).



# Network Service Orchestrator Overview

Model Driven  
Transactional  
Automation Engine  
Multi-Vendor  
Built for Network engineers  
API into the Network



# Network Service Orchestrator Components

NorthBound API

REST

WebUI

Python & Java API

NSO Servers

Service Manager

Device Manager

Configuration Database

Multi-Vendor  
Network Element Drivers  
(NED)

IOS

IOS-XR

NX-OS

# The “Service” in Network Service Orchestrator

A Network Service is a collection of configurations across one or multiple devices and servers that enable a capability.

An example is Basic Wireless Service:

Gateway Configuration

Wireless Service

WLC Configuration

Switch Configuration

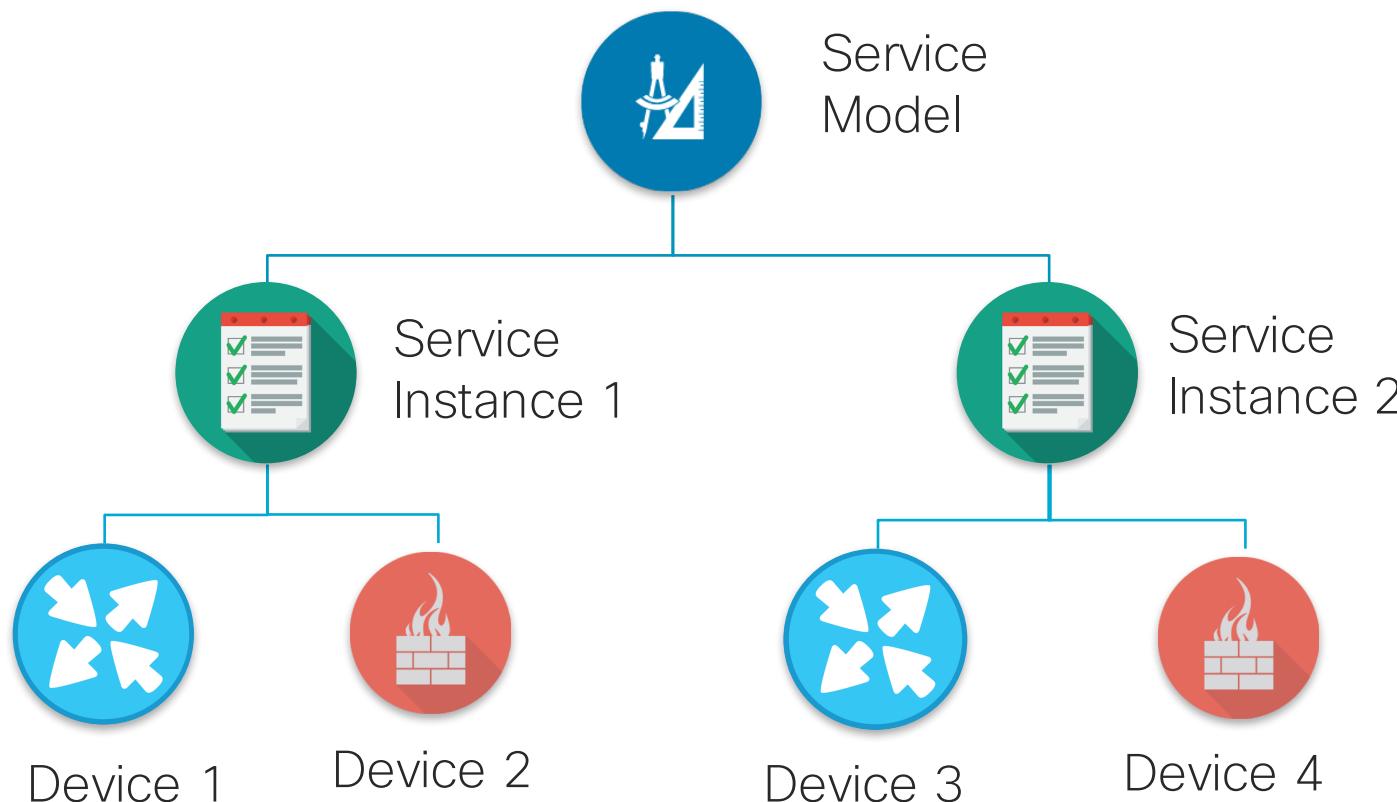


# Why is the ‘S’ in NSO so useful? And what does it stand for?



# NSO Service Manager & Models

NSO Manages Network Services through the Service Model Construct:



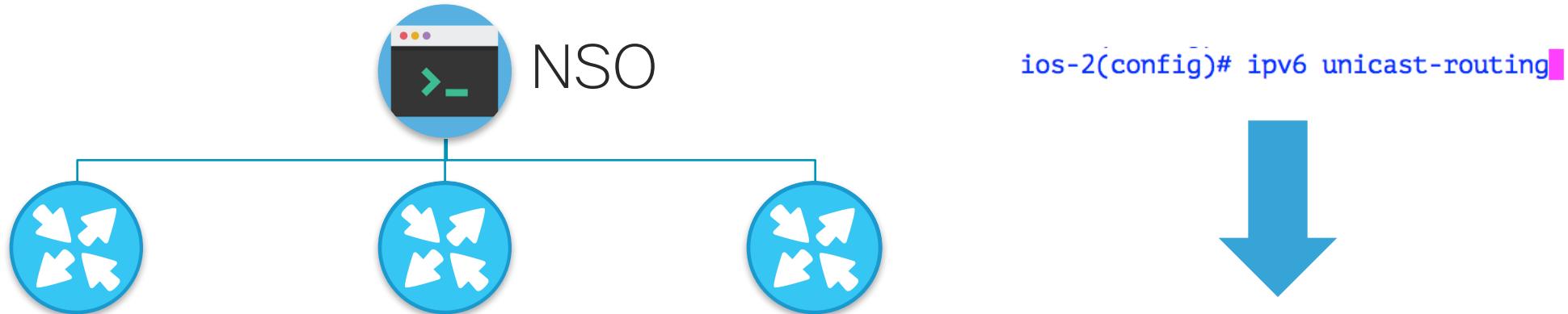
Designed in YANG and modeled with XML templates, code or both

Instantiated in NSO with input parameters  
Service's lifecycle is managed by NSO  
(Deployment, Compliance and Removal)

NSO Pushes configuration based upon service logic  
And input parameters to the devices.

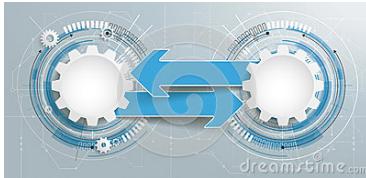
# NSO Device Manager

- Devices are added to NSO to be managed
- NSO Syncs the devices running config into the NSO config Database
- Devices can be bundled into groups and managed collectively
- Makes simple large scale changes trivial (example: ipv6 unicast-routing)



# Network Element Drivers (NED)

```
<spanning-tree xmlns="urn:ios" >
  <extend>
    <system-id/>
  </extend>
  <mode>
    pvst
  </mode>
</spanning-tree>
```



spanning-tree extend system-id  
spanning-tree mode pvst

# Configuration Database

- Keeps copy of managed devices configuration
- Maintains Configurations for network services across instances and devices



# Northbound APIs



## REST API

GET,PUT,POST, DELETE

High Level API into:

NSO Service and Device Manager

## Python API

Low Level and High Level APIs into:

NSO cDB

NSO Transaction Engine

NSO Service and Device Managers

## Java API

Low Level and High Level APIs into:

NSO cDB

NSO Transaction Engine

NSO Service and Device Managers

# Building Blocks of NSO Devices

- NSO can connect to any device assuming it has the IP, login credentials, NED (CLI type)
- NSO device names are independent of DNS lookups, the IP is the key piece of info to connect to the device.
- Devices can be in device groups, you can have device groups of device groups
- To make changes to a device NSO needs a local copy of the Config and the device needs to be unlocked. By default a device is locked when added.

# Building Blocks of NSO Devices

- Typical flow of adding a device:
  - Add required information for device.
  - Unlock device to be able to pull config (default is admin-state locked)
  - Commit changes to NSO
  - Fetch the ssh keys from the device
  - sync-from the device the config, so NSO has local copy of running-config
  - Admin-state lock the device

# Building Blocks of NSO Devices

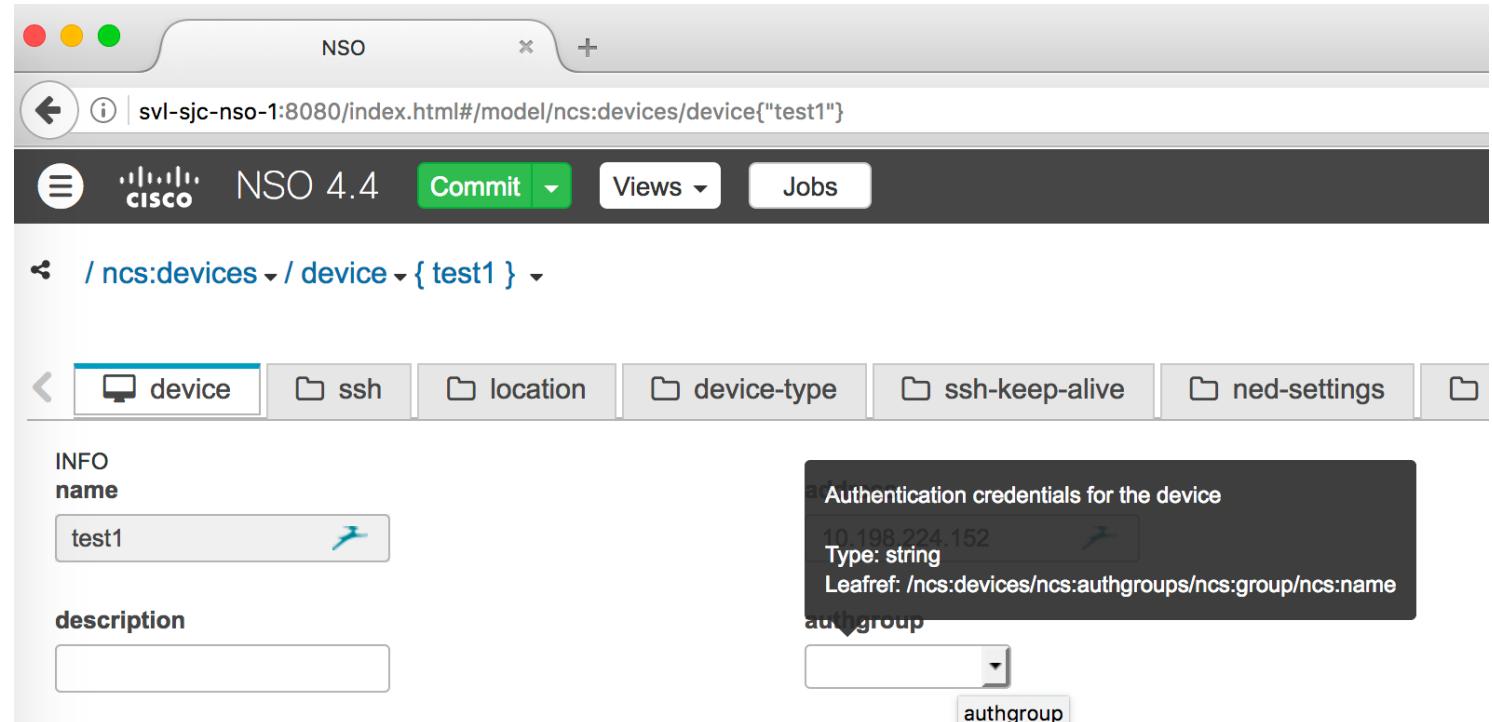
- Typical flow of configuring a device:
  - Enter Config Mode ( ‘config’ )
  - Tell NSO which device or device-group to configure ( ‘devices device DEVICENAME config’ )
  - Use the **NED prefix** (‘ios:’) for commands, **use ‘?’ to verify options**. Some commands have prefix, some don’t depending on how the data is structured in the XML. ( ‘devices device DEVICENAME config ios:interface GigabitEthernet 1/47’)
  - **Don’t use shorthand commands** like gig 1/47 instead of GigabitEthernet 1/47. Use Tab completion instead.

# Building Blocks of NSO CLI

- Everything is within a hierarchy
- Most common commands are under the ‘devices device’ or ‘devices ...’ options.
- Use ‘?’ to explore options
- Use ‘l’ to change output format, debug, or to save output to file. File will be saved to ncs-run directory.
- All changes in config mode need to be committed, all changes can be previewed with commit dry-run

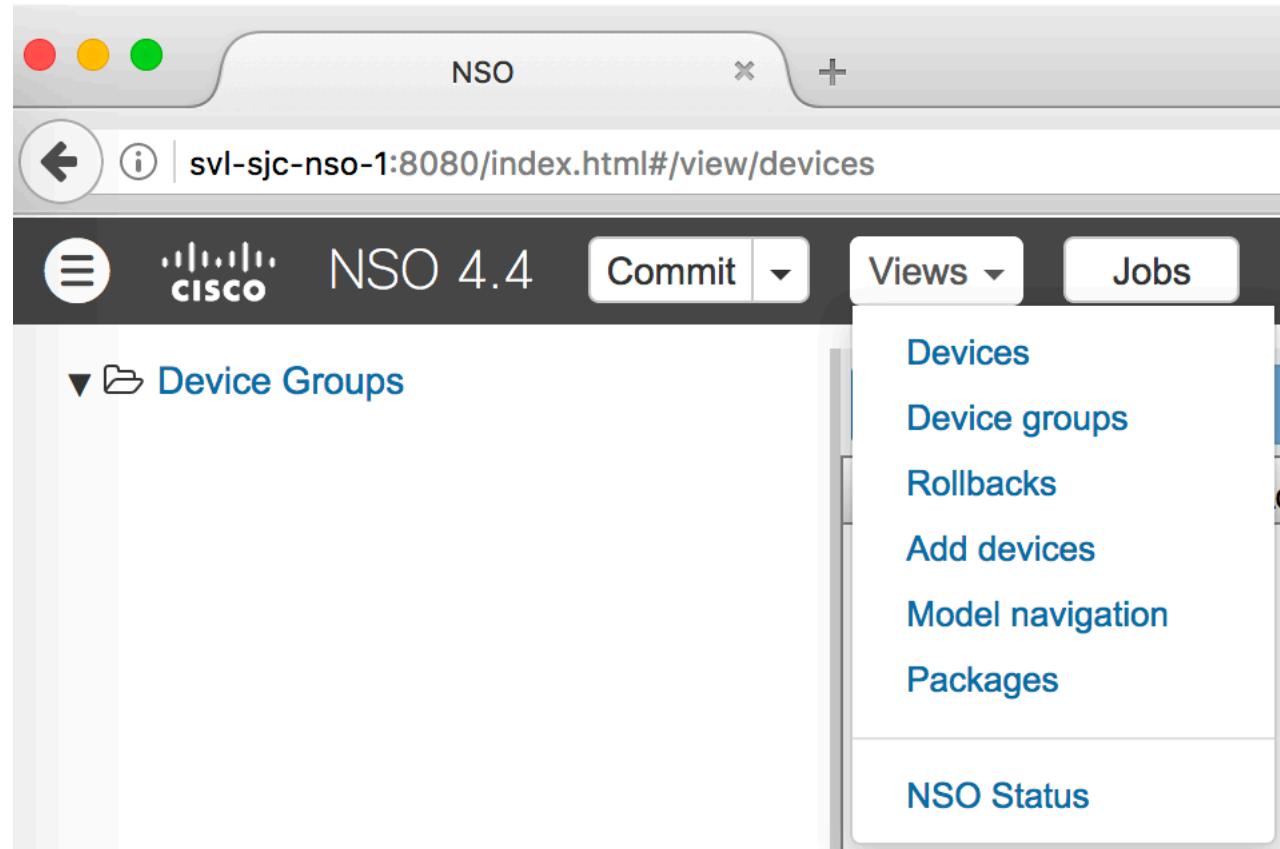
# Demo NSO GUI

- Devices View
- Adding a Device
- Commit
- Commit Dry Run
- Alarms
- Rollback
- Xpath Mouse Hover



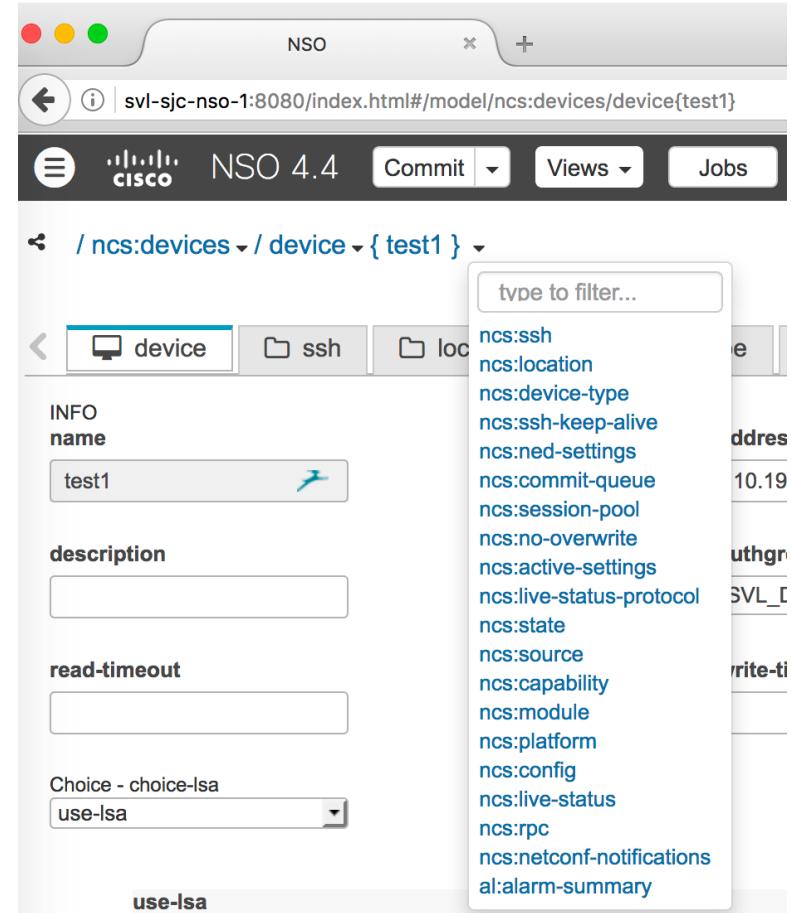
# Building Blocks of NSO GUI

- Everything is within a hierarchy
- Views are good entry points to explore.
- Add devices View allows netsim devices to be added



# NSO GUI Tips

- Use GUI for visualizing the CLI and understanding data model better
- Use arrows at end of breadcrumbs for more options
- Go to Devices, then click on the device name as a hyperlink to go to details



# Lab 1 - Creating Your First Network

# BRACE YOURSELF

# LUNCH IS COMING



# NSO Components: Device Manager

admin@ncs# show devices list					
NAME	ADDRESS	DESCRIPTION	NED ID	ADMIN STATE	
aaaaaaaaaNETSIM	127.0.0.1	-	cisco-ios	unlocked	
aaaaaaaaaa3850LABBY	rtp5-itnlab-3850-sw1.cisco.com	-	cisco-ios	unlocked	
aar02-lab-gw1.cisco.com	10.49.95.153	-	cisco-ios	locked	
aar02-sw1.cisco.com	10.49.95.2	-	cisco-ios	locked	
aar02-wan-gw1.cisco.com	10.49.68.17	-	cisco-ios	locked	

#	Name	Address	Port	Description	Authgroup	Oper State	Admin State
<input type="checkbox"/>	aaaaaaaaaNETSIM	127.0.0.1	10022		default	unknown	unlocked
<input type="checkbox"/>	aaaaaaaaaa3850LABBY	rtp5-itnlab-3850-sw1.cisco.com	22		jabelk.web.auth	unknown	unlocked
<input type="checkbox"/>	aar02-lab-gw1.cisco.com	10.49.95.153	22		jabelk.web.auth	unknown	locked
<input type="checkbox"/>	aar02-sw1.cisco.com	10.49.95.2	22		jabelk.web.auth	unknown	locked
<input type="checkbox"/>	aar02-wan-gw1.cisco.com	10.49.68.17	22		jabelk.web.auth	unknown	locked

# NSO Components: Config Management

The screenshot shows the NSO 4.4 interface with the following navigation path: /ncs:devices / device { aar02-lab-gw1.cisco.com } / config / ios:ip / access-list / standard. The page title is "Standard Access List". A table lists six entries under the heading "std-named-acl".

#	
1	ise-snmp-acl
2	lab_nets
3	match-all
4	multicast_ssm_range
5	npc-snmp-acl
6	servicenow-snmp-acl

```
admin@ncs# show running-config devices device aar02-lab-gw1.cisco.com config ios:ip access-list standard | include ios:  
ios:ip access-list standard ise-snmp-acl  
ios:ip access-list standard lab_nets  
ios:ip access-list standard match-all  
ios:ip access-list standard multicast_ssm_range  
ios:ip access-list standard npc-snmp-acl  
ios:ip access-list standard servicenow-snmp-acl  
admin@ncs#
```

# NSO Components: Config Management

The screenshot shows the NSO 4.4 interface with the following navigation path: / ncs:devices / device { aar02-lab-gw1.cisco.com } / config / ios:ip / access-list / standard / std-named-acl { lab\_nets }.

The interface displays a table of access list rules:

#	rule (k)
<input type="checkbox"/>	permit 10.49.95.153
<input type="checkbox"/>	permit 10.49.96.0 0.0.0.255
<input type="checkbox"/>	permit 10.49.95.164 0.0.0.3

Below the interface, a terminal window shows the running configuration for the device:

```
admin@ncs# show running-config devices device aar02-lab-gw1.cisco.com config ios:ip access-list standard lab_nets
devices device aar02-lab-gw1.cisco.com
config
  ios:ip access-list standard lab_nets
    permit 10.49.95.153
    permit 10.49.96.0 0.0.0.255
    permit 10.49.95.164 0.0.0.3
!
!
!
admin@ncs#
```

# Individual or Group device Configuration

```
admin@ncs(config)# devices device aar02-lab-gw1.cisco.com config
admin@ncs(config-config)# ios:ip access-list standard lab_nets
admin@ncs(config-std-nacl)# permit 127.0.0.1
admin@ncs(config-std-nacl)# permit 172.0.0.2
admin@ncs(config-std-nacl)# commit dry-run outformat native
native {
    device {
        name aar02-lab-gw1.cisco.com
        data ip access-list standard lab_nets
            permit 127.0.0.1
            permit 172.0.0.2
        !
    }
}
admin@ncs(config-std-nacl)#
```

# Static Templates

```
admin@ncs(config)# devices template "lab_nets template example"
admin@ncs(config-template-lab_nets template example)# config
admin@ncs(config-config)# ios:ip access-list standard std-named-acl lab_nets
admin@ncs(config-std-named-acl-lab_nets)# std-access-list-rule "permit 127.0.0.1"
admin@ncs(config-std-access-list-rule-permit 127.0.0.1)# exit
admin@ncs(config-std-named-acl-lab_nets)# std-access-list-rule "permit 127.0.0.2"
admin@ncs(config-std-access-list-rule-permit 127.0.0.2)# commit dry-run outformat native
native {
}
```

# Static template creation

```
admin@ncs(config-std-access-list-rule-permit 127.0.0.2)# commit dry-run
cli {
  local-node {
    data devices {
      +   template "lab_nets template example" {
        +     config {
          +       ios:ip {
            +         access-list {
              +           standard {
                +             std-named-acl lab_nets {
                  +               std-access-list-rule "permit 127.0.0.1";
                  +               std-access-list-rule "permit 127.0.0.2";
                +             }
              +           }
            +         }
          +       }
        +     }
      +   }
    + }
  }
}
admin@ncs(config-std-access-list-rule-permit 127.0.0.2)#

```

# Static template applied to a device

```
admin@ncs(config)# devices device aar02-lab-gw1.cisco.com apply-template template-name ?
Possible completions:
  lab_nets template example
admin@ncs(config)# devices device aar02-lab-gw1.cisco.com apply-template template-name lab_nets\ template\ example
apply-template-result {
    device aar02-lab-gw1.cisco.com
    result ok
}
admin@ncs(config)# commit dry-run outformat native
native {
    device {
        name aar02-lab-gw1.cisco.com
        data ip access-list standard lab_nets
            permit 127.0.0.1
            permit 127.0.0.2
        !
    }
}
admin@ncs(config)#
```

# Template with Variables

## Template with variables

```
admin@ncs(config)# devices template template_with_vars
admin@ncs(config-template-template_with_vars)# config
admin@ncs(config-config)# ios:ip access-list standard std-named-acl {$LIST-NAME}
admin@ncs(config-std-named-acl-{$LIST-NAME})# std-access-list-rule {$ACL-RULE}
admin@ncs(config-std-access-list-rule-{$ACL-RULE})# exit
admin@ncs(config-std-named-acl-{$LIST-NAME})# std-access-list-rule {$ACL-RULE-2}
admin@ncs(config-std-access-list-rule-{$ACL-RULE-2})# commit
Commit complete.
admin@ncs(config-std-access-list-rule-{$ACL-RULE-2})# █
```

## Original Static template without variables

```
admin@ncs(config)# devices template "lab_nets template example"
admin@ncs(config-template-lab_nets template example)# config
admin@ncs(config-config)# ios:ip access-list standard std-named-acl lab_nets
admin@ncs(config-std-named-acl-lab_nets)# std-access-list-rule "permit 127.0.0.1"
admin@ncs(config-std-access-list-rule-permit 127.0.0.1)# exit
admin@ncs(config-std-named-acl-lab_nets)# std-access-list-rule "permit 127.0.0.2"
admin@ncs(config-std-access-list-rule-permit 127.0.0.2)# commit dry-run outformat native
native {  
}
```

- Variable using syntax {\$somename} (upper or lower case)
- In this case list-name replaces lab\_nets
- Acl-rule replaces “permit 127.0.0.1”
- Acl-rule-2 replaces “permit 127.0.0.2”
- Note that NSO IOS NED represents the ACL syntax as an entire string unit (includes permit + rule within the variable, for example, Nexus NED has separate values for each part of the rule)

# Template with variables application

```
admin@ncs(config-device-aar02-lab-gw1.cisco.com)# apply-template template-name template_with_var
variable { name LIST-NAME value 'lab_nets' } variable { name ACL-RULE value 'permit\ 127.0.0.1'
variable { name ACL-RULE-2 value 'permit\ 127.0.0.2' }
apply-template-result {
    device aar02-lab-gw1.cisco.com
    result ok
}
admin@ncs(config-device-aar02-lab-gw1.cisco.com)# commit dry-run outformat native
native {
    device {
        name aar02-lab-gw1.cisco.com
        data ip access-list standard lab_nets
            permit 127.0.0.1
            permit 127.0.0.2
        !
    }
}
admin@ncs(config-device-aar02-lab-gw1.cisco.com)#[
```

- Note that the variables are inclosed in single quotes and words with spaces need an escape character '\'

# Check Sync and out of band changes

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com check-sync  
result in-sync
```

Now I logged in a separate ssh session and made a change (without NSO knowing it)

```
rtp5-itnlab-dt-sw1(config-if)#int gigabitEthernet 1/5  
rtp5-itnlab-dt-sw1(config-if)#desc  
rtp5-itnlab-dt-sw1(config-if)#description automation_test  
rtp5-itnlab-dt-sw1(config-if)#end  
rtp5-itnlab-dt-sw1#wr  
Building configuration...  
Compressed configuration from 138460 bytes to 37538 bytes[OK]  
rtp5-itnlab-dt-sw1#
```

# Check-Sync/Compare-Config with difference

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com check-sync
result out-of-sync
info got: 9effb7a4329ebeb30f95cb91f46d7026 expected: 710cd4880d4214b48de34f937ff5ec02

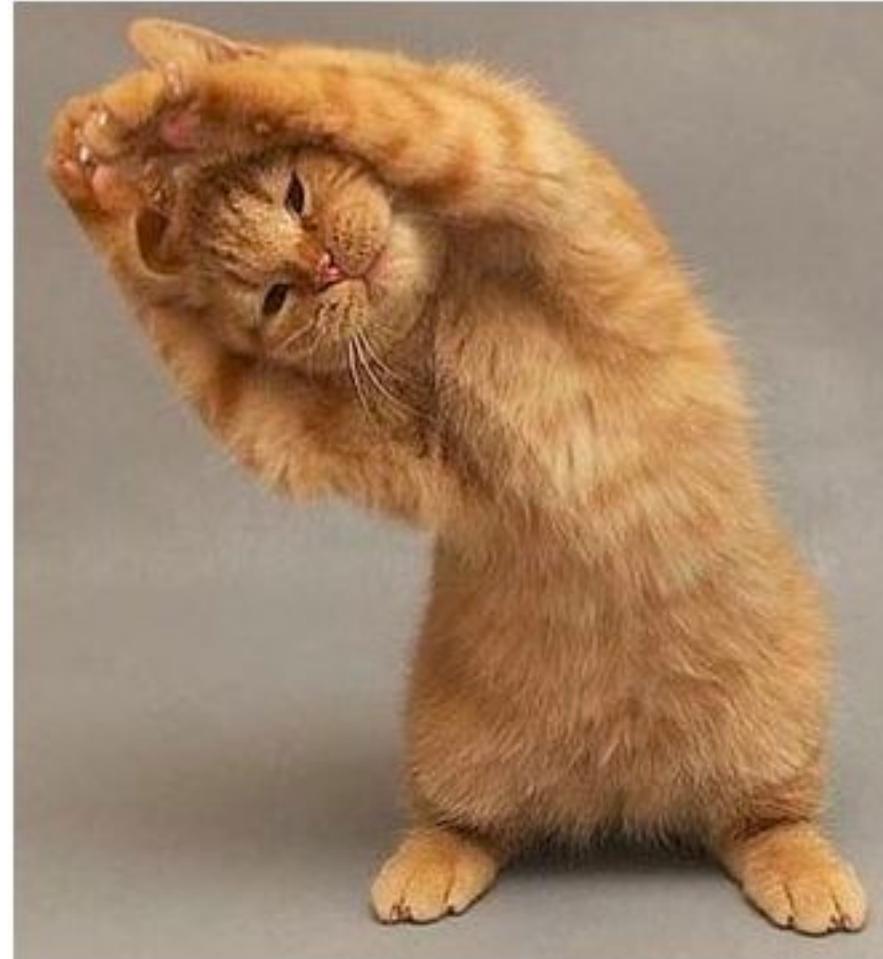
admin@ncs# *** ALARM out-of-sync: got: 9effb7a4329ebeb30f95cb91f46d7026 expected: 710cd4880d4214b48de34f937ff5ec02

admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com compare-config
diff
devices {
    device rtp5-itnlab-dt-sw1.cisco.com {
        config {
            ios:interface {
                GigabitEthernet 1/5 {
                    -           description "applying demosite acl";
                    +           description automation_test;
                }
            }
        }
    }
}
```

# Use Sync-from to make local NSO DB in sync

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com sync-from  
result true  
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com check-sync  
result in-sync  
admin@ncs#
```

# Stretch Break!



# Device Groups, Templates and Rollback

- A device can be added to one or many device group(s), a device group can be nested into another device group
- Templates can either have static configs enforced every time, or variables put in to be declared at the time of usage. Service templates will be covered later.
- You can rollback any change, or part of a change, in NSO through the Rollback in GUI or on CLI (config -> rollback)

# Lab 2 - Configuring Device IOS Config & Templates & Device Groups

# Show Commands

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com live-status ios-stats:exec ?
Possible completions:
any          Execute any command on device
clear        Reset functions
copy         Copy from one file to another
license      Smart licensing Commands
ping         Send echo messages
reload       Halt and perform a cold restart
show         Execute show commands
traceroute   Trace route to destination
verify       Verify a file
```

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com live-status ios-stats:exec any ?
Possible completions:
WORD  any "<cmd> [option(s)]", e.g: any "show ppp summary"
|     Output modifiers
<CR>
```

```
admin@ncs# devices device rtp5-itnlab-dt-sw1.cisco.com live-status ios-stats:exec any "show ip int br"
result
> show ip int br
Interface          IP-Address      OK? Method Status      Protocol
FastEthernet1      unassigned    YES unset  down       down
GigabitEthernet1/1 unassigned    YES unset  down       down
GigabitEthernet1/2 unassigned    YES unset  down       down
GigabitEthernet1/3 unassigned    YES unset  down       down
```

Lab

Open Discussion –  
Feedback, Demos, Deep  
Dives?