Programming for Network Engineers
LABRST-2678

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Table of Contents

Prerequisites

- Basic Python programming, Linux and REST API knowledge
- It is strongly recommended to go through the lab guide. This will give you a good foundation of interacting with NX-OS through various methods other than CLI like Bash, NX-API and Python scripts.

Disclaimer

This training document is to familiarize with Cisco NX-OS programming capabilities. Although the lab design and configuration and python script examples could be used as a reference, it's not a real design, thus not all recommended features are used, or enabled optimally to use in production networks. For the design related questions please contact your representative at Cisco, or a Cisco partner. Else feel free to reach out to us. We will be glad to answer.

Pre-Configuration

Due to limited duration of WISP lab, we have some pre-configuration, already configured to save your time.

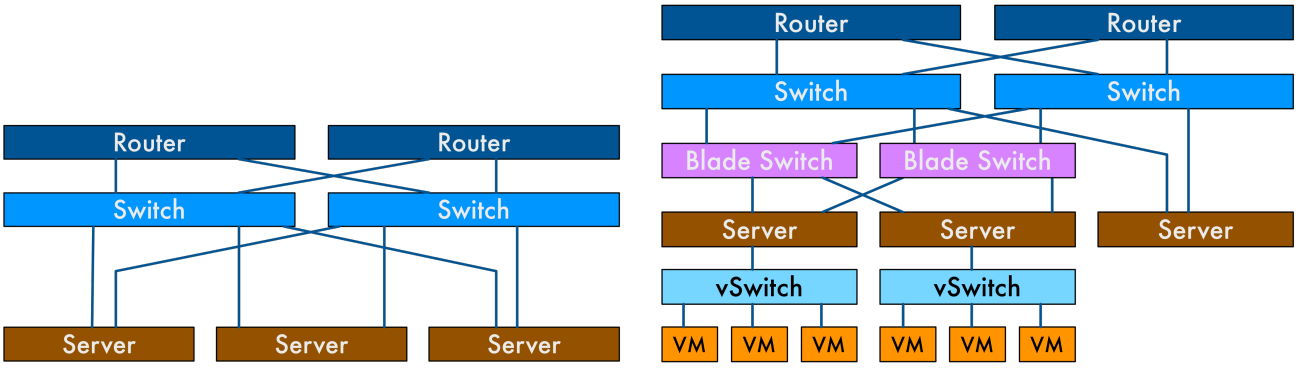
Lab completion

Upon completion of this lab, you will be able to:

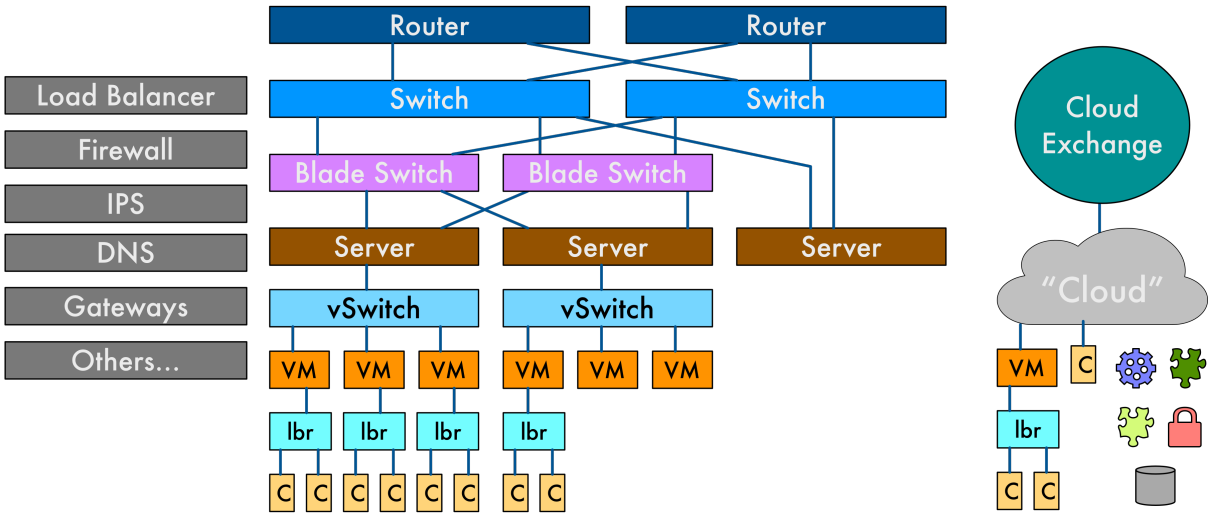
- Describe various use cases and examples of NX-OS network programmability.
- Interact with Cisco NX-OS using various programmable interfaces.
- Use NX-API to communicate with Nexus devices.
- Leverage python scripts to manage network devices.

Introduction

In the SDN Era, the roles and responsibilities of the Network Engineers are drastically changing. Reducing Opex and Faster Time to market are the key business drivers for most of the IT organizations today. As the networks grow in size, it has increased the management and operations complexity to a very high level. State of the Network has changed a lot over the recent years from a simple three tier architecture to multi-level modern network architecture.



Simple Network

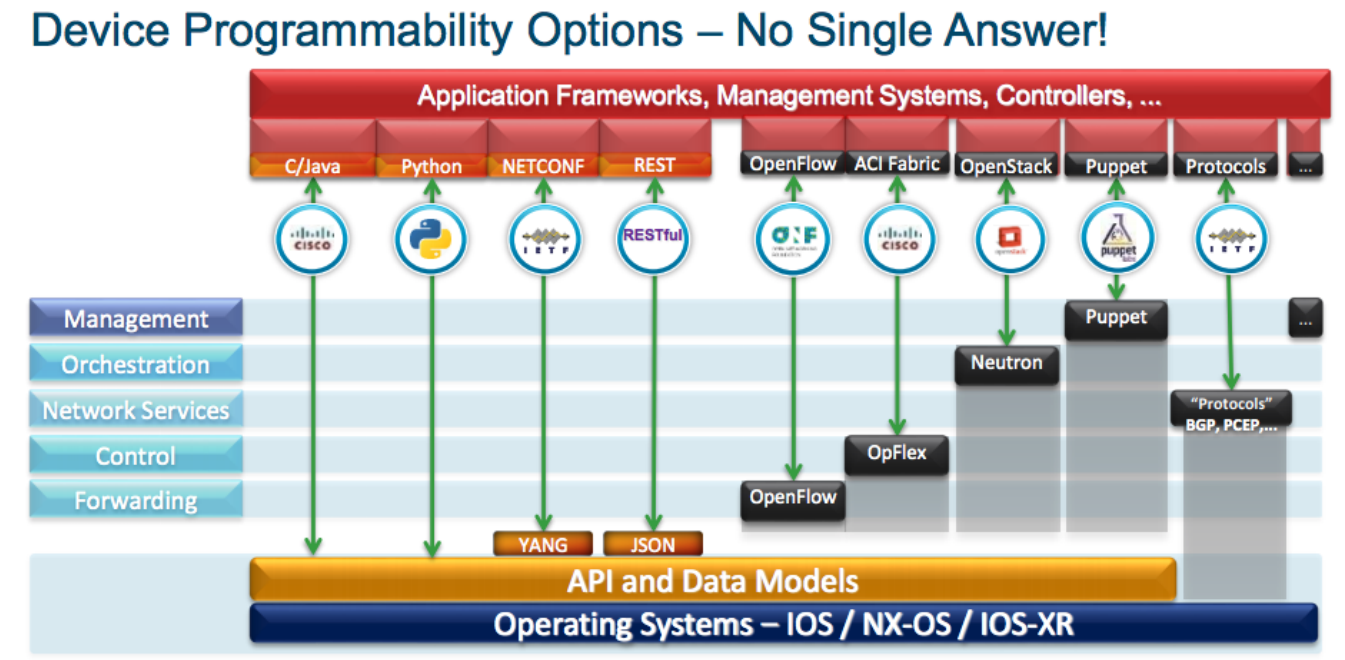


Modern Network

Network Programmability is the new way of communicating with the network devices. In today's world network administrators want programming capabilities in their networking devices for several reasons. The main reason is to automate provisioning, push configuration changes and troubleshoot complex network issues. Yet business and application teams demands the network devices to be provisioned faster, with less resources and no human-error.

CLI is still a critical tool in the network engineers tool kit, it is readily available, easy to use and grants valuable insights about the state of network. Unfortunately, CLI is not without its flaws, especially when it comes to network programmability and automation. CLI is inherently not scalable and it is designed to have 1:1 human interaction which makes it slow. Another issue is that the CLI outputs or data passed over CLI are unstructured raw data which are traditionally designed in a human readable fashion.

So the general rule here is “Use Programmability and Automation whenever possible and fallback to using CLI for the tasks that cannot be automated.



Network Programmability in Cisco can be implemented with these industry standards and free protocols:

- **RESTFul** Interface: In a simple sense, Representational State Transfer (REST) is the standard for common web browsers to interact with a website. Cisco has opened up RESTful interfaces on many routers and switches, and also in other SDN controller and orchestration platforms for Network Programmability.

- **Python**: This free programming language has grown considerably in popularity in the Linux community for years. Cisco has now integrated the interpreted scripting language of python into the NX-OS operating system, ACI and other Cisco platforms.

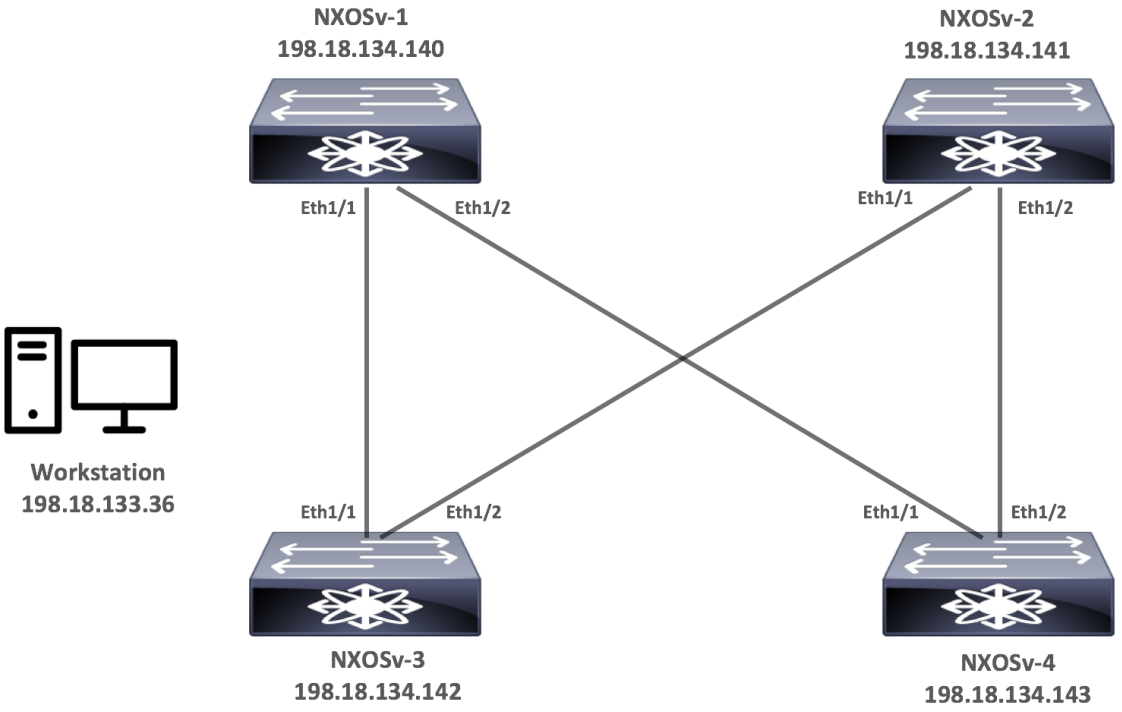
- **XML** and **JSON**: Extensible Markup Language (XML) and JavaScript Object Notation (JSON) are standard data encoding formats that are both human-readable and machine-readable. For instance, an entire router or switch configuration can be displayed in XML or JSON, edited with a text editor, then used with Python or REST to automate changes to the network.

- **Data Models**: A data model is a standard way to define how data relates to other data and how all data is processed and stored. All of the configurations of most networking devices can be represented in a large data model. Data models can then be automated with Network Programmability. Another emerging data model that can be applied to Cisco routers and switches is the YANG model. YANG is a data model from the expression “Yet Another Next Generation,” which is an open standard designed to overcome the weaknesses of SNMP.

The main goal of this lab session is to educate Network engineers about the different access methods available to interact with the Networking devices other than CLI. This lab is designed for Network Engineers who are getting started with programming. The lab demonstrates Cisco NX-OS network programming capabilities by using various access methods like Bash, NX-API and Python. You will learn how to interact with the network devices using SSH and API by leveraging Python libraries and NX-API Sandbox. You will also learn how easy it is to get started with programming and automate basic day to day networking tasks.

Other Cisco Operating Systems and products also supports many more programmability options, please check the Devnet zone, breakout sessions and reference section to learn more on this topic.

Lab Topology



Note: The workstation (wkst1) provides all the required access to the nxos devices

Lab 0: Connect to dCloud lab network

This lab leverages dCloud, which uses virtual servers and switches that runs on a simulator. These devices have most of the functions of actual hardware based devices, but there is no data plane traffic.

You need to VPN into the dCloud environment in order to access devices to complete this lab.

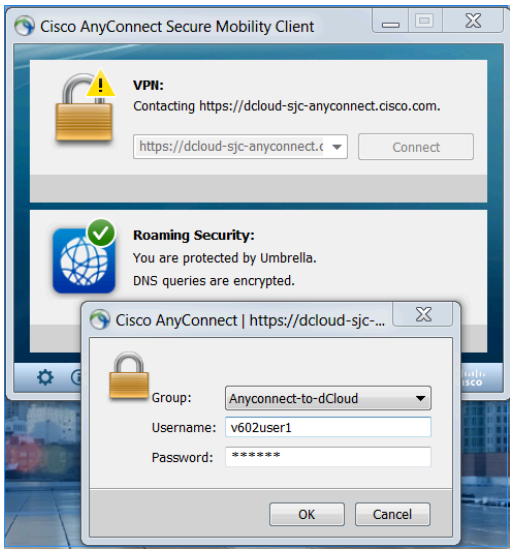
Click on the Cisco AnyConnect client and check to see if the client is connected to another VPN session. If yes, go ahead and disconnect.

To reach dCloud, enter the following server url to connect:

https://dcloud-sjc-anyconnect.cisco.com

For the vpn credentials, input the username and password that is provided by the lab instructor.

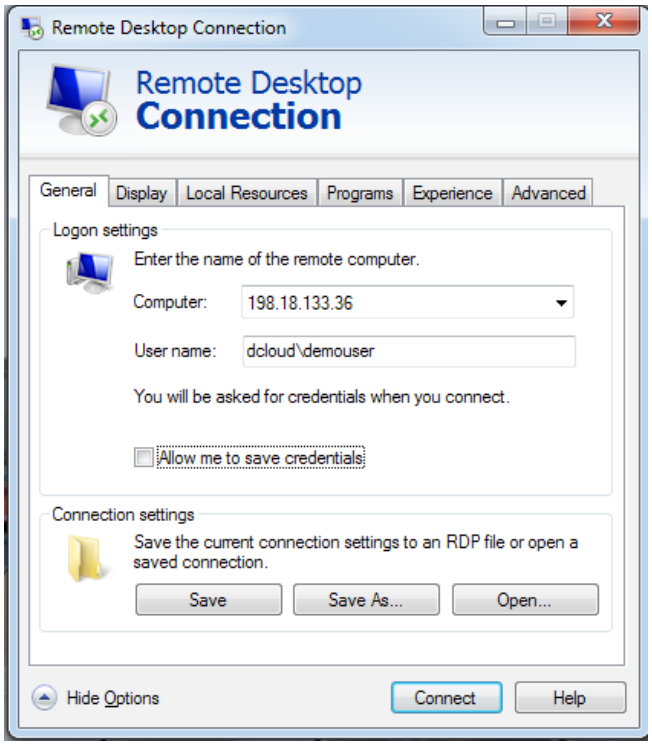
Input the username and password. Click OK.

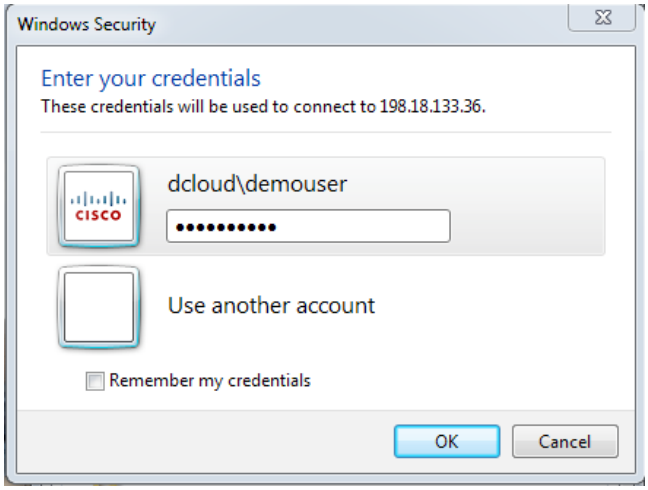


Once VPN connection is successful, you should be able to access the lab environment.

Now open a Remote Desktop Connection (RDP) to the lab workstation.

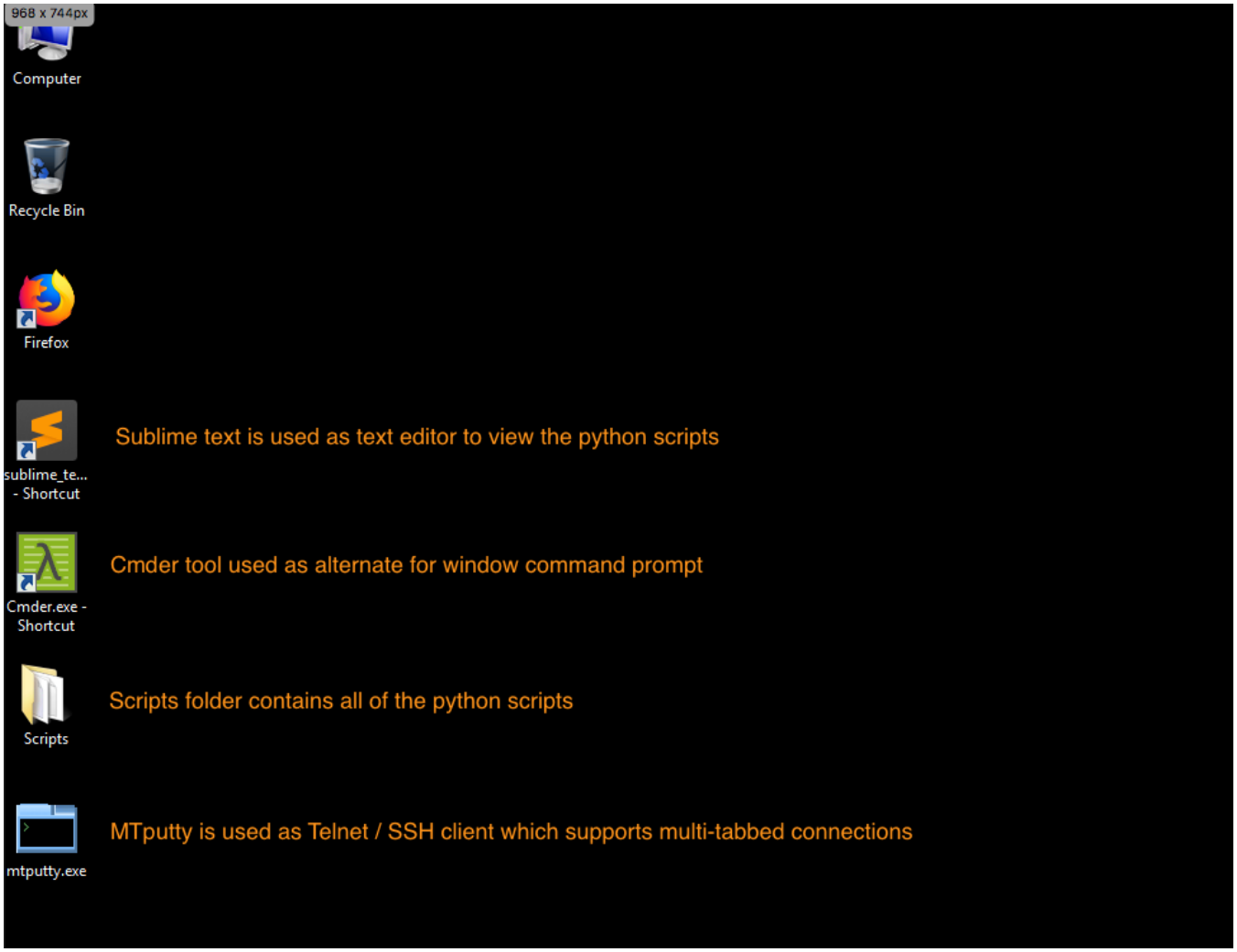
Workstation (Windows 7)
IP Address:
198.18.133.36
Credentials:
username: dcloud\demouser
password: C1sco12345





Enter the password for the RDP connection – C1sco12345

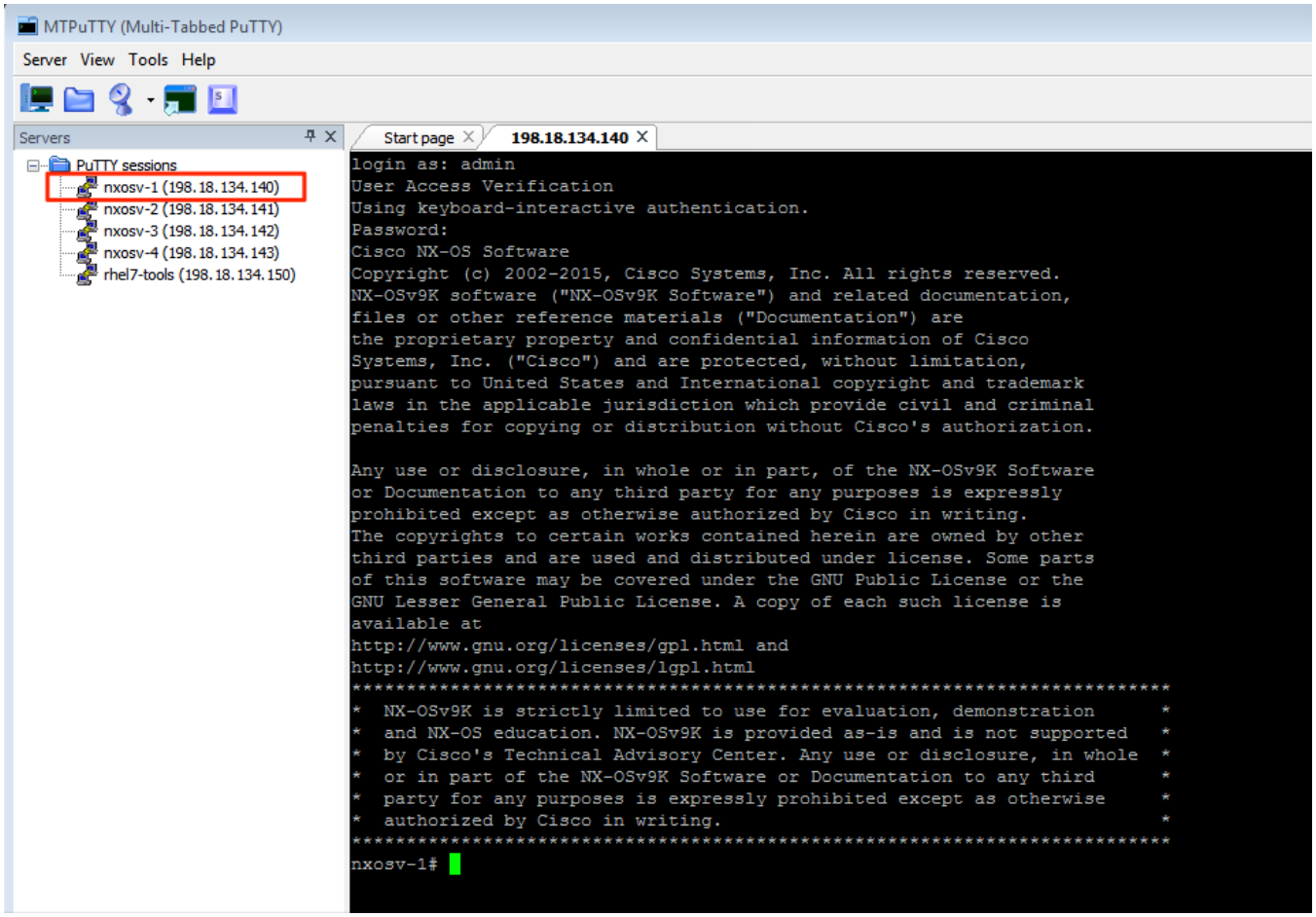
After establishing the RDP connection, you will see a similar desktop screen setup as shown below. Use the tools as needed to complete the lab tasks.



Lab 1: Explore the bash-shell features on the Cisco Nexus 9000 Series Switches

Establish a SSH connection to “nxosv-1” switch using the MTPutty client.

IP Address: 198.18.134.140
Port: 22
Username: admin
Password: C1sco12345



Step 1.1:

In this exercise we will enable the bash shell feature, copy the running config to a temp file, edit the hostname on the temp file and then copy the temp file to the running config.

On the switch CLI enter:

```
nxos-v1#
nxos-v1# conf t
Enter configuration commands, one per line. End with CNTL/Z.
nxos-v1(config)# feature bash-shell
nxos-v1(config)# exit
```

```
nxos-v1# copy running-config bootflash:temp
Copy complete, now saving to disk (please wait)...
nxos-v1#
nxos-v1#
```

switch to bash shell by typing the following command:

```
nxos-v1# run bash
bash-4.2$
bash-4.2$ cd /bootflash/
bash-4.2$
bash-4.2$ pwd
/bootflash
bash-4.2$
bash-4.2$ ls
20151214_185114_poap_8293_init.log   nxos.7.0.3.I2.1.bin  virt_strg_pool_bf_vdc_1
cisco_node_utils-1.1.0.gem           scripts               virtual-instance
home                                 staert                virtual-instance.conf
install_puppet.sh                    temp
n9000_sample-1.0.0-7.0.3.x86_64.rpm
bash-4.2$
bash-4.2$ vi temp
```

Change the hostname to NXOSv-1

```
bash-4.2$
bash-4.2$ more temp
!Command: show running-config
!Time: Sun Jan 28 10:49:46 2018
version 7.0(3)I2(1)
hostname NXOSv-1
vdc nxosv-1 id 1
bash-4.2$
bash-4.2$ exit
exit
nxos-v1#
nxos-v1# copy bootflash:temp running-config
Copy complete.
NXOSv-1#
```

NOTE: Ignore some of the syntax errors but you should see the Hostname changed

```
N9K-04# conf t
Enter configuration commands, one per line. End with CNTL/Z.
N9K-04(config)# feature bash-shell
N9K-04(config)# exit
N9K-04# copy running-config bootflash:temp
Copy complete, now saving to disk (please wait)...
N9K-04# run bash
bash-4.2$ cd /bootflash/
bash-4.2$ pwd
/bootflash
bash-4.2$ ls
20150511_160838_poap_8048_init.log  ResetSwitchConfig
20150511_214829_poap_8086_init.log  scripts
GoldConfigDoNotDelete               temp
home                                virt_strg_pool_bf_vdc_1
n9000-dk9.7.0.3.I2.0.268.bin        virtual-instance
n9000-dplug.7.0.3.I2.0.198.gbin     virtual-instance.conf
bash-4.2$ vi temp
bash-4.2$ exit
exit
N9K-04# copy bootflash:temp running-config
```

***Figure**. Sample screen output for reference*

Step 1.2: Monitoring Processes

In the Bash shell enter:

```
NXOSv-1#
NXOSv-1# run bash
bash-4.2$
bash-4.2$ ps -aux
Warning: bad ps syntax, perhaps a bogus '-'? See http://procps.sf.net/faq.html
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0   4224   688 ?        Ss   03:48   0:03 init [3]
root         2  0.0  0.0      0     0 ?        S    03:48   0:00 [kthreadd]
root         3  0.0  0.0      0     0 ?        S    03:48   0:00 [ksoftirqd/0]
root         4  0.0  0.0      0     0 ?        S    03:48   0:14 [kworker/0:0]
```

***Figure**. Sample screen output for reference*

```
USER       PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root         1  0.0  0.0   4216   700 ?        Ss   Jun02   0:03 init [3]
root         2  0.0  0.0      0     0 ?        S    Jun02   0:00 [kthreadd]
root         3  0.0  0.0      0     0 ?        S    Jun02   0:00 [ksoftirqd/0]
root         6  0.0  0.0      0     0 ?        S    Jun02   0:00 [migration/0]
root         7  0.0  0.0      0     0 ?        S    Jun02   0:00 [watchdog/0]
root         8  0.0  0.0      0     0 ?        S    Jun02   0:00 [migration/1]
root         9  0.0  0.0      0     0 ?        S    Jun02   0:00 [kworker/1:0]
root        10  0.0  0.0      0     0 ?        S    Jun02   0:02 [ksoftirqd/1]
root        11  0.0  0.0      0     0 ?        S    Jun02   0:15 [kworker/0:1]
root        12  0.0  0.0      0     0 ?        S    Jun02   0:00 [watchdog/1]
root        13  0.0  0.0      0     0 ?        S    Jun02   0:00 [migration/2]
root        15  0.0  0.0      0     0 ?        S    Jun02   0:02 [ksoftirqd/2]
root        16  0.0  0.0      0     0 ?        S    Jun02   0:00 [watchdog/2]
root        17  0.0  0.0      0     0 ?        S    Jun02   0:00 [migration/3]
root        18  0.0  0.0      0     0 ?        S    Jun02   0:00 [kworker/3:0]
root        19  0.0  0.0      0     0 ?        S    Jun02   0:02 [ksoftirqd/3]
root        20  0.0  0.0      0     0 ?        S    Jun02   0:00 [watchdog/3]
root        21  0.0  0.0      0     0 ?        S<   Jun02   0:00 [cpuset]
root        22  0.0  0.0      0     0 ?        S<   Jun02   0:00 [khelper]
```

In the bash prompt run the top command.

```
bash-4.2$ top
```

type ‘q’ to quit the command

Figure. *results of the top command*

```
top - 03:02:58 up 1 day, 20:18,  2 users,  load average: 1.19, 1.12, 1.14
Tasks: 261 total,   2 running, 257 sleeping,   0 stopped,   2 zombie
Cpu(s): 17.4%us, 15.5%sy,  0.0%ni, 65.1%id,  0.3%wa,  1.4%hi,  0.2%si,  0.0%st
Mem:  12282516k total,  4373996k used,  7908520k free,   178208k buffers
Swap:        0k total,        0k used,        0k free,  1838888k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 6377 root      20   0  238m  14m 7348 S   99  0.1   2644:44 l2fwder
31592 admin     20   0  323m  52m  40m S   15  0.4   0:00.44 vsh
 7421 root      20   0  233m 9640 6184 S   10  0.1 201:40.13 ecp
31591 root      20   0  225m 9412 7016 S    2  0.1   0:00.07 dcos_sshd
 6211 root      20   0  511m 113m  75m S    1  0.9  30:03.96 svc_ifc_policye
 6243 root      20   0  577m  99m  62m S    1  0.8  28:22.94 svc_ifc_eventmg
 6309 root      20   0  522m  86m  47m S    1  0.7  27:45.47 svc_ifc_confele
 6315 root      20   0  327m  53m  39m S    1  0.4   0:05.05 aaad
 6452 root      20   0  807m  86m  43m S    1  0.7   1:22.74 netstack
 6202 root      20   0  335m  61m  39m S    0  0.5   0:39.78 syslogd
31324 root      20   0  225m 9348 6944 S    0  0.1   0:00.17 dcos_sshd
31587 admin     20   0 19512 1436  976 R    0  0.0   0:00.09 top
    1 root      20   0  4216  700  604 S    0  0.0   0:03.27 init
    2 root      20   0     0    0    0 S    0  0.0   0:00.00 kthreadd
    3 root      20   0     0    0    0 S    0  0.0   0:00.31 ksoftirqd/0
    6 root      RT   0     0    0    0 S    0  0.0   0:00.24 migration/0
    7 root      RT   0     0    0    0 S    0  0.0   0:00.07 watchdog/0
    8 root      RT   0     0    0    0 S    0  0.0   0:00.44 migration/1
    9 root      20   0     0    0    0 S    0  0.0   0:00.00 kworker/1:0
   10 root      20   0     0    0    0 S    0  0.0   0:02.55 ksoftirqd/1
   11 root      20   0     0    0    0 S    0  0.0   0:15.25 kworker/0:1
   12 root      RT   0     0    0    0 S    0  0.0   0:00.12 watchdog/1
   13 root      RT   0     0    0    0 S    0  0.0   0:00.42 migration/2
   15 root      20   0     0    0    0 S    0  0.0   0:02.71 ksoftirqd/2
   16 root      RT   0     0    0    0 S    0  0.0   0:00.12 watchdog/2
   17 root      RT   0     0    0    0 S    0  0.0   0:00.37 migration/3
   18 root      20   0     0    0    0 S    0  0.0   0:00.00 kworker/3:0
   19 root      20   0     0    0    0 S    0  0.0   0:02.80 ksoftirqd/3
   20 root      RT   0     0    0    0 S    0  0.0   0:00.18 watchdog/3
   21 root       0 -20     0    0    0 S    0  0.0   0:00.00 cpuset
   22 root       0 -20     0    0    0 S    0  0.0   0:00.00 khelper
   23 root      20   0     0    0    0 S    0  0.0   0:00.00 kdevtmpfs
   24 root       0 -20     0    0    0 S    0  0.0   0:00.00 netns
   25 root      20   0     0    0    0 S    0  0.0   0:00.34 sync_supers
   26 root      20   0     0    0    0 S    0  0.0   0:00.00 bdi-default
   27 root       0 -20     0    0    0 S    0  0.0   0:00.00 kblockd
```

Step 1.3: Controlling interfaces with Linux commands

The version of code on our lab Nexus 9000 supports the iproute2(ip link show) package as well as the older net-tools(ifconfig). Spend a few minutes trying each of the commands below:

In the Bash shell enter:

```
bash-4.2$ip address show

bash-4.2$ip link show

bash-4.2$ifconfig
```

Figure. *Output screen of previous commands*

```
bash-4.2$ ip address show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/16 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
4: eth2: <BROADCAST,MULTICAST,PROMISC,UP,LOWER_UP> mtu 1500 qdisc mq state UNKNOWN qlen 1
000
    link/ether 00:50:56:91:40:80 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::250:56ff:fe91:4080/64 scope link
       valid_lft forever preferred_lft forever
14: ps-inb: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9400 qdisc mq state UNKNOWN qlen 1000
    link/ether 00:00:00:01:01:01 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::200:ff:fe01:101/64 scope link
       valid_lft forever preferred_lft forever
15: veobc: <BROADCAST,UP,LOWER_UP> mtu 1494 qdisc noqueue state UNKNOWN
    link/ether 00:00:00:00:01:01 brd ff:ff:ff:ff:ff:ff
    inet 127.1.2.1/24 brd 127.1.2.255 scope host veobc
    inet 127.1.1.1/16 brd 127.1.255.255 scope global veobc
    inet6 fe80::200:ff:fe00:101/64 scope link
       valid_lft forever preferred_lft forever
21: ps-diag: <BROADCAST,UP,LOWER_UP> mtu 9212 qdisc pfifo_fast state UP qlen 100
    link/ether 00:00:00:00:1b:02 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::200:ff:fe00:1b02/64 scope link
       valid_lft forever preferred_lft forever
22: ps-sup-eth1: <BROADCAST,UP,LOWER_UP> mtu 9212 qdisc pfifo_fast state UP qlen 100
    link/ether 00:00:00:00:1b:03 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::200:ff:fe00:1b03/64 scope link
       valid_lft forever preferred_lft forever
23: sflow: <BROADCAST,UP,LOWER_UP> mtu 9212 qdisc pfifo_fast state UP qlen 100
    link/ether 00:00:00:00:1b:04 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::200:ff:fe00:1b04/64 scope link
       valid_lft forever preferred_lft forever
40: Eth1-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 100
    link/ether 00:50:56:91:40:88 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::250:56ff:fe91:4088/64 scope link
       valid_lft forever preferred_lft forever
41: Eth1-2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen 100
    link/ether 00:50:56:91:40:89 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::250:56ff:fe91:4089/64 scope link
```

In the Bash shell enter:

```
bash-4.2$ip link show Eth1-1

bash-4.2$sudo ifconfig Eth1-1 down

bash-4.2$ip link show Eth1-1

bash-4.2$sudo ifconfig Eth1-1 up

bash-4.2$ip link show Eth1-1
```

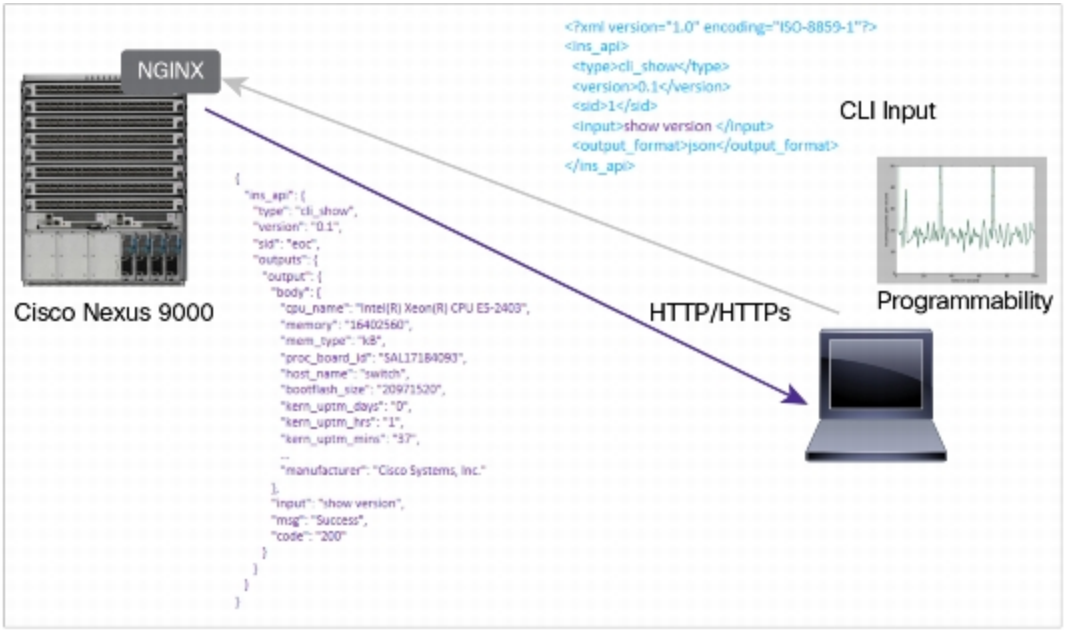
Figure. *Output screen of previous commands*

```
bash-4.2$ ip link show Eth1-1
40: Eth1-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode DEF
AULT qlen 100
    link/ether 00:50:56:91:40:88 brd ff:ff:ff:ff:ff:ff
bash-4.2$ sudo ifconfig Eth1-1 down
bash-4.2$ ip link show Eth1-1
40: Eth1-1: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast state DOWN mode DEFAULT qlen
100
    link/ether 00:50:56:91:40:88 brd ff:ff:ff:ff:ff:ff
bash-4.2$ sudo ifconfig Eth1-1 up
bash-4.2$ ip link show Eth1-1
40: Eth1-1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode DEF
AULT qlen 100
    link/ether 00:50:56:91:40:88 brd ff:ff:ff:ff:ff:ff
bash-4.2$
```

Lab 2: Manage Cisco Nexus 9000 Switch using the Cisco NX-API

Cisco NX-OS API (NX-API) allows web-based programmatic access to the Cisco Nexus 9000 Series Switches. This support is delivered through an open source web server, NGINX. NX-API exposes the complete configuration and management capabilities of the CLI through web-based APIs. The Cisco Nexus 9000 Series Switches can be instructed to publish the output of the API calls in either XML or JSON format. This comprehensive, easy-to-use API enables rapid deployment on the Cisco Nexus 9000 Series Switches.

Figure. *Programmatic Access to Cisco Nexus 9000 Series through Cisco NX-API*



Step 2.1: Enabling NX-API

Type the following commands through CLI:

```
NXOSv-1# conf t
Enter configuration commands, one per line. End with CNTL/Z.
NXOSv-1(config)#
NXOSv-1(config)# feature nxapi
NXOSv-1(config)#
NXOSv-1(config)# exit
NXOSv-1#
NXOSv-1# show feature | in nxapi
nxapi                 1          enabled
NXOSv-1#
```

Figure. *Output screen of previous commands*

```
N9K-02(config)# feature nxapi
N9K-02(config)# exit
N9K-02# show feature | inc nxapi
nxapi                 1          enabled
N9K-02#
```

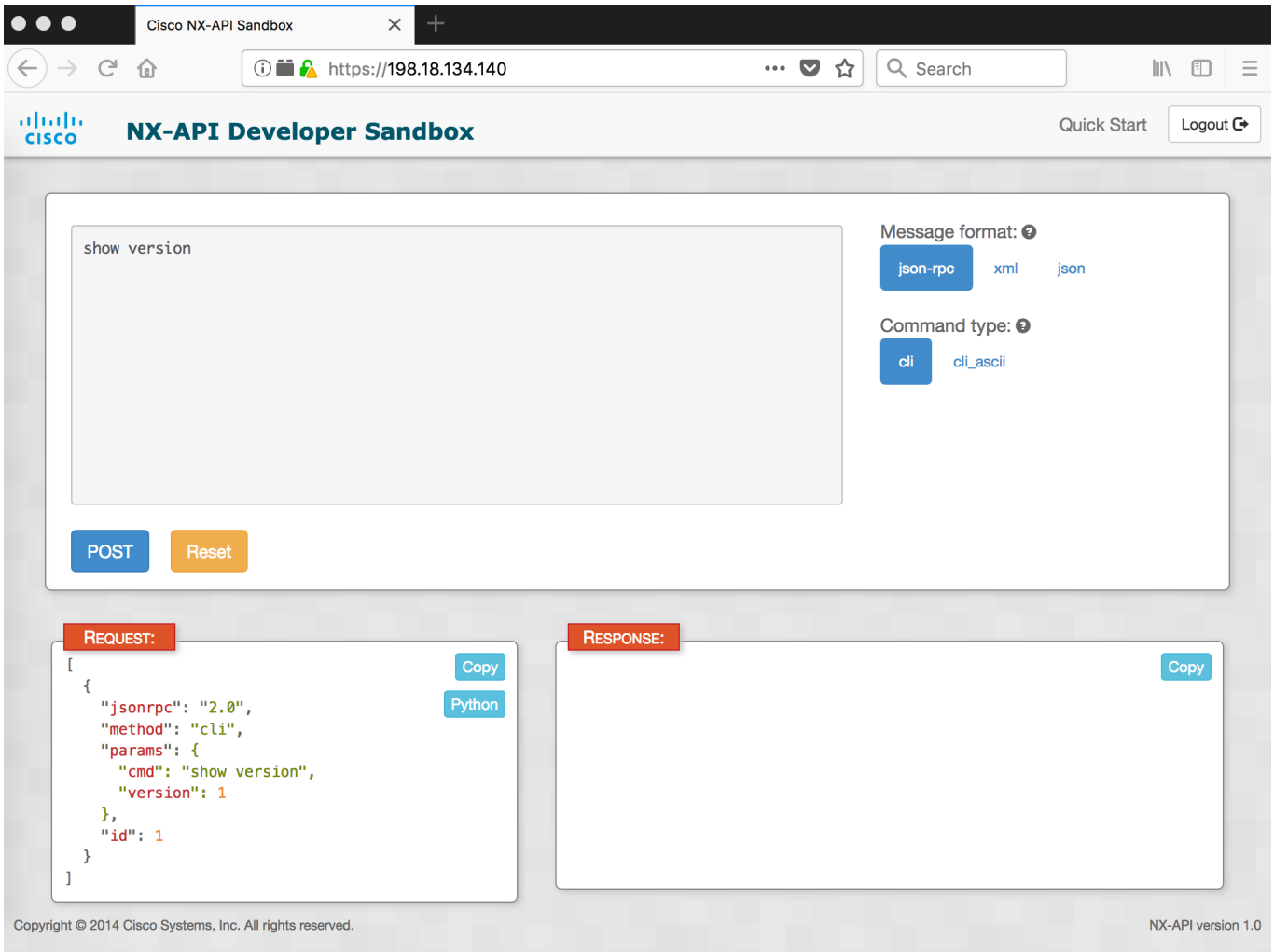
Step 2.2: Accessing NX-API

To Access the NX-API interface, Open the web browser and point it to switch's MGMT 0 interface ip address in the browser address bar

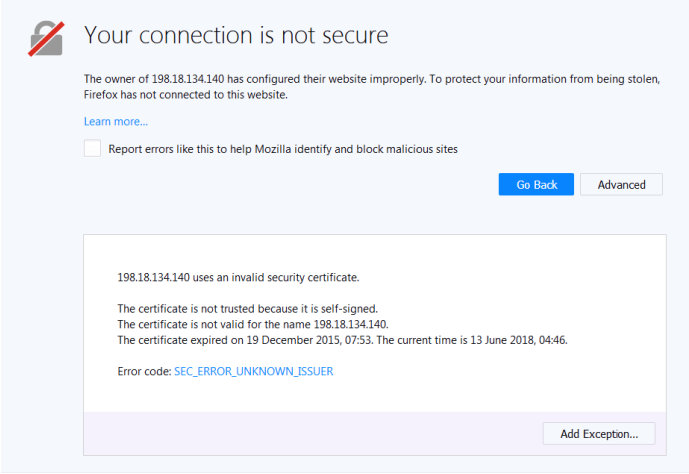
https://198.18.134.140/

Username: admin
Password: C1sco12345

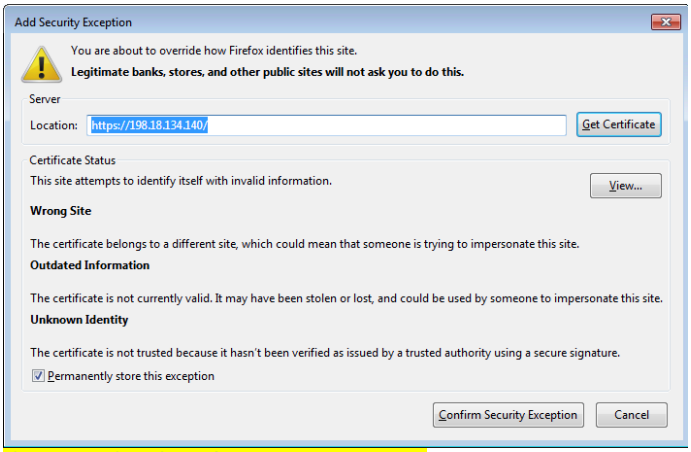
in the top left box enter "show version", change the message format to json-rpc, command type to cli and click on the POST button



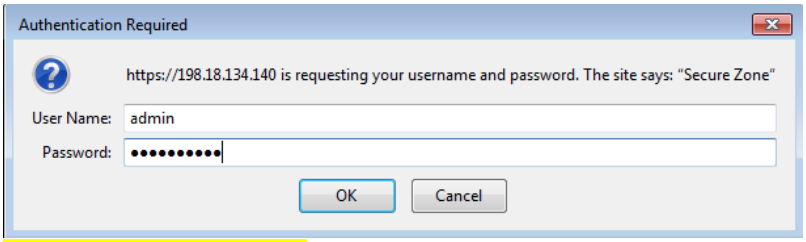
Note: Please follow the below mentioned steps if you experience any certificate warnings.



Click Add Exception

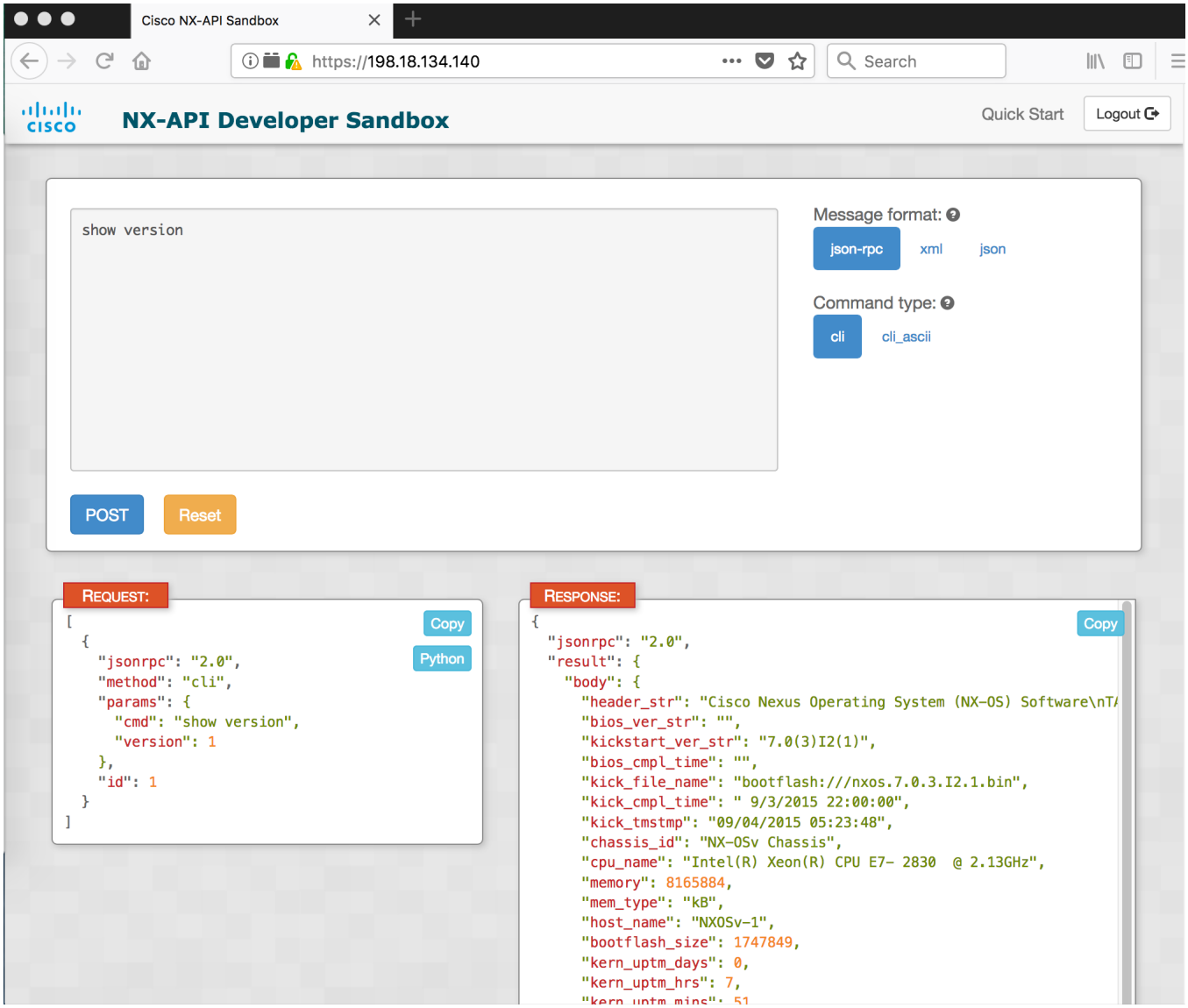


Click on Confirm Security Exception



Type the login credentials

Now you have successfully posted an API call to the switch. The API call output should look like this



Notice the output in the response field. Next click the python button in the request window. This will generate the python code for "show version" command. Now we can use the NX-API generated python code to interact with the device via API calls.

Step 2.3: Basic API call to Nexus device using python

The nxapi_shver script is created from the NX-API output. Since we are getting structured data back from the device, we can retrieve any data easily by parsing and extracting the specific key:value pairs or list from the json output.

In this example we are extracting the NX-OS version running on the switch using an API call.

Open the cmder tool and type the following commands:

```
C:\Users\demouser\Desktop\Scripts
python nxapi_shver.py
```

Now you are launching the below mentioned code via CLI. The script will make an API call to the Nexus 9000 switch. Collect the show version output in the json format and print out NX-OS version.

```
import requests
import json

"""
Modify these please
"""
url='http://198.18.134.140/ins'
switchuser='admin'
switchpassword='C1sco12345'

myheaders={'content-type':'application/json-rpc'}
payload=[
  {
    "jsonrpc": "2.0",
    "method": "cli",
    "params": {
      "cmd": "show version",
      "version": 1
    },
    "id": 1
  }
]
response = requests.post(url,data=json.dumps(payload),
headers=myheaders,auth=(switchuser,switchpassword)).json()
print "Version: %s" % response['result']['body']['kickstart_ver_str']
```

Figure. *Output screen off the script*

```
C:\Users\demouser\Desktop\Scripts
λ python nxapi_shver.py
Version: 7.0(3)I2(1)
```

This is a very basic example of how you can interact with NX-OS via NX-API. But you can do lot more with NX-API, please refer the link for more information : https://developer.cisco.com/site/nx-api/

Lab:3 Configure NX-OS via Python programming

Python is a very powerful and easy to learn programming language. Python Programming skills are mandatory for today's Network engineers, one needs to know how to write, edit, modify, and expand python scripts to utilize SSH, APIs and data models to effectively automate day to day networking tasks.

In this lab section we will look into how to leverage Python programming language and python libraries to manage the network devices efficiently. The main benefit of using python for network programmability is that, we don't need to reinvent the wheel. There are lot of open-source and community driven libraries that we can leverage to quickly get started with automating our day to day networking tasks.

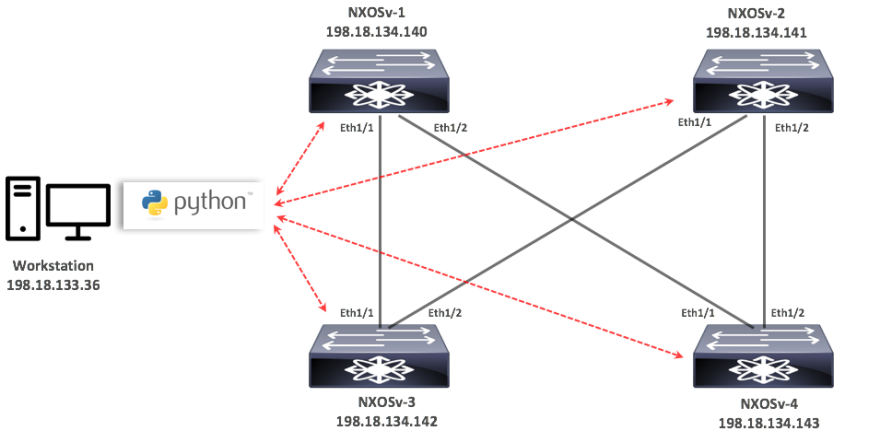
Using python programming you can automate most of the repeated network admin tasks any no. of times without any typo or human errors. So we can save lot of time wasted in doing manual way of configuring devices. But you should be very careful, "With great power comes great responsibility". Error prone scripts can break the network very fast and can cause major business impact. So the advice here is to build and test the python scripts in a safe lab environment first, not once but multiple times, before trying it out in production.

For this lab we will be using a very popular python library named Netmiko. Netmiko is an open-source python library based on Paramiko SSH library. It provides a uniform programming interface across a broad set of network devices. It also handles many of the low-level SSH details that can be time consuming and problematic when you are a beginner and getting started with programming.

Since Netmiko is based on SSH, it is still a legacy screen-scraping interface. In other words, Netmiko uses an interface primarily intended for humans (SSH) and returns text strings that have to be processed (as contrasted to using an API that returns structured data). This is where NX-API will be helpful to extract structured data from Nexus devices.

Now we are moving away from manual methods of configuring and collecting information the devices. If done correct the python scripts can efficiently handle all the network administration tasks.

Figure: *Python based network automation*



Note: All python scripts are available in GitHub for your reference.
GitHub link : https://github.com/jagadnag/Scripts

Step 3.1: Building blocks of netmiko python script

First we have to import the Connection handler from the netmiko library

```
from netmiko import ConnectHandler
```

The connection parameters are collected in a Python dictionary. The connection parameters provide Netmiko with everything it needs to create the SSH connection.

```
nxos1 = {
    'device_type': 'cisco_nxos',
    'ip': '172.21.56.125',
    'username': 'admin',
    'password': 'cisco',
}
```

ConnectHandler is a Netmiko function that calls the necessary connection parameters and device type (cisco_ios, cisco_xr, cisco_nxos, etc.) This ConnectHandler call will launch the SSH connection and login into the device.

```
net_connect = ConnectHandler(**nxos1)
```

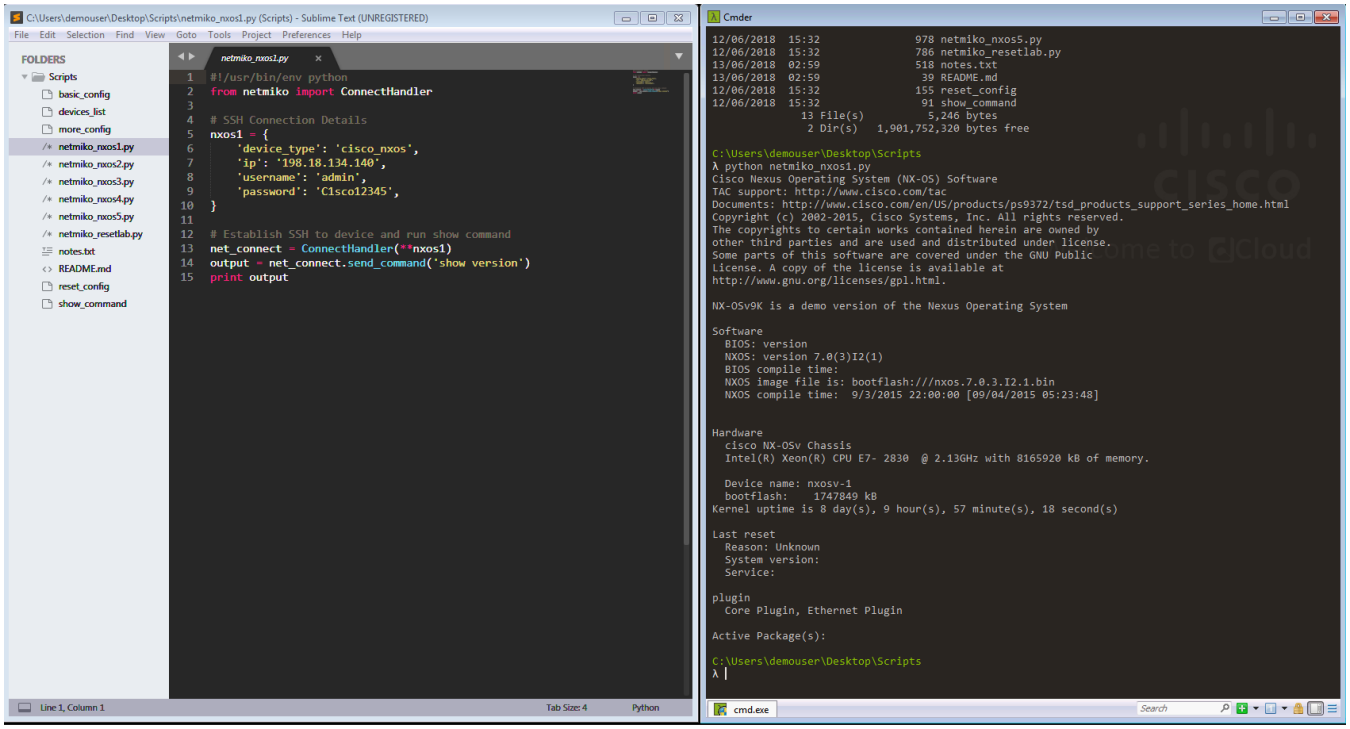
.send_command() method is used to send show commands over the channel and receive the output back. Here, we have used 'show version' command.

```
output = net_connect.send_command('show version')
```

Using the send_config_set() method, we program the network device to enter into configuration mode and execute the config_commands and then exit the configuration mode.

```
output = net_connect.send_config_set(config_commands)
```

We can send one or more lines of commands by converting it into a simple list. The session output are stored in an output variable and then printed out for our reference. Next step you will launch a simple python script to collect show version command output and print it.



We recommend to have a similar desktop window setup with Sublime and cmder tools side by side, so you can view the script and output at the sametime.

Step 3.2: Execute a show command using netmiko on one device

Let's execute our first netmiko python script. Use the cmder to launch the python script

```
C:\Users\demouser\Desktop\Scripts
python netmiko_nxos1.py
```

netmiko_nxos1.py

```
#!/usr/bin/env python
from netmiko import ConnectHandler

# SSH Connection Details
nxos1 = {
    'device_type': 'cisco_nxos',
    'ip': '198.18.134.140',
    'username': 'admin',
    'password': 'C1sco12345',
}

# Establish SSH to device and run show command
net_connect = ConnectHandler(**nxos1)
output = net_connect.send_command('show version')
print output
```

Now you can see how easy it is to get started with python programming. Though it is a very simple python program with only few lines of code, in the following steps we will quickly develop it to send multiple lines of config commands or retrieve multiple show command outputs from multiple devices.

The idea here is to understand the basic programmability logic first, build a base skeleton for the code and quickly iterate through it to build more complex tasks on top of it.

Note: After launching the script it will take 20-30 seconds for the program to complete all the tasks and print the output. These scripts are not designed to handle errors, developing scripts with exception handling capabailites are beyond the scope of this lab.

Step 3.3: Execute a configuration command using netmiko on one device

Now you will launch another simple program to configure the nexus device.

Launch the python script from the command prompt

```
C:\Users\demouser\Desktop\Scripts
python netmiko_nxos2.py
```

netmiko_nxos2.py

```
#!/usr/bin/env python
from netmiko import ConnectHandler

# SSH Connection Details
nxos1 = {
    'device_type': 'cisco_nxos',
    'ip': '198.18.134.140',
    'username': 'admin',
    'password': 'C1sco12345',
}

# Establish SSH to device and run config command
net_connect = ConnectHandler(**nxos1)
output = net_connect.send_config_set('logging server 1.1.1.1')
print output
```

Login to nxosv-1 switch using SSH client and verify the script configured the device correctly.

Step 3.4: Send multiple configuration commands to one device

In this step we will use a file named 'basic_config' to send few lines of configuration commands to the nxosv-1 switch. The script will iterate through the configuration commands using a for loop and configure the device accordingly. This is where programming is very useful, it can do repeated tasks any no. of times without any typo or human errors.

basic_config file:

```
logging console
logging server 1.1.1.2
vlan 10
name python_vlan_10
vlan 20
name python_vlan_20
```

Launch the python script from the command prompt

```
C:\Users\demouser\Desktop\Scripts
python netmiko_nxos3.py
```

netmiko_nxos3.py

```
#!/usr/bin/env python

from netmiko import ConnectHandler

# Sending multiple lines of config stored in a file
with open('basic_config') as f:
    commands_to_send = f.read().splitlines()

# SSH Connection details
nxos1 = {
    'device_type': 'cisco_nxos',
    'ip': '198.18.134.140',
    'username': 'admin',
    'password': 'C1sco12345',
}

all_devices = [nxos1]

# Iterate through device list and configure the devices
for devices in all_devices:
    net_connect = ConnectHandler(**devices)
    output = net_connect.send_config_set(commands_to_send)
    print output
```

Login to nxosv-1 switch using SSH client and verify the script configured the device correctly.

Step 3.5: Send multiple configuration commands to many devices

In this step we will use a file named 'more_config' to send more lines of configuration commands to multiple devices. Now we have extracted manually hardcoding the configuration commands, device ips and connection details like username and passwords out of the main script. Especially hardcoding username and password on the scripts are not advisable. To securely handle the passwords the script uses getpass() python module. The script requests the user to enter the login credentials to establish a SSH connection. Then it iterates through the lines in more_config and device_ip in a for loop to configure the device accordingly.

more_config file:

```
logging console
logging server 1.1.1.3
ip access-list TEST_ACL
permit ip 1.1.1.0 0.0.0.255 any
permit ip 2.2.2.0 0.0.0.255 any
permit ip 3.3.3.0 0.0.0.255 any
vlan 101
name python_vlan_101
vlan 102
name python_vlan_102
feature ospf
router ospf 1
interface Ethernet1/1
ip router ospf 1 area 0
ip ospf network point-to-point
```

devices_list file:

```
198.18.134.140
198.18.134.142
```

Launch the python script from the command prompt

```
C:\Users\demouser\Desktop\Scripts
python netmiko_nxos4.py
```

netmiko_nxos4.py

```
#!/usr/bin/env python

from netmiko import ConnectHandler
from getpass import getpass

# SSH username and password provided by user
username = raw_input('Enter your SSH username: ')
password = getpass()

# Sending multiple lines of config stored in a file
with open('more_config') as f:
    commands_list = f.read().splitlines()

# Sending device ip's stored in a file
with open('devices_list') as f:
    devices_list = f.read().splitlines()

# Iterate through device list and configure the devices
for devices in devices_list:
    print 'Connecting to device ' + devices
    ip_address_of_device = devices

    # SSH Connection details
    nxos_device = {
        'device_type': 'cisco_nxos',
        'ip': ip_address_of_device,
        'username': username,
        'password': password
    }

    net_connect = ConnectHandler(**nxos_device)
    output = net_connect.send_config_set(commands_list)
    print output
```

Login to nxosv-1 and nxosv-3 switch using SSH client and verify the script configured the device correctly.

Now you can alter the configuration lines by editing more_config file or manage additional devices by simply adding the device managment ip to the devices_list. This is the power of python programming where you initially start with very simple program, streamline the logic and operation and then modify the script to start building complex tasks.

Step 3.6: Collect multiple show command output from many devices

In this step we will use a python script to quickly verify whether all the devices are configured correctly. This is very similar to precheck and postcheck validation task when we make a configuration change in the network. Here we are using a file named 'show_command' to send multiple show commands to multiple devices and capture the output for config verification.

show_command file:

```
show vlan brief
show runn | in logging
show ip access-lists TEST_ACL
show ip ospf neighbors
```

Launch the python script from the command prompt

```
C:\Users\demouser\Desktop\Scripts
python netmiko_nxos5.py
```

netmiko_nxos5.py

```
#!/usr/bin/env python

from netmiko import ConnectHandler
from getpass import getpass

# SSH username and password provided by user
username = raw_input('Enter your SSH username: ')
password = getpass()

# Sending list of show commands stored in a file
with open('show_command') as f:
    show_commands = f.readlines()

# Sending device ip's stored in a file
with open('devices_list') as f:
    devices_list = f.read().splitlines()

# Iterate through device list
for devices in devices_list:
    print 'Connecting to device ' + devices
    ip_address_of_device = devices

    # SSH Connection details
    nxos_device = {
        'device_type': 'cisco_nxos',
        'ip': ip_address_of_device,
        'username': username,
        'password': password
    }
    # Iterate through show command list
    net_connect = ConnectHandler(**nxos_device)
    for command in show_commands:
        output = net_connect.send_command(command)
        print command + output + '\n'
```

Validate the show command output printed in the command prompt.

Step 3.7: Reset the lab configurations

After completing all the above mentioned steps, please run the reset script to reconfigure the devices to its original state.

Launch the python scripts from the command prompt

```
C:\Users\demouser\Desktop\Scripts
python netmiko_resetlab.py
python reset.py
```

Login to nxosv-1 and nxosv-3 via SSH and verify whether all the configurations are removed correctly.

There are lot more you can do with Python programming, we have barely scratched the surface of python capabalities here. This lab just gave you a headstart for starting your network programming journey.

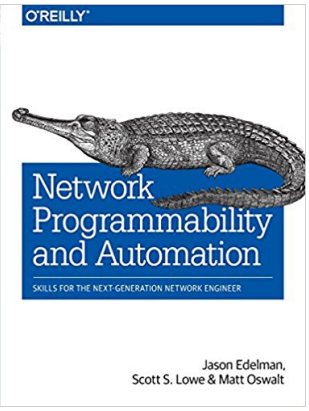
Conclusion

You have successfully completed the lab. Please handover the WISP Lab card to the front desk. Thanks for attending this lab, please share your valuable feedback.

Reference

Additional Reading and Reference:
https://developer.cisco.com/video/net-prog-basics/
https://learninglabs.cisco.com/tracks
https://pynet.twb-tech.com/blog/automation/netmiko.html

Books:
http://shop.oreilly.com/product/0636920042082.do



https://automatetheboringstuff.com/
https://learnpythonthehardway.org/python3/