Discovery 1: Perform NSO System Install

Introduction

In this activity, you will learn how to install NSO in a production environment, also called an NSO System Installation, how to install NEDs, and do basic NSO configuration.

After completing this activity, you will be able to:

- Perform a system installation of NSO
- Install and verify NEDs
- Make changes to NSO configuration

Job Aid

The following job aid is available to help you complete the lab activities:

- Lab Guide

The following table contains passwords that you might need.

Device	Username	Password
student-vm	student	1234QWer
nso-server	student	1234QWer

Required Resources

The following resources and equipment are required for completing the activities in this lab guide:

- PC or laptop with a web browser
- Access to the internet

Command List

The following are the most common commands that you will need:

Linux Shell:

Command	Comment
source /opt/ncs/ncs-6.1/ncsrc	Source NSO environmental variable in Docker container.
ls|ll	Display contents of the current directory.
cd	Move directly to user home directory.
cd ..	Exit out of current directory.
cd test	Move into the "test" folder, which is a subfolder of the current directory.

Command	Comment
cd /home/student	Move into the "student" folder by specifying the direct path to it starting from the root of the directory system.
ncs_cli -C	Log in to NSO CLI directly from local server.

NSO CLI:

Command	Comment
switch cli	Change CLI style.
show ?	Display all command options for current mode.
configure	Enter configuration mode.
commit	Commit new configuration (configuration mode only command).
show configuration	Display new configuration that has not yet been committed (configuration mode only command).

Makefile commands for Docker environment:

Command	Comment
make build	Builds the main NSO Docker image.
make testenv-start	Starts the NSO Docker environment.
make testenv-stop	Stops the NSO Docker environment.
make testenv-build	Recompiles and reloads the NSO packages.
make testenv-cli	Enters the NSO CLI of the NSO Docker container.
make testenv-shell	Enters the Linux shell of the NSO Docker container.
make dev-shell	Enters the Linux shell of the NSO Docker development container.

Command Syntax Reference

This lab guide uses the following conventions for **command syntax**:

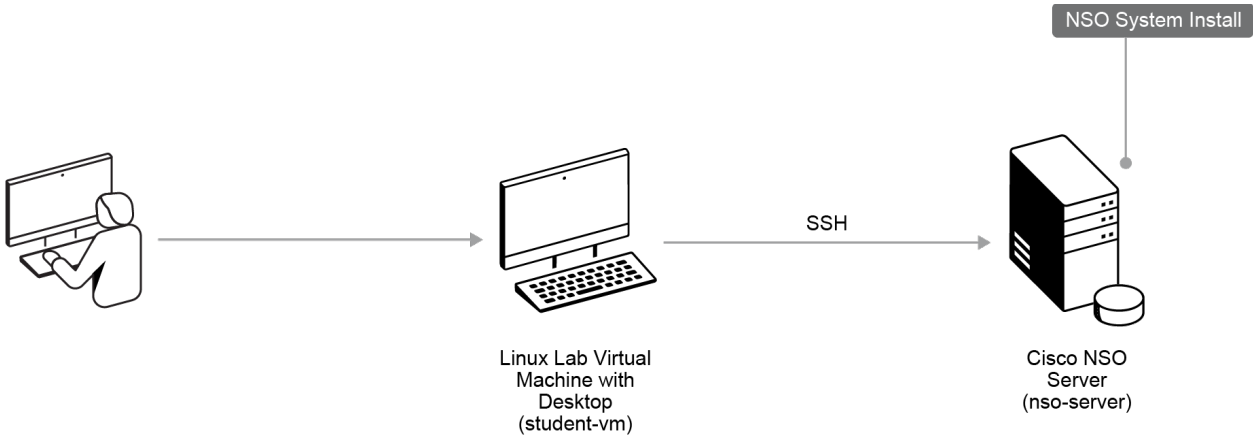
Formatting	Description and Examples
show running config	Commands in steps use this formatting.
Example	Type **show running config**
Example	Use the **name** command.
`show running config`	Commands in CLI outputs and configurations use this formatting.

Formatting	Description and Examples
highlight	CLI output that is important is highlighted.
Example	`student@student-vm:~$ ncs --version` `6.1`
Example	Save your current configuration as the default **startup config**. `Router Name# copy running startup`
brackets ([ ])	Indicates optional element. You can choose one of the options.
Example:	`(config-if)# frame-relay lmi-type {ansi|cisco|q933a}`
italics font	Arguments for which you supply values.
Example	Open file **ip tcp window-size** *bytes*
angle brackets (<>)	In contexts that do not allow italics, arguments for which you supply values are enclosed in angle brackets [<>]. Do not type the brackets when entering the command.
Example	If the command syntax is **ping** <*ip_address*>, you enter ping *10.0.0.102*.
string	A non-quoted set of characters. Type the characters as-is.
Example	(config)# **hostname MyRouter**
vertical line (|)	Indicates that you enter one of the choices. The vertical line separates choices. Do not type the vertical line when entering the command.
Example	If the command syntax is **show ip route|arp**, you enter either **show ip route** or **show ip arp**, but not both.

Lab Topology Information

Your lab session is your own personal sandbox. Whatever you do in your session will not be reflected in anyone else's session. Your lab environment is a Linux server (Student-VM) acting as a jumphost and a Linux server (NSO-server) acting as a NSO server. This is where you will be installing NSO.

Topology



Task 1: Install NSO

In this task, you will install the NSO software.

Activity

Complete these steps:

Step 1

Connect to the Student-VM.

You can connect to the server either by choosing the Student-VM from the device list or by clicking on the Student-VM icon in the topology map.

Step 2

Open the terminal window and connect through SSH to the NSO server.

You can open the terminal window using the **Terminal** icon on the bottom bar.

Connect to the *nso-server* NSO server with the student user using the SSH client. The authentication is already preconfigured with public key authentication, therefore the password is not needed. The prompt will change stating you are now connected to the nso-server.

```
student@student-vm:~$ ssh student@nso-server
Last login: Tue Oct 3 09:14:42 2023 from 10.0.0.102
student@nso-server:~$
```

Step 3

Review the information required for installing the NSO software.

Start the installation by using the information provided in the following table. It lists all the information required for installing the NSO software.

Parameter	Value	Comment
Location of installation	/opt	Directory reserved for all the software and add-on

Parameter	Value	Comment
package		packages that are not part of the default installation.
NSO installation type	system	System installation is intended for use in production environments.
Installation directory	/opt/ncs/ncs-VERSION	Replace VERSION with the NSO version as seen from the installation file. Linked to /opt/ncs/current
Running directory	/var/opt/ncs	CDB, packages directory, rollbacks, and other runtime files reside here.
Log directory	/var/log/ncs	Various NSO logs.
Configuration directory	/etc/ncs	ncs.conf is located here

Step 4

Verify that Java JDK-8x or higher is installed.

Java JDK-8.x or higher must be installed on the system where you will install NSO. Ensure that it is installed with the **java --version** command.

```
student@nso-server:~$ java --version
openjdk 11.0.20.1 2023-08-24
OpenJDK Runtime Environment (build 11.0.20.1+1-post-
Ubuntu-0ubuntu122.04)
OpenJDK 64-Bit Server VM (build 11.0.20.1+1-post-Ubuntu-0ubuntu122.04,
mixed mode, sharing)
```

Step 5

Verify that Python 3.7 or higher is installed.

Python version 3.7 or higher is supported. Check that it is installed.

```
student@nso-server:~$ python --version
Python 3.10.12
```

Step 6

Go to the home directory.

Go to the home directory by using the **cd** command and display its contents.

```
student@nso-server:~$ cd
student@nso-server:~$ ls -l
```

```
total 211336
drwxr-xr-x 2 student student      4096 Aug 17 12:42 Desktop
drwxr-xr-x 2 student student      4096 Jun 27 11:59 Documents
drwxr-xr-x 2 student student      4096 Oct  3 10:09 Downloads
drwxrwxr-x 7 student student      4096 Oct  1 17:47 lab
drwxr-xr-x 2 student student      4096 Jun 27 11:59 Music
drwxrwxr-x 5 student student      4096 Oct  9  2022 neds
-rwxrwxr-x 1 student student 216352789 Oct  3 08:38
nso-6.1.linux.x86_64.installer.bin
drwxr-xr-x 2 student student      4096 Aug 17 12:38 Pictures
drwxr-xr-x 2 student student      4096 Jun 27 11:59 Public
drwxrwxr-x 2 student student      4096 Aug 18 14:49 scripts
-rwxrw-r-- 1 student student        42 Oct  1 17:03 set_resolution.sh
drwx------ 3 student student      4096 Jun 27 11:59 snap
drwxr-xr-x 2 student student      4096 Jun 27 11:59 Templates
drwxr-xr-x 2 student student      4096 Jun 27 11:59 Videos
student@nso-server:~$
```

Step 7

Make the *nso-6.1.linux.x86_64.installer.bin* file executable.

Make the signed binary executable with the **chmod +x** command (in this lab, it already is executable).

```
student@nso-server:~$ chmod +x nso-6.1.linux.x86_64.installer.bin
student@nso-server:~$
```


Pressing the **Tab** key while typing a binary name autocompletes the name, makes the Tab and the process of writing commands more accurate and faster.

Step 8

Perform the NSO system install and specify the *student* user as a daemon user.

By default, NSO (system install) runs the process as root. This should be avoided for security reasons. That is why you will use *student* user which is already created on the lab machine and has sudo privileges. Run the binary with **sudo ./nso-<VERSION>. linux.x86_64.installer.bin**. You also must specify the **--system-install** option and **--run-as-user student** to avoid running the NSO process as root.

```
student@nso-server:~$ sudo ./nso-6.1.linux.x86_64.installer.bin  --
system-install --run-as-user student
[sudo] password for student:
INFO  Using temporary directory /tmp/ncs_installer.9109 to stage NCS
installation bundle
INFO  Using /opt/ncs/ncs-6.1 for static files
INFO  Using /etc/ncs for configuration files
INFO  Using /var/opt/ncs for run-time state files
INFO  Using /var/log/ncs for log files
INFO  Doing install for running as user nso
```

```
INFO  Unpacked ncs-6.1 in /opt/ncs/ncs-6.1
INFO  Found and unpacked corresponding DOCUMENTATION_PACKAGE
INFO  Found and unpacked corresponding EXAMPLE_PACKAGE
INFO  Found and unpacked corresponding JAVA_PACKAGE
INFO  Generating default SSH hostkey (this may take some time)
INFO  SSH hostkey generated
INFO  Generating self-signed certificates for HTTPS
INFO  Environment set-up generated in /opt/ncs/ncs-6.1/ncsrc
INFO  NSO installation script finished
INFO  Found and unpacked corresponding NETSIM_PACKAGE
INFO  Generating keys for encrypted-strings
INFO  Configuring installation for PAM authentication
INFO  Using PAM service common-auth for authentication
INFO  Installed init script /etc/init.d/ncs
INFO  Installed user profile script ncs.sh in /etc/profile.d
INFO  Installed user profile script ncs.csh in /etc/profile.d
INFO  Installed 'logrotate' configuration file ncs in /etc/logrotate.d

INFO  The installation has been configured for PAM authentication,
INFO  with group assignment based on the OS group database
INFO  (e.g. /etc/group file). Users that need access to NCS must
INFO  belong to either the 'ncsadmin' group (for unlimited access
INFO  rights) or the 'ncsoper' group (for minimal access rights).
INFO  To create the 'ncsadmin' group, use OS shell command:

  groupadd ncsadmin

INFO  To create the 'ncsoper' group, use OS shell command:

  groupadd ncsoper

INFO  To add an existing user to one of these groups, use OS shell
command:

  usermod -a -G <groupname> <username>

INFO  The following files have been installed with elevated privileges:
  /opt/ncs/ncs-6.1/lib/ncs/lib/core/pam/priv/epam: setuid-root
  /opt/ncs/ncs-6.1/lib/ncs/erts/bin/ncs.smp: capability
cap_net_bind_service
  /opt/ncs/ncs-6.1/lib/ncs/bin/ip: capability cap_net_admin
  /opt/ncs/ncs-6.1/lib/ncs/bin/arping: capability cap_net_raw

INFO  NCS installation complete
```

Step 9

Verify the contents of the installation directory.

To display the contents of the installation directory, use the **cd** command.

```
student@nso-server:~$ ls -l /opt/ncs/ncs-6.1/
total 256
drwxr-xr-x  2 root root  4096 Oct  3 10:22 bin
-rw-r--r--  1 root root 80772 Apr 14 09:27 CHANGES
drwxr-xr-x  5 root root  4096 Apr 14 09:39 doc
drwxr-xr-x  4 root root  4096 Apr 14 09:27 erlang
```

```
drwxr-xr-x  3 root root  4096 Apr 14 09:27 etc
drwxr-xr-x 13 root root  4096 Apr 14 09:36 examples.ncs
drwxr-xr-x  2 root root  4096 Apr 14 09:27 include
drwxr-xr-x  3 root root  4096 Oct  3 10:22 java
drwxr-xr-x  7 root root  4096 Apr 14 09:28 lib
-rw-r--r--  1 root root 94915 Apr 14 09:27 LICENSE
drwxr-xr-x  6 root root  4096 Apr 14 09:47 man
-rw-r--r--  1 root root   539 Oct  3 10:22 ncsrc
-rw-r--r--  1 root root   507 Oct  3 10:22 ncsrc.tcsh
drwxr-xr-x  3 root root  4096 Oct  3 10:22 netsim
drwxr-xr-x  7 root root  4096 Apr 14 09:36 packages
-rw-r--r--  1 root root  7155 Apr 14 09:27 README
drwxr-xr-x  4 root root  4096 Apr 14 09:27 scripts
drwxr-xr-x  3 root root  4096 Apr 14 09:27 src
drwxr-xr-x  4 root root  4096 Apr 14 09:27 support
drwxr-xr-x  3 root root  4096 Apr 14 09:27 var
-rw-r--r--  1 root root   410 Oct  3 10:22 VERSION
student@nso-server:~$
```


The **doc** directory is full of useful documentation and different NSO documents. The **src** is where you can find the NSO source yang and the Python code. The **examples.ncs** directory contains many example projects that you can use for practicing or as a base for your future projects.

Step 10

Create **ncsadmin** and **ncsoper** groups.

As stated in the output of the installation script, you need to create **ncsadmin** and **ncsoper** groups to do a group assignment of users who need access to NSO.

```
student@nso-server:~$ sudo groupadd ncsadmin
student@nso-server:~$ sudo groupadd ncsoper
```

Step 11

Assign *student* user to **ncsadmin** group.

To assign *student* user to the group, use the **usermod** command.

```
student@nso-server:~$ sudo usermod -aG ncsadmin student
student@nso-server:~$
```

Step 12

Restart the virtual machine and reopen the terminal window after the virtual machine has come online.

Use the **sudo reboot** command. You need to restart the virtual machine so that the group membership changes that were made to the currently logged in user take effect. You will be disconnected from the server. SSH to the server again after the virtual machine has come online.

```
student@nso-server:~$ sudo reboot
student@nso-server:~$ Connection to nso-server closed by remote host.
Connection to nso-server closed.
student@student-vm:~$ ssh student@nso-server
Last login: Tue Oct  3 10:21:14 2023 from 10.0.0.102
student@nso-server:~$
```

Step 13

Set the NSO environment variables.

Set the environment variables for the NSO source **/etc/profile.d/ncs.sh** file.

```
student@nso-server:~$ source /etc/profile.d/ncs.sh
student@nso-server:~$
```


The installation program creates a shell script file in each NSO installation, which sets the environment variables needed to run NSO. With the --system-install option, by default these settings are set on the shell to explicitly set the variables, source ncs.sh or ncs.csh, depending on your shell type.

Step 14

Verify the status of NSO daemon.

Check the NSO status by using the **ncs --status** | grep "status: started"status: started command.

```
student@nso-server:~$ ncs --status | grep "status: started"
status: started
student@nso-server:~$
```

Activity Verification

You have completed this task when you attain the following result:

- You have installed the NSO software
- You have verified the status of the NSO daemon

Task 2: Install NEDs

In this task, you will add Network Element Drivers (NEDs) to the previously installed NSO. You will be using the NEDs that are provided in this lab.

Activity

Complete these steps:

Step 1

Display the content of the NSO installation directory in which lab grade NEDs are stored.

To display the contents, use the **ls** command.

```
student@nso-server:~$ ls -l /opt/ncs/ncs-6.1/packages/neds/
total 40
drwxr-xr-x 8 root root 4096 Apr 14 09:36 a10-acos-cli-3.0
drwxr-xr-x 7 root root 4096 Apr 14 09:36 alu-sr-cli-3.4
drwxr-xr-x 8 root root 4096 Apr 14 09:36 cisco-asa-cli-6.6
drwxr-xr-x 7 root root 4096 Apr 14 09:36 cisco-ios-cli-3.0
drwxr-xr-x 7 root root 4096 Apr 14 09:36 cisco-ios-cli-3.8
drwxr-xr-x 8 root root 4096 Apr 14 09:36 cisco-iosxr-cli-3.0
drwxr-xr-x 8 root root 4096 Apr 14 09:36 cisco-iosxr-cli-3.5
drwxr-xr-x 8 root root 4096 Apr 14 09:36 cisco-nx-cli-3.0
drwxr-xr-x 8 root root 4096 Apr 14 09:36 dell-ftos-cli-3.0
drwxr-xr-x 5 root root 4096 Apr 14 09:36 juniper-junos-nc-3.0
student@nso-server:~$
```


You will use the latest production-grade NEDs in your Lab which can be found in ~/neds. You can obtain the latest production-grade NEDs directly from Cisco. A privileged CCO account might be needed to download them.

Step 2

Copy the production-grade NEDs for Cisco IOS and IOS XR devices to the **/var/opt/ncs/packages** folder.

In your environment, you want to configure Cisco IOS and IOS XR devices. Copy the corresponding NEDs from ~/neds to the running directory.

```
student@nso-server:~$ cd
student@nso-server:~$ sudo cp -r neds/cisco-ios-cli-6.85/ /var/opt/ncs/
packages
student@nso-server:~$ sudo cp -r neds/cisco-iosxr-cli-7.41/ /var/opt/
ncs/packages
student@nso-server:~$
```


Packages that you are copying over are already compiled for the NSO version that you are using. This is also true for NEDs that are part of the NSO installation bundle. This means that you do not have to compile them (**make**). If you want to create packages yourself from the beginning, or if you have packages that were used with older versions of the NSO, you must compile them.

Step 3

Connect to the NSO CLI and use the Cisco style of NSO CLI.

Connect to the NSO CLI with **ncs_cli -C**, where **-C** stands for the Cisco style of NSO

CLI.

```
student@nso-server:~$ ncs_cli -C

student connected from 10.0.0.102 using ssh on nso-server
student@ncs#
```

Step 4

Reload the packages and verify all are running.

Reload the packages and view the output. All results should be **true**.

```
student@ncs# packages reload

>>> System upgrade is starting.
>>> Sessions in configure mode must exit to operational mode.
>>> No configuration changes can be performed until upgrade has
completed.
>>> System upgrade has completed successfully.
reload-result {
    package cisco-ios-cli-6.85
    result true
}
reload-result {
    package cisco-iosxr-cli-7.41
    result true
}
student@ncs#
System message at 2023-10-03 10:40:17...
    Subsystem started: ncs-dp-1-cisco-ios-cli-6.85:IOSDp
student@ncs#
```

Step 5

Verify the NED package versions.

Versions should match the output below.

```
student@ncs# show packages package package-version
                     PACKAGE
NAME                 VERSION
------------------------------
cisco-ios-cli-6.85   6.85.2
cisco-iosxr-cli-7.41 7.41.2

student@ncs# exit
student@nso-server:~$
```

Activity Verification

You have completed this task when you attain these results:

- You have connected to the NSO CLI.
- Checked NED package versions.

Task 3: Configure NSO CLI for SSH Access

In this task, you will enable SSH connectivity on the NSO CLI northbound interface.

Activity

Complete these steps:

Step 1

Open the ncs.conf file using the nano editor.

The file is located in directory **/etc/ncs/ncs.conf**. Use *nano* to open the file.

```
student@nso-server:~$ sudo nano /etc/ncs/ncs.conf
```

Step 2

Enable the built-in SSH server.

In ncs.conf, find the section for CLI settings and enable the built-in SSH server. This will enable operators to connect to the NSO CLI, using an SSH connection to port 2024.

```
...
<cli>
<enabled>true</enabled>

<!-- Use the builtin SSH server -->
<ssh>
<enabled>true</enabled>
```

Step 3

Review that the PAM option is enabled and that external and local authentication is disabled.

Find section **aaa**, where authentication settings can be configured. Review that the PAM option is **enabled** and that external and local authentication is **disabled**.

```
...
<aaa>
<ssh-server-key-dir>${NCS_CONFIG_DIR}/ssh</ssh-server-key-dir>

<!-- Depending on OS - and also depending on user requirements -->
<!-- the pam service value value must be tuned. -->

<pam><enabled>true</enabled><external-authentication><enabled>false</
enabled><local-authentication><enabled>false</enabled>
```

Step 4

Save the file and exit the editor.

To save the file and exit the editor, press **CTRL+X** and confirm modifications with **Yes**.

Step 5

Reload NSO to apply the configuration.

Reload the NSO daemon.

```
student@nso-server:~$ sudo /etc/init.d/ncs reload
Reloading ncs: .
student@nso-server:~$
```


You are using PAM to do user authentication. This is convenient because you can provide the same set of users with access to both the Linux server and NSO.

Step 6

Test the connectivity to the NSO CLI over SSH.

Use the **ssh** command to test the connectivity. The password for user student in **/etc/passwd** will be checked and **/etc/group** consulted to do group assignment. When asked, confirm the connection with **yes** and enter the password of the **student** user.

```
student@nso-server:~$ ssh 127.0.0.1 -p 2024
The authenticity of host '[127.0.0.1]:2024 ([127.0.0.1]:2024)' can't be
established.
ED25519 key fingerprint is SHA256:jgHD46oxh/XPNdbel/5aB3xXwDc04Vc2Z/
vIo0JGHWE.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])?
yes
Warning: Permanently added '[127.0.0.1]:2024' (ED25519) to the list of
known hosts.
student@127.0.0.1's password: *********

User student last logged in 2023-10-03T10:39:06.225085+00:00, to nso-
server, from 10.0.0.102 using cli-ssh
student connected from 127.0.0.1 using ssh on nso-server
student@ncs> exit
Connection to 127.0.0.1 closed.
student@nso-server:~$
```

Activity Verification

You have completed this task when you attain these results:

- You have successfully connected over SSH using student user.

What is the minimum version of Python required for Cisco NSO version 6.1?

- 2.7
- 3.6
- 3.7
- 3.10