



**OpenStack Labs**

**Lab 05: Customizing Instances**

## Contents

Introduction .....	iii
Objectives .....	iv
Lab Settings.....	v
1 Setting Up the Environment.....	1
2 Creating a Customized Instance Using the Horizon Dashboard .....	13
3 Creating a Customized Instance Using the OpenStack Unified CLI .....	22

## About This Document

- This document was developed by a team at the University of Tennessee at Chattanooga led by Dr. Mengjun Xie ([mengjun-xie@utc.edu](mailto:mengjun-xie@utc.edu)).
- The development of this document was supported by a National Centers of Academic Excellence in Cybersecurity Grant (#H98230-20-1-0351), housed at the National Security Agency.
- This document is licensed with a Creative Commons Attribution 4.0 International License.

## Introduction

In this lab, you will use the **cloud-init** utility to customize OpenStack instances. This utility is used to perform actions from an instance upon creation. For example, it can be used to install a list of packages or change the message of the day displayed upon login to the instance.

## Objectives

- Customize an instance with **cloud-init** using the *Horizon Dashboard*.
- Customize an instance with **cloud-init** using the *OpenStack Unified CLI*.
- Verify instance customization.

## Lab Settings

The information in the table below will be needed in order to complete the lab. The task sections below provide details on the use of this information.

Virtual Machine	IP Address	Account	Password
workstation	ens3: 192.168.1.21 ens4: 172.25.250.21	ubuntu	ubuntu
devstack	ens3: 192.168.20 ens4: 172.25.250.20	ubuntu	ubuntu

# 1 Setting Up the Environment

In this task, you will set up the OpenStack environment to support the customized external instances you will create in the following sections.

- 1.1. Log into the **workstation** machine as the **ubuntu** user with password **ubuntu**.

```
Ubuntu 18.04.6 LTS workstation tty1
workstation login: ubuntu
Password:
```

- 1.2. Launch the graphical user interface.

```
ubuntu@workstation:~$ startx

Welcome to Ubuntu 18.04.6 LTS (GNU/Linux 4.15.0-213-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

 System information as of Fri Jun  7 21:01:55 UTC 2024

 System load:  0.6                 Processes:           197
 Usage of /:   7.9% of 116.12GB   Users logged in:     0
 Memory usage: 13%                IP address for ens3: 192.168.1.21
 Swap usage:   0%                 IP address for ens4: 172.25.250.21

Expanded Security Maintenance for Infrastructure is not enabled.

2 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

146 additional security updates can be applied with ESM Infra.
Learn more about enabling ESM Infra service for Ubuntu 18.04 at
https://ubuntu.com/18-04

ubuntu@workstation:~$ startx_
```

- 1.3. Open a terminal window and source the keystone credentials for the **admin** user.

```
ubuntu@workstation:~$ source ~/keystonerc-admin
```

```
ubuntu@workstation:~$ source ~/keystonerc-admin
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.4.** In this lab, we will create our own router and external network. First, the default router and external network need to be deleted. List the routers to find the default router's name so it can be deleted.

```
ubuntu@workstation:~$ openstack router list \
> --max-width 80
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router list \
> --max-width 80
+-----+-----+-----+-----+-----+-----+-----+
| ID      | Name    | Status | State | Distributed | HA    | Project  |
+-----+-----+-----+-----+-----+-----+-----+
| 07df5a07-87 | router1 | ACTIVE | UP    | False       | False | 39e851b14f864 |
| 95-4d8e-    |          |         |        |             |        | 573aad60582c3 |
| acccf-f9d7e4 |          |         |        |             |        | 5e40dc   |
| cbb4ee     |          |         |        |             |        |           |
+-----+-----+-----+-----+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

### Tip

When typing the command, make sure there is a space between **list** and the **\** character, and press **Enter** to get the **>** and continue typing the rest of the command.

- 1.5.** Before the router can be deleted, it must be disconnected from all subnets. Show more details about **router1** to see the subnets to which it is connected.

```
ubuntu@workstation:~$ openstack router show router1 \
> --max-width 80
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router show router1 \
> --max-width 100
+-----+-----+
| Field            | Value          |
+-----+-----+
| admin_state_up   | UP
| availability_zone_hints | 
| availability_zones | 
| created_at       | 2024-02-09T19:58:10Z
| description      | 
| distributed      | False
| external_gateway_info | {"network_id": "32da4c25-b517-40c5-97e3-cea031467d13", "enable_snat": true, "external_fixed_ips": [{"subnet_id": "c7916655-8954-4bf4-913d-416702f35d1b", "ip_address": "172.24.4.73"}, {"subnet_id": "4fc6bf88-919c-49df-83c4-b09bd65776ad", "ip_address": "2001:db8::1"}]}
| flavor_id        | None
| ha              | False
| id              | 07df5a07-8795-4d8e-accf-f9d7e4cbb4ee
| interfaces_info | [{"subnet_id": "fa8a2545-5a8c-44a2-bacc-1b86c253b880", "ip_address": "10.0.0.1", "port_id": "a05f4e1c-4014-4d25-9538-64e8114197e1"}, {"subnet_id": "674205b6-1357-4727-a21a-94220492a57f", "ip_address": "fd96:731b:22b0::1", "port_id": "d369b706-db4a-4239-b715-721708931870"}]
| name            | router1
| project_id      | 39e851b14f864573aad60582c35e40dc
| revision_number | 6
| routes          | 
| status          | ACTIVE
| tags            | 
| updated_at      | 2024-02-09T19:58:27Z
+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.6.** The previous command only outputs IDs, which can be used to remove the subnets from the router. However, to avoid having to type long ID strings, find the names of the subnets and remove them that way. List the subnets to see the which names are mapped to the IDs from the previous step.

```
ubuntu@workstation:~$ openstack subnet list \
> --max-width 100
```

ID	Name	Network	Subnet
4fc6bf88-919c-49df-83c4-b09bd65776ad	ipv6-public-subnet	32da4c25-b517-40c5-97e3-c	2001:db8::/64 ea031467d13
674205b6-1357-4727-a21a-94220492a57f	ipv6-private-subnet	966ecb4f-4ff8-44ea-a476-2	fd96:731b:22b0::/64 d2f18955085
7e456257-76e5-4fcf-bf3f-b2a3876dba40	shared-subnet	9f23266f-d833-4337-9a27-4	192.168.233.0/24 818a6d28e9e
c7916655-8954-4bf4-913d-416702f35d1b	public-subnet	32da4c25-b517-40c5-97e3-c	172.24.4.0/24 ea031467d13
fa8a2545-5a8c-44a2-bacc-1b86c253b880	private-subnet	966ecb4f-4ff8-44ea-a476-2	10.0.0.0/26 d2f18955085

- 1.7.** By matching the names and IDs, you can see that the router is connected to the **private-subnet** and **ipv6-private-subnet** subnets. Remove **private-subnet** from **router1**.

```
ubuntu@workstation:~$ openstack router remove subnet \
> router1 \
> private-subnet
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router remove subnet \
> router1 \
> private-subnet
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.8.** Now, remove **ipv6-private-subnet** from **router1**.

```
ubuntu@workstation:~$ openstack router remove subnet \
> router1 \
> ipv6-private-subnet
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router remove subnet \
> router1 \
> ipv6-private-subnet
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.9.** Now, the router can be deleted. Delete **router1**.

```
ubuntu@workstation:~$ openstack router delete router1
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router delete router1
[ubuntu@workstation (keystone-admin)]:~$ █
```

**Tip**

While you cannot delete a router that still has connections to subnets through the OpenStack Unified CLI, deleting a router through the Horizon Dashboard will automatically remove its connections.

- 1.10. List the available networks to find the name of the default external network.

```
ubuntu@workstation:~$ openstack network list \
> --max-width 100
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack network list \
> --max-width 80
+-----+-----+-----+
| ID      | Name   | Subnets
+-----+-----+-----+
| 32da4c25-b517-40c5-97e3-cea0314 | public  | 4fc6bf88-919c-49df-
| 67d13          |          | 83c4-b09bd65776ad,
|                  |          | c7916655-8954-4bf4-913d-
|                  |          | 416702f35d1b
| 966ecb4f-    | private | 674205b6-1357-4727-a21a-
| 4ff8-44ea-a476-2d2f18955085 |          | 94220492a57f, fa8a2545-5a8c-44a2
|                  |          | -bacc-1b86c253b880
| 9f23266f-d833-4337-9a27-4818a6d | shared   | 7e456257-76e5-4cfc-bf3f-
| 28e9e          |          | b2a3876dba40
+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.11. From the output of the previous step, you can see that the **public** network should be the default external network. Delete the **public** network.

```
ubuntu@workstation:~$ openstack network delete public
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack network delete public
[ubuntu@workstation (keystone-admin)]:~$ █
```

**Tip**

You can confirm that **public** is an external network by viewing its details with the command **openstack network show public**.

- 1.12. Now, we will create our own resources. First, create an external network named **extern-net**. Set the network type to **flat** and the physical network to **public**. Set the network as shared and external.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack network create \
> --external --share \
> --provider-network-type flat \
> --provider-physical-network public \
> extern-net
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack network create \
> --external --share \
> --provider-network-type flat \
> --provider-physical-network public \
> extern-net
+-----+
| Field | Value |
+-----+
| admin_state_up | UP |
| availability_zone_hints | |
| availability_zones | |
| created_at | 2024-06-20T00:32:56Z |
| description | |
| dns_domain | None |
| id | 3a5fd05e-cabe-4940-b5e1-68543c89d908 |
| ipv4_address_scope | None |
| ipv6_address_scope | None |
| is_default | False |
| is_vlan_transparent | None |
| mtu | 1500 |
| name | extern-net |
| port_security_enabled | True |
| project_id | 39e851b14f864573aad60582c35e40dc |
| provider:network_type | flat |
| provider:physical_network | public |
| provider:segmentation_id | None |
| qos_policy_id | None |
| revision_number | 1 |
| router:external | External |
| segments | None |
| shared | True |
| status | ACTIVE |
| subnets | |
| tags | |
| updated_at | 2024-06-20T00:32:56Z |
+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.13. Create a subnet named **extern-subnet** in the **extern-net** network. Give the subnet a range of **172.25.250.60** to **172.25.250.80**. Disable DHCP services for the subnet and use the address **172.25.250.254** as the gateway as well as the DNS name server.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack subnet create \
> --subnet-range 172.25.250.0/24 \
> --no-dhcp \
> --gateway 172.25.250.254 \
> --dns-nameserver 172.25.250.254 \
> --allocation-pool start=172.25.250.60,end=172.25.250.80 \
> --network extern-net \
> extern-subnet
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack subnet create \
> --subnet-range 172.25.250.0/24 \
> --no-dhcp \
> --gateway 172.25.250.254 \
> --dns-nameserver 172.25.250.254 \
> --allocation-pool start=172.25.250.60,end=172.25.250.80 \
> --network extern-net \
> extern-subnet
+-----+
| Field          | Value
+-----+
| allocation_pools | 172.25.250.60-172.25.250.80
| cidr           | 172.25.250.0/24
| created_at     | 2024-06-20T00:36:30Z
| description    |
| dns_nameservers | 172.25.250.254
| enable_dhcp    | False
| gateway_ip     | 172.25.250.254
| host_routes    |
| id              | 3f03a85a-ed86-418c-bc6e-07f4ee2d95cf
| ip_version      | 4
| ipv6_address_mode | None
| ipv6_ra_mode    | None
| name            | extern-subnet
| network_id      | 3a5fd05e-cabe-4940-b5e1-68543c89d908
| project_id      | 39e851b14f864573aad60582c35e40dc
| revision_number | 0
| segment_id      | None
| service_types   |
| subnetpool_id   | None
| tags            |
| updated_at      | 2024-06-20T00:36:30Z
+-----+
[ubuntu@workstation (keystone-admin)]:~$
```

- 1.14. List the floating IPs to make sure none are already allocated. The list should be empty.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack floating ip list
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack floating ip list
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.15. From the floating IP pool in the **extern-net** network, create a floating IP.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack floating ip create extern-net
```

Field	Value
created_at	2024-06-20T00:38:36Z
description	
fixed_ip_address	None
floating_ip_address	172.25.250.76
floating_network_id	3a5fd05e-cabe-4940-b5e1-68543c89d908
id	2cebf804-081c-4a96-815f-bfec7c7f5ddc
name	172.25.250.76
port_id	None
project_id	39e851b14f864573aad60582c35e40dc
qos_policy_id	None
revision_number	0
router_id	None
status	DOWN
subnet_id	None
updated_at	2024-06-20T00:38:36Z

- 1.16. Create a router named **extern-router**.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router create extern-router
```

Field	Value
admin_state_up	UP
availability_zone_hints	
availability_zones	
created_at	2024-06-20T00:40:08Z
description	
distributed	False
external_gateway_info	None
flavor_id	None
ha	False
id	c92e57ef-ba53-4081-92be-d4856d09ae1b
name	extern-router
project_id	39e851b14f864573aad60582c35e40dc
revision_number	1
routes	
status	ACTIVE
tags	
updated_at	2024-06-20T00:40:08Z

- 1.17.** List the available subnets to see what the router can be connected to.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack subnet list
```

- 1.18.** Connect the router to the **shared-subnet** subnet.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router add subnet \
> ext-router shared-subnet
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router add subnet \
> ext-router shared-subnet
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.19. Set the `extern-net` network as the gateway for the router.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router set \
> --external-gateway extern-net \
> extern-router
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack router set \
> --external-gateway ext-extern-net \
> ext-extern-router
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.20.** List the current key pairs to make sure there are not any already allocated. The list should be empty.

```
[ubuntu@workstation keystone-admin]:~$ openstack keypair list
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack keypair list
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.21.** Create the key pair **dev-keypair** and save the private key to the file **~/Downloads/dev-keypair.pem**.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack keypair create \
> dev-keypair > ~/Downloads/dev-keypair.pem
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack keypair create \
> dev-keypair > ~/Downloads/dev-keypair.pem
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.22.** View the permission of the **~/Downloads/dev-keypair.pem** file. You can see that the **ubuntu** user has read and write privileges to the file, the **ubuntu** user group has read and write privileges to the file, and other users have read permissions to the file. However, this is a sensitive file, and only the **ubuntu** user should have any privileges to it.

```
[ubuntu@workstation (keystone-admin)]:~$ ls -l ~/Downloads/dev-keypair.pem
```

```
[ubuntu@workstation (keystone-admin)]:~$ ls -l ~/Downloads/dev-keypair.pem
-rw-rw-r-- 1 ubuntu ubuntu 1680 Jun 20 00:50 /home/ubuntu/Downloads/dev-keypair.pem
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.23.** Use the **chmod** command with a mode of **600** to make it so that the **ubuntu** user has read/write permissions on the file, and groups and other users have no permissions to the file.

```
[ubuntu@workstation (keystone-admin)]:~$ chmod 600 ~/Downloads/dev-keypair.pem
```

```
[ubuntu@workstation (keystone-admin)]:~$ chmod 600 ~/Downloads/dev-keypair.pem
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.24.** List the permissions again to ensure that the change took effect.

```
[ubuntu@workstation (keystone-admin)]:~$ ls -l ~/Downloads/dev-keypair.pem
```

```
[ubuntu@workstation (keystone-admin)]:~$ ls -l ~/Downloads/dev-keypair.pem
-rw----- 1 ubuntu ubuntu 1680 Jun 20 00:50 /home/ubuntu/Downloads/dev-keypair.pem
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.25.** Create the **dev-secgroup** security group.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group create \
> dev-secgroup
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group create \
> --max-width 80 dev-secgroup
+-----+
| Field      | Value
+-----+
| created_at | 2024-06-20T00:53:21Z
| description | dev-secgroup
| id          | 3eed79d7-1d19-4732-94a4-4e988e045c65
| name        | dev-secgroup
| project_id  | 39e851b14f864573aad60582c35e40dc
| revision_number | 1
| rules       |
|             | created_at='2024-06-20T00:53:21Z', direction='egress',
|             | ethtertype='IPv4', id='091d1937-a73c-
|             | 43f5-8611-a73e6fd4b283', standard_attr_id='54',
|             | updated_at='2024-06-20T00:53:21Z'
|             | created_at='2024-06-20T00:53:21Z', direction='egress',
|             | ethtertype='IPv6',
|             | id='20264157-0ee5-4c59-94d0-d8cd62a1bb7f',
|             | standard_attr_id='53', updated_at='2024-06-20T00:53:21Z'
|             | 2024-06-20T00:53:21Z
+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

## 1.26. List the default security group rules.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule list \
> --fit-width dev-secgroup
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule list \
> --max-width 80 dev-secgroup
+-----+-----+-----+-----+-----+
| ID      | IP Protocol | IP Range | Port Range | Remote Security Group |
+-----+-----+-----+-----+-----+
| 091d1937-a73c-43f | None     | None    |           | None
| 5-8611-a73e6fd4b2 |
| 83
| 20264157-0ee5-4c5 |
| 9-94d0-d8cd62a1bb |
| 7f
+-----+-----+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

### Note

You can verify with the command **openstack security group rule show RULE\_ID** that the default rules allow any outgoing traffic over IPv4 or IPv6.

## 1.27. Add a security rule in the **dev-secgroup** security group to allow remote ICMP traffic.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule create \
> --protocol icmp \
> dev-secgroup
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule create \
> --protocol icmp \
> dev-secgroup
+-----+-----+
| Field | Value |
+-----+-----+
| created_at | 2024-06-20T00:55:48Z |
| description | ingress |
| direction | IPv4 |
| ether_type | IPv4 |
| id | b3b9272c-17de-44b2-bc6b-72bd247bb1f0 |
| name | None |
| port_range_max | None |
| port_range_min | None |
| project_id | 39e851b14f864573aad60582c35e40dc |
| protocol | icmp |
| remote_group_id | None |
| remote_ip_prefix | 0.0.0.0/0 |
| revision_number | 0 |
| security_group_id | 3eed79d7-1d19-4732-94a4-4e988e045c65 |
| updated_at | 2024-06-20T00:55:48Z |
+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.28. Add another security rule to allow remote connection using SSH on the default port 22.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule create \
> --protocol tcp \
> --dst-port 22 \
> dev-secgroup
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule create \
> --protocol tcp \
> --dst-port 22 \
> dev-secgroup
+-----+-----+
| Field | Value |
+-----+-----+
| created_at | 2024-06-20T00:56:23Z |
| description | ingress |
| direction | IPv4 |
| ether_type | IPv4 |
| id | 18e86e58-65d6-4197-8058-a1d80768f64b |
| name | None |
| port_range_max | 22 |
| port_range_min | 22 |
| project_id | 39e851b14f864573aad60582c35e40dc |
| protocol | tcp |
| remote_group_id | None |
| remote_ip_prefix | 0.0.0.0/0 |
| revision_number | 0 |
| security_group_id | 3eed79d7-1d19-4732-94a4-4e988e045c65 |
| updated_at | 2024-06-20T00:56:23Z |
+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.29. List the security group rules again to see that the new rules have taken effect.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule list
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack security group rule list \
> --max-width 80 dev-secgroup
+-----+-----+-----+-----+-----+
| ID      | IP Protocol | IP Range   | Port Range | Remote Security Group |
+-----+-----+-----+-----+-----+
| 091d1937-a73c-43f
5-8611-a73e6fd4b2
83
18e86e58-65d6-419
7-8058-a1d80768f6
4b
20264157-0ee5-4c5
9-94d0-d8cd62a1bb
7f
b3b9272c-17de-
44b2-bc6b-
72bd247bb1f0
| None      | None       | 0.0.0.0/0  | 22:22      | None
| None      | None       | 0.0.0.0/0  |            | None
| None      | None       | 0.0.0.0/0  |            | None
+-----+-----+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 1.30.** Close the terminal window and continue to the next task.

## 2 Creating a Customized Instance Using the Horizon Dashboard

In this task, you will create a customized instance using the Horizon Dashboard and log into the instance to verify that the customization took effect.

- 2.1. Open the web browser and navigate to **192.168.1.20**. Log into the dashboard as **admin** with the password **secret**.
- 2.2. Make sure the **demo** project is selected. Navigate to **Project > Compute > Instances**, and click **Launch Instance**.

- 2.3. In the *Details* tab, enter **instance1** in the *Instance Name* field and click **Next**.

- 2.4.** In the *Source* tab, make sure **Image** is selected in the *Select Boot Source* dropdown and click **No** under *Create New Volume*. Select the **ubuntu** image by clicking the  $\uparrow$  symbol in the same row. Click **Next**.

Launch Instance

Details	Instance source is the template used to create an instance. You can use an image, a snapshot of an instance (image or snapshot), a volume or a volume snapshot (if enabled). You can also choose to use persistent storage by creating a new volume.				
Source *	Select Boot Source		Create New Volume		
Flavor *	Image		Yes	No	
Networks *	Allocated				
Network Ports	Displaying 0 items				
Security Groups	Name	Updated	Size	Format	Visibility
	Select an item from Available items below				
Key Pair	Displaying 0 items				
Configuration					
Server Groups	▼ Available 2 Select one				
Scheduler Hints	<input type="text"/> Click here for filters or full text search.				
Metadata	Displaying 2 items				
	Name	Updated	Size	Format	Visibility
	➤ cirros-0.6.2-x86_64-disk	11/8/23 9:23 PM	20.44 MB	QCOW2	Public
	➤ ubuntu	11/8/23 10:23 PM	642.75 MB	QCOW2	Public
	Displaying 2 items				
	<input type="button"/> Cancel <input type="button"/> < Back <input type="button"/> Next > <input type="button"/> Launch Instance				

Stop

Before proceeding to the next step, confirm that **ubuntu** appears underneath the *Allocated* section.

- 2.5.** In the *Flavor* tab, click the  $\uparrow$  symbol in the same row as **m1.small** Click **Next**.

Launch Instance

**Allocated**

Flavors manage the sizing for the compute, memory and storage capacity of the instance.

**Flavor \***

Networks \*

Network Ports

Security Groups

Key Pair

Configuration

Server Groups

Scheduler Hints

Metadata

Available 12

Select one

Click here for filters or full text search.

Name	VCPUS	RAM	Total Disk	Root Disk	Ephemeral Disk	Public	
m1.nano	1	128 MB	1 GB	1 GB	0 GB	Yes	↑
m1.micro	1	192 MB	1 GB	1 GB	0 GB	Yes	↑
cirros256	1	256 MB	1 GB	1 GB	0 GB	Yes	↑
m1.tiny	1	512 MB	1 GB	1 GB	0 GB	Yes	↑
ds512M	1	512 MB	5 GB	5 GB	0 GB	Yes	↑
ds1G	1	1 GB	10 GB	10 GB	0 GB	Yes	↑
m1.small	1	2 GB	20 GB	20 GB	0 GB	Yes	↑
ds2G	2	2 GB	10 GB	10 GB	0 GB	Yes	↑
m1.medium	2	4 GB	40 GB	40 GB	0 GB	Yes	↑
ds4G	4	4 GB	20 GB	20 GB	0 GB	Yes	↑
m1.large	4	8 GB	80 GB	80 GB	0 GB	Yes	↑
m1.xlarge	8	16 GB	160 GB	160 GB	0 GB	Yes	↑

Displaying 12 items

Cancel

< Back

Next >

Launch Instance

### Stop

Before proceeding to the next step, confirm that **m1.small** appears underneath the *Allocated* section.

- 2.6. In the *Networks* tab, click the ↑ symbol in the same row as **shared**. Click **Next**.

Launch Instance

**Details**

Networks provide the communication channels for instances in the cloud. You can select ports instead of networks or a mix of both.

**Allocated**

Displaying 0 items

Network	Subnets Associated	Shared	Admin State	Status
Select one or more networks from the available networks below.				

**Network Ports**

Displaying 0 items

**Available** (3)

Select one or more

**Security Groups**

**Key Pair**

**Configuration**

Displaying 3 items

**Server Groups**

Network	Subnets Associated	Shared	Admin State	Status	
shared	shared-subnet	Yes	Up	Active	↑
extern-net	extern-subnet	Yes	Up	Active	↑
private	ipv6-private-subnet private-subnet	No	Up	Active	↑

Displaying 3 items

**Cancel** **Next >** **Launch Instance**

### Stop

Before proceeding to the next step, confirm that **shared** appears underneath the **Allocated** section.

- 2.7. In the *Network Ports* tab, click **Next**.

Launch Instance

**Details**

Ports provide extra communication channels to your instances. You can select ports instead of networks or a mix of both.

**Allocated**

Displaying 0 items

Name	IP	Admin State	Status
Select one or more ports from the available ports below.			

**Network Ports**

Displaying 0 items

**Available** 0

Select one or more

**Key Pair**

**Configuration**

Displaying 0 items

**Server Groups**

Name	IP	Admin State	Status
No items to display.			

**Scheduler Hints**

Displaying 0 items

**Metadata**

Displaying 0 items

**Cancel** **Next >** **Launch Instance**

- 2.8. In the *Security Groups* tab, click the ↓ symbol in the same row as **default**, and click the ↑ symbol in the same row as **dev-secgroup**. Click **Next**.

Launch Instance

**Details**

Select the security groups to launch the instance in.

**Allocated** 1

Displaying 1 item

Name	Description
default	Default security group

**Network Ports**

Displaying 1 item

**Security Groups**

**Available** 1

Select one or more

**Key Pair**

**Configuration**

Displaying 1 item

**Server Groups**

Name	Description
dev-secgroup	dev-secgroup

**Scheduler Hints**

Displaying 1 item

**Metadata**

Displaying 1 item

**Cancel** **Next >** **Launch Instance**

### Stop

Before proceeding to the next step, confirm that only **dev-secgroup** appears underneath the *Allocated* section.

- 2.9.** In the *Key Pair* tab, ensure that the key pair **dev-keypair** has been selected and is underneath the *Allocated* section. Click **Next**.

Launch Instance

Details

A key pair allows you to SSH into your newly created instance. You may select an existing key pair, import a key pair, or generate a new key pair.

Source

+ Create Key Pair    Import Key Pair

Flavor

Allocated

Displaying 1 item

Name	Type	Fingerprint
dev-keypair	ssh	bc:c6:93:d6:a8:71:08:bc:9d:e1:74:6e:e8:8f:b5:2b

Network Ports

Security Groups

Key Pair

Configuration

Server Groups

Scheduler Hints

Metadata

Available 0

Select one

Click here for filters or full text search.

Displaying 0 items

Name	Type	Fingerprint
No items to display.		

Displaying 0 items

< Back    Next >    Launch Instance

- 2.10.** In the *Configuration* tab, populate the **Customization Script** field with the content below. Once finished, click **Launch Instance**.

```
#!/bin/bash
echo 'Hello, world!' > /root/hello.txt
```

Launch Instance

Details	You can customize your instance after it has launched using the options available here. "Customization Script" is analogous to "User Data" in other systems.	
Source	Load Customization Script from a file <input type="button" value="Browse..."/> No file selected.	
Flavor	Customization Script (Modified)	
Networks	Content size: 50 bytes of 16.00 KB	
Network Ports		
Security Groups		
Key Pair		
Configuration	#!/bin/bash echo 'Hello, world!' > /root/hello.txt	
Server Groups	<input type="button" value="Automatic"/>	
Scheduler Hints	<input type="checkbox"/> Configuration Drive	
Metadata		

Cancel      < Back      Next >      Launch Instance

### Tip

A customization script can be used to perform many commands automatically upon instance creation, such as installing packages, configuring a host name, etc. The simple script above is just an example.

- 2.11. Once the status for **instance1** is **Active**, attach a floating IP address to it. Select **Associate Floating IP** from the dropdown menu next to **Create Snapshot** in the row for the instance.

Project / Compute / Instances

Instances

<input type="checkbox"/>	Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
<input type="checkbox"/>	instance1	ubuntu	192.168.233.7	m1.small	dev-keypair	Active	nova	None	Running	0 minutes	<input type="button" value="Create Snapshot"/> <div style="background-color: #f0f0f0; padding: 5px; border: 1px solid #ccc; position: absolute; right: -10px; top: 0; width: 150px; height: 150px; display: none;"> <span style="margin-right: 10px;">Associate Floating IP</span> <span>Attach Interface</span> <span>Detach Interface</span> <span>Edit Instance</span> </div>

Displaying 1 item

- 2.12. Select any one of the IP addresses from the *IP Address* dropdown and select **instance1: 192.168.233.XYZ** as the *Port to be associated*. Click **Associate**.

## Manage Floating IP Associations



**IP Address \***

172.25.250.76

Select the IP address you wish to associate with the selected instance or port.



**Port to be associated \***

instance1: 192.168.233.7

[Cancel](#)

[Associate](#)

- 2.13.** To verify that the customization script worked, first click on **instance1** under the *Instance Name* column, then navigate to the *Console* tab if you are not directed there automatically. Click on **Click here to show only the console**. Log into the instance as **root** with the password **secret**.

```
Connected to QEMU (Instance-00000009)

Ubuntu 22.04.3 LTS instance1 tty1

instance1 login: root
Password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-87-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

 System information as of Thu Nov 30 17:42:55 UTC 2023

 System load:  0.0927734375   Processes:          81
 Usage of /:   15.0% of 9.51GB  Users logged in:     0
 Memory usage: 17%              IPv4 address for ens3: 192.168.233.250
 Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update
Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your Internet connection or proxy settings

Last login: Wed Nov 29 22:05:32 UTC 2023 on tty1
root@instance1:~#
```

### Note

Be patient for the login prompt. Even if OpenStack reports the instance to be active, it may still take several minutes to fully launch and present the login prompt.

- 2.14.** Check **/var/log/cloud-init.log** to confirm that **cloud-init** ran. Use the **tail** command to print the last 10 lines of the log.

```
root@instance1:~# sudo tail /var/log/cloud-init.log
```

```
Connected to QEMU (Instance-00000009)

root@instance1:~# sudo tail /var/log/cloud-init.log
sudo: unable to resolve host instance1: Temporary failure in name resolution
2023-11-30 17:32:30,843 - util.py[DEBUG]: Writing to /var/lib/cloud/instance/boot-finished - wb: [644] 70 bytes
2023-11-30 17:32:30,852 - handlers.py[DEBUG]: finish: modules-final/config-final_message: SUCCESS: config-final_message ran successfully
2023-11-30 17:32:30,853 - main.py[DEBUG]: Ran 11 modules with 0 failures
2023-11-30 17:32:30,860 - atomic_helper.py[DEBUG]: Atomically writing to file /var/lib/cloud/data/status.json (via temporary file /var/lib/cloud/data/tmppufilegz_) - w: [644] 590 bytes/chars
2023-11-30 17:32:30,867 - atomic_helper.py[DEBUG]: Atomically writing to file /var/lib/cloud/data/result.json (via temporary file /var/lib/cloud/data/tmpwymssadmy) - w: [644] 87 bytes/chars
2023-11-30 17:32:30,870 - util.py[DEBUG]: Creating symbolic link from '/run/cloud-init/result.json' => '../../../../../var/lib/cloud/data/result.json'
2023-11-30 17:32:30,872 - util.py[DEBUG]: Reading from /proc/uptime (quiet=False)
2023-11-30 17:32:30,875 - util.py[DEBUG]: Read 12 bytes from /proc/uptime
2023-11-30 17:32:30,877 - util.py[DEBUG]: cloud-init mode 'modules' took 3.172 seconds (3.17)
2023-11-30 17:32:30,878 - handlers.py[DEBUG]: finish: modules-final: SUCCESS: running modules for final
root@instance1:~# _
```

- 2.15.** Ensure that the **/root/hello.txt** file exists and has the correct content.

```
root@instance1:~# cat /root/hello.txt
```

```
Connected to QEMU (Instance-0000000b)

root@instance1:~# cat /root/hello.txt
Hello, world!
root@instance1:~# _
```

- 2.16.** Close the tab with the terminal window and navigate back to **Project > Compute > Instances** if you are not already on that page. We are finished with this instance and will create another one in the next section. Select the checkbox next to **instance1** and click **Delete Instances**.

Project / Compute / Instances

## Instances

Instance ID =	Filter	Launch Instance	Delete Instances	More Actions						
Displaying 1 item										
Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
<input checked="" type="checkbox"/> instance1	ubuntu	192.168.233.7, 172.25.250.76	m1.small	dev-keypair	Active	nova	None	Running	8 minutes	<button>Create Snapshot</button>

Displaying 1 item

- 2.17.** Log out of the *Horizon Dashboard* and close the web browser.

- 2.18.** Continue to the next task.

### 3 Creating a Customized Instance Using the OpenStack Unified CLI

In this task, you will verify that **cloud-init** has correctly customized the two instances created in the previous section.

- 3.1. If a terminal window is not already open, open one and source the admin credentials from the `~/keystonerc-admin` file.

```
[ubuntu@workstation (keystone-admin)]:~$ source ~/keystonerc-admin
```

- 3.2. Another instance will be created and customized using the *OpenStack Unified CLI*. First, create a **user-data** script that will be attached to the instance at creation. Create a script called `~/hello` that matches the content shown below. When the instance runs this script, it will create the file `/root/hello.txt` with the contents **Hello, world!**, and it will append the line **127.0.1.1 instance2** to the `/etc/hosts` file. This simply suppresses a warning when issuing a command with root privileges (i.e., `sudo ...`). Press **CTRL+X**, then **Y** to accept the file changes. Press **Enter** to confirm and exit back to the terminal.

```
[ubuntu@workstation (keystone-admin)]:~$ nano ~/hello
```

```
#!/bin/bash
echo 'Hello, world!' > /root/hello.txt
echo '127.0.1.1' hostname >> /etc/hosts
```



```
GNU nano 2.9.3          hello          Modified

#!/bin/bash
echo 'Hello, world!' > /root/hello.txt
echo '127.0.1.1' hostname >> /etc/hosts

^G Get Help  ^O Write Out  ^W Where Is  ^K Cut Text  ^J Justify  ^C Cur Pos
^X Exit      ^R Read File  ^\ Replace   ^U Uncut Text  ^T To Spell  ^_ Go To Line
```

- 3.3. Launch an instance using the **user-data** option with the previously created script to perform the customization. Use the **ubuntu** image, the **m1.small** flavor, the **shared** network, the **dev-secgroup** security group, and the **dev-keypair** key pair.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server create \
> --image ubuntu \
> --flavor m1.small \
> --nic net-id=shared \
> --security-group dev-secgroup \
> --key-name dev-keypair \
> --user-data ~/hello \
> instance2
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server create \
> --image ubuntu \
> --flavor m1.small \
> --nic net-id=shared \
> --security-group dev-secgroup \
> --key-name dev-keypair \
> --user-data ~/hello \
> instance2
+-----+
| Field | Value |
+-----+
| OS-DCF:diskConfig | MANUAL
| OS-EXT-AZ:availability_zone | None
| OS-EXT-SRV-ATTR:host | None
| OS-EXT-SRV-ATTR:hypervisor_hostname | None
| OS-EXT-SRV-ATTR:instance_name | instance2
| OS-EXT-STS:power_state | NOSTATE
| OS-EXT-STS:task_state | scheduling
| OS-EXT-STS:vm_state | building
| OS-SRV-USG:launched_at | None
| OS-SRV-USG:terminated_at | None
| accessIPv4 | 
| accessIPv6 | 
| addresses | 
| adminPass | X45SA4HjiThD
| config_drive | 
| created | 2024-06-20T14:38:02Z
| flavor | m1.small (2)
| hostId | 
| id | 352cc7e5-8e0a-4bc7-946e-aac5da0bb683
| image | ubuntu (329d361e-f6dc-4b72-b200-3de0ec230e65)
| key_name | dev-keypair
| name | instance2
| progress | 0
| project_id | 39e851b14f864573aad60582c35e40dc
| properties | 
| security_groups | name='9894fdd9-f5d4-486a-b85e-8f4a0a88f9d7'
| status | BUILD
| updated | 2024-06-20T14:38:01Z
| user_id | 14f5376f00c04e90b7103dd8d4263040
| volumes_attached | 
+-----+
[ubuntu@workstation (keystone-admin)]:~$
```

### 3.4. Verify that the status of the **instance2** instance is **ACTIVE**.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server list
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server list
+-----+-----+-----+-----+-----+
| ID      | Name    | Status | Networks          | Image   | Flavor  |
+-----+-----+-----+-----+-----+
| 352cc7e5-8e0a-4bc7-946e-aac5da0bb683 | instance2 | ACTIVE | shared=192.168.233.16 | ubuntu | m1.small |
+-----+-----+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ ]
```

- 3.5.** List the floating IPs to see the free address, which was disassociated from the previous instance when the instance was deleted.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack floating ip list
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack floating ip list \
> --max-width 80
+-----+-----+-----+-----+-----+
| ID      | Floating IP Address | Fixed IP Address | Port | Floating Network | Project  |
+-----+-----+-----+-----+-----+
| 44459475-75 | 172.25.250.76 | None           | None | bdfcd0d0-02e5-43 | 39e851b14f864 |
| b8-4532-a70 |
| 0-115d0c394 |
| 6db       |
+-----+-----+-----+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ ]
```

- 3.6.** Assign the floating IP to **instance2**.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server add floating ip \
instance2 172.25.250.76
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server add floating ip \
> instance2 172.25.250.76
[ubuntu@workstation (keystone-admin)]:~$ ]
```

- 3.7.** Verify that the instance was assigned the floating IP address.

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server list \
> -c Name \
> -c Networks
```

```
[ubuntu@workstation (keystone-admin)]:~$ openstack server list \
> -c Name \
> -c Networks
+-----+-----+
| Name      | Networks          |
+-----+-----+
| instance2 | shared=192.168.233.16, 172.25.250.76 |
+-----+-----+
[ubuntu@workstation (keystone-admin)]:~$ ]
```

- 3.8. Use the **scp** command to copy the **~/Downloads/dev-keypair.pem** file to the **devstack** machine. When prompted to enter the password for **ubuntu@192.168.1.20**, enter **ubuntu**.

```
[ubuntu@workstation (keystone-admin)]:~$ scp ~/Downloads/dev-keypair.pem \
> ubuntu@192.168.1.20:~/dev-keypair.pem
```

```
[ubuntu@workstation (keystone-admin)]:~$ scp ~/Downloads/dev-keypair.pem \
> ubuntu@192.168.1.20:~/dev-keypair.pem
ubuntu@192.168.1.20's password:
dev-keypair.pem                                              100% 1676      2.0MB/s   00:00
[ubuntu@workstation (keystone-admin)]:~$ █
```

- 3.9. SSH into the **devstack** machine. Enter **ubuntu** when prompted for a password.

```
[ubuntu@workstation (keystone-admin)]:~$ ssh 192.168.1.20
```

```
[ubuntu@workstation (keystone-admin)]:~$ ssh 192.168.1.20
ubuntu@192.168.1.20's password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-94-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

This system has been minimized by removing packages and content that are
not required on a system that users do not log into.

To restore this content, you can run the 'unminimize' command.
Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your
Internet connection or proxy settings

Last login: Fri Feb  9 22:37:16 2024
ubuntu@devstack:~$ █
```

- 3.10. SSH into **instance2** using the **dev-keypair** private key.

```
ubuntu@devstack:~$ ssh -i ~/dev-keypair.pem 172.25.250.76
```

```
ubuntu@devstack:~$ ssh -i ~/dev-keypair.pem 172.25.250.76
The authenticity of host '172.25.250.76 (172.25.250.76)' can't be established.
ED25519 key fingerprint is SHA256:rl4Akqw7dM+Hv79JX5xvY2Nj3pxV9eR4ZIYZRT1ZPww.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '172.25.250.76' (ED25519) to the list of known hosts.
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-92-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

System information as of Thu Jun 20 14:46:06 UTC 2024

System load:  0.5302734375   Processes:          85
Usage of /:   7.4% of 19.20GB  Users logged in:    0
Memory usage: 8%              IPv4 address for ens3: 192.168.233.16
Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@instance2:~$
```

### Note

It may take several minutes for the instance to fully boot and be available for an SSH connection. Until then, the connection will be refused.

### 3.11. Check `/var/log/cloud-init.log` to confirm that the `cloud-init` script ran.

```
ubuntu@instance2:~$ sudo tail /var/log/cloud-init.log
```

```
ubuntu@instance2:~$ sudo tail /var/log/cloud-init.log
sudo: unable to resolve host instance2: Temporary failure in name resolution
2024-01-14 19:36:22,239 - util.py[DEBUG]: Writing to /var/lib/cloud/instance/boot-finished - wb: [644] 70 bytes
2024-01-14 19:36:22,252 - handlers.py[DEBUG]: finish: modules-final/config-final_message: SUCCESS: config-final_message ran successfully
2024-01-14 19:36:22,253 - main.py[DEBUG]: Ran 11 modules with 0 failures
2024-01-14 19:36:22,261 - atomic_helper.py[DEBUG]: Atomically writing to file /var/lib/cloud/data/status.json (via temporary file /var/lib/cloud/data/tmponx5ch9u) - w: [644] 591 bytes/chars
2024-01-14 19:36:22,267 - atomic_helper.py[DEBUG]: Atomically writing to file /var/lib/cloud/data/result.json (via temporary file /var/lib/cloud/data/tmp9qkr_8a5) - w: [644] 87 bytes/chars
2024-01-14 19:36:22,270 - util.py[DEBUG]: Creating symbolic link from '/run/cloud-init/result.json' => '../../../../../var/lib/cloud/data/result.json'
2024-01-14 19:36:22,272 - util.py[DEBUG]: Reading from /proc/uptime (quiet=False)
2024-01-14 19:36:22,274 - util.py[DEBUG]: Read 13 bytes from /proc/uptime
2024-01-14 19:36:22,276 - util.py[DEBUG]: cloud-init mode 'modules' took 4.037 seconds (4.03)
2024-01-14 19:36:22,277 - handlers.py[DEBUG]: finish: modules-final: SUCCESS: running modules for final
ubuntu@instance2:~$ █
```

- 3.12.** View the **/etc/hosts** file to ensure that the hostname was appended correctly.

```
ubuntu@instance2:~$ cat /etc/hosts
```

```
ubuntu@instance2:~$ cat /etc/hosts
127.0.0.1 localhost

# The following lines are desirable for IPv6 capable hosts
::1 ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
ff02::3 ip6-allhosts
127.0.1.1 hostname
ubuntu@instance2:~$ █
```

- 3.13.** Ensure that the **/root/hello.txt** file exists and has the correct content.

```
ubuntu@instance2:~$ sudo cat /root/hello.txt
```

```
ubuntu@instance2:~$ sudo cat /root/hello.txt
Hello, world!
ubuntu@instance2:~$ █
```

- 3.14.** The lab is now complete.