Universität Göttingen
Institute for Computer Science / GWDG
Julian Kunkel, Jonathan Decker, Lauritz Rasbach



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It may seem like a lot at first, but follow the steps calmly.
Everything will fall into place.
And if you ever get stuck, we're just a message away!

## Exercise Introduction

This sheet describes the format of the course and instructions on how to prepare the cloud environment for the hands-on exercises.

## Course Format: Practicals

The course *High-Performance Computing System Administration 2025/26* takes place in an online format as a block course from 19.10.26 to 23.10.26 and utilizes Big Blue Button (BBB) rooms.

The first day will cover the basics and practical usage of cluster management. The latter days of the block course will go more in-depth on topics regarding the system administration aspects of high-performance computing.

On 23.10.26, we are offering on-site sessions in our compute center (RzGö) at Burckhardt-Weg 4, including tours of the data center and exercises with hands-on hardware. For the on-site session, participation is limited to 20 people.

The main BBB room is called **HPCSA**. In this room, the lecturer will present the slides and guide you through the course.
As this course is intended to provide hands-on experience, the lecturers will ask you to complete exercises during the course.
These exercises should be completed individually; however, you will form groups to support each other in case you get stuck.

To allow for communication within said groups, each group will receive its own breakout room in BBB.
The second BBB room, called **HPCSA - Support**, will be used for this. We will use two BBB rooms as Big Blue Button is limited, and it is currently not possible to be connected to a breakout room while also being able to listen to the main room. If you need help from outside your group, feel free to ask for help in the broadcast room, where the lecturer and a few helpers will be available. The format will be explained in more detail during the first session.

As you will be working with other participants of the course, you should be able to communicate with them via microphone if possible.

**Examination** The university students in this course will be able to choose topics related to High-Performance Computing System Administration at the end of the block course and work on a project based on said topic. For this, each student will be assigned a supervisor who is an expert on the given topic and who will guide the student. The student is expected to hand in a report by the end of the semester, which will be graded.

For further details on the examination, see the course page as well as the student assignment sheet provided at the end of the session on Thursday, 22.10.26.

`https://hps.vi4io.org/teaching/autumn_term_2026/hpcsa#examination`

**For the beginning of the course, it is enough to join the Course room.**

**Course Room:** `https://meet.academiccloud.de/gl/rooms/jul-pfo-7mr-txo`

**Support Room:** `https://meet.academiccloud.de/gl/rooms/jul-mii-pfh-shu`

**Please confirm before the course that you can connect to a BBB room and your microphone is working.** You may use the Support room BBB instance to test your setup.[1]

[1] If it doesn't work, please try first `https://test.bigbluebutton.org/`, then try with a different browser.

# Contents

**Task 1: Prepare Cloud Environment (45 min)** 3

**2 Useful Commands** 14

# Task 1: Prepare Cloud Environment (45 min)

During the HPCSA block course, you will be completing exercises that involve the installation and configuration of software under a Linux system. As this typically requires root permission on a given system, which cannot be granted on the HPC system, you will instead use Virtual Machines (VMs) handled by the GWDG OpenStack environment. The following steps will show you how to set up a VM using the OpenStack web interface and how to connect to it. During the course, you will be responsible for managing your VMs.

## Login

This section shows how to log in to the OpenStack Dashboard.

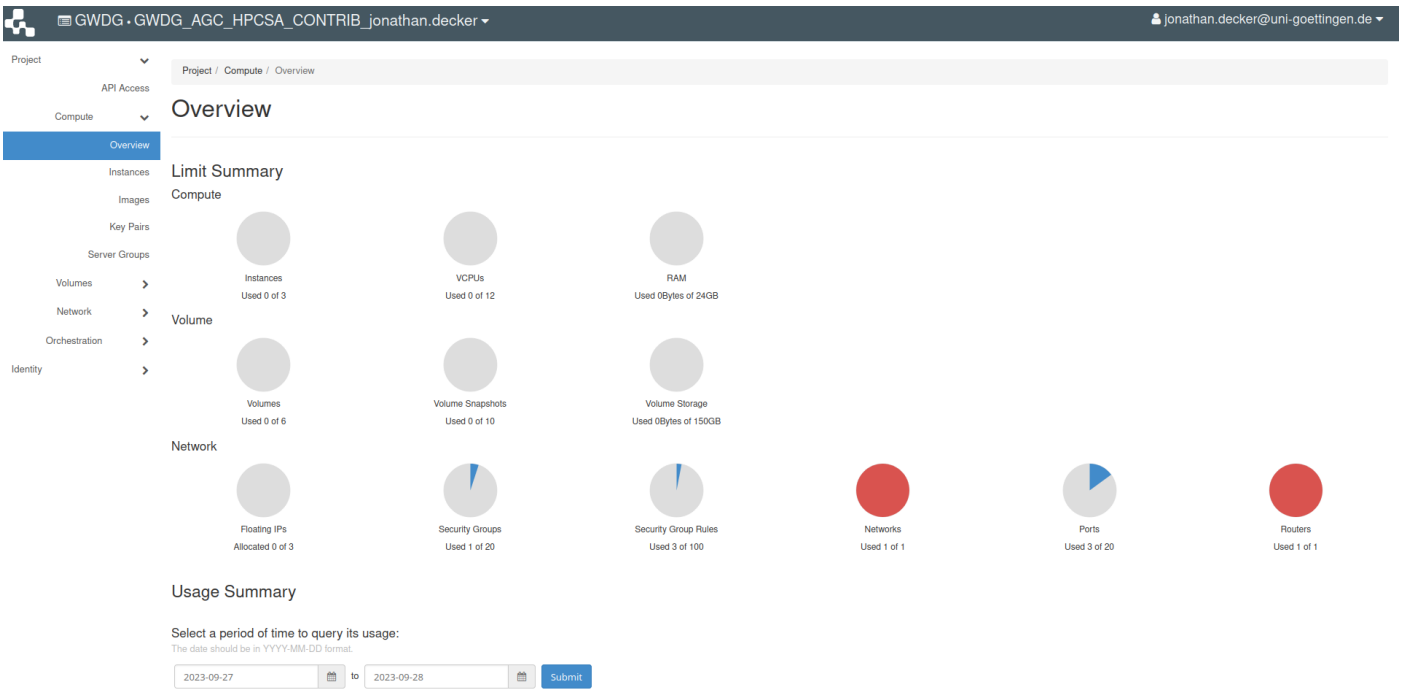


Figure 1: GWDG OpenStack Horizon Dashboard

1. Find your username and password in the course email.
2. Open `https://cloud.gwdg.de` in your browser and select **Login via AcademicID**.
3. Use your username and password to log in to the AcademicID web page.
4. You should be directed back to `https://cloud.gwdg.de` and see the OpenStack Horizon Dashboard similar to Figure 1

## Upload or Create SSH Key

This section shows how to upload an SSH key or create an SSH key pair, which can later be used to log in to your VMs.

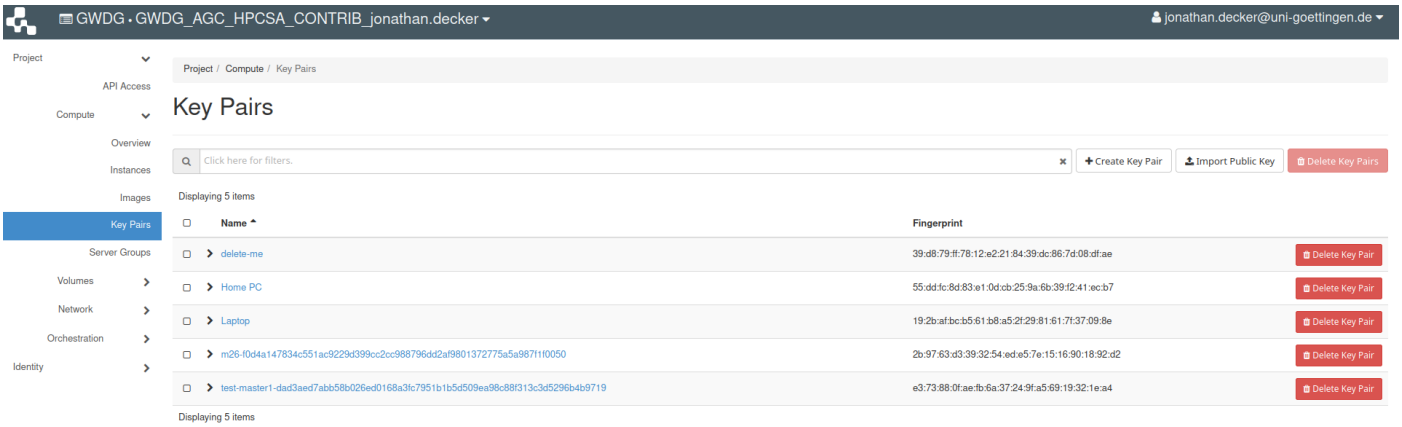


Figure 2: OpenStack key pairs

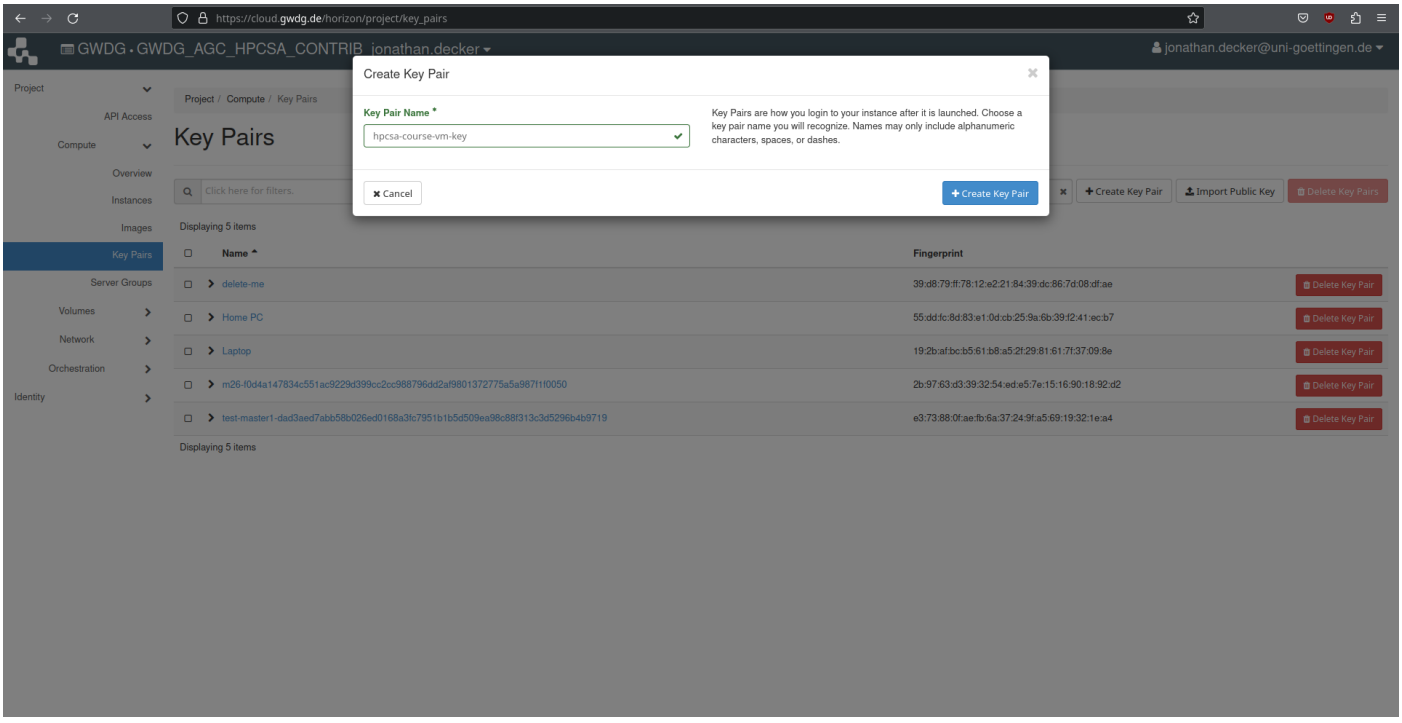


Figure 3: Create a new key pair

On the left side under **Compute** tab, select **Key Pairs**. You should see an empty key list similar to Figure 2 If the list is not empty and a key with the name **hpcsa-course-vm-key** already exists, delete it. You can either upload/import the public key for an SSH key you already have or create an SSH key pair.

**Upload** To upload/import a public key, click on **Import Public Key**. Name it **hpcsa-course-vm-key** and paste the public key. Then import it. You should see the uploaded/imported SSH key in the overview.

**Create** To create an SSH key pair instead, click on **Create Key Pair** and name it **hpcsa-course-vm-key**. See Figure 3 for reference. Then create the key pair. This will automatically download the private key to your computer, which will be required later to connect to the VMs. You should see the created key pair in the overview.

## Launch Main Instance

This section shows how to launch your main instance, which will use Alma 10 and be reachable from your machine via SSH.

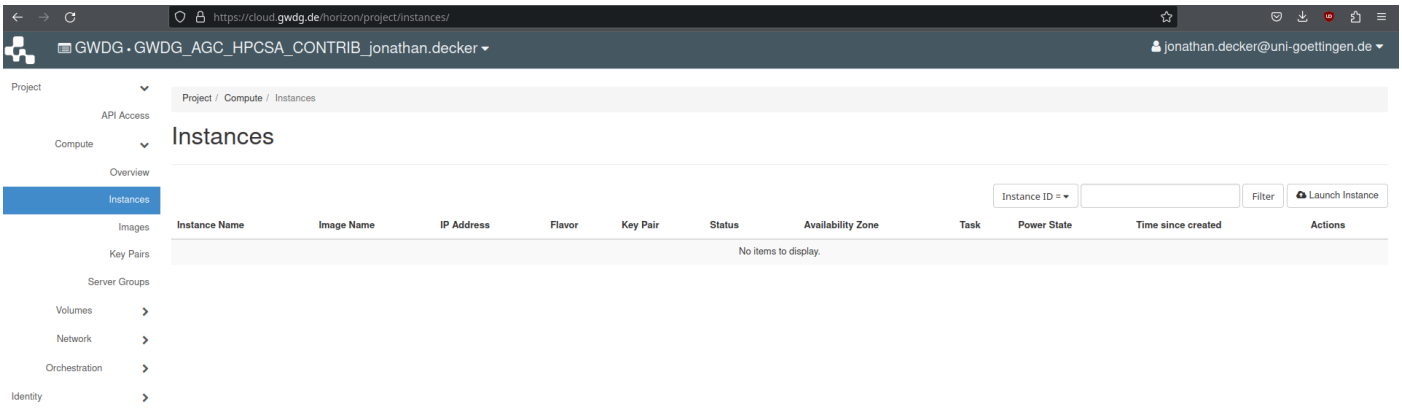


Figure 4: OpenStack Instance Overview Empty

1. On the left side, under **Compute** tab, select **Instances**. This opens the instance overview, which should show no instances as in Figure 4.

2. Click on **Launch Instance** and name your instance **cluster-manager** as shown in Figure 5.

3. Press **Next** to configure the **Source**. In the list at the bottom, find **Alma 10** and press the up arrow on the right to select it. Then ensure that **Create New Volume** and **Delete Volume on Instance Delete** are both set to **Yes**. The dialog should look the same as shown in Figure 6.

4. Press **Next** to configure **Flavor**, which refers to the preset of compute resources your new instance will have. From the list, find **c1.large** and press the arrow up on the right to select it such that it looks as shown in Figure 7.

5. Go to **Networks** and select the private network without pxe in its name.

6. Skip **Network Ports** and **Security Groups**.

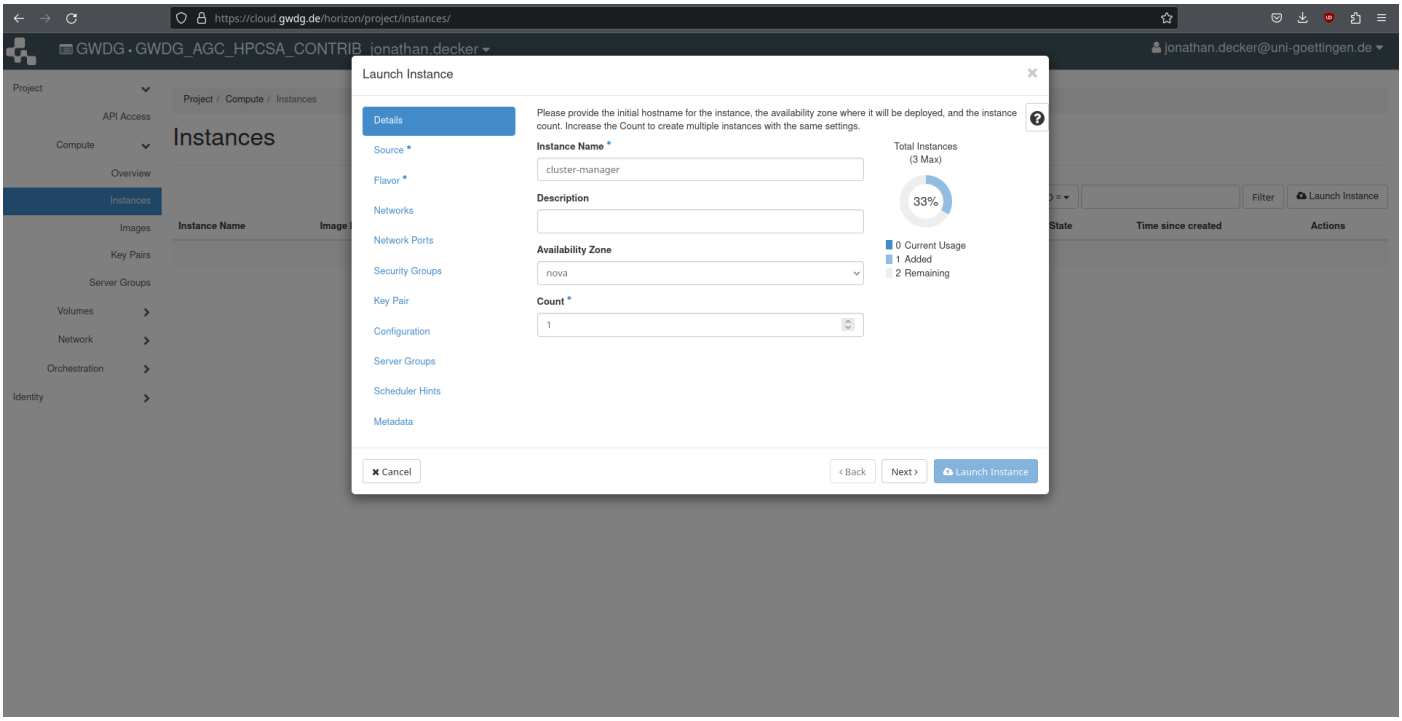


Figure 5: Launch Instance Details for Cluster-Manager

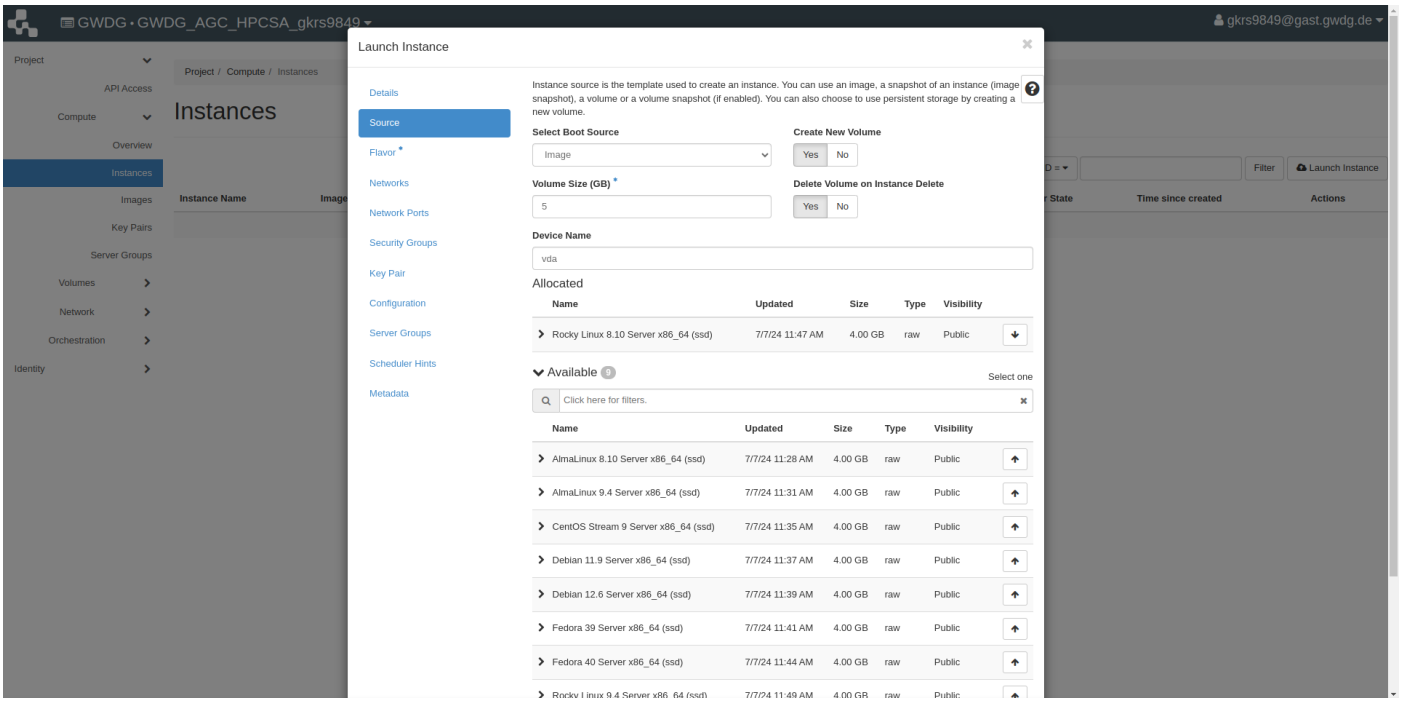


Figure 6: Launch Instance Source for Cluster-Manager

7. Move on to **Key Pair** and select the key pair called **hpcsa-course-vm-key**, which you had uploaded/imported or created earlier via the arrow on the right such that the key is under **Allocated** and it looks similar to Figure 8.

8. Press **Launch Instance** and see that the system is now working on provisioning your VM as can be seen in Figure 9.

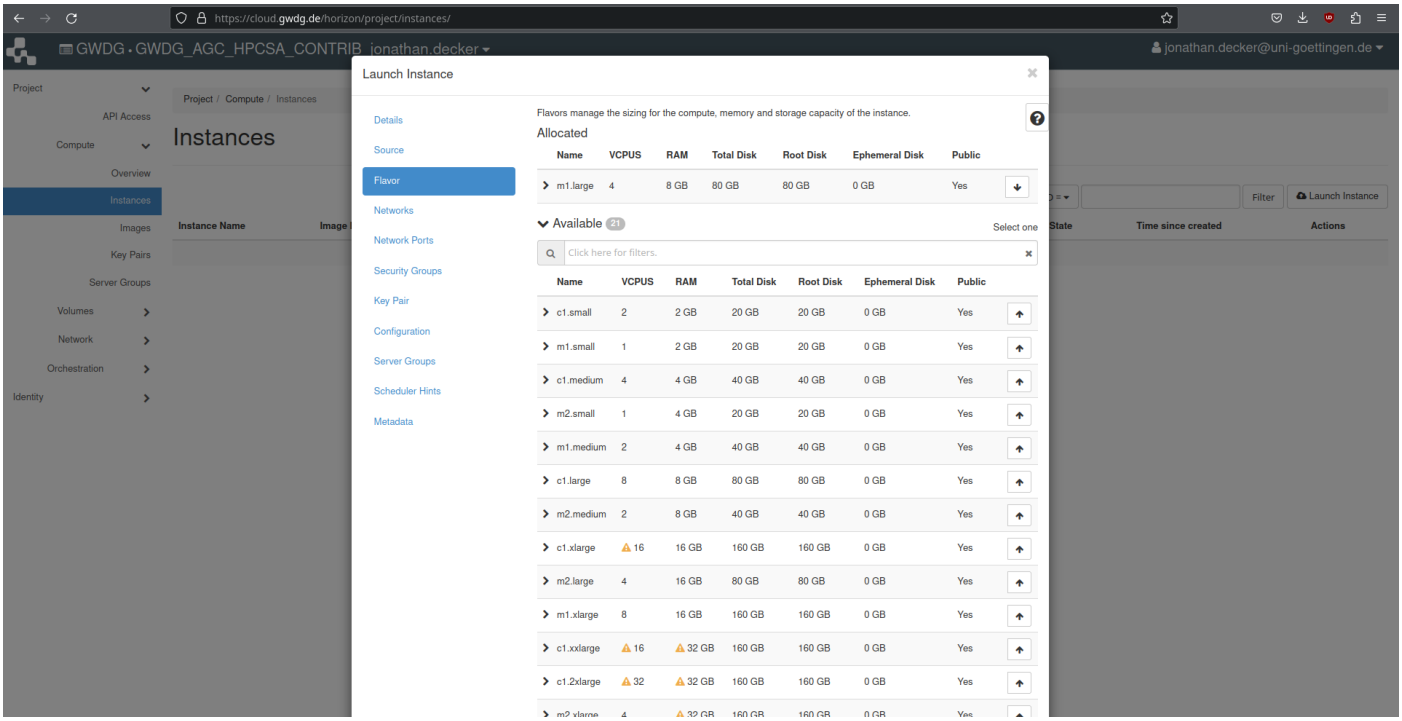


Figure 7: Launch Instance Flavor for Cluster-Manager

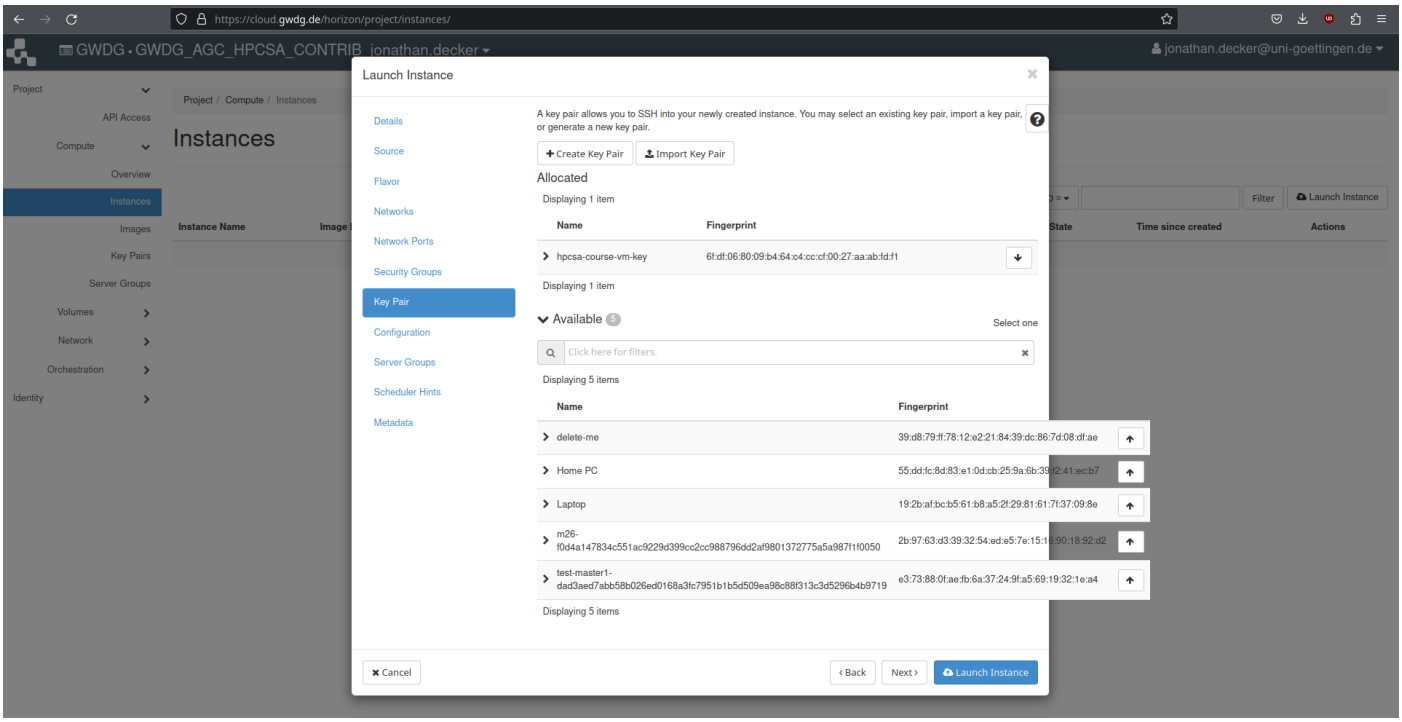


Figure 8: Launch Instance Key Pair for Cluster-Manager

9. After a short time, the instance should be ready and visible in the overview, similar to Figure 10.

10. Once the instance is there, go into the overview, switch to interfaces, click on the drop-down menu next to “Create Snapshot” and select “Attach Interface”. Select the “private-pxe” interface and attach it.

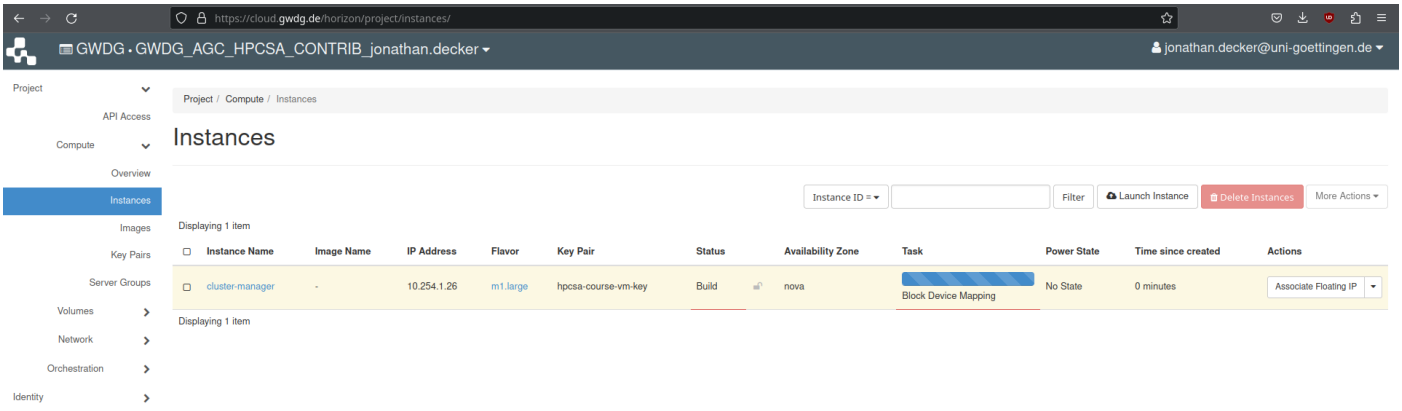


Figure 9: Cluster-Manager Instance is Launching

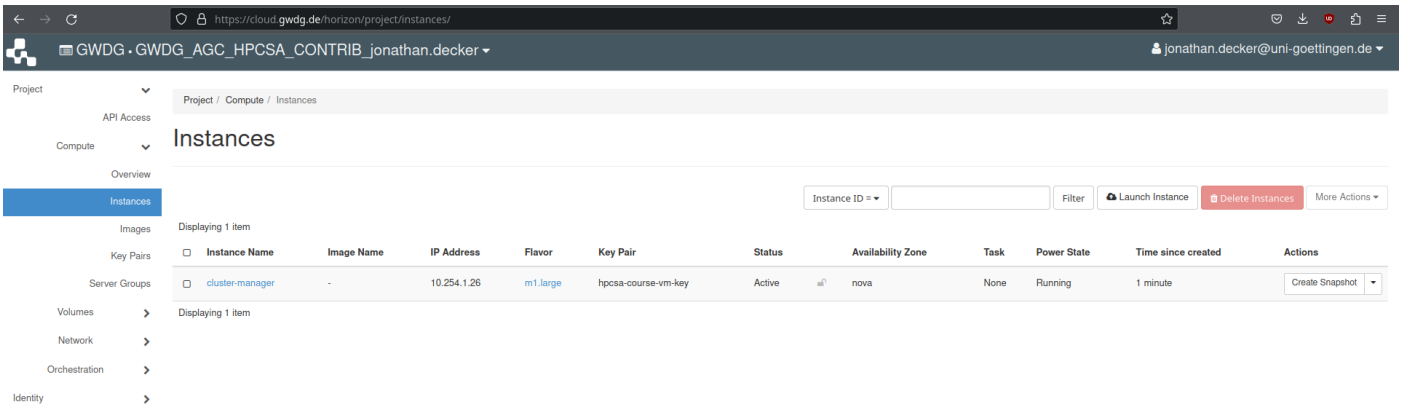


Figure 10: Cluster-Manager Instance is Running

## Add a Floating IP Address

This section shows how to associate a floating IP address with your VM, which makes it possible to connect to the VM.

1. Under the **Compute** tab, on **Instances**, open the drop-down menu for your **cluster-manager** instance

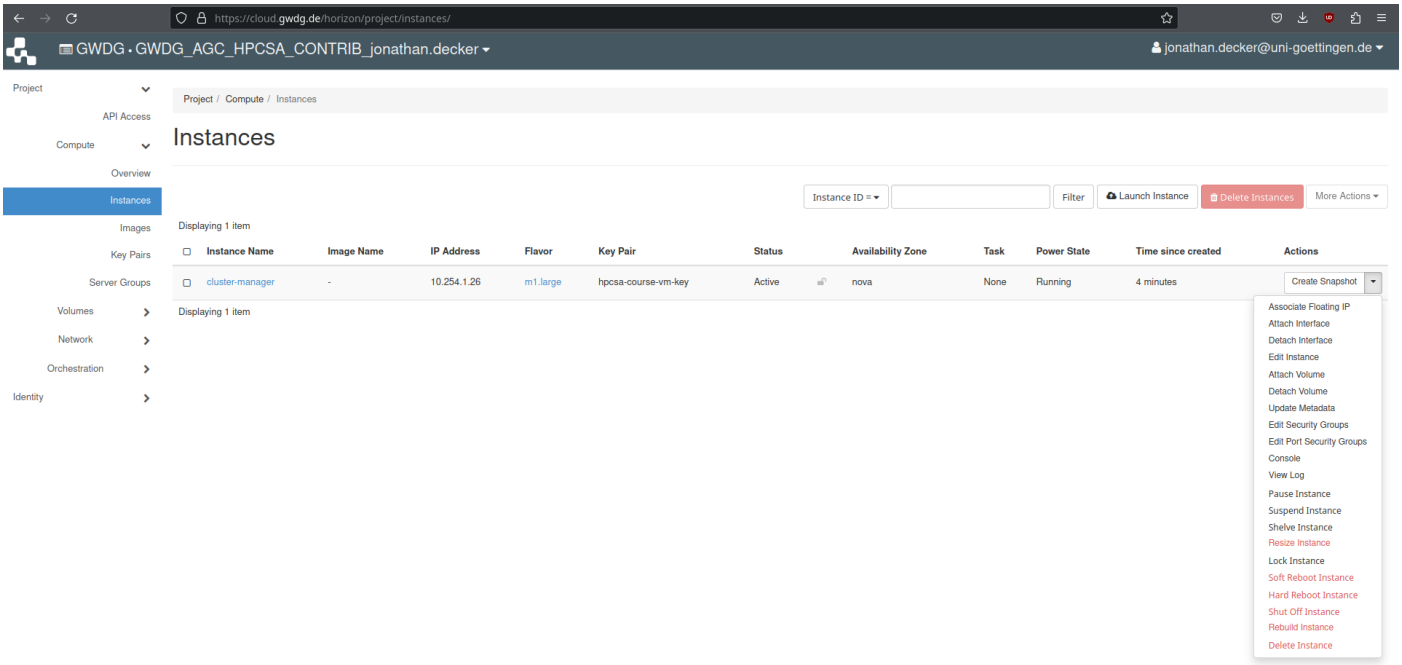


Figure 11: Cluster-Manager Actions Drop-Down Menu

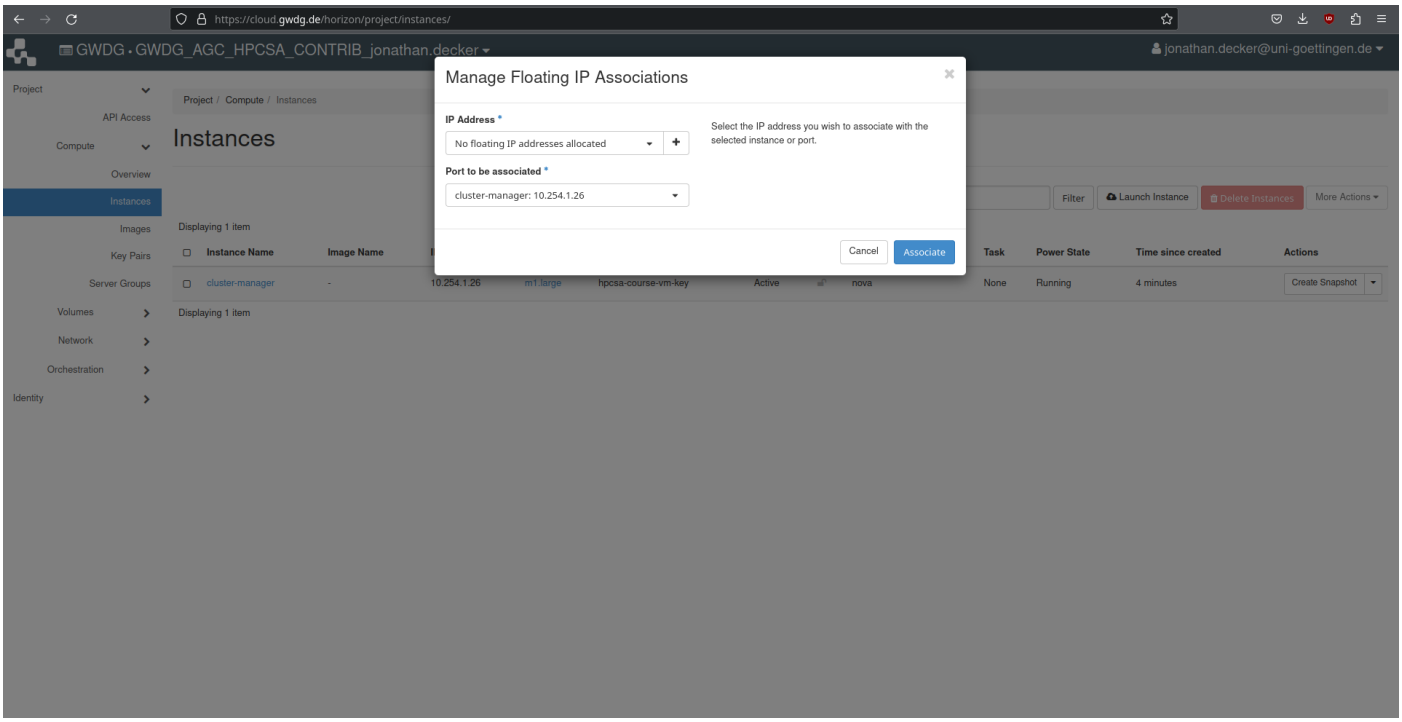


Figure 12: Manage Floating IP Dialog without Allocated Floating IP

and select **Associate Floating IP** from it as shown in Figure 11.

2. In the new dialog, click on the plus sign next to the **IP Address** drop-down menu, as shown in Figure 12, to allocate a new IP address.

3. In the following dialog, press **Allocate IP** without changing anything as shown in Figure 13.

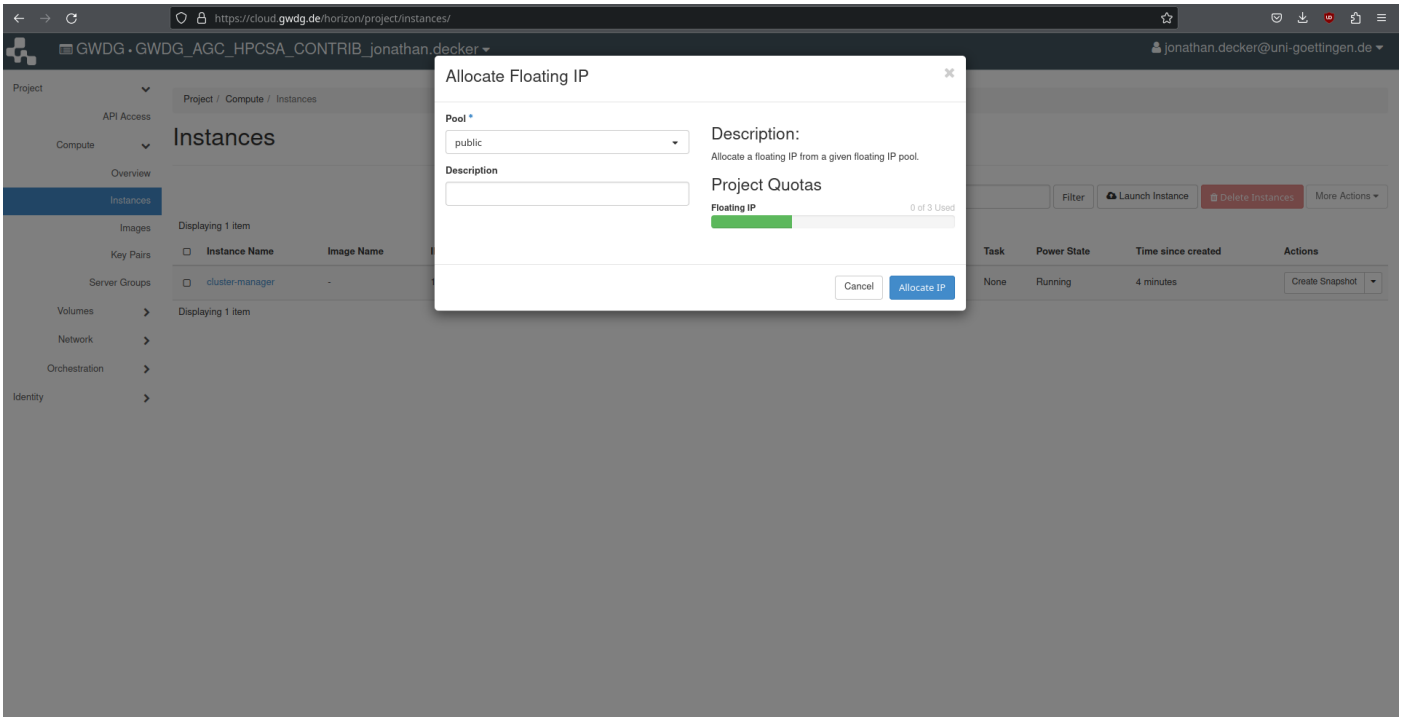


Figure 13: Allocate Floating IP Dialog

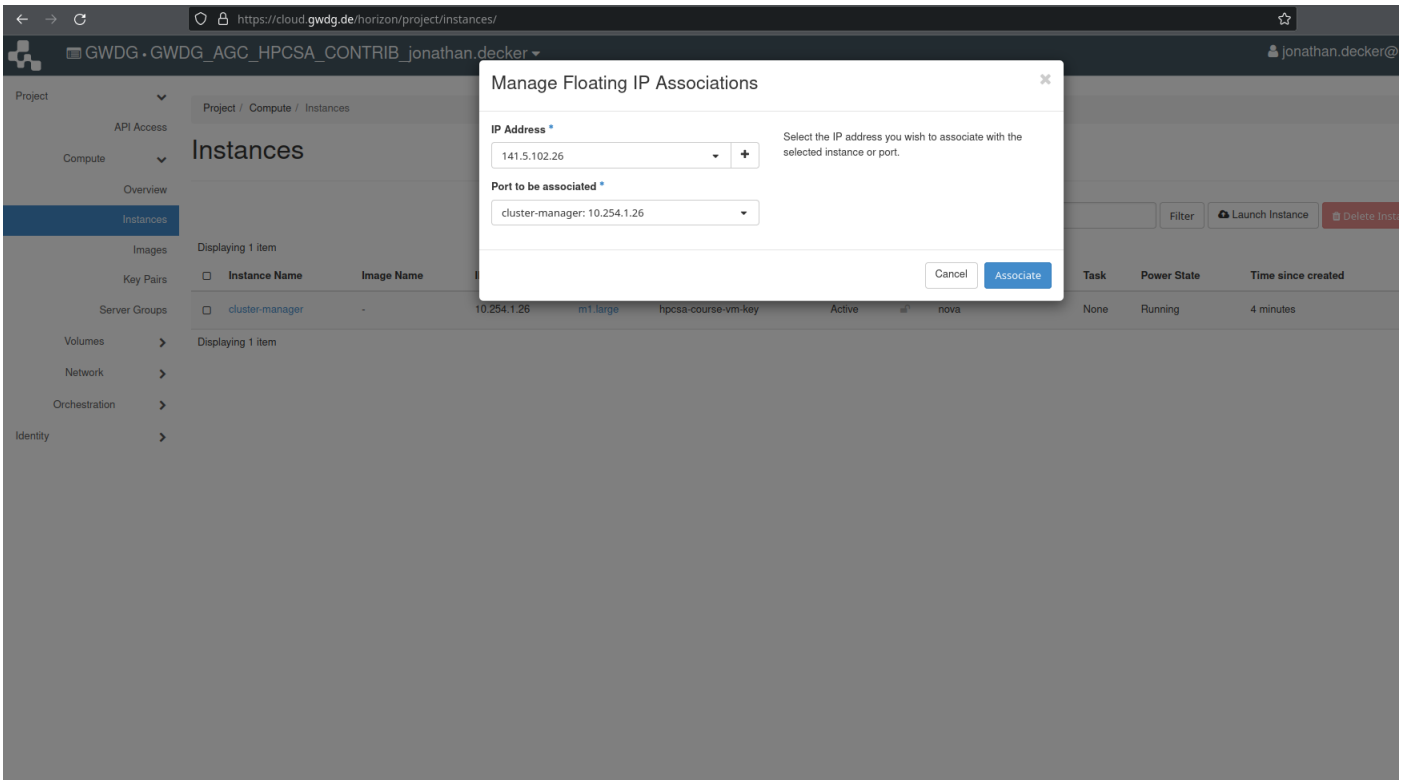


Figure 14: Manage Floating IP Dialog with Allocated Floating IP

4. You are returned to the previous dialog, where an IPv4 address is now shown under the **IP Address** drop-down menu as shown in Figure 14. Confirm the association by pressing **Associate**.

5. In the instances overview, you should now see two IP addresses for your **cluster-manager** instance in the

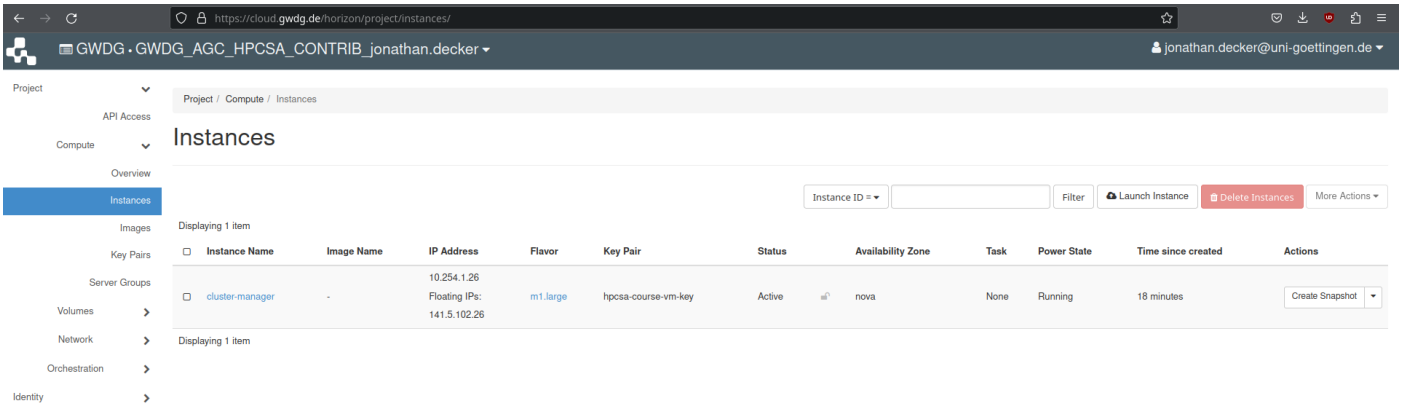


Figure 15: Instance Overview with Cluster-Manager with Floating IP

respective column as shown in Figure 15. Make a note of the IP noted after **Floating IPs** as you will need it in the next step.

## Connect to Instance with SSH

This section shows how to use SSH and your SSH key to connect to your VM.

1. If you created an SSH key pair, find the **hpcsa-course-vm-key.pem** you downloaded in your **Downloads** folder or where you have saved it and move it into your user folder. If you uploaded/imported an SSH key you already had, make sure it is in your user folder.

2. Open a terminal and confirm that you have **SSH** installed by following the platform specific instructions:

### MacOS/Linux

1. Search for **Terminal** and open it.

2. Check ssh is provided by running the command `ssh -V`

On MacOS/Linux you need to set the correct permission for the key (e.g. **hpcsa-course-vm-key.pem**) before it can be used with SSH.
Run `chmod 600 hpcsa-course-vm-key.pem` in the same folder as the key.

### Windows 10/11

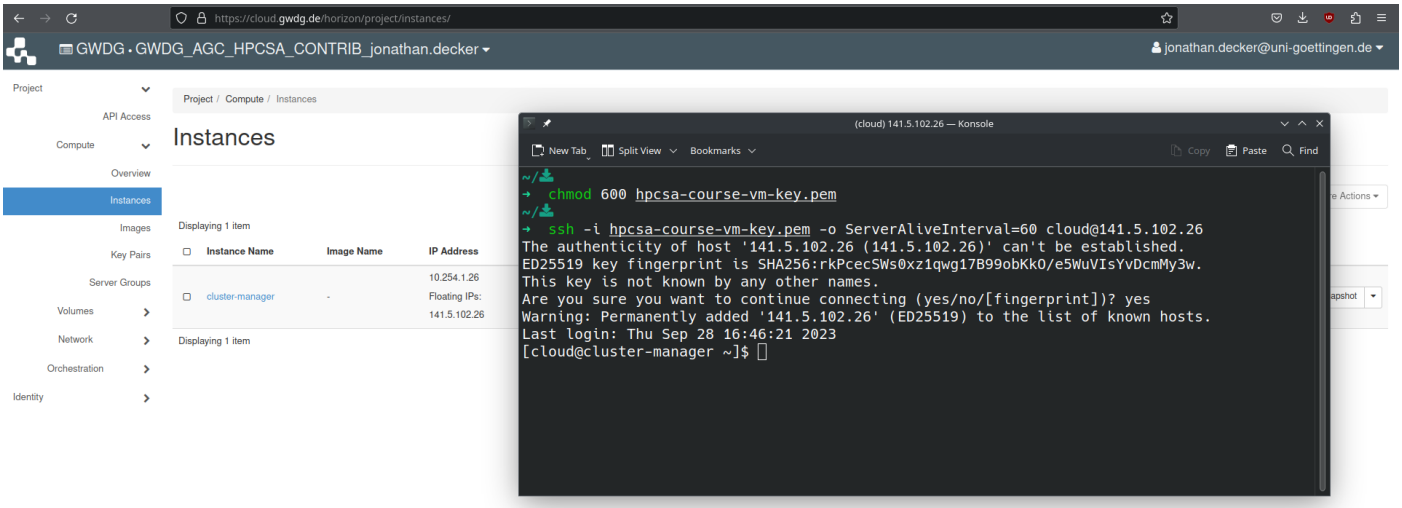


Figure 16: Connection to Cluster-Manager with SSH

### Windows 10/11

1. Open **PowerShell** as Administrator:
   Press `Win` , type **PowerShell**, right-click → *Run as administrator*.
2. Check whether OpenSSH client is available:

   ```
   Get-WindowsCapability -Online | Where-Object Name -like '*SSH*'
   ```

   If it shows `NotPresent` , install it:

   ```
   Add-WindowsCapability -Online -Name OpenSSH.Client~~~~0.0.1.0
   ```

3. Verify it works:

   ```
   ssh -V
   ```

On Windows 11, you might get an error about the permission to open when running SSH with the key. If that happens, you can try the following workaround:

**Windows 11 SSH Permission Workaround**

1. Select **hpcsa-course-vm-key.pem** and open properties. (Shortcut: Alt + Shift)
2. Go to Security → Edit.
3. Remove all users except Administrators.
4. Click on Apply and OK.
5. Now open PowerShell as administrator

6. Run the code below

```
# Set Key File Variable:
New-Variable -Name Key -Value "$env:UserProfile\.ssh\known_hosts"

# Remove Inheritance:
Icacls $Key /c /t /Inheritance:d

# Set Ownership to Owner:
# Key's within $env:UserProfile:
Icacls $Key /c /t /Grant ${env:UserName}:F

# Key's outside of $env:UserProfile:
TakeOwn /F $Key
Icacls $Key /c /t /Grant:r ${env:UserName}:F

# Remove All Users, except for Owner:
Icacls $Key /c /t /Remove:g Administrator "Authenticated Users"
 BUILTIN\Administrators BUILTIN Everyone System Users

# Verify:
Icacls $Key

# Remove Variable:
Remove-Variable -Name Key
```

Note: If the code above does not work, try again with the full path to the ssh known_hosts file instead of using a variable.

**Using SSH**

1. In PowerShell or Terminal, type the following command.

   ```
   ssh -i hpcsa-course-vm-key.pem -o ServerAliveInterval=60 cloud@YOUR_IP
   ```

   where YOUR_IP is the IP address you got earlier.

2. When asked whether you want to continue, type in `yes` . See Figure 16 for comparison.

3. Confirm that running `hostname` returns **cluster-manager.novalocal**.

# 2 Useful Commands

## Rebooting Instances

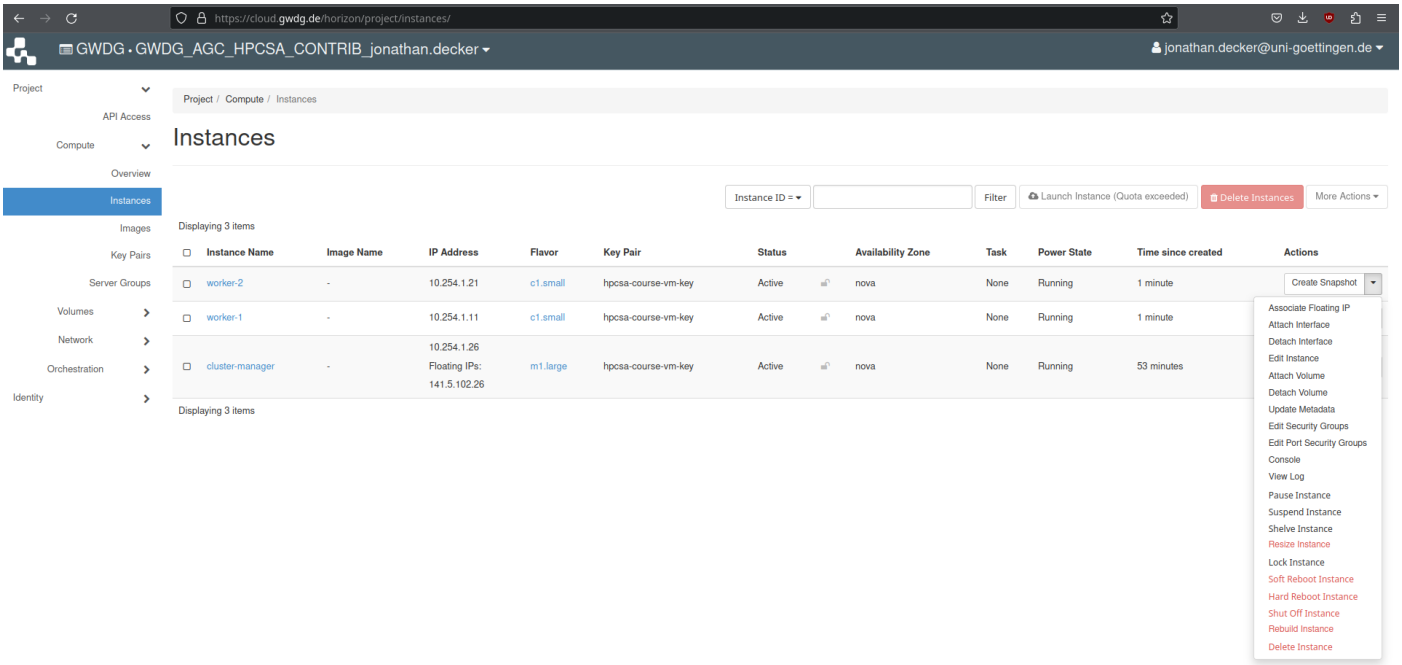


Figure 17: Instance Overview Actions Drop-Down Menu Reboot

When working with VMs, it might be necessary to reboot them via an external command.

Under **Compute** tab, select **Instances** and find the **Actions** drop-down menu for each of your instances.

This menu contains the options **Soft Reboot Instance** and **Hard Reboot Instance**, which cause an instance to restart. See for reference Figure 17.

## SSH Port Forwarding

When deploying applications on one of your VMs that expose a web interface, e.g., a web page, you might need to open said interface in a web browser on your workstation.
For this, you have two options: Opening the port in the security groups settings (not recommended) or using SSH port forwarding.

1. Opening the port, especially globally, poses certain security risks and should not be done casually.
   This option also only works when the application is running on a port on your **cluster-manager** and not on one of your **workers**.

2. The alternative is to use SSH port forwarding. You can forward a port from your cluster-manager to your workstation as follows:

   ```
   ssh -L PORT_YOUR_WORKSTATION:REMOTE_ADDRESS:REMOTE_PORT -o ServerAliveInterval=60 -i
       ↪ hpcsa-course-vm-key.pem cloud@FLOATING_IP
   ```

   Where `REMOTE_ADDRESS` is the address (IP address or hostname) relative to **cluster-manger** that you want to forward, `REMOTE_PORT` is the port on `REMOTE_ADDRESS` you want forwarded.

`PORT_YOUR_WORKSTATION` is the port on your local workstation it will be forwarded to, and `FLOATING_IP` is the floating IP address of **cluster-manger**. If you are forwarding a port on **cluster-manger** itself, you should set `REMOTE_ADDRESS` to `localhost` or to one of **cluster-manger**'s interface IP addresses. Use the floating IP of the **cluster-manager** as FLOATING_IP and the port the application is using on the **cluster-manger** as REMOTE_PORT. For `PORT_YOUR_WORKSTATION` , you can use any port that is open on your workstation, even the same number as the remote port.

Please note that on Linux machines, the port numbers up to 1024 are typically handled as privileged ports, so assigning any of them will require root privileges. Alternatively, you can use a higher port locally, such as having the remote port 80 forwarded to your local port 8080.

While the port forward is running, you should be able to access the forwarded application under

`localhost:PORT_YOUR_WORKSTATION`

It is also possible to forward the port of a worker to your workstation as follows:

```
ssh -L PORT_YOUR_WORKSTATION:YOUR_WORKER_IP:YOUR_WORKER_PORT -o ServerAliveInterval=60 -i
    ↪ hpcsa-course-vm-key.pem cloud@FLOATING_IP
```

Another version of this command that port forwards the remote port to your workstation in the background goes as follows:

```
ssh -N -L PORT_YOUR_WORKSTATION:REMOTE_ADDRESS:REMOTE_PORT -o ServerAliveInterval=60 -i
    ↪ hpcsa-course-vm-key.pem cloud@FLOATING_IP >/dev/null 2>&1 &
```

The `-N` flag tells the system not to open a shell, the `>/dev/null 2>&1` ensures that messages from the port forwarding are not sent to the shell, and the final `&` sends SSH into the background. Alternatively, the `-f` flag does the same as the final `&` .

## File Transfer

You can use the `scp` command to transfer files from your system to one of your VMs and from one of your VMs to your local system. To upload to **cluster-manager**:

```
scp -i hpcsa-course-vm-key.pem LOCAL_FILE cloud@FLOATING_IP:/home/cloud
```

Instead of `/home/cloud` you can specify another location for your file on the VM.

To download from **cluster-manager**:

```
scp -i hpcsa-course-vm-key.pem cloud@FLOATING_IP:PATH_TO_THE_FILE .
```

The `.` specifies the location where to place the downloaded file, which means in the current folder. To download from a **worker**:

```
scp -i hpcsa-course-vm-key.pem LOCAL_FILE cloud@WORKER_IP:/home/cloud -o ProxyCommand='ssh -W %h:%p
    ↪ cloud@YOUR_FLOATING_IP -i hpcsa-course-vm-key.pem'
```

To upload to a **worker**:

```
scp -i hpcsa-course-vm-key.pem cloud@WORKER\_IP:PATH_TO_THE_FILE . -o ProxyCommand='ssh -W %h:%p
    ↪ cloud@YOUR_FLOATING_IP -i hpcsa-course-vm-key.pem'
```