

# **CLOUD COMPUTING - PROJET**

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## Phase I : Cloudsim

Ce programme permet de simuler **numériquement** l'infrastructure Cloud de l'Université Abdelmalek Essaadi pour tester sa viabilité sans coût matériel

```
package org.cloudbus.cloudsim.examples;

import org.cloudbus.cloudsim.*;
import org.cloudbus.cloudsim.core.CloudSim;
import org.cloudbus.cloudsim.provisioners.*;
import java.util.*;

public class UAEimulation {

    public static void main(String[] args) {
        try {
            // 1. Initialisation de CloudSim
            CloudSim.init(1, Calendar.getInstance(), false);

            // 2. Création du Datacenter UAE (Infrastructure physique)
            Datacenter uaeDatacenter = createDatacenter("UAE_Datacenter");

            // 3. Création du Broker (Gestionnaire de requêtes)
            DatacenterBroker uaeBroker = new
DatacenterBroker("UAE_Broker");
            int brokerId = uaeBroker.getId();

            // 4. Création des VMs pour les services de l'Université
            List<Vm> vms = new ArrayList<Vm>();

            // VM Moodle (E-learning) : 4GB RAM, 2 CPUs
            vms.add(new Vm(0, brokerId, 1000, 2, 4096, 1000, 10000, "Xen",
new CloudletSchedulerTimeShared()));

            // VM Scolarité (Inscriptions) : 2GB RAM, 1 CPU
            vms.add(new Vm(1, brokerId, 1000, 1, 2048, 1000, 10000, "Xen",
new CloudletSchedulerTimeShared()));

            uaeBroker.submitGuestList(vms);

            // 5. Création des Cloudlets (Charges de travail des
étudiants)
            List<Cloudlet> cloudlets = new ArrayList<Cloudlet>();
            UtilizationModel model = new UtilizationModelFull();

            for (int i = 0; i < 10; i++) {
                Cloudlet cl = new Cloudlet(i, 20000, 1, 300, 300, model,
model, model);
                cl.setUserId(brokerId);
                cl.setVmId(i % 2); // Alterne entre Moodle et Scolarité
                cloudlets.add(cl);
            }

            // Commande exacte pour les Cloudlets
            uaeBroker.submitCloudletList(cloudlets);

            // 6. Démarrage de la simulation
        }
    }
}
```

```

CloudSim.startSimulation();
List<Cloudlet> results = uaeBroker.getCloudletReceivedList();
CloudSim.stopSimulation();

    // 7. Affichage des résultats
    System.out.println("\n--- RESULTATS UAE CLOUD (120 000
ETUDIANTS SIMULÉS) ---");
    for (Cloudlet c : results) {
        String service = (c.getVmId() == 0) ? "MOODLE" :
"SCOLARITE";
        System.out.println("ID: " + c.getCloudletId() + " | Service:
" + service + " | Status: SUCCESS | Finish: " + c.getFinishTime());
    }

} catch (Exception e) {
    e.printStackTrace();
}
}

private static Datacenter createDatacenter(String name) throws Exception
{
    List<Host> hostList = new ArrayList<Host>();
    List<Pe> peList = new ArrayList<Pe>();
    peList.add(new Pe(0, new PeProvisionerSimple(3000)));

    // Simuler un serveur de l'Université (16GB RAM)
    hostList.add(new Host(0, new RamProvisionerSimple(16384), new
BwProvisionerSimple(10000), 1000000, peList, new
VmSchedulerTimeShared(peList)));

    DatacenterCharacteristics characteristics = new
DatacenterCharacteristics("x86", "Linux", "Xen", hostList, 10.0, 3.0, 0.05,
0.001, 0.0);
    return new Datacenter(name, characteristics, new
VmAllocationPolicySimple(hostList), new LinkedList<Storage>(), 0);
}
}

```

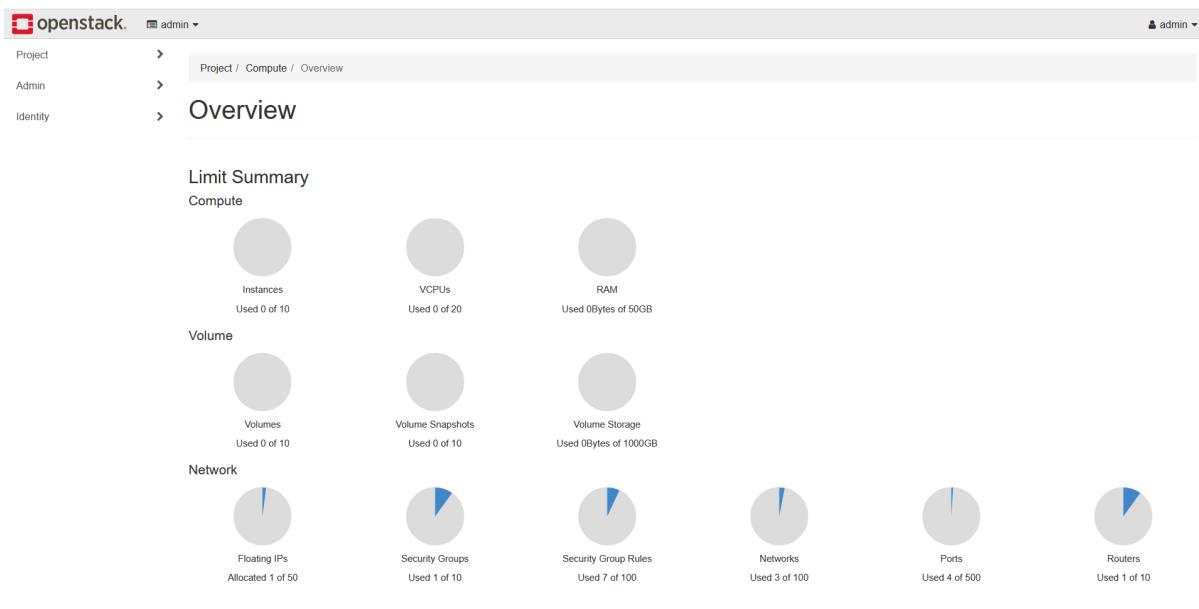
# Phase II : OpenStack

## 1. Installation de Openstack

Post-stack database query stats:		
db	op	count
keystone	SELECT	20515
keystone	UPDATE	7
keystone	INSERT	93
neutron	DESCRIBE	2
neutron	CREATE	1
neutron	SHOW	4
neutron	SELECT	5972
neutron	INSERT	4121
neutron	DELETE	28
neutron	UPDATE	134
placement	SELECT	26
placement	INSERT	69
placement	SET	2
nova_api	SELECT	50
nova_cell0	SELECT	27
nova_cell1	SELECT	95
nova_cell0	INSERT	4
nova_cell0	UPDATE	6
placement	UPDATE	3
nova_cell1	INSERT	4
nova_cell1	UPDATE	43
cinder	SELECT	57
cinder	INSERT	5
cinder	UPDATE	5
glance	INSERT	14
glance	SELECT	28
glance	UPDATE	2
nova_api	INSERT	20
nova_api	SAVEPOINT	10
nova_api	RELEASE	10
cinder	DELETE	1

## 2. Test des fonctionnalités du Middleware

Le "middleware" regroupe les services d'OpenStack (Nova, Neutron, Keystone, etc.).



## Liste des Services

```
samirtaous@samirtaous:~/devstack$ openstack service list
```

ID	Name	Type
31cd11f7037f4eafaf8d4ae670691d2a	cinder	block-storage
37771616b732418ba87b90fd6f06226a	neutron	network
4431233a134f48dc204c831f1c2f717	cinderv3	volumev3
a2c88de5a4bc4b519750b15fa82f72e6	keystone	identity
a7b6b974c61f4cd6961f4afa6a4cf679	nova_legacy	compute_legacy
b1445e3b332c4ab8b57aa99a426533ec	glance	image
b766a5b910424b48976139a5f88e5781	nova	compute
fb0cda7c8ecb4328bfa422c7cea5c68a	placement	placement

## Liste des Services Compute

```
samirtaous@samirtaous:~/devstack$ openstack compute service list
```

ID	Binary	Host	Zone	Status	State	Updated At
1a5b0e1c-e744-4f6a-bbed-e16829110195	nova-conductor	samirtaous	internal	enabled	up	2026-01-11T00:14:03.000000
9a8ca9da-a114-45b4-a294-0cebe9ab90fc	nova-compute	samirtaous	nova	enabled	up	2026-01-11T00:14:05.000000
b9e5b1b6-1c04-4576-86db-6000221acecc	nova-scheduler	samirtaous	internal	enabled	up	2026-01-11T00:13:21.000000
753c528c-3e58-4b89-9850-9feb981de75f	nova-conductor	samirtaous	internal	enabled	up	2026-01-11T00:13:39.000000

## Liste des Agents Network

```
samirtaous@samirtaous:~/devstack$ openstack network agent list
```

ID	Agent Type	Host	Availability Zone	Alive	State	Binary
839502f7-8c47-	OVN Controller	samirtaous		:-)	UP	ovn-controller
45a4-b68d-	Gateway agent					
bb1376a9d17d						
0ef893c9-9eb8-	OVN Metadata	samirtaous		:-)	UP	neutron-ovn-
5128-becc-	agent					metadata-agent
0f87c1ad1534						

## Liste des images ( CirrOS active )

```
samirtaous@samirtaous:~/devstack$ openstack image list
```

ID	Name	Status
c9351551-87a0-482b-bc18-c9e0e412c1bd	cirros-0.6.2-x86_64-disk	active

### 3. Implémentation IaaS basé sur cirrOS

#### 3.1- Création key-pair

The screenshot shows the 'Key Pairs' page in the OpenStack interface. At the top, there is a navigation bar with 'Project / Compute / Key Pairs'. Below the navigation is a search bar and several buttons: '+ Create Key Pair', 'Import Public Key', and 'Delete Key Pairs'. A message 'Displaying 1 item' is shown above a table. The table has a header row with columns for 'Name' and 'Actions'. It contains one data row for a key pair named 'cle-projet-cloud', which includes a delete button labeled 'Delete Key Pair'. Below the table, another message 'Displaying 1 item' is visible.

#### 3.2- Configuration de la Sécurité

Par défaut, OpenStack bloque tout le trafic. On ouvre les "portes" pour le Ping et le SSH.

Manage Security Group Rules: default (146c51d9-ccd8-4f6d-ba4c-1509e912ff5a)

The screenshot shows the 'Security Group Rules' page for the 'default' security group. At the top, there are buttons for '+ Add Rule' and 'Delete Rules'. A message 'Displaying 7 items' is shown above a table. The table has a header row with columns for 'Direction', 'Ether Type', 'IP Protocol', 'Port Range', 'Remote IP Prefix', 'Remote Security Group', 'Description', and 'Actions'. It contains seven data rows, each with a 'Delete Rule' button. The rules are as follows:

Direction	Ether Type	IP Protocol	Port Range	Remote IP Prefix	Remote Security Group	Description	Actions
Egress	IPv4	Any	Any	0.0.0.0/0	-	-	Delete Rule
Egress	IPv6	Any	Any	::/0	-	-	Delete Rule
Ingress	IPv4	Any	Any	-	default	-	Delete Rule
Ingress	IPv4	ICMP	Any	0.0.0.0/0	-	-	Delete Rule
Ingress	IPv4	TCP	Any	0.0.0.0/0	-	-	Delete Rule
Ingress	IPv4	TCP	22 (SSH)	0.0.0.0/0	-	-	Delete Rule
Ingress	IPv6	Any	Any	-	default	-	Delete Rule

### 3.3- Lancement de l'instance CirrOS

Launch Instance

Details

Please provide the initial hostname for the instance, the availability zone where it will be deployed, and the instance count. Increase the Count to create multiple instances with the same settings.

Instance Name \*

Description

Total Instances (10 Max)   
10%  
0 Current Usage  
1 Added  
9 Remaining

Source

Flavor \*

Networks \*

Network Ports

Security Groups

Key Pair

Configuration

Server Groups

Scheduler Hints

Metadata

< Back Next > Launch Instance

### Selection de notre keypair

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
cle-projet-cloud	ssh

Network Ports

Security Groups

Key Pair

Configuration

Server Groups

Scheduler Hints

Metadata

Available 1 Select one

Click here for filters or full text search.

Displaying 1 item

Name	Type
busa-key	ssh

Displaying 1 item

## Source

**Details**

**Source**

Flavor	Image	Create New Volume										
Networks	Volume Size (GB) *	Yes No										
Network Ports	1	Delete Volume on Instance Delete										
Security Groups	Allocated											
Key Pair	Displaying 1 item											
Configuration	<table border="1"> <tr> <th>Name</th> <th>Updated</th> <th>Size</th> <th>Type</th> <th>Visibility</th> </tr> <tr> <td>cirros</td> <td>11/29/25 5:32 PM</td> <td>12.13 MB</td> <td>QCOW2</td> <td>Public</td> </tr> </table>		Name	Updated	Size	Type	Visibility	cirros	11/29/25 5:32 PM	12.13 MB	QCOW2	Public
Name	Updated	Size	Type	Visibility								
cirros	11/29/25 5:32 PM	12.13 MB	QCOW2	Public								
Server Groups	Displaying 1 item											
Scheduler Hints	Available 1											
Metadata	<div style="border: 1px solid #ccc; padding: 5px;"> <span style="font-size: 1.5em;">Q</span> Click here for filters or full text search.         </div>											
	Select one											
	Displaying 1 item											
	<table border="1"> <thead> <tr> <th>Name</th> <th>Updated</th> <th>Size</th> <th>Type</th> <th>Visibility</th> </tr> </thead> <tbody> <tr> <td>ubuntu-22.04</td> <td>11/29/25 6:35 PM</td> <td>659.13 MB</td> <td>QCOW2</td> <td>Public</td> </tr> </tbody> </table>		Name	Updated	Size	Type	Visibility	ubuntu-22.04	11/29/25 6:35 PM	659.13 MB	QCOW2	Public
Name	Updated	Size	Type	Visibility								
ubuntu-22.04	11/29/25 6:35 PM	659.13 MB	QCOW2	Public								
	Displaying 1 item											

## On vérifie la création de l'instance

Project		admin	
Compute		admin	
Instances		Instances	
Images	Displaying 1 item	Instance ID =	Filter
Key Pairs		Launch Instance	Delete Instances
Server Groups		More Actions	
Volumes	instance-cirros	192.168.233.178	m1 tiny
Network	-	Active	nova
Admin		None	Running
Identity		0 minutes	Create Snapshot

Finalement pour tester avec Putty, on associe l'instance avec une ip flottante

The screenshot shows the OpenStack dashboard under the 'Compute' tab. In the 'Instances' section, there is one item displayed:

Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
instance-cirros	cirros-0.6.2-x86_64-disk	192.168.233.178, 172.24.4.134	m1 tiny	cle-projet-cloud	Active	nova	None	Running	15 minutes	Create Snapshot

### 3.4. Convertissement pem to ppk

The screenshot shows the PuTTY Key Generator interface. The 'Key' tab is selected, displaying a public key for pasting into an SSH authorized\_keys file. Below the key, there are fields for 'Key fingerprint' and 'Key comment'. The 'PuTTYgen Warning' dialog box is overlaid, asking if the user wants to save the key without a passphrase. The 'Yes' button is highlighted.

Public key for pasting into OpenSSH authorized\_keys file:

```
ssh-rsa AAAAB3NzaC1yc2EAAAQABAAQCYgR0cxTw6dUnNyPfkYg96R58yRAVgFDUjOw/NZV
+byssp6CPDWwLDkmJSa5NALFBGmFb19LY0dc9i4RQOGLfNkExherNGdDuhw08PVk9rysOJSW7YMjzei0bR7zu18RBLT
taqJrPshJD8QIMWLkMD59KROZwl26TE4ya1eoDr5ChtPKHcKDhJKnuRn4/4r
+15pMgFsTjqF4PjXIS7+Rv09AMxCCFP5mnfZUgCPXXZzu0PM/P0ybT/TDBVI9Y/5c4tjzUj0fa/3W0qnmHozkmqj5LMwDR
qX000ZO3DzlFjnAlvs+8BXw0VQ9vBn78+vhC/lcj2GLpGsRbzFtsQV imported-openssh-key
```

Key fingerprint: ssh-rsa 2048 SHA256:Qjbx6/jtNDyuYmOW0Nz+mCqzWZ0kjVOhfUZTHoDUb0Y

Key comment: imported-openssh-key

Key passphrase:

Confirm passphrase:

PuTTYgen Warning

Are you sure you want to save this key without a passphrase to protect it?

Yes      No

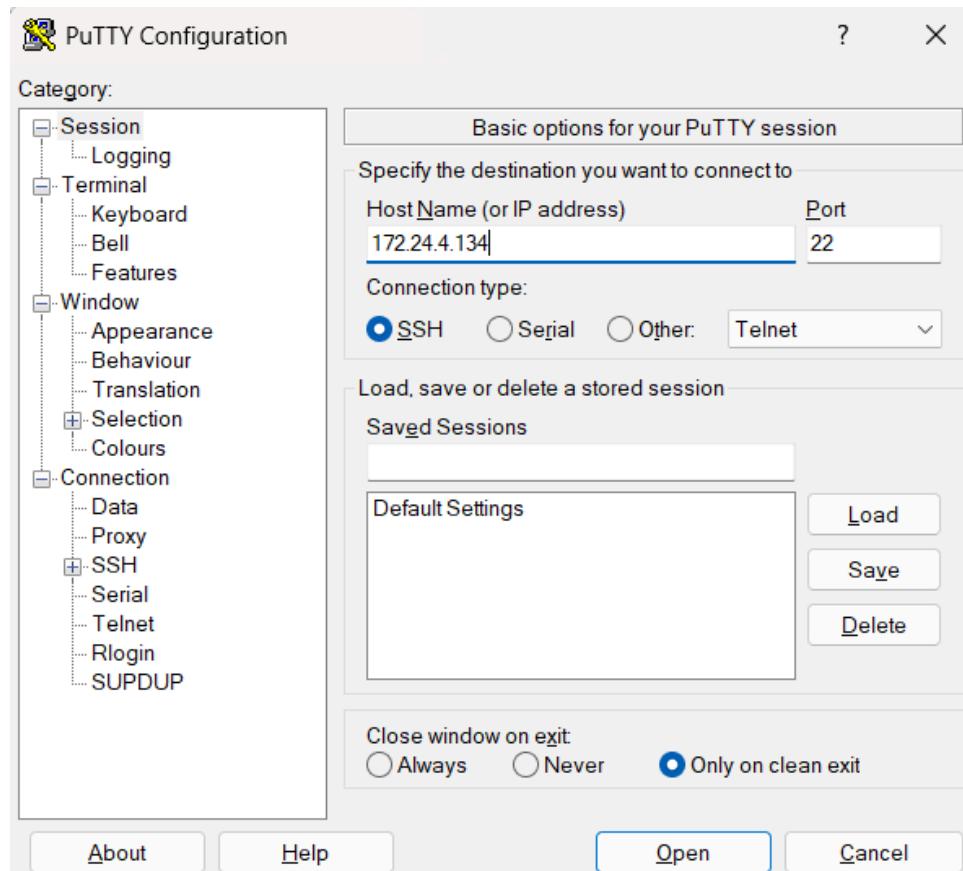
Generate      Load

Save public key      Save private key

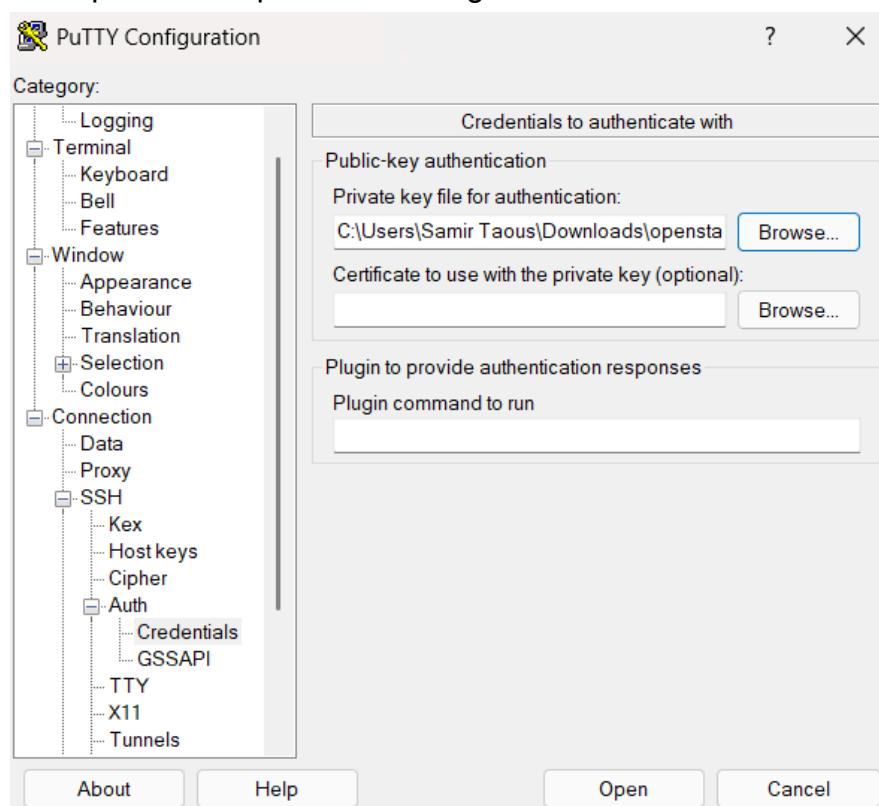
Number of bits in a generated key: 2048

DSA      EdDSA      SSH-1 (RSA)

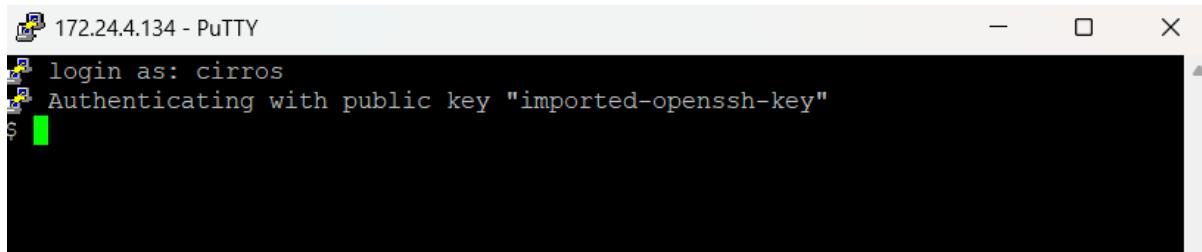
### 3.5. Configuration de connexion Putty



On importe la clé privée téléchargée

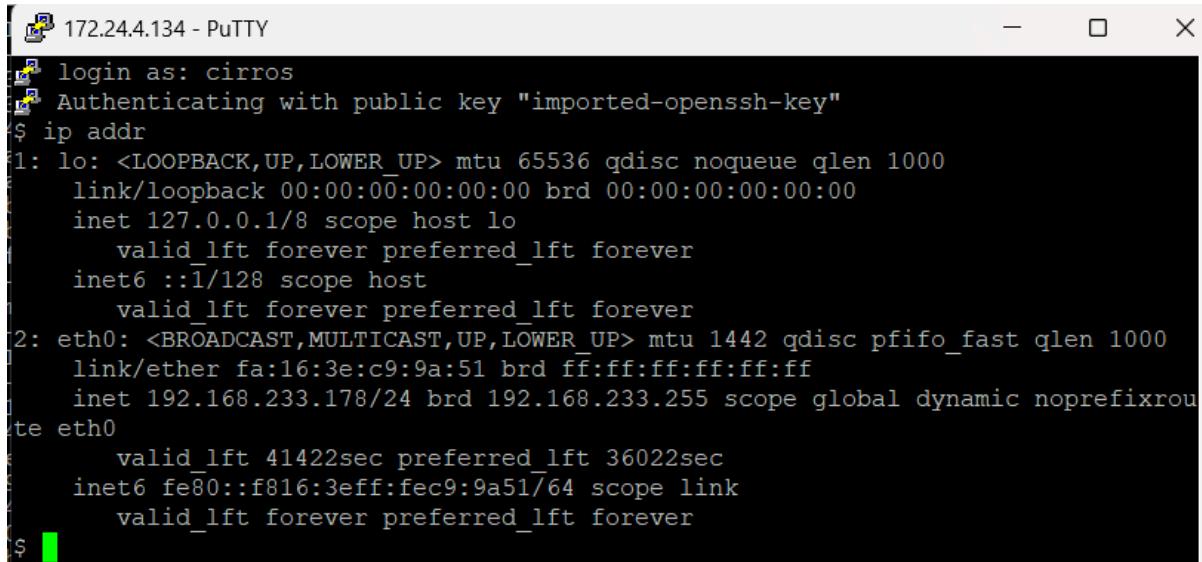


### 3.6. Test de connexion avec CirrOS



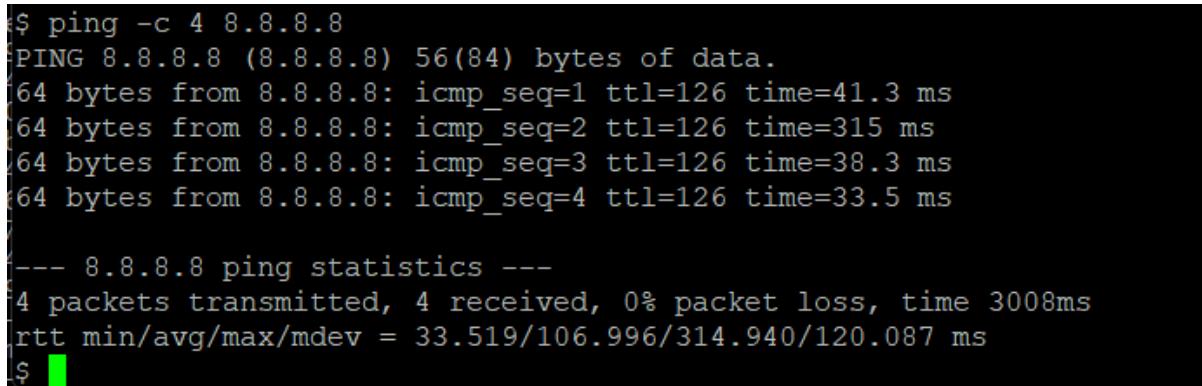
```
172.24.4.134 - PuTTY
login as: cirros
Authenticating with public key "imported-openssh-key"
$
```

Ip interne assigné par OpenStack pour vérifier que le bridge est actif



```
172.24.4.134 - PuTTY
login as: cirros
Authenticating with public key "imported-openssh-key"
$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1442 qdisc pfifo_fast qlen 1000
    link/ether fa:16:3e:c9:9a:51 brd ff:ff:ff:ff:ff:ff
    inet 192.168.233.178/24 brd 192.168.233.255 scope global dynamic noprefixroute eth0
        valid_lft 41422sec preferred_lft 36022sec
    inet6 fe80::f816:3eff:fec9:9a51/64 scope link
        valid_lft forever preferred_lft forever
$
```

Ping pour tester que la configuration network est correcte



```
$ ping -c 4 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=126 time=41.3 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=126 time=315 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=126 time=38.3 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=126 time=33.5 ms

--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3008ms
rtt min/avg/max/mdev = 33.519/106.996/314.940/120.087 ms
$
```

## 4. Implémentation d'un SaaS dans une VM CentOS

### 4.1. Téléversement de l'image CentOS dans Glance

Create Image

Image Details

Specify an image to upload to the Image Service.

**Image Name**

**Image Description**

Metadata

Image Source

**File\***  CentOS-Stream-Gene... 06.0.x86\_64.qcow2

**Format\***

Image Requirements

**Kernel**

**Ramdisk**

**Architecture**

**Minimum Disk (GB)**

**Minimum RAM (MB)**

Image Sharing

**Visibility**

**Protected**

On vérifie la création de l'image CentOS-SaaS

Images

Click here for filters or full text search.

+ Create Image

Displaying 2 items

<input type="checkbox"/>	Owner	Name ^	Type	Status	Visibility	Protected	Disk Format	Size	
<input type="checkbox"/>	> admin	CentOS-SaaS	Image	Active	Shared	No	QCOW2	887.63 MB	<input type="button" value="Launch"/> <input type="button" value="▼"/>
<input type="checkbox"/>	> admin	cirros-0.6.2-x86_64-disk	Image	Active	Public	No	QCOW2	20.44 MB	<input type="button" value="Launch"/> <input type="button" value="▼"/>

Displaying 2 items

## 4.2. Création de l'instance CentOS (VM)

On utilise le flavor ds2G ( 10 gb Disk Space - 2 gb ram )

Launch Instance

Details

Please provide the initial hostname for the instance, the availability zone where it will be deployed, and the instance count. Increase the Count to create multiple instances with the same settings.

Source: admin

Project Name: admin

Total Instances (10 Max): 20%

Flavor: admin

Instance Name\*: CentOS-SaaS-VM

Description:

Networks: CentOS-SaaS-VM

Network Ports: 1

Security Groups: CentOS-SaaS-VM

Key Pair: nova

Availability Zone: nova

Configuration: nova

Server Groups: 1

Scheduler Hints: 1

Metadata:

< Back | Next > | Launch Instance

On vérifie la création de l'instance

### Instances

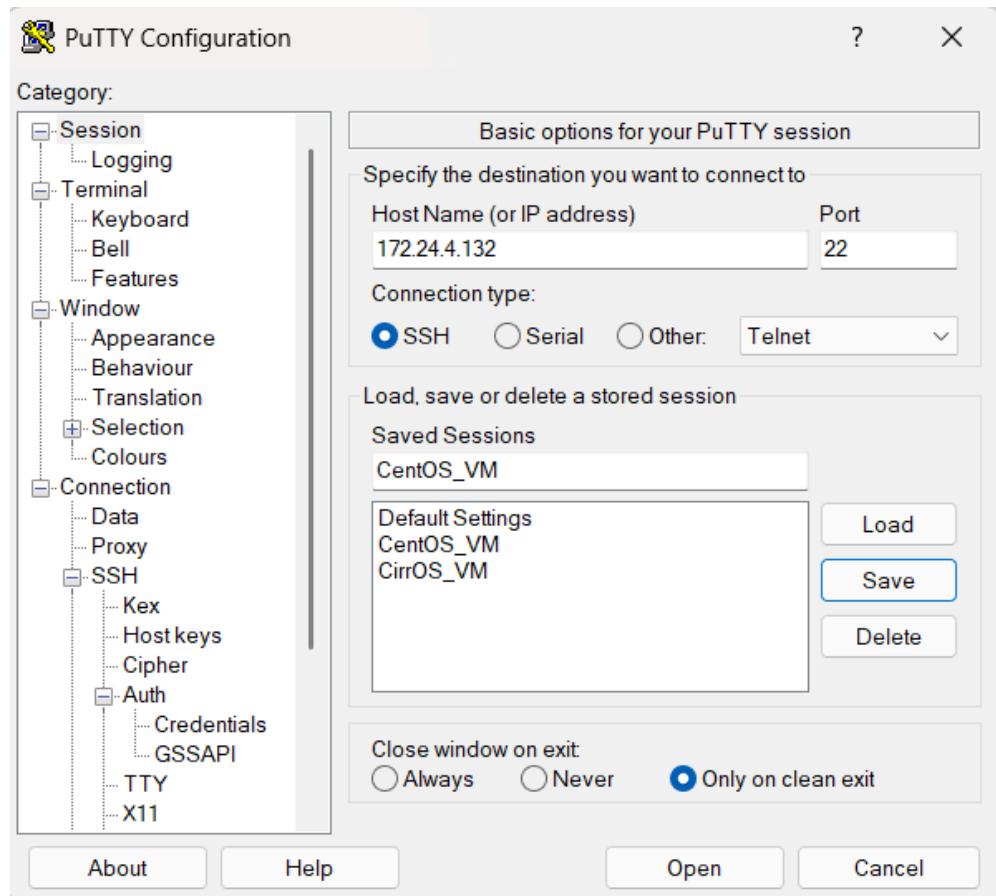
Instance ID	Filter	Launch Instance	Delete Instances	More Actions
Displaying 2 items				
<input type="checkbox"/> CentOS-SaaS-VM	-	192.168.233.164	ds2G cle-projet-cloud Active	Running 2 minutes
<input type="checkbox"/> instance-cirros	cirros-0.6.2-x86_64-disk	192.168.233.178, 172.24.4.134	m1.tiny cle-projet-cloud Shutoff	Shut Down 1 hour, 29 minutes

Comme pour cirrOS, on associe une ip flottante à l'instance créée

### Instances

Instance ID	Filter	Launch Instance	Delete Instances	More Actions
Displaying 2 items				
<input type="checkbox"/> CentOS-SaaS-VM	CentOS-SaaS	192.168.233.164, 172.24.4.132	ds2G cle-projet-cloud Active	Running 7 minutes
<input type="checkbox"/> instance-cirros	cirros-0.6.2-x86_64-disk	192.168.233.178, 172.24.4.134	m1.tiny cle-projet-cloud Shutoff	Shut Down 1 hour, 36 minutes

#### 4.3. Configuration et Test avec Putty



On vérifie la connexion avec putty

```
centos@centos-saas-vm:~$ login as: centos
[1]  +  Authenticating with public key "imported-openssh-key"
Last failed login: Tue Jan 13 02:20:35 UTC 2026 on ttym1
There were 5 failed login attempts since the last successful login.
[centos@centos-saas-vm ~]$
```

#### 4.4. Installation du Serveur Web

```
Installed:  
    httpd.x86_64 0:2.4.6-99.el7.centos.1  
  
Dependency Installed:  
    apr.x86_64 0:1.4.8-7.el7           apr-util.x86_64 0:1.5.2-6.el7_9.1  
    httpd-tools.x86_64 0:2.4.6-99.el7.centos.1 mailcap.noarch 0:2.1.41-2.el7  
  
Complete!  
[centos@centos-saas-vm yum.repos.d]$ ~~~
```

#### 4.5. Création du Contenu SaaS

```
[centos@centos-saas-vm yum.repos.d]$ echo "<h1>Samir's Cloud SaaS Demo</h1><p>Ru  
nning on CentOS 7 via OpenStack DevStack.</p><p>Status: Online</p>" | sudo tee /  
var/www/html/index.html  
<h1>Samir's Cloud SaaS Demo</h1><p>Running on CentOS 7 via OpenStack DevStack.</p>  
<p>Status: Online</p>  
[centos@centos-saas-vm yum.repos.d]$ ~~~
```

#### 4.6. Test du SaaS

On ouvre le port 80 sur la VM et on teste sur la machine hôte



# Phase III : Terraform et Ansible

## 1. Installation Terraform et Ansible

```
samirtaous@samirtaous:~/devstack$ # Installer Terraform
sudo apt-get update && sudo apt-get install -y gnupg software-properties-common
wget -O- https://apt.releases.hashicorp.com/gpg | sudo gpg --dearmor | sudo tee /usr/share/keyrings/hashicorp-archive-keyring.gpg > /dev/null
echo "deb [signed-by=/usr/share/keyrings/hashicorp-archive-keyring.gpg] https://apt.releases.hashicorp.com $(lsb_release -cs) main" | sudo tee /etc/apt/sources.list.d/hashicorp.list
sudo apt-get update && sudo apt-get install terraform -y

# Installer Ansible
sudo apt-get install ansible -y
Hit:1 http://security.ubuntu.com/ubuntu noble-security InRelease
Hit:2 http://ma.archive.ubuntu.com/ubuntu noble InRelease
Hit:3 http://ma.archive.ubuntu.com/ubuntu noble-updates InRelease
Hit:4 http://ma.archive.ubuntu.com/ubuntu noble-backports InRelease
Reading package lists... 23%
```

## 2. Création de l'image et instance Ubuntu

Create Image

**Image Details**

Specify an image to upload to the Image Service.

**Image Name**

**Image Description**

**Image Source**

**File\***

**Format\***

**Image Requirements**

**Kernel**

**Ramdisk**

**Architecture**

**Minimum Disk (GB)**

**Minimum RAM (MB)**

**Image Sharing**

**Visibility**  Private  Shared  Community  Public

**Protected**  Yes  No

**Buttons**

## Instances

Instances													
Actions		Instance ID	Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
Displaying 3 items													
<input type="checkbox"/>	Ubuntu-instance	-			192.168.233.134	m1.tiny.ubuntu	cle-projet-cloud	Active	nova	None	Running	1 minute	<button>Create Snapshot</button>
<input type="checkbox"/>	CentOS-SaaS-V M	CentOS-SaaS			192.168.233.92, 172.24.4.61	ds2G	cle-projet-cloud	Shutoff	nova	None	Shut Down	55 minutes	<button>Start Instance</button>
<input type="checkbox"/>	instance-iaas-cirros	cirros-0.6.2-x86_64-disk			192.168.233.235, 172.24.4.237	m1.tiny	cle-projet-cloud	Shutoff	nova	None	Shut Down	1 hour, 16 minutes	<button>Start Instance</button>

## 3. Configuration Terraform

```
# 1. Définition du fournisseur OpenStack
terraform {
  required_providers {
    openstack = {
      source  = "terraform-provider-openstack/openstack"
      version = "~> 1.50.0"
    }
  }
}

provider "openstack" {
  # Les identifiants sont récupérés automatiquement depuis votre fichier openrc
}

# 2. Création de l'instance Ubuntu
resource "openstack_compute_instance_v2" "vm_nginx" {
  name          = "ubuntu-nginx-terraform"
  image_name    = "ubuntu-jammy"
  flavor_name   = "m1.tiny.ubuntu"
  key_pair      = "cle-projet-cloud"
  security_groups = ["default"]

  network {
    name = "private" # Nom du réseau interne de votre DevStack
  }
}

# 3. Création d'une IP flottante
resource "openstack_networking_floatingip_v2" "fip_ubuntu" {
  pool = "public" # Pool d'IPs externes de DevStack
}

# 4. Association de l'IP flottante à la VM
resource "openstack_compute_floatingip_associate_v2" "fip_assoc" {
  floating_ip = openstack_networking_floatingip_v2.fip_ubuntu.address
  instance_id = openstack_compute_instance_v2.vm_nginx.id
}

# 5. Affichage de l'IP à la fin (utile pour Ansible)
output "ip_de_la_vm" {
  value = openstack_networking_floatingip_v2.fip_ubuntu.address
}
```

## 4. Execution de Terraform

### 4.1. Initialisation

```
Samirtaous@samirtaous:~/terraform-deploy$ terraform init
Initializing the backend...
Initializing provider plugins...
- Finding terraform-provider-openstack/openstack versions matching "~> 1.50.0"...
- Installing terraform-provider-openstack/openstack v1.50.0...
- Installed terraform-provider-openstack/openstack v1.50.0 (self-signed, key ID 4F80527A391BEFD2)
  Partner and community providers are signed by their developers.
  If you'd like to know more about provider signing, you can read about it here:
  https://developer.hashicorp.com/terraform/cli/plugins/signing
  Terraform has created a lock file .terraform.lock.hcl to record the provider
  selections it made above. Include this file in your version control repository
  so that Terraform can guarantee to make the same selections by default when
  you run "terraform init" in the future.

Terraform has been successfully initialized!

You may now begin working with Terraform. Try running "terraform plan" to see
any changes that are required for your infrastructure. All Terraform commands
should now work.

If you ever set or change modules or backend configuration for Terraform,
rerun this command to reinitialize your working directory. If you forget, other
commands will detect it and remind you to do so if necessary.
Samirtaous@samirtaous:~/terraform-deploy$
```

### 4.2. Vérification

```
Samirtaous@samirtaous:~/terraform-deploy$ terraform plan
Terraform used the selected providers to generate the following execution plan. Resource actions are
indicated with the following symbols:
+ create

Terraform will perform the following actions:

# openstack_compute_floatingip_associate_v2.fip_assoc will be created
+ resource "openstack_compute_floatingip_associate_v2" "fip_assoc" {
  + floating_ip = (known after apply)
  + id          = (known after apply)
  + instance_id = (known after apply)
  + region      = (known after apply)
}

# openstack_compute_instance_v2.vm_nginx will be created
+ resource "openstack_compute_instance_v2" "vm_nginx" {
  + access_ip_v4    = (known after apply)
  + access_ip_v6    = (known after apply)
  + all_metadata    = (known after apply)
  + all_tags        = (known after apply)
  + availability_zone = (known after apply)
  + created        = (known after apply)
  + flavor_id       = (known after apply)
  + flavor_name     = "m1.tiny.ubuntu"
  + force_delete    = false
  + id              = (known after apply)
  + image_id        = (known after apply)
  + image_name      = "ubuntu-jammy"
  + key_pair        = "cle-projet-cloud"
  + name            = "ubuntu-nginx-terraform"
  + power_state     = "active"
  + region          = (known after apply)
  + security_groups = [
    + "default",
  ]
  + stop_before_destroy = false
  + updated         = (known after apply)

  + network {
    + access_network = false
    + fixed_ip_v4   = (known after apply)
    + fixed_ip_v6   = (known after apply)
    + floating_ip   = (known after apply)
    + mac           = (known after apply)
    + name          = "private"
    + port          = (known after apply)
    + uuid          = (known after apply)
  }
}

# openstack_networking_floatingip_v2.fip_ubuntu will be created
+ resource "openstack_networking_floatingip_v2" "fip_ubuntu" {
  + address      = (known after apply)
  + all_tags     = (known after apply)
  + dns_domain   = (known after apply)
  + dns_name     = (known after apply)
  + fixed_ip     = (known after apply)
  + id           = (known after apply)
  + pool          = "public"
```

## 4.3. Execution

```
samirtaous@samirtaous:~/terraform-deploy$ terraform apply -auto-approve

Terraform used the selected providers to generate the following execution plan. Resource actions are
indicated with the following symbols:
+ create

Terraform will perform the following actions:

# openstack_compute_floatingip_associate_v2.fip_assoc will be created
+ resource "openstack_compute_floatingip_associate_v2" "fip_assoc" {
    + floating_ip = (known after apply)
    + id          = (known after apply)
    + instance_id = (known after apply)
    + region      = (known after apply)
}

# openstack_compute_instance_v2.vm_nginx will be created
+ resource "openstack_compute_instance_v2" "vm_nginx" {
    + access_ip_v4      = (known after apply)
    + access_ip_v6      = (known after apply)
    + all_metadata      = (known after apply)
    + all_tags          = (known after apply)
    + availability_zone = (known after apply)
    + created           = (known after apply)
    + flavor_id         = (known after apply)
    + flavor_name       = "m1.tiny.ubuntu"
    + force_delete      = false
    + id                = (known after apply)
    + image_id          = (known after apply)
}
```

## Résultat final de l'exécution

```
Changes to Outputs:
+ ip_de_la_vm = "172.24.4.15"
openstack_compute_instance_v2.vm_nginx: Creating...
openstack_compute_instance_v2.vm_nginx: Still creating... [00m10s elapsed]
openstack_compute_instance_v2.vm_nginx: Still creating... [00m20s elapsed]
openstack_compute_instance_v2.vm_nginx: Still creating... [00m30s elapsed]
openstack_compute_instance_v2.vm_nginx: Still creating... [00m40s elapsed]
openstack_compute_instance_v2.vm_nginx: Still creating... [00m50s elapsed]
openstack_compute_instance_v2.vm_nginx: Creation complete after 53s [id=d7b1a33f-738d-4886-b679-f875313
07be]
openstack_compute_floatingip_associate_v2.fip_assoc: Creating...
openstack_compute_floatingip_associate_v2.fip_assoc: Creation complete after 3s [id=172.24.4.15/d7b1a33
f-738d-4886-b679-f87531307be/]

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.

Outputs:
ip_de_la_vm = "172.24.4.15"
samirtaous@samirtaous:~/terraform-deploy$ |
```

## 5. Déploiement avec Ansible

On mets à jour le hosts.ini avec la nouvelle ip

```
GNU nano 7.2                                     hosts.ini
[webserver]
172.24.4.15

[webserver:vars]
ansible_user=ubuntu
ansible_ssh_private_key_file=~/ssh/id_rsa
ansible_ssh_common_args='-o StrictHostKeyChecking=no'
```

On teste la configuration