Labs 1-5

Student ID: 23905652

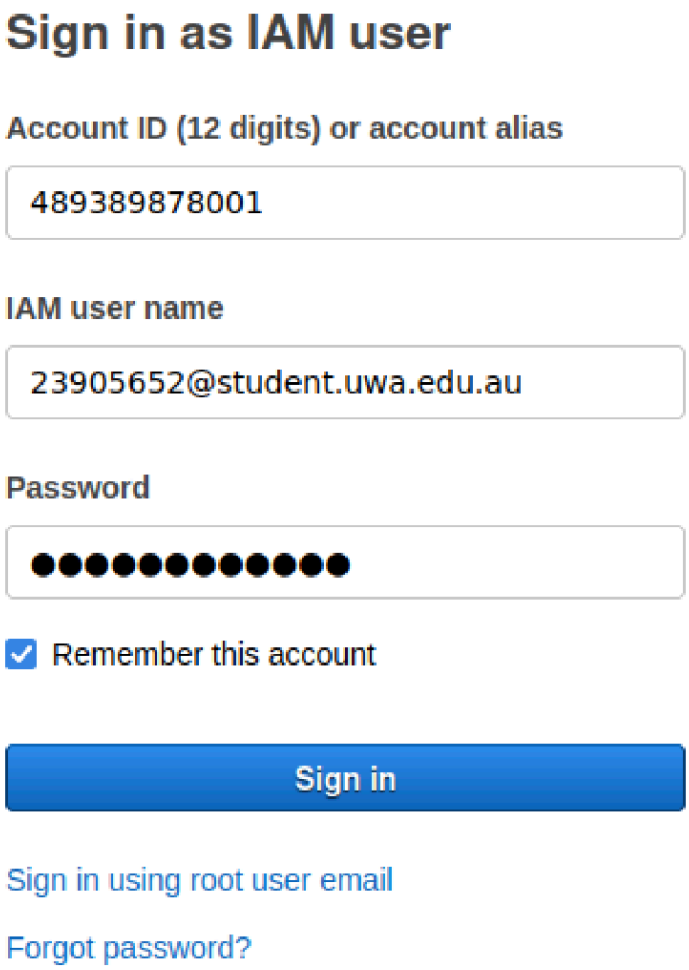
Student Name: Zhe Han

Lab 1 Intro Set up

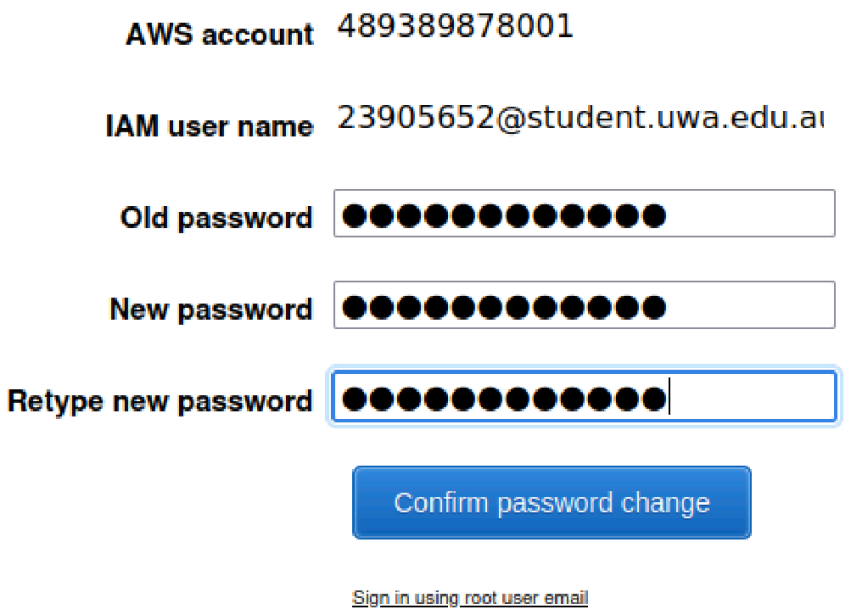
AWS Account and Log in

[1] Log into an IAM user account created for you on AWS.

Navigate in the browser to https://489389878001.signin.aws.amazon.com/console, enter the **account root user ID 489389878001**, as well as the **IAM user name** and **password** provided in student email, and click login.

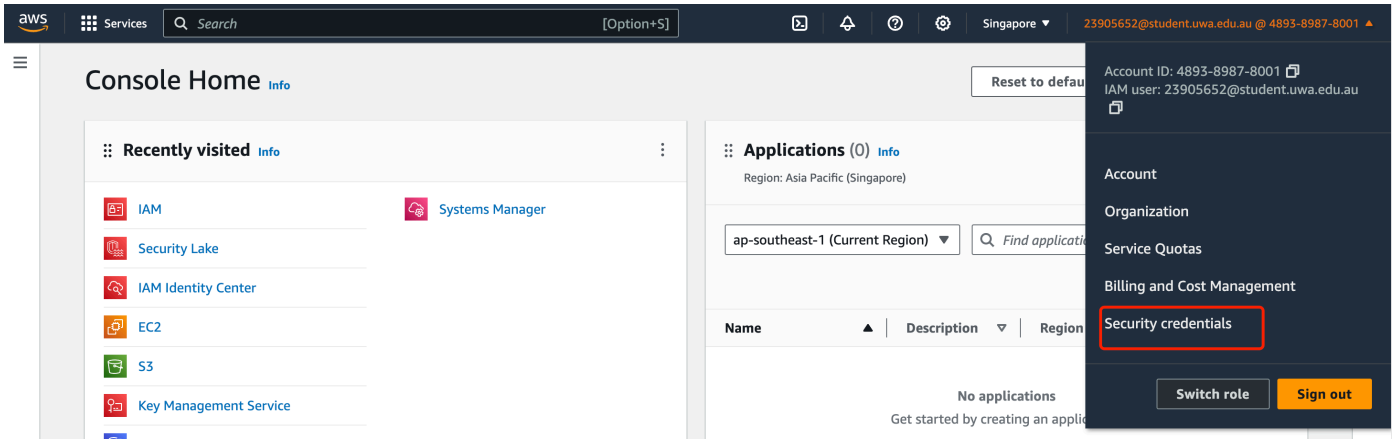


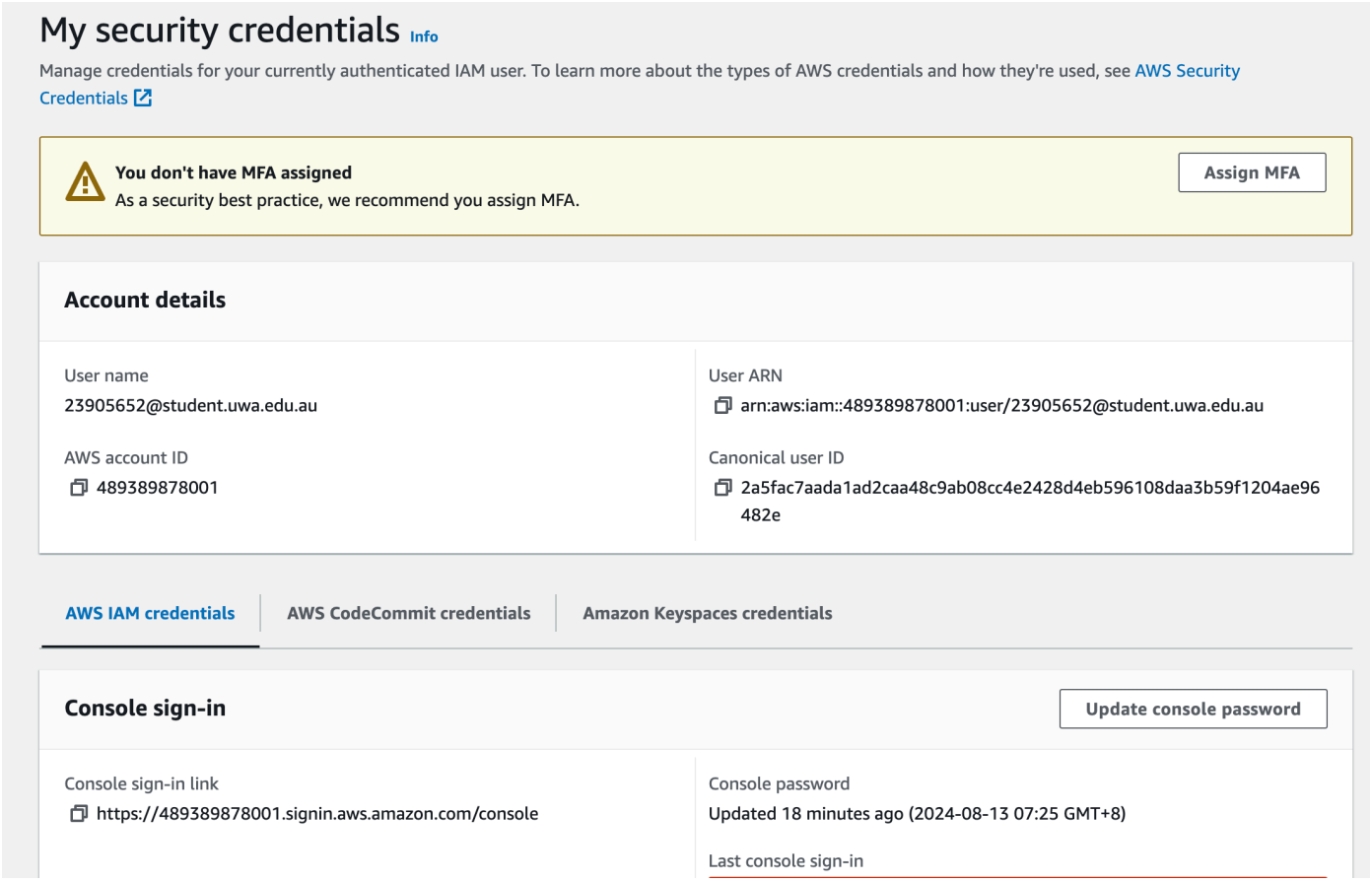
After logging in, change the password to a personal one.



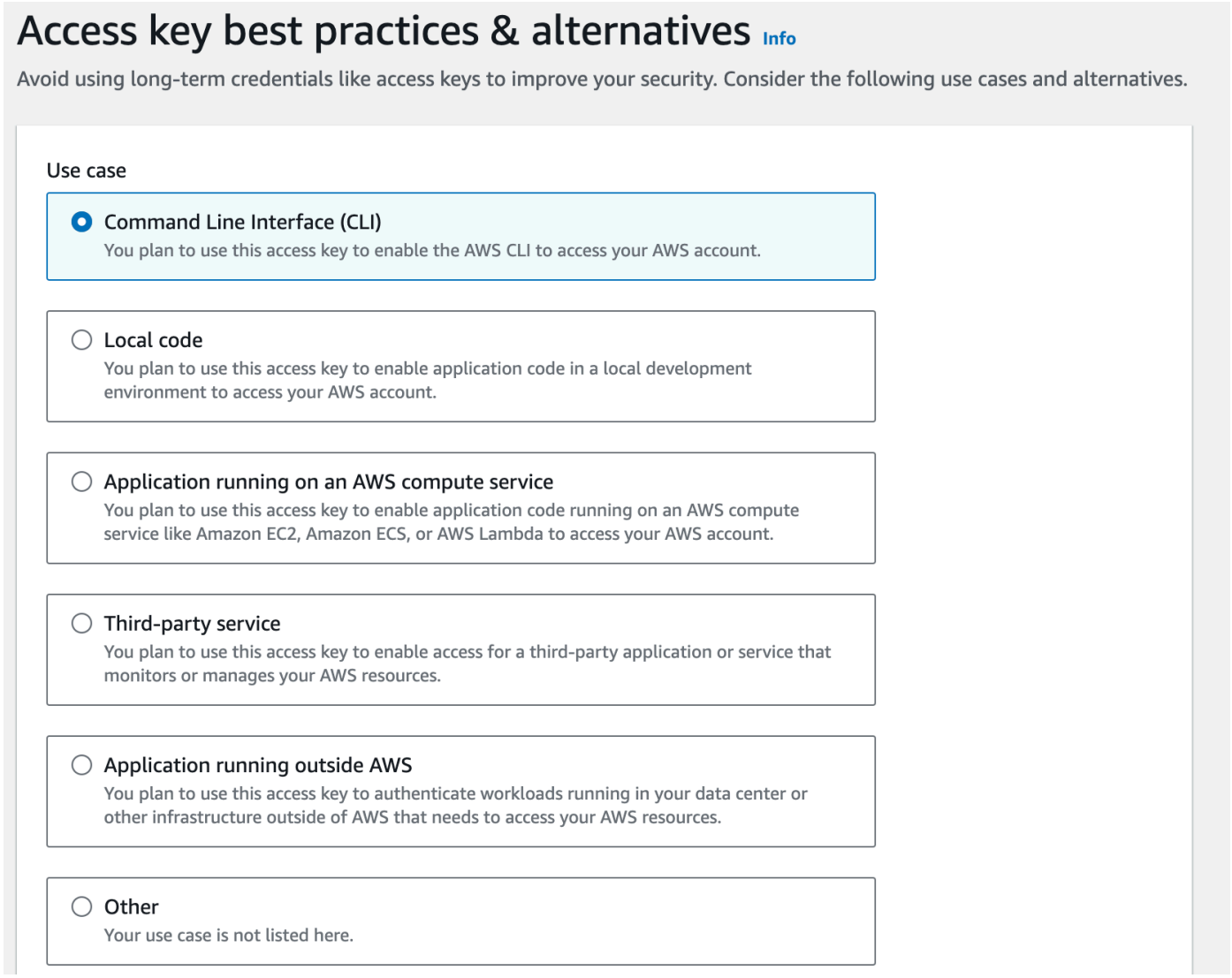
[2] Search and open Identity Access Management

After entering the home page, click the dropdown menu of **the account name** in the upper-right corner, and select **"Security credentials"** to navigate to the Security Credentials page. Here, we can see some detailed information about the user.

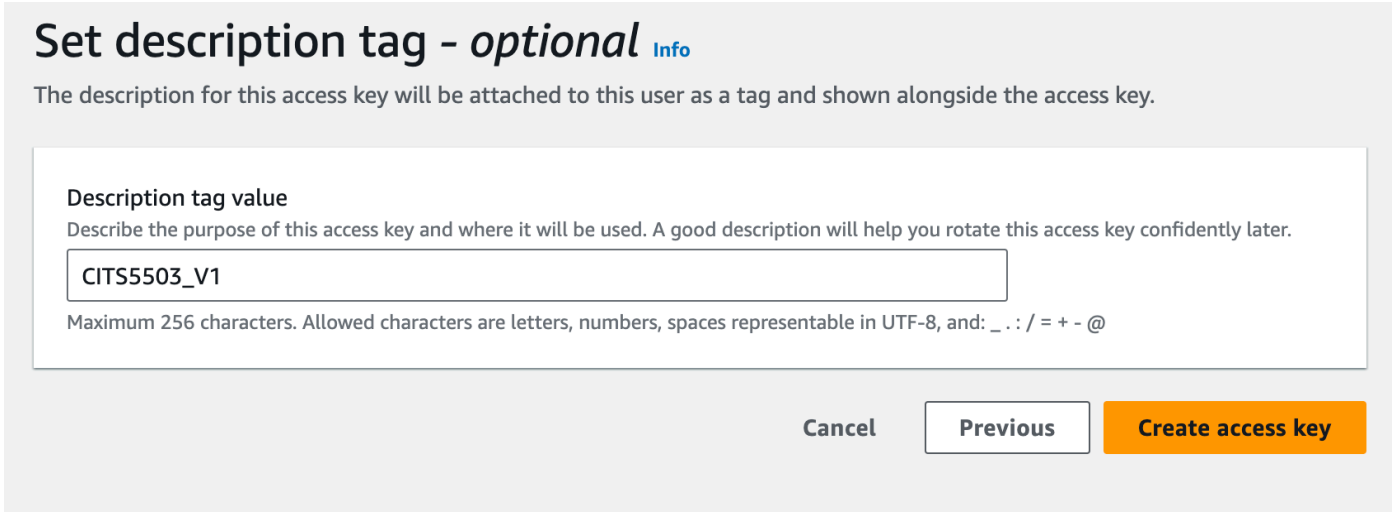




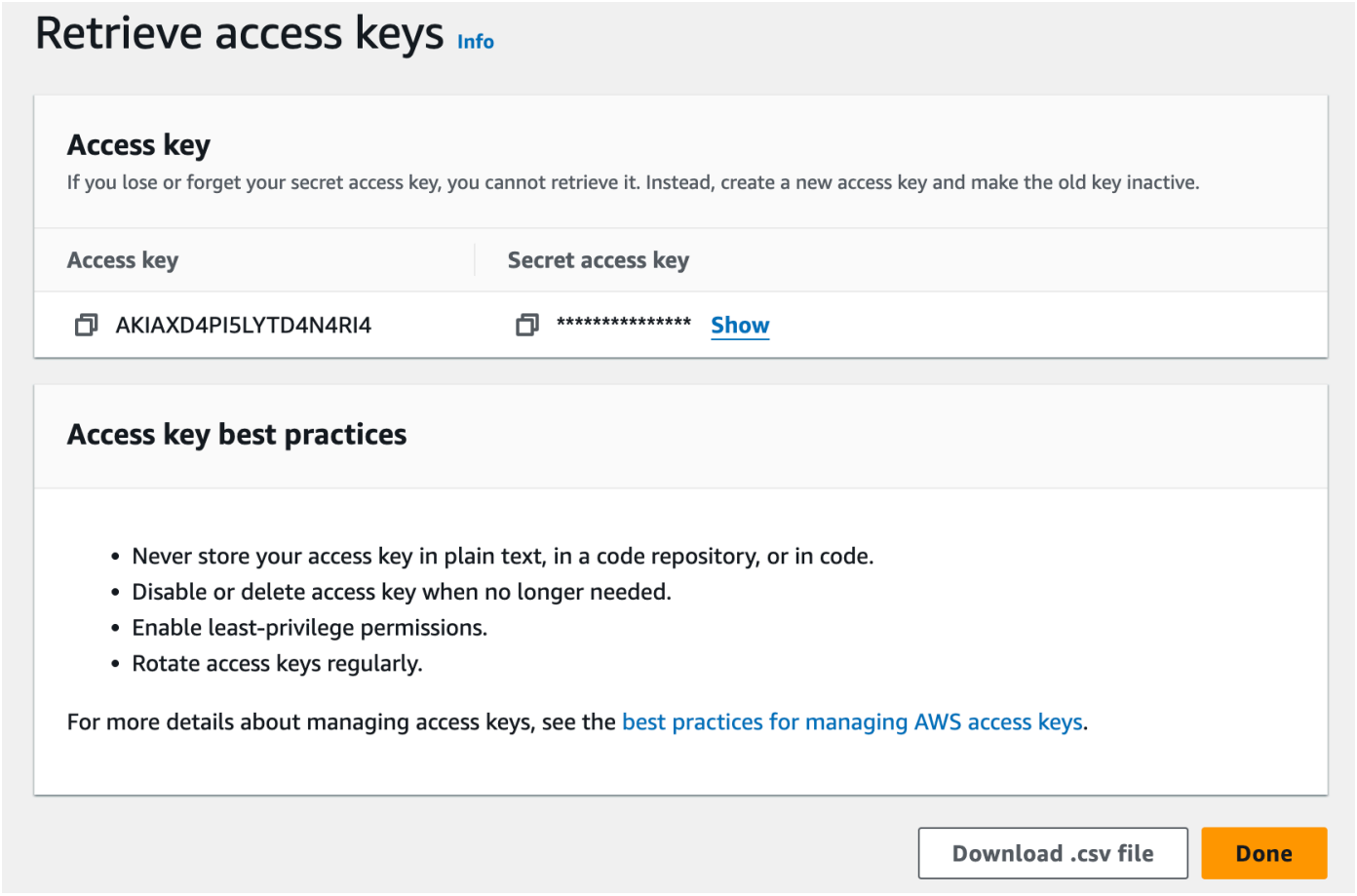
Scroll down the page, and in the **"Access keys"** section, click “create an access key”. And for the use case, select **"Command Line Interface (CLI)"** to allow command-line control.



Create a tag for the access key, which can include the purpose of the access key to differentiate between different access keys. After entering the details, click "Create access key."



After successfully creating the key, click "Download .csv file" to save the Access Key ID and Secret Access Key for secure storage. If the Access Key ID and Secret Access Key are compromised, these details can allow someone to create extensive resources and misuse the user account, so **we have to handle them with caution**.

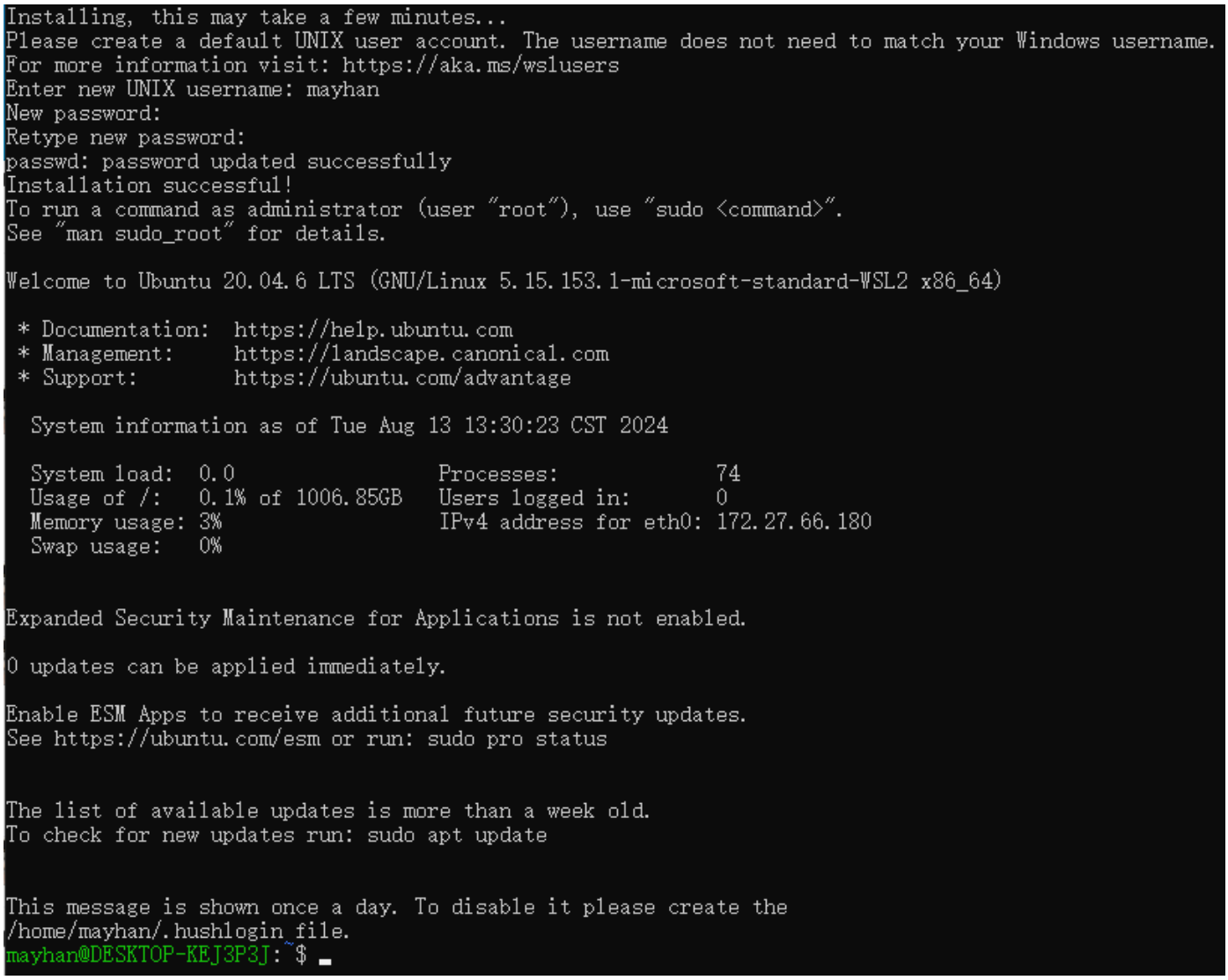


Set up recent Linux OSes

For the labs in this unit, WSL on Windows will be used. Install WSL from the command line by running:

```
> wsl --install -d Ubuntu-20.04
```

This command will enable the features required to run WSL and install the recommended version of Ubuntu 20.04 from the lab sheet. Once installed, enter a username and password to complete the setup:



Install Linux packages

[1] Install Python 3.8.x

Enter the following command in the terminal to check the Python version:

```
python3 -V
```

Enter the following command to install pip3, which is a tool that will allow us to install and manage Python libraries:

```
sudo apt install -y python3-pip
```

```
mayhan@DESKTOP-KEJ3P3J:~$ python3 -V
Python 3.8.10
mayhan@DESKTOP-KEJ3P3J:~$ sudo apt install -y python3-pip
[sudo] password for mayhan:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu build-essential cpp cpp-9 dpkg-dev fakeroot g++ g++-9 gcc gcc-9
  gcc-9-base libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl libasan5 libatomic1 libbinutils
  libc-dev-bin libc6-dev libcc1-0 libcrypt-dev libctf-nobfd0 libctf0 libdpkg-perl libexpat1-dev libfakeroot
  libfile-fcntllock-perl libgcc-9-dev libgomp1 libisl22 libitm1 liblsan0 libmpc3 libpython3-dev libpython3.8-dev
  libquadmath0 libstdc++-9-dev libtsan0 libubsan1 linux-libc-dev make manpages-dev python-pip-whl python3-dev
  python3-wheel python3.8-dev zlib1g-dev
Suggested packages:
  binutils-doc cpp-doc gcc-9-locales debian-keyring g++-multilib g++-9-multilib gcc-9-doc gcc-multilib autoconf
  automake libtool flex bison gdb gcc-doc gcc-9-multilib glibc-doc bzr libstdc++-9-doc make-doc
The following NEW packages will be installed:
  binutils binutils-common binutils-x86-64-linux-gnu build-essential cpp cpp-9 dpkg-dev fakeroot g++ g++-9 gcc gcc-9
  gcc-9-base libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl libasan5 libatomic1 libbinutils
  libc-dev-bin libc6-dev libcc1-0 libcrypt-dev libctf-nobfd0 libctf0 libdpkg-perl libexpat1-dev libfakeroot
  libfile-fcntllock-perl libgcc-9-dev libgomp1 libisl22 libitm1 liblsan0 libmpc3 libpython3-dev libpython3.8-dev
  libquadmath0 libstdc++-9-dev libtsan0 libubsan1 linux-libc-dev make manpages-dev python-pip-whl python3-dev
  python3-pip python3-wheel python3.8-dev zlib1g-dev
0 upgraded, 50 newly installed, 0 to remove and 0 not upgraded.
Need to get 52.3 MB of archives.
```

From the output, we have successfully installed Python 3.8.10 and pip3 in WSL.

[2] Install awscli

Enter the following command to install awscli:

```
sudo apt install awscli
```

```
mayhan@DESKTOP-KEJ3P3J: $ sudo apt install awscli
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  docutils-common fontconfig fonts-droid-fallback fonts-noto-mono fonts-urw-base35 ghostscript groff gsfonts
  hicolor-icon-theme imagemagick imagemagick-6-common imagemagick-6.q16 libavahi-client3 libavahi-common-data
  libavahi-common3 libcairo2 libcups2 libdatrie1 libdjvulibre-text libdjvulibre21 libfftw3-double3 libgraphite2-3
  libgs9 libgs9-common libharfbuzz0b libidn11 libijs-0.35 libilmbase24 libimagequant0 libjbig0 libjbig2dec0
  libjpeg-turbo8 libjpeg8 liblcms2-2 liblqr-1-0 libmagickcore-6.q16-6 libmagickcore-6.q16-6-extra
  libmagickwand-6.q16-6 libnetpbm10 libopenexr24 libopenjp2-7 libpango-1.0-0 libpangocairo-1.0-0 libpangoft2-1.0-0
  libpaper-utils libpaper1 libpixman-1-0 libthai-data libthai0 libtiff5 libwebp6 libwebpdemux2 libwebpmux3 libwmf0.2-7
  libxcb-render0 netpbm poppler-data psutils python3-botocore python3-dateutil python3-docutils python3-jmespath
  python3-olefile python3-pil python3-pygments python3-roman python3-rsa python3-s3transfer sgml-base xml-core
Suggested packages:
  fonts-noto fonts-freefont-otf | fonts-freefont-ttf fonts-texgyre ghostscript-x imagemagick-doc autotrace cups-bsd
  | lpr | lprng enscript ffmpeg gimp gnuplot grads graphviz hp2xx html2ps libwmf-bin mplayer povray radiance
  sane-utils texlive-base-bin transfig ufraw-batch xdg-utils cups-common libfftw3-bin libfftw3-dev liblcms2-utils
  inkscape libjxr-tools libwmf0.2-7-gtk poppler-utils fonts-japanese-mincho | fonts-ipafont-mincho
  fonts-japanese-gothic | fonts-ipafont-gothic fonts-arphic-ukai fonts-arphic-uming fonts-nanum docutils-doc
  fonts-linuxlibertine | ttf-linux-libertine texlive-lang-french texlive-latex-base texlive-latex-recommended
  python-pil-doc python3-pil-dbg python-pygments-doc ttf-bitstream-vera sgml-base-doc debhelper
```

Then:

```
pip3 install awscli --upgrade
```

```
mayhan@DESKTOP-KEJ3P3J: $ pip3 install awscli --upgrade
Collecting awscli
  Downloading awscli-1.33.41-py3-none-any.whl (4.5 MB)
     |████████████████████████████████| 4.5 MB 584 kB/s
Requirement already satisfied, skipping upgrade: docutils<0.17,>=0.10 in /usr/lib/python3/dist-packages (from awscli) (0
.16)
Collecting botocore==1.34.159
  Downloading botocore-1.34.159-py3-none-any.whl (12.5 MB)
     |████████████████████████████████| 12.5 MB 8.9 MB/s
Requirement already satisfied, skipping upgrade: colorama<0.4.7,>=0.2.5 in /usr/lib/python3/dist-packages (from awscli)
(0.4.3)
Requirement already satisfied, skipping upgrade: PyYAML<6.1,>=3.10 in /usr/lib/python3/dist-packages (from awscli) (5.3.
1)
Requirement already satisfied, skipping upgrade: rsa<4.8,>=3.1.2 in /usr/lib/python3/dist-packages (from awscli) (4.0)
Collecting s3transfer<0.11.0,>=0.10.0
  Downloading s3transfer-0.10.2-py3-none-any.whl (82 kB)
     |████████████████████████████████| 82 kB 785 kB/s
Requirement already satisfied, skipping upgrade: urllib3<1.27,>=1.25.4; python_version < "3.10" in /usr/lib/python3/dist
-packages (from botocore==1.34.159->awscli) (1.25.8)
Requirement already satisfied, skipping upgrade: jmespath<2.0.0,>=0.7.1 in /usr/lib/python3/dist-packages (from botocore
==1.34.159->awscli) (0.9.4)
Requirement already satisfied, skipping upgrade: python-dateutil<3.0.0,>=2.1 in /usr/lib/python3/dist-packages (from bot
ocore==1.34.159->awscli) (2.7.3)
Installing collected packages: botocore, s3transfer, awscli
Successfully installed awscli-1.33.41 botocore-1.34.159 s3transfer-0.10.2
```

From the output, we can see that the installation was successful.

[3] Configure AWS

Enter the following command to start configuring AWS:

```
aws configure
```

Enter the access key ID and secret access key generated in the first step. Set the region name to **ap-southeast-1** based on the student number:

```
mayhan@DESKTOP-KEJ3P3J:~$ aws configure
AWS Access Key ID [None]: AKIAXD4PI5LYTD4N4RI4
AWS Secret Access Key [None]: [redacted]
Default region name [None]: ap-southeast-1
Default output format [None]: json
```

[4] Install boto3

Enter the following command to install boto3:

```
pip3 install boto3
```

```
mayhan@DESKTOP-KEJ3P3J:~$ pip3 install boto3
Collecting boto3
  Downloading boto3-1.34.159-py3-none-any.whl (139 kB)
     |████████████████████████████████| 139 kB 567 kB/s
Requirement already satisfied: s3transfer<0.11.0,>=0.10.0 in ./.local/lib/python3.8/site-packages (from boto3) (0.10.2)
Requirement already satisfied: botocore<1.35.0,>=1.34.159 in ./.local/lib/python3.8/site-packages (from boto3) (1.34.159
)
Requirement already satisfied: jmespath<2.0.0,>=0.7.1 in /usr/lib/python3/dist-packages (from boto3) (0.9.4)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/lib/python3/dist-packages (from botocore<1.35.0,>=1.3
4.159->boto3) (2.7.3)
Requirement already satisfied: urllib3<1.27,>=1.25.4; python_version < "3.10" in /usr/lib/python3/dist-packages (from bo
tocore<1.35.0,>=1.34.159->boto3) (1.25.8)
Installing collected packages: boto3
Successfully installed boto3-1.34.159
```

Test the installed environment

[1] Test the AWS environment

Enter the following command to test the AWS environment:

```
aws ec2 describe-regions --output table
```

```
mayhan@DESKTOP-KEJ3P3J:~$ aws ec2 describe-regions --output table
-------------------------------------------------------------------------------
|                              DescribeRegions                                |
+-----------------------------------------------------------------------------+
||                                Regions                                    ||
|+-----------------------------------+---------------------+-----------------+|
||            Endpoint               |     OptInStatus     |   RegionName    ||
|+-----------------------------------+---------------------+-----------------+|
||  ec2.ap-south-1.amazonaws.com     |  opt-in-not-required |  ap-south-1     ||
||  ec2.eu-north-1.amazonaws.com     |  opt-in-not-required |  eu-north-1     ||
||  ec2.eu-west-3.amazonaws.com      |  opt-in-not-required |  eu-west-3      ||
||  ec2.eu-west-2.amazonaws.com      |  opt-in-not-required |  eu-west-2      ||
||  ec2.eu-west-1.amazonaws.com      |  opt-in-not-required |  eu-west-1      ||
||  ec2.ap-northeast-3.amazonaws.com |  opt-in-not-required |  ap-northeast-3 ||
||  ec2.ap-northeast-2.amazonaws.com |  opt-in-not-required |  ap-northeast-2 ||
||  ec2.ap-northeast-1.amazonaws.com |  opt-in-not-required |  ap-northeast-1 ||
||  ec2.ca-central-1.amazonaws.com   |  opt-in-not-required |  ca-central-1   ||
||  ec2.sa-east-1.amazonaws.com      |  opt-in-not-required |  sa-east-1      ||
||  ec2.ap-southeast-1.amazonaws.com |  opt-in-not-required |  ap-southeast-1 ||
||  ec2.ap-southeast-2.amazonaws.com |  opt-in-not-required |  ap-southeast-2 ||
||  ec2.eu-central-1.amazonaws.com   |  opt-in-not-required |  eu-central-1   ||
||  ec2.us-east-1.amazonaws.com      |  opt-in-not-required |  us-east-1      ||
||  ec2.us-east-2.amazonaws.com      |  opt-in-not-required |  us-east-2      ||
||  ec2.us-west-1.amazonaws.com      |  opt-in-not-required |  us-west-1      ||
||  ec2.us-west-2.amazonaws.com      |  opt-in-not-required |  us-west-2      ||
|+-----------------------------------+---------------------+-----------------+|
```

This command outputs a table with information about the available AWS regions for the EC2 service. And we can obtain the output of this table indicates that **our AWS environment has been successfully configured**.

[2] Test the Python environment

We can test the Python environment by entering the following commands:

```
python3
>>> import boto3
>>> ec2 = boto3.client('ec2')
>>> response = ec2.describe_regions()
>>> print(response)
```

This command will create an un-tabulated response, also retrieving information about the available AWS regions for the EC2 service.

[3] Write a Python script

Next, we will write a Python script to format the un-tabulated response into a table with only two columns: Endpoint and RegionName.

```
import boto3

# Create an EC2 client
ec2 = boto3.client('ec2')

# Get the region descriptions
response = ec2.describe_regions()

# Extract the needed data
regions = response['Regions']

# Print the header
# 'Endpoint':<40 means left-align and occupy a width of 40 characters.
# The second line prints 50 equal signs as a separator
print(f"{'Endpoint':<40} {'RegionName'}")
print("="*50)

# Print each region's Endpoint and RegionName
for region in regions:
    endpoint = region['Endpoint']
    region_name = region['RegionName']
    print(f"{endpoint:<40} {region_name}")
```

Save the script in a file called '5503_lab01.py' and **run the script using the following command**:

```
python3 5503_lab01.py
```

The output will be as shown:

```
mayhan@DESKTOP-KEJ3P3J:~/document$ python3 5503_lab01.py
Endpoint                                    RegionName
================================================
ec2.ap-south-1.amazonaws.com                ap-south-1
ec2.eu-north-1.amazonaws.com                eu-north-1
ec2.eu-west-3.amazonaws.com                 eu-west-3
ec2.eu-west-2.amazonaws.com                 eu-west-2
ec2.eu-west-1.amazonaws.com                 eu-west-1
ec2.ap-northeast-3.amazonaws.com            ap-northeast-3
ec2.ap-northeast-2.amazonaws.com            ap-northeast-2
ec2.ap-northeast-1.amazonaws.com            ap-northeast-1
ec2.ca-central-1.amazonaws.com              ca-central-1
ec2.sa-east-1.amazonaws.com                 sa-east-1
ec2.ap-southeast-1.amazonaws.com            ap-southeast-1
ec2.ap-southeast-2.amazonaws.com            ap-southeast-2
ec2.eu-central-1.amazonaws.com              eu-central-1
ec2.us-east-1.amazonaws.com                 us-east-1
ec2.us-east-2.amazonaws.com                 us-east-2
ec2.us-west-1.amazonaws.com                 us-west-1
ec2.us-west-2.amazonaws.com                 us-west-2
```

Lab 2 EC2 & Docker

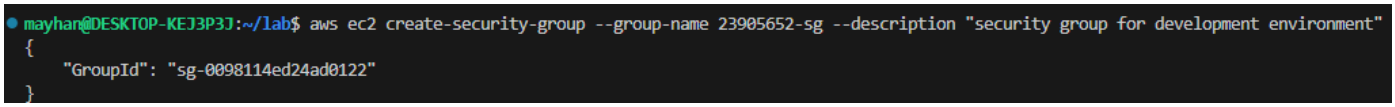
Create an EC2 instance using awscli

[1] Create a security group

Security groups in AWS act as virtual firewalls for EC2 instances and other resources, controlling inbound and outbound traffic at the instance level to enhance network security. Enter the following command in the terminal to create a security group named "23905652-sg", named after the student number:

```
aws ec2 create-security-group --group-name 23905652-sg --description "security group for development environment"
```

Output:



Record the security group ID, "sg-0098114ed24ad0122", for later use.

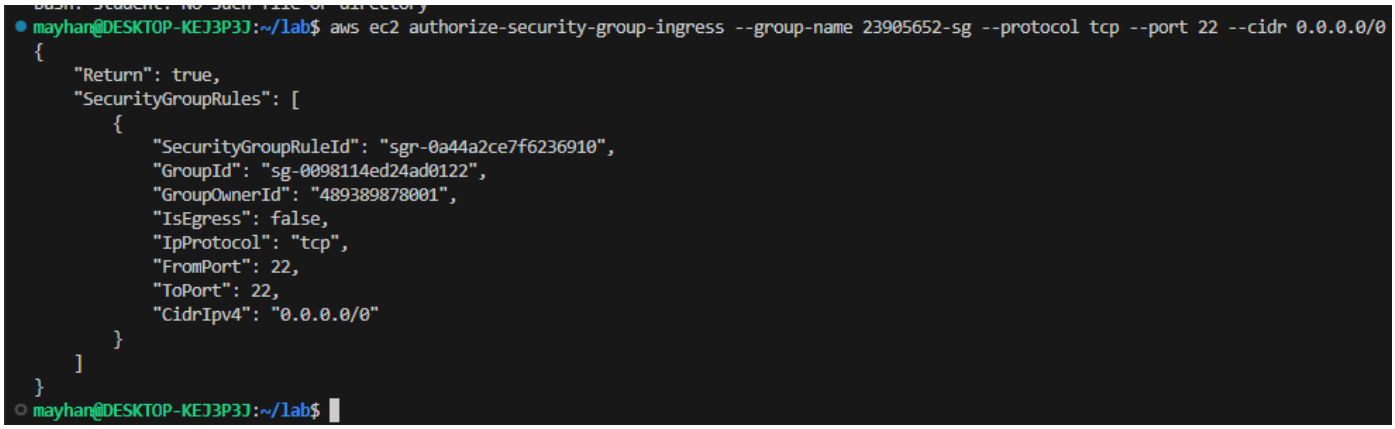
[2] Authorise inbound traffic for ssh

Enter the following command to authorize inbound traffic for SSH. This command **adds a rule to the security group named "23905652-sg" that allows incoming TCP traffic on port 22 (SSH) from any IP address**:

```
aws ec2 authorize-security-group-ingress --group-name 23905652-sg --protocol tcp --port 22 --cidr 0.0.0.0/0
```

Where:

- `aws ec2 authorize-security-group-ingress`: This is the AWS CLI command used to add an inbound rule to the security group.
- `--group-name 23905652-sg`: Specifies the name of the security group where the rule is to be added.
- `--protocol tcp`: Sets the protocol for the rule to TCP.
- `--port 22`: Specifies that the rule applies to port 22, typically used for SSH connections.
- `--cidr 0.0.0.0/0`: Defines the allowed source IP range. 0.0.0.0/0 means "from any IP address."



[3] Create a key pair

In AWS, **key pairs** provide secure access to EC2 instances, allowing for encrypted SSH connections to Linux instances or RDP to Windows instances. The following command is used to create a key pair named "23905652-key":

```
aws ec2 create-key-pair --key-name 23905652-key --query 'KeyMaterial' --output text > 23905652-key.pem
```

After running this command, it retrieves the private key material and saves it to a file named "23905652-key.pem" in the current directory.

To use this file to connect to the EC2 instance, we also need to set permissions for the file using the following command:

```
chmod 400 23905652-key.pem
```

This command sets read-only permissions for the file owner, restricting access for others.

[4] Create the instance

Use the following command to create an instance:

```
aws ec2 run-instances --image-id ami-0497a974f8d5dcef8 --security-group-ids 23905652-sg --count 1 --instance-type t2.micro --key-name 23905652-key --query 'Instances[0].InstanceId'
```

Where:

- `aws ec2 run-instances`: Used to create an EC2 instance.
- `--image-id ami-0497a974f8d5dcef8`: Specifies the Amazon Machine Image (AMI) for the instance. In this case, it corresponds to the AMI for the "ap-southeast-1" region.
- `--security-group-ids 23905652-sg`: Assigns the previously created security group to the instance.
- `--count 1`: Launches one instance.
- `--instance-type t2.micro`: Sets the instance type to t2.micro, a small general-purpose instance.
- `--key-name 23905652-key`: Associates the key pair just created with the instance to allow SSH access.

- `--query 'Instances[0].InstanceId'`: Filters the output to return only the ID of the created instance.

After executing this command, we will receive the ID of the created instance:

```
"i-06dc94e32950071fd"
```

[5] Add a tag to your Instance

Use the following command to add a tag to the instance, to help distinguish between different instances:

```
aws ec2 create-tags --resources i-06dc94e32950071fd --tags Key=lab02,Value=23905652
```

[6] Get the public IP address

Enter the following command to retrieve the public IP address of the instance:

```
aws ec2 describe-instances --instance-ids i-06dc94e32950071fd --query
'Reservations[0].Instances[0].PublicIpAddress'
```

The output will contain the public IP address:

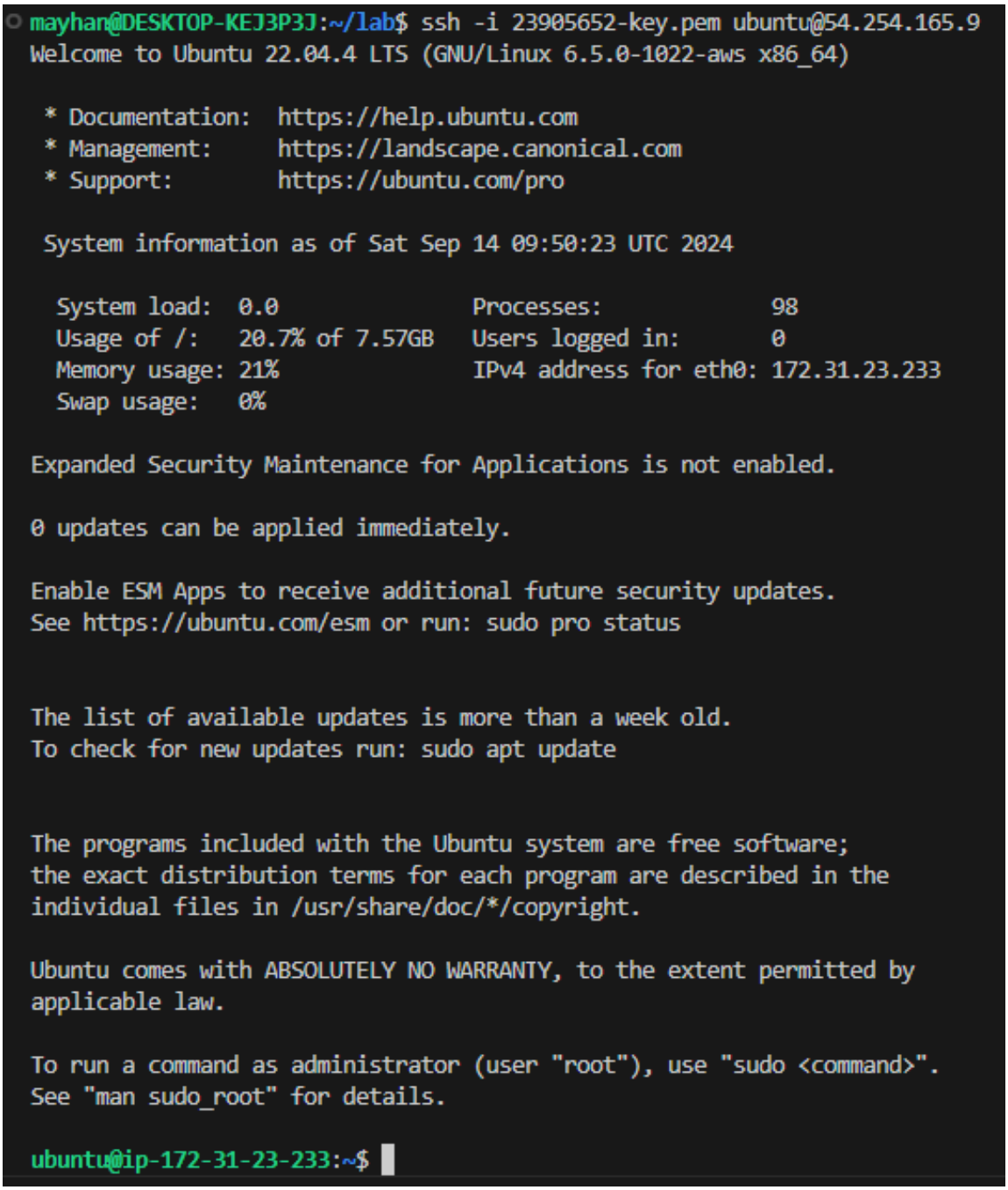
```
"54.254.165.9"
```

[7] Connect to the instance via ssh

We use the key pair and the public IP address obtained in the previous step to connect to the instance via SSH:

```
ssh -i 23905652-key.pem ubuntu@54.254.165.9
```

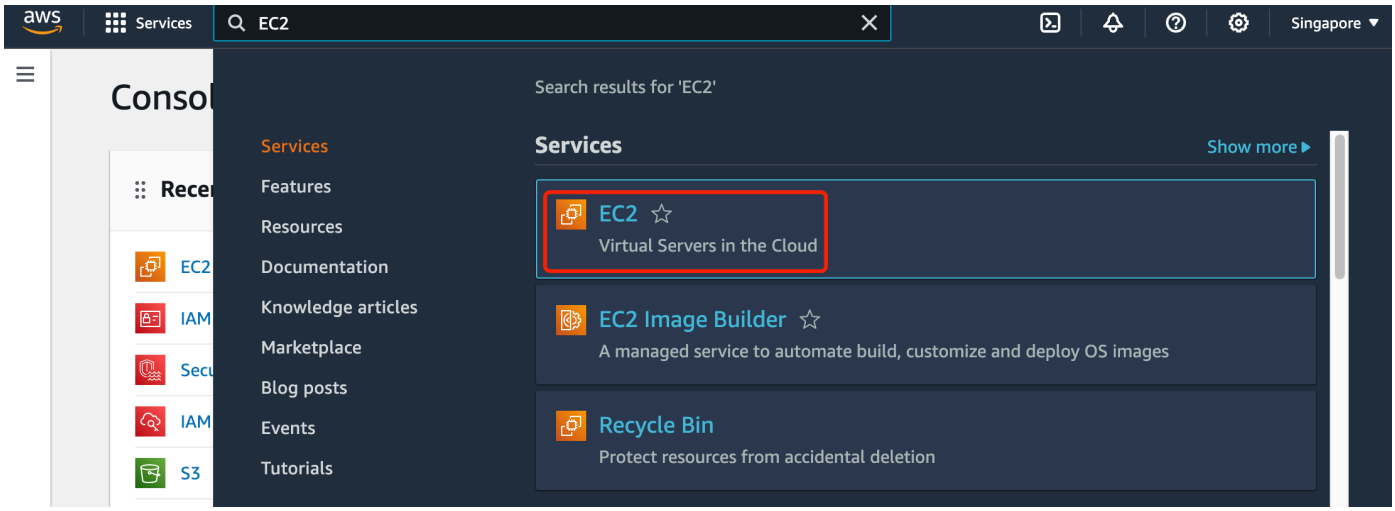
Output:



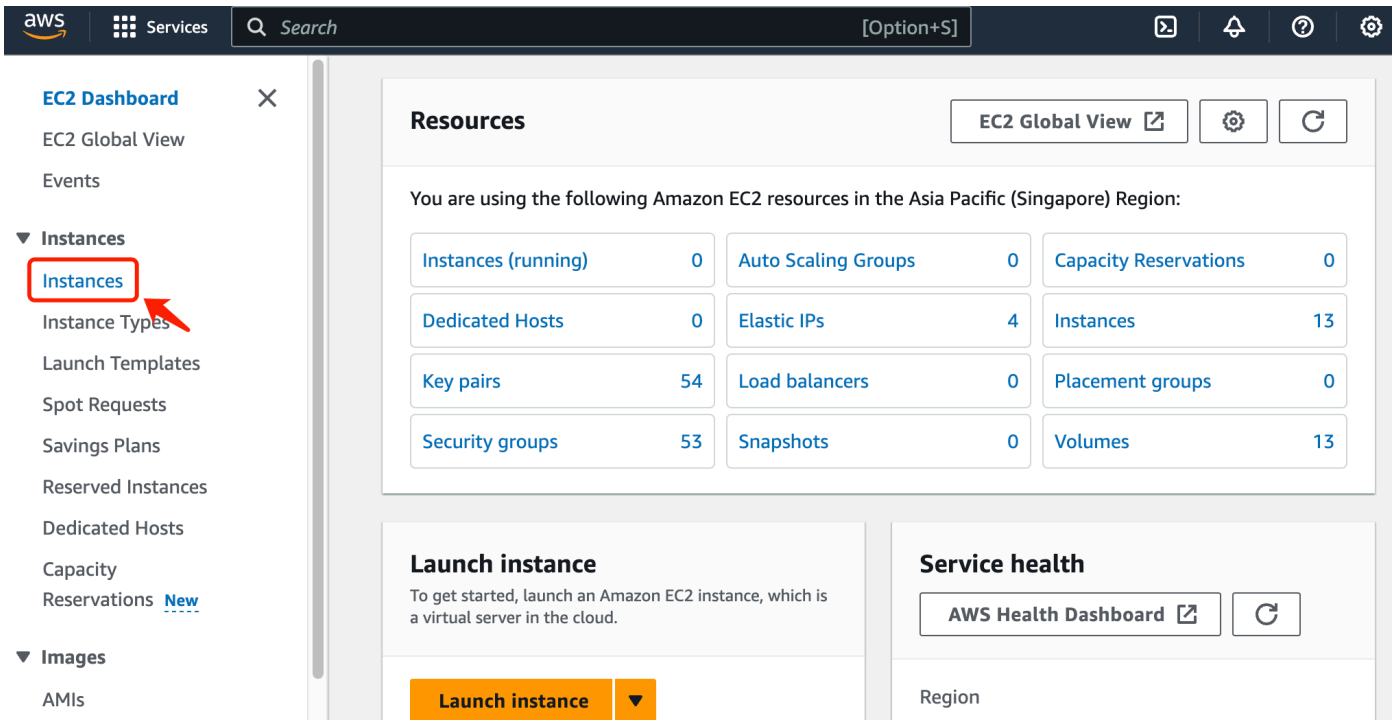
Connection successful.

[8] List the created instance using the AWS console

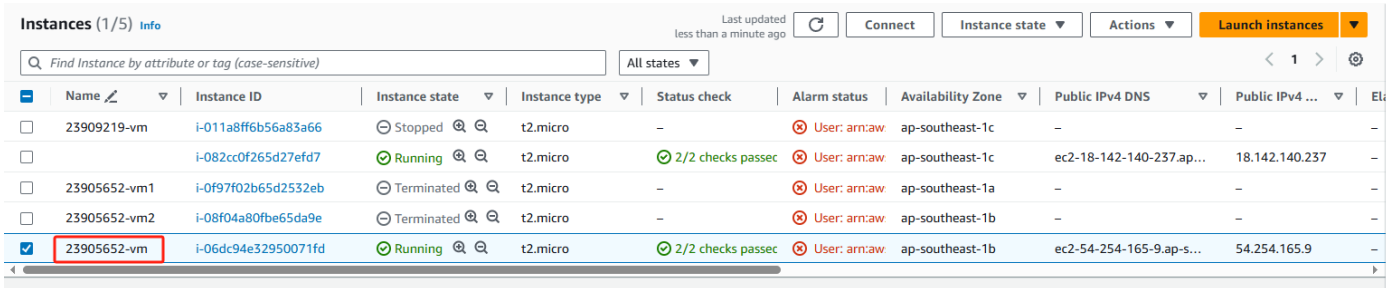
In the AWS home page, search for "EC2" in the search bar to navigate to the EC2 service page.



On the left-hand menu of the EC2 service page, select "Instances" under the "Instances" section:



We will be able to see the instance we created in the AWS console, name it "23905652-vm":



Create an EC2 instance with Python Boto3

1. Next, we'll implement steps 1-6 using a Python script, step-by-step explanations are written in the code comments.:

```
# Import necessary libraries. boto3 is AWS's Python SDK, os is used for file and directory operations
```

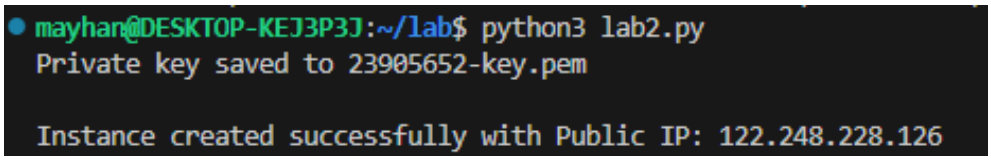
```python
import boto3
import os

student_number = "23905652"
region = "ap-southeast-1"

# Initialize the EC2 client
ec2 = boto3.client('ec2', region)

# Step [1]
# Create a security group and get its ID
response = ec2.create_security_group(
    GroupName=f"{student_number}-sg",
    Description="security group for development environment"
)
security_group_id = response['GroupId']

# Step [2]
# Authorize inbound SSH traffic for the security group
ec2.authorize_security_group_ingress(
    GroupId=security_group_id,
    IpProtocol="tcp",
    FromPort=22,
    ToPort=22,
    CidrIp="0.0.0.0/0"
)

# Step [3]
# Create a key pair and save the private key to a file
response = ec2.create_key_pair(KeyName=f"{student_number}-key")
private_key = response['KeyMaterial']

private_key_file = f"{student_number}-key.pem"

# Allow writing to the private key file
with open(private_key_file, 'w') as key_file:
    key_file.write(private_key)

# Set the correct permissions for the private key file
os.chmod(private_key_file, 0o400)

# Print message to confirm key file creation
print(f"Private key saved to {private_key_file}")

# Step [4] and [5]
# Launch an EC2 instance
response = ec2.run_instances(
    ImageId="ami-0497a974f8d5dcef8",
    SecurityGroupIds=[security_group_id],
    MinCount=1,
    MaxCount=1,
    InstanceType="t2.micro",
```

```
    KeyName=f"{student_number}-key"
)

print("Instance created successfully")

instance_id = response['Instances'][0]['InstanceId']

# Wait for the instance to be up and running
ec2.get_waiter('instance_running').wait(InstanceIds=[instance_id])

# Step [6]
# Describe the instance to get its public IP address
response = ec2.describe_instances(InstanceIds=[instance_id])
public_ip_address = response['Reservations'][0]['Instances'][0]['PublicIpAddress']
print(f"Instance created successfully with Public IP: {public_ip_address}")
```

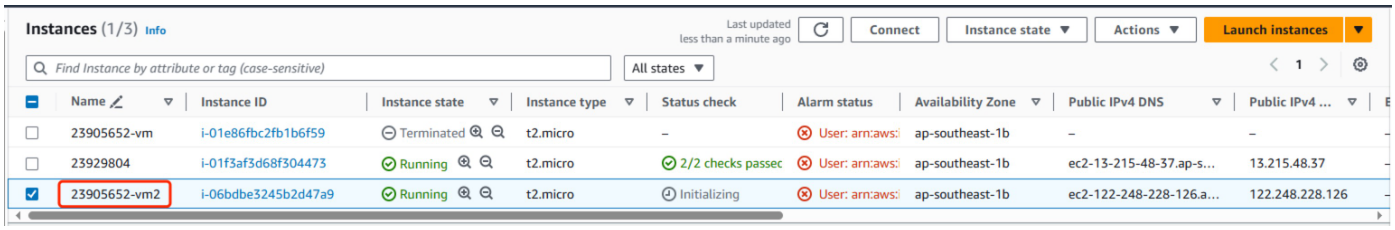
2. Save the Python script as "lab2.py", and **run the script with the following command**:

```
python3 lab2.py
```

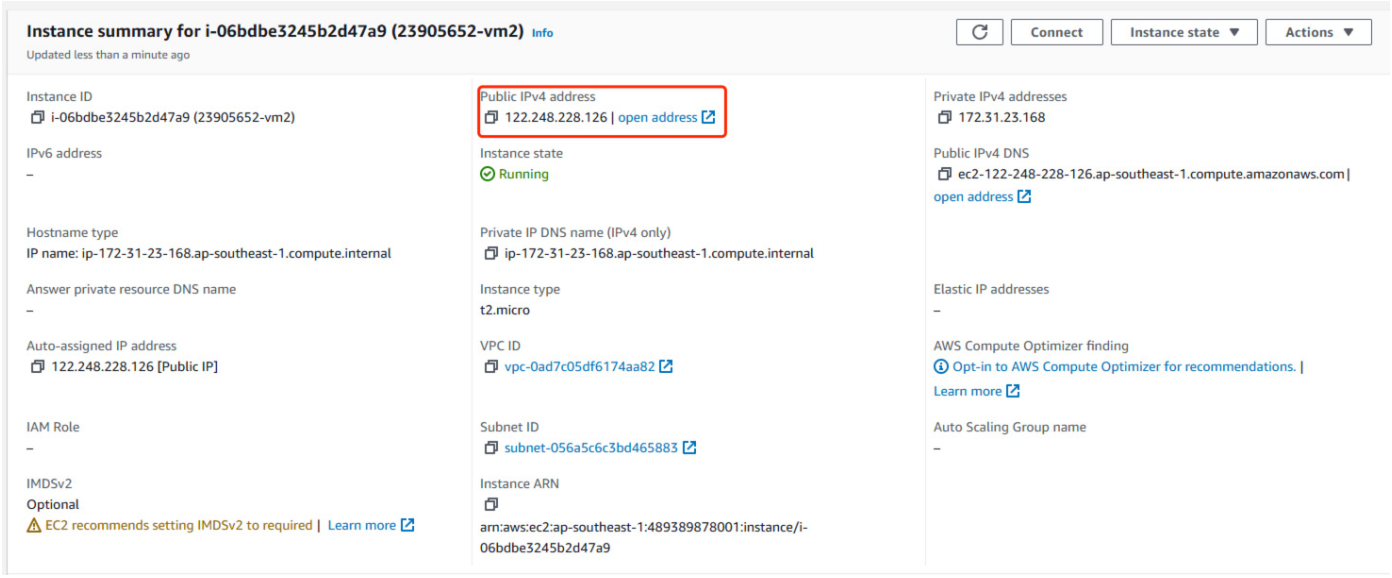
We will **get the IP address of the created instance**:



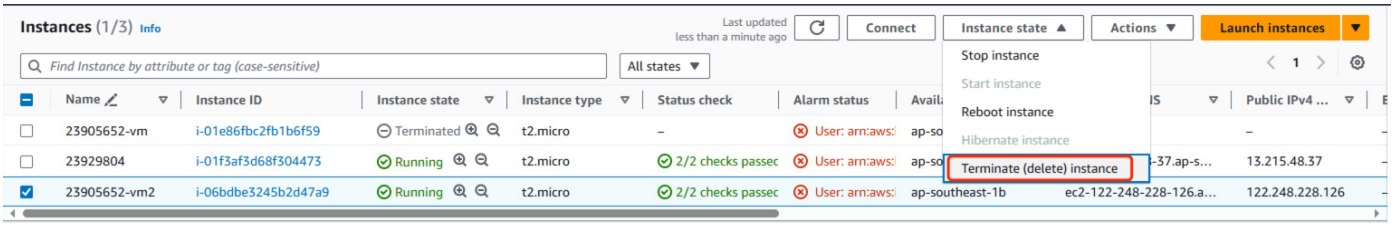
3. Use the same method to view the created instances in the AWS console, name it "23905652-vm2" this time to distinguish with the instance we created before:



Below are the details, we can see that the public IP address matches the one output in Terminal earlier:



4. Finally, terminate the created instance in the console:



Use Docker inside a Linux OS

[1] Install Docker

Use the following command to install Docker:

```
sudo apt install docker.io -y
```

Enter the device password to complete the installation.

```
mayhan@DESKTOP-KEJ3P3J: $ sudo apt install docker.io -y
[sudo] password for mayhan:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  bridge-utils containerd dns-root-data dnsmasq-base pigz runc ubuntu-fan
Suggested packages:
  ifupdown aufs-tools cgroupfs-mount | cgroup-lite debootstrap docker-doc rinse zfs-fuse | zfsutils
The following NEW packages will be installed:
  bridge-utils containerd dns-root-data dnsmasq-base docker.io pigz runc ubuntu-fan
0 upgraded, 8 newly installed, 0 to remove and 0 not upgraded.
Need to get 69.0 MB of archives.
After this operation, 284 MB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu focal/universe amd64 pigz amd64 2.4-1 [57.4 kB]
Get:2 http://archive.ubuntu.com/ubuntu focal/main amd64 bridge-utils amd64 1.6-2ubuntu1 [30.5 kB]
Get:3 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 runc amd64 1.1.12-0ubuntu2~20.04.1 [8066 kB]
Get:4 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 containerd amd64 1.7.12-0ubuntu2~20.04.1 [34.1 MB]
Get:5 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 dns-root-data all 2023112702~ubuntu0.20.04.1 [5308 B]
Get:6 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 dnsmasq-base amd64 2.90-0ubuntu0.20.04.1 [350 kB]
Get:7 http://archive.ubuntu.com/ubuntu focal-updates/universe amd64 docker.io amd64 24.0.7-0ubuntu2~20.04.1 [26.3 MB]
Get:8 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 ubuntu-fan all 0.12.13ubuntu0.1 [34.4 kB]
Fetched 69.0 MB in 16s (4314 kB/s)
Preconfiguring packages ...
Selecting previously unselected package pigz.
(Reading database ... 48810 files and directories currently installed.)
Preparing to unpack .../0-pigz_2.4-1_amd64.deb ...
Unpacking pigz (2.4-1) ...
Selecting previously unselected package bridge-utils.
```

[2] Start Docker

Use the following command to start Docker:

```
sudo systemctl start docker
```

[3] Enable Docker

Use the following command to enable Docker:

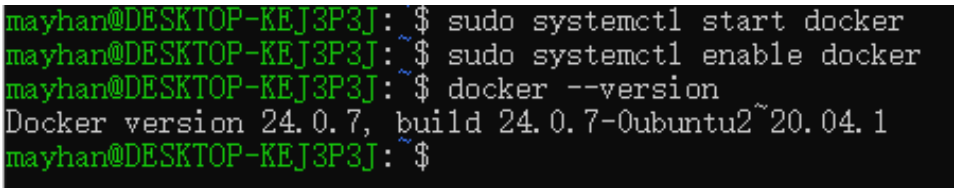
```
sudo systemctl enable docker
```

[4] Check the version

Use the following command to check the Docker version:

```
docker --version
```

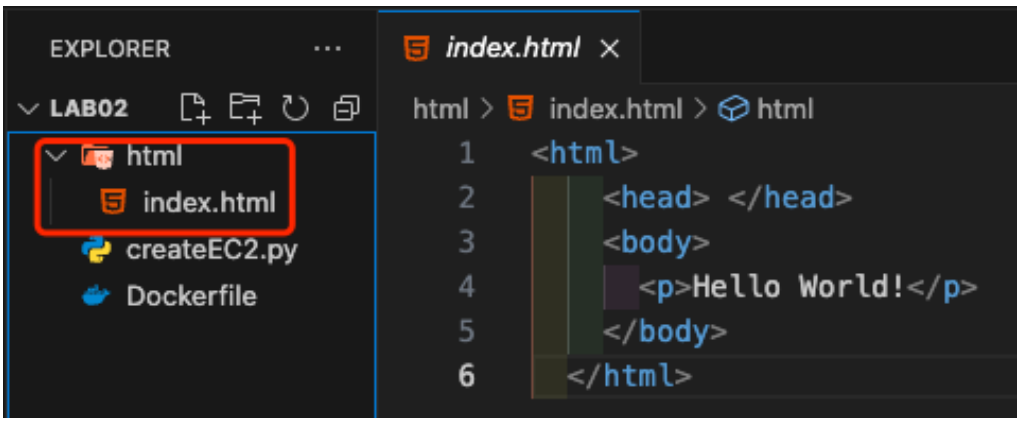
Output:



[5] Build and run an httpd container

1. Create a directory named `html`, and create an **`index.html`** file inside it with the following content:

```
<html>
  <head> </head>
  <body>
    <p>Hello World!</p>
  </body>
</html>
```

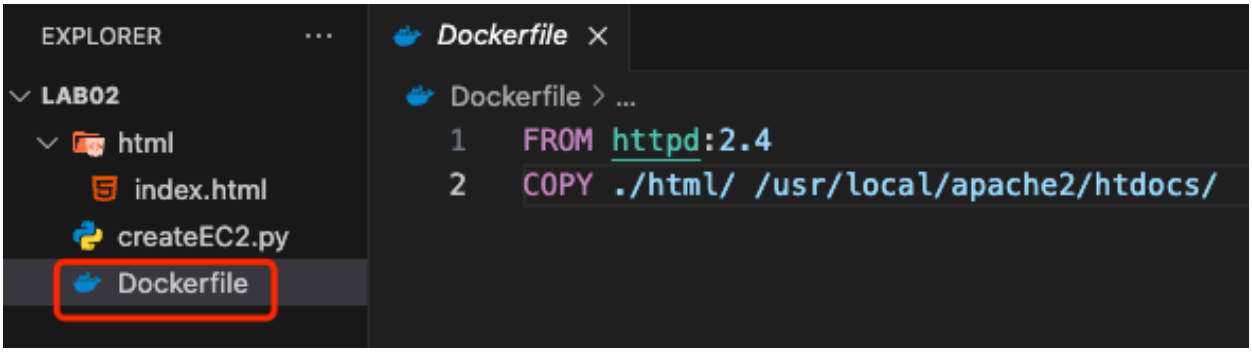


2. Create a **`Dockerfile`** with the following content:

```
FROM httpd:2.4
COPY ./html/ /usr/local/apache2/htdocs/
```

This Dockerfile creates an image that:

- Uses **Apache HTTP Server 2.4** as its base.
- Copies custom HTML files into the appropriate directory for Apache to serve them.



3. Use the following command to build the Docker image:

```
docker build -t my-apache2 .
```

Where:

- `docker build`: Used to build a new Docker image from a Dockerfile
- `-t my-apache2`: Tags the new image
- `.`: Looks for the Dockerfile in the current directory

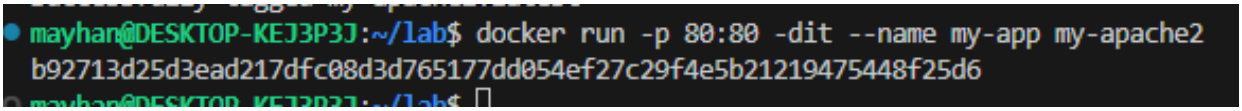
Output:

```
mayhan@DESKTOP-KEJ3P3J:~/lab$ docker build -t my-apache2 .
DEPRECATED: The legacy builder is deprecated and will be removed in a future release.
            Install the buildx component to build images with BuildKit:
            https://docs.docker.com/go/buildx/

Sending build context to Docker daemon  9.216kB
Step 1/2 : FROM httpd:2.4
2.4: Pulling from library/httpd
e4fff0779e6d: Pull complete
1d0292c3dcd2: Pull complete
4f4fb700ef54: Pull complete
1316399d8fbf: Pull complete
b4cc6570db82: Pull complete
fd1a778092db: Pull complete
Digest: sha256:3f71777bcfac3df3aff5888a2d78c4104501516300b2e7ecb91ce8de2e3debc7
Status: Downloaded newer image for httpd:2.4
 ---> a49fd2c04c02
Step 2/2 : COPY ./html/ /usr/local/apache2/htdocs/
 ---> e66b01b90095
Successfully built e66b01b90095
Successfully tagged my-apache2:latest
mayhan@DESKTOP-KEJ3P3J:~/lab$
```

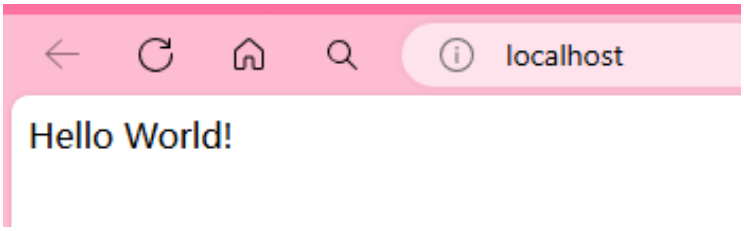
4. Use the following command to run the image and return the container ID:

```
docker run -p 80:80 -dit --name my-app my-apache2
```

Output:



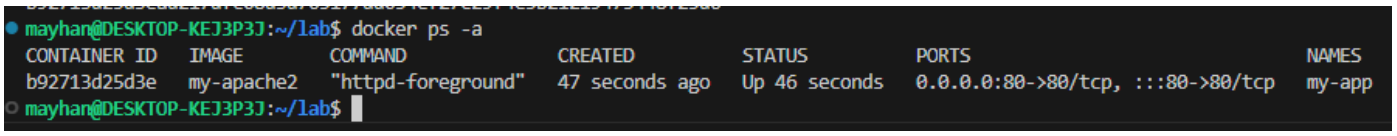
5. Open a browser and visit: http://localhost, check that it outputs "Hello World!":



[6] Other docker commands

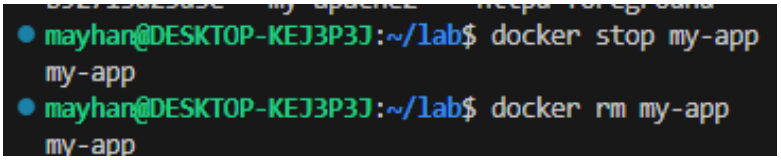
Use the following command to check running contents:

```
docker ps -a
```



Stop and remove the container:

```
docker stop my-app
docker rm my-app
```

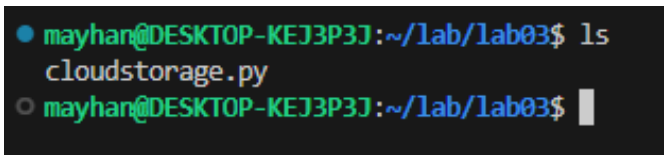


Lab 3 S3 & DynamoDB

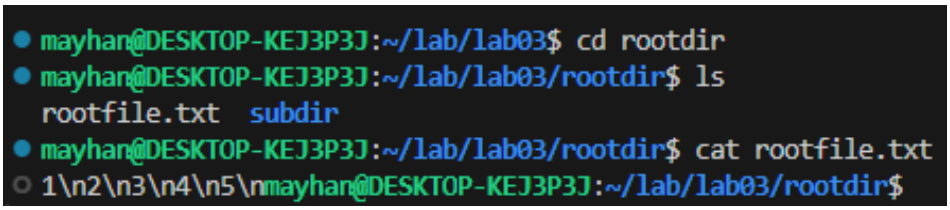
Program

[1] Preparation

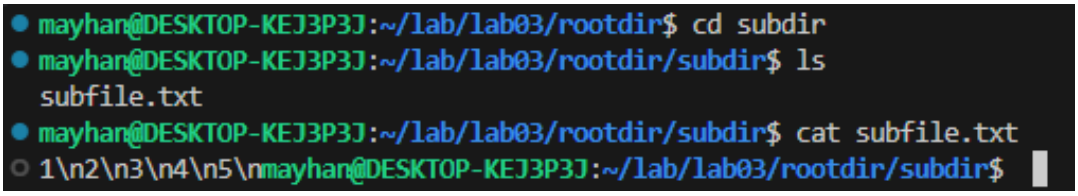
Download the `cloudstorage.py` file from the lab sheet and save it in the "lab03" folder:



Next, we will prepare the files to be stored in S3. Create a directory `rootdir`, create a file named `rootfile.txt` inside it, and write `1\n2\n3\n4\n5\n` in it:



Create a `subdir` folder inside `rootdir`, and create a file `subfile.txt` in it with the same content `1\n2\n3\n4\n5\n`:



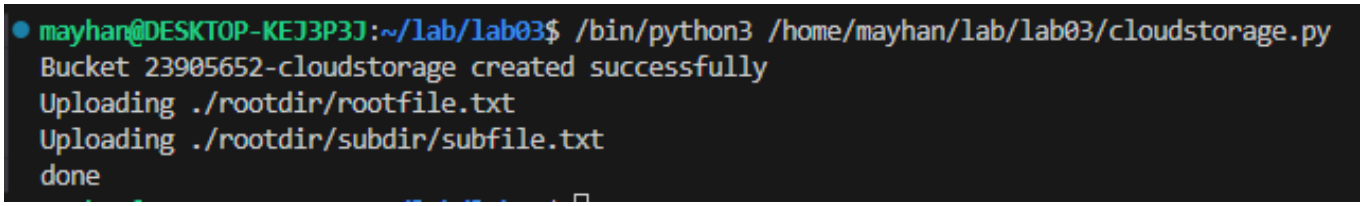
[2] Save to S3 by updating `cloudstorage.py`

Next, we modify the downloaded file `cloudstorage.py` to create an S3 bucket named `23905652-cloudstorage`. The script is as follows, **with detailed code explanations written in the comments**:

```
import os
import boto3
import base64

# ------------------------------
# CITS5503
#
# cloudstorage.py
#
# Skeleton application to copy local files to S3
#
# Given a root local directory, will return files in each level and
# copy to same path on S3
#
# ------------------------------
```

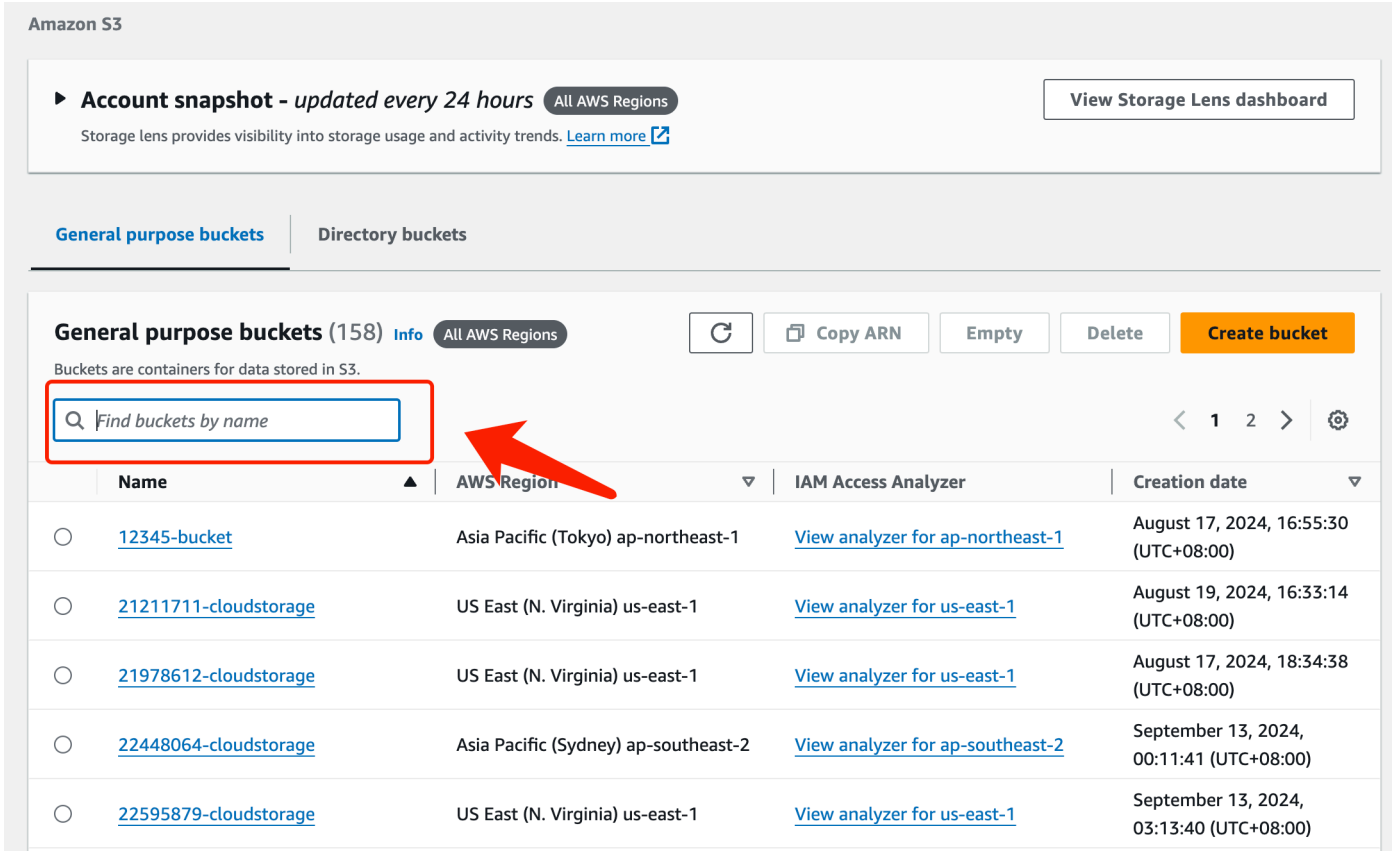
```
ROOT_DIR = '.'  # Set the local root directory to the current directory
ROOT_S3_DIR = '23905652-cloudstorage'  # Set the S3 bucket name

s3 = boto3.client("s3")  # Create an S3 client

bucket_config = {'LocationConstraint': 'ap-southeast-1'}  # Set the bucket region
configuration, replaced the region according to the student number in the table

def upload_file(folder_name, file, file_name):
    print(f"Uploading {file}")
    s3_key = os.path.join(folder_name, file_name)  # Construct the S3 file key (path)
    s3.upload_file(file, ROOT_S3_DIR, s3_key)  # Upload the file to S3

# Main program

# Attempt to create bucket if not there
try:
    s3.create_bucket(Bucket=ROOT_S3_DIR, CreateBucketConfiguration=bucket_config)
    print(f"Bucket {ROOT_S3_DIR} created successfully")
except Exception as error:
    print(f"Error creating bucket or bucket already exists: {error}")

# Parse directory and upload files

for dir_name, subdir_list, file_list in os.walk(ROOT_DIR, topdown=True):
    if dir_name != ROOT_DIR:  # If not the root directory
        relative_dir = os.path.relpath(dir_name, ROOT_DIR)  # Calculate relative path
        for fname in file_list:  # Iterate through all files in the directory
            file_path = os.path.join(dir_name, fname)  # Construct full file path
            upload_file(relative_dir, file_path, fname)  # Call upload function

print("done")
```

Run the modified script:

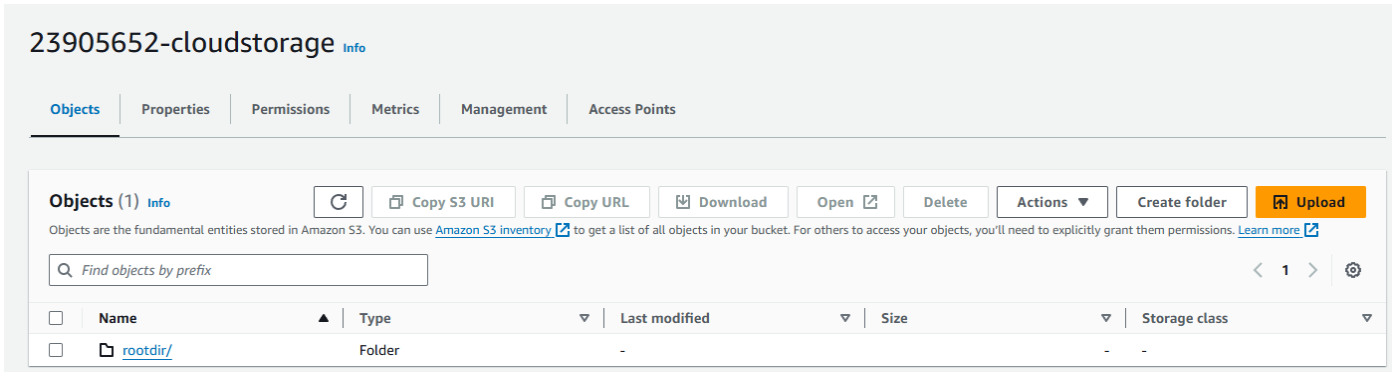


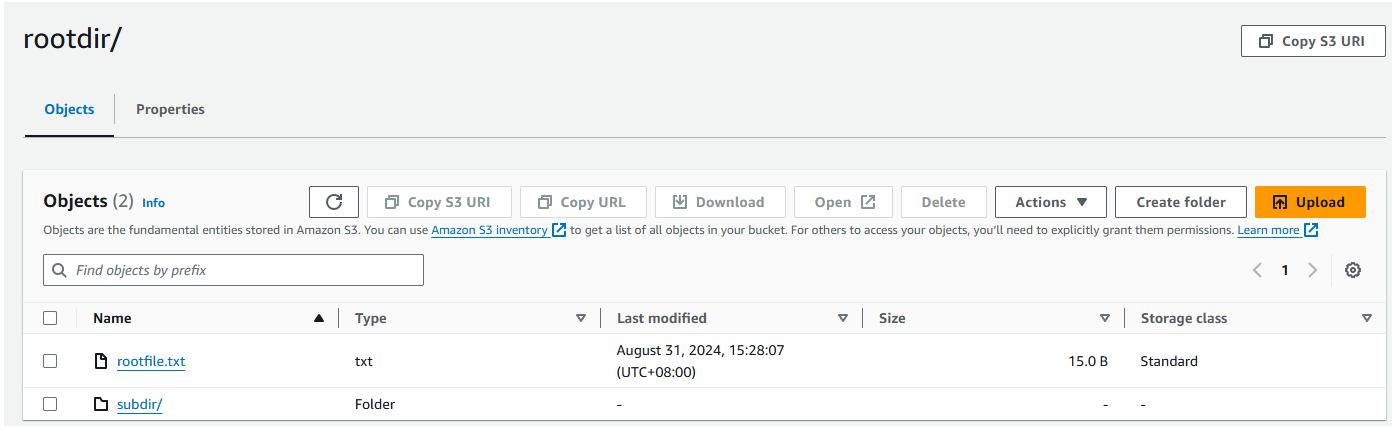
The print result shows success.

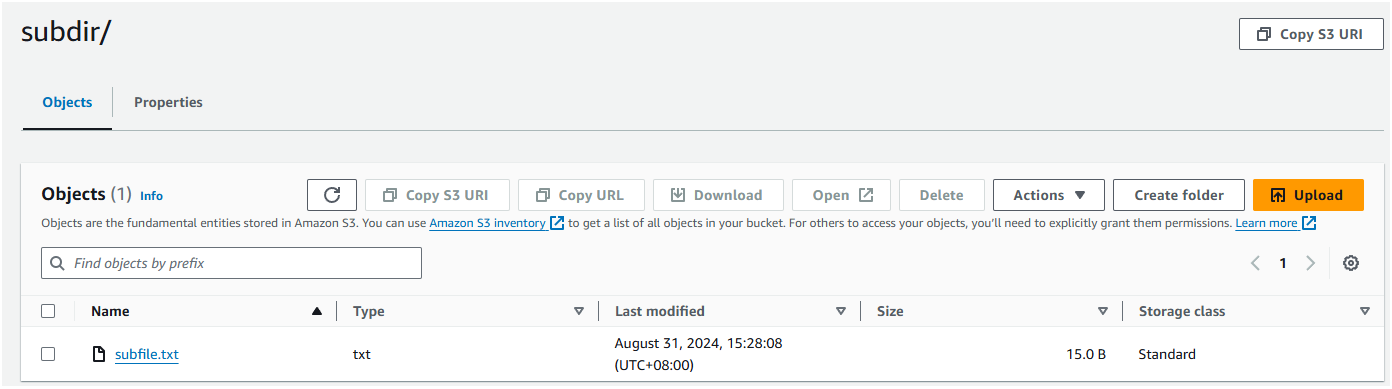
We can go to the AWS Console, search for “S3” in the search bar, find the S3 service. On the S3 service homepage, search for “23905652” (my student number) to find the newly created S3 bucket.



Find the created S3 bucket and click its name to enter the details page. Confirm that the files in the S3 bucket have the same structure as shown in `[1] Preparation`:







[3] Restore from S3

Create a new script to read from the S3 bucket and download its contents, **with detailed code explanations provided in the comments**:

```
import os
import boto3

# Description: This script downloads all files from an S3 bucket to the local directory.

# Set the local and S3 root directories
ROOT_DIR = '.'  # Set the local root directory to the current directory
ROOT_S3_DIR = '23905652-cloudstorage'
REGION = 'ap-southeast-1'

# Configure the S3 bucket location
bucket_config = {'LocationConstraint': REGION}

# Initialize the S3 client
s3 = boto3.client("s3", region_name=REGION)

# Define a function to download a file from S3
def download_file(s3_key, local_path):
    # Create the local directory structure if it doesn't exist
    os.makedirs(os.path.dirname(local_path), exist_ok=True)

    # Download the file from S3 to the local path
    s3.download_file(ROOT_S3_DIR, s3_key, local_path)

    print(f"Downloaded: {s3_key}")

# List objects in the S3 bucket and download them
response = s3.list_objects(Bucket=ROOT_S3_DIR)  # Get a list of all objects in the bucket

# Iterate through each object in the bucket
for obj in response.get('Contents', []):
    s3_key = obj['Key']  # Get the S3 key (path) of the object
    local_path = os.path.join(ROOT_DIR, s3_key)  # Construct the local path for the file
    download_file(s3_key, local_path)  # Call the download function for each file
```

```
print("Download complete")
```

Save the script with the name `restorefromcloud.py`. To check if the download was successful, we can rename the original `rootdir` to `rootdir_origin`, then **run the code and obtain**:

```
done
mayhan@DESKTOP-KEJ3P3J:~/lab/lab03$ /bin/python3 /home/mayhan/lab/lab
03/restorefromcloud.py
Downloaded: rootdir/rootfile.txt
Downloaded: rootdir/subdir/subfile.txt
Download complete
```

We can then see the newly downloaded files **in local file system**, and the structure of the downloaded files matches the original:

[4] Write information about files to DynamoDB

1. Run the following commands to install DynamoDB and JRE:

```
mkdir dynamodb
cd dynamodb
sudo apt-get install default-jre
wget https://s3-ap-northeast-1.amazonaws.com/dynamodb-local-
tokyo/dynamodb_local_latest.tar.gz
```

Output:

```
mayhan@DESKTOP-KEJ3P3J:~$ mkdir dynamodb
mayhan@DESKTOP-KEJ3P3J:~$ cd dynamodb
mayhan@DESKTOP-KEJ3P3J:~/dynamodb$ sudo apt-get install default-jre
[sudo] password for mayhan:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  at-spi2-core ca-certificates-java default-jre-headless
  fonts-dejavu-extra java-common libatk-bridge2.0-0
  libatk-wrapper-java libatk-wrapper-java-jni libatk1.0-0
```

```
mayhan@DESKTOP-KEJ3P3J:~/dynamodb$ wget https://s3-ap-northeast-1.ama
zonaws.com/dynamodb-local-tokyo/dynamodb_local_latest.tar.gz
--2024-08-31 16:00:08--  https://s3-ap-northeast-1.amazonaws.com/dyna
modb-local-tokyo/dynamodb_local_latest.tar.gz
Resolving s3-ap-northeast-1.amazonaws.com (s3-ap-northeast-1.amazonaw
s.com)... 104.244.46.186, 2a03:2880:f10a:83:face:b00c:0:25de
Connecting to s3-ap-northeast-1.amazonaws.com (s3-ap-northeast-1.amaz
onaws.com)|104.244.46.186|:443... failed: Connection timed out.
Connecting to s3-ap-northeast-1.amazonaws.com (s3-ap-northeast-1.amaz
onaws.com)|2a03:2880:f10a:83:face:b00c:0:25de|:443... failed: Network
 is unreachable.
```

It was found that there was an issue with the "ap-northeast-1" network connection, which prevented the successful download of the DynamoDB local version's compressed file. Thus, we tried downloading from the “us-west-2” region and succeeded:

```
mayhan@DESKTOP-KEJ3P3J:~/dynamodb$ wget https://s3.us-west-2.amazonaw
s.com/dynamodb-local/dynamodb_local_latest.tar.gz
--2024-08-31 16:14:08--  https://s3.us-west-2.amazonaws.com/dynamodb-
local/dynamodb_local_latest.tar.gz
Resolving s3.us-west-2.amazonaws.com (s3.us-west-2.amazonaws.com)...
52.92.204.208, 52.218.177.56, 52.92.152.136, ...
Connecting to s3.us-west-2.amazonaws.com (s3.us-west-2.amazonaws.com)
|52.92.204.208|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 54892500 (52M) [application/x-tar]
Saving to: ‘dynamodb_local_latest.tar.gz’

dynamodb_local_la 100%[==========>]  52.35M  4.50MB/s    in 13s

2024-08-31 16:14:23 (4.03 MB/s) - ‘dynamodb_local_latest.tar.gz’ save
d [54892500/54892500]
```

2. Use the following command to unzip the compressed file:

```
tar -zxvf dynamodb_local_latest.tar.gz
```

Output:

```
mayhan@DESKTOP-KEJ3P3J:~/dynamodb$ tar -zxvf dynamodb_local_latest.ta
r.gz
DynamoDBLocal_lib/
DynamoDBLocal.jar
DynamoDBLocal_lib/Apache-HttpComponents-HttpClient-4.5.x.jar
DynamoDBLocal_lib/Apache-HttpComponents-HttpCore-4.4.x.jar
DynamoDBLocal_lib/AwsFlowJava-1.0.jar
DynamoDBLocal_lib/AwsJavaSdk-CognitoIdentity-2.0.jar
DynamoDBLocal_lib/AwsJavaSdk-CognitoIdentityProvider-2.0.jar
DynamoDBLocal_lib/AwsJavaSdk-Core-2.0.jar
DynamoDBLocal_lib/AwsJavaSdk-Core-Annotations-2.0.jar
DynamoDBLocal_lib/AwsJavaSdk-Core-Auth-2.0.jar
DynamoDBLocal_lib/AwsJavaSdk-Core-AwsCore-2.0.jar
```

3. Use the following command to start the local version of DynamoDB:

```
java -Djava.library.path=./DynamoDBLocal_lib -jar DynamoDBLocal.jar –sharedDb
```

Output:

```
mayhan@DESKTOP-KEJ3P3J:~/dynamodb$ java -Djava.library.path=./DynamoD
BLocal_lib -jar DynamoDBLocal.jar -sharedDb
Initializing DynamoDB Local with the following configuration:
Port:   8000
InMemory:       false
Version:        1.25.0
DbPath: null
SharedDb:       false
shouldDelayTransientStatuses:   false
CorsParams:     null
```

4. Next, we have to use the AWS CLI command to create a new table `CloudFiles`, with the table attributes:

```
        CloudFiles = {
            'userId',
            'fileName',
            'path',
            'lastUpdated',
            'owner',
            'permissions'
            }
        )
```

The `userId` is the partition key and `fileName` is the sort key.

Here is the AWS CLI command used:

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab03$ aws dynamodb create-table \
>     --table-name CloudFiles \
>     --attribute-definitions \
>         AttributeName=userId,AttributeType=S \
>         AttributeName=fileName,AttributeType=S \
>     --key-schema \
>         AttributeName=userId,KeyType=HASH \
>         AttributeName=fileName,KeyType=RANGE \
>     --provisioned-throughput \
>         ReadCapacityUnits=5,WriteCapacityUnits=5 \
>     --endpoint-url http://localhost:8000 \
>     --region ap-southeast-1
```

The response received after running the code is as follows:

The returned result displays detailed information about the created table.

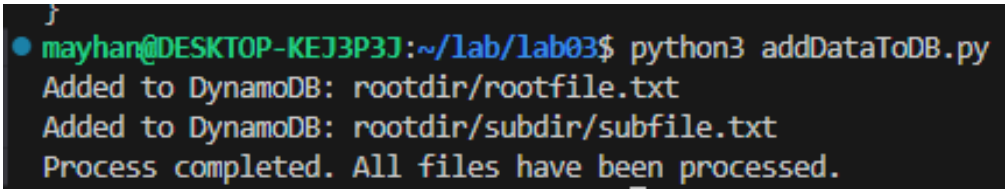
5. To write the attributes of all files in S3 to the created table, we created the following script, **with detailed code explanations provided in the comments**:

```
import boto3
from botocore.exceptions import ClientError

# Constants
S3_BUCKET_NAME = '23905652-cloudstorage'  # Name of the S3 bucket to process
DYNAMODB_TABLE_NAME = 'CloudFiles'  # Name of the DynamoDB table to write to
REGION = 'ap-southeast-1'  # AWS region for the services

# Initialize clients
s3 = boto3.client('s3', region_name=REGION)
# Create a DynamoDB resource for interacting with the DynamoDB service
# Using a local DynamoDB instance for development/testing
```

```
dynamodb = boto3.resource('dynamodb', endpoint_url='http://localhost:8000',
region_name=REGION)

def get_file_attributes(bucket, key):
    """
    Retrieve attributes of a file from S3.

    Args:
    bucket (str): The name of the S3 bucket.
    key (str): The key (path) of the file in the bucket.

    Returns:
    dict: A dictionary containing file attributes, or None if an error occurs.
    """
    try:
        # Get the metadata of the object from S3
        response = s3.head_object(Bucket=bucket, Key=key)
        return {
            'fileName': key,
            'path': f"s3://{bucket}/{key}",
            'lastUpdated': response['LastModified'].isoformat()
        }
    except ClientError as e:
        print(f"Error getting attributes for {key}: {e}")
        return None

def write_to_dynamodb(table, user_id, owner, file_info):
    """
    Write file information to a DynamoDB table.

    Args:
    table (boto3.resources.factory.dynamodb.Table): The DynamoDB table resource.
    user_id (str): The ID of the user who owns the file.
    owner (str): The display name of the file owner.
    file_info (dict): Information about the file to be written.
    """
    try:
        # Prepare the item to be written to DynamoDB
        item = {
            'userId': user_id,
            'owner': owner,
            'permissions': s3.get_bucket_acl(Bucket=S3_BUCKET_NAME)['Grants'][0]
['Permission'],
            **file_info
        }
        # Write the item to the DynamoDB table
        table.put_item(Item=item)
        print(f"Added to DynamoDB: {file_info['fileName']}")
    except ClientError as e:
        print(f"Error writing to DynamoDB: {e}")

def main():
```

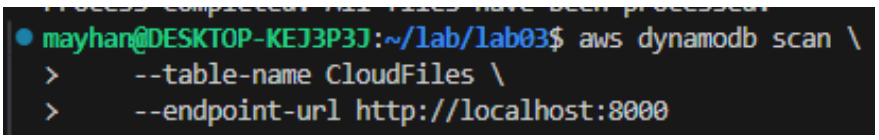
```
    """
    Main function to process S3 objects and write their information to DynamoDB.
    """
    # Get the DynamoDB table resource
    table = dynamodb.Table(DYNAMODB_TABLE_NAME)

    try:
        # List objects in the S3 bucket
        response = s3.list_objects(Bucket=S3_BUCKET_NAME)

        # Extract user ID and owner name from the first object
        user_id = str(response['Contents'][0]['Owner']['ID'])
        owner = response['Contents'][0]['Owner']['DisplayName']

        # Process each object in the bucket
        for obj in response.get('Contents', []):
            # Get file attributes
            file_attributes = get_file_attributes(S3_BUCKET_NAME, obj['Key'])
            if file_attributes:
                # Write file information to DynamoDB
                write_to_dynamodb(table, user_id, owner, file_attributes)

        print("Process completed. All files have been processed.")

    except ClientError as e:
        print(f"Error listing S3 objects: {e}")

if __name__ == "__main__":
    main()
```

Run the code and obtained:



[5] Scan the table

Use the following AWS CLI command to scan the created DynamoDB table and check if the table contains information about the S3 files:



Output result:

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab03$ aws dynamodb scan \
>     --table-name CloudFiles \
>     --endpoint-url http://localhost:8000
{
    "Items": [
        {
            "owner": {
                "S": "zhi.zhang"
            },
            "path": {
                "S": "s3://23905652-cloudstorage/rootdir/rootfile.txt"
            },
            "lastUpdated": {
                "S": "2024-08-31T07:28:07+00:00"
            },
            "fileName": {
                "S": "rootdir/rootfile.txt"
            },
            "userId": {
                "S": "2a5fac7aada1ad2caa48c9ab08cc4e2428d4eb596108daa3b59f1204ae96482e"
            },
            "permissions": {
                "S": "FULL_CONTROL"
            }
        },
        {
            "owner": {
                "S": "zhi.zhang"
            },
            "path": {
                "S": "s3://23905652-cloudstorage/rootdir/subdir/subfile.txt"
            },
            "lastUpdated": {
                "S": "2024-08-31T07:28:08+00:00"
            },
            "fileName": {
                "S": "rootdir/subdir/subfile.txt"
            },
            "userId": {
                "S": "2a5fac7aada1ad2caa48c9ab08cc4e2428d4eb596108daa3b59f1204ae96482e"
            },
            "permissions": {
                "S": "FULL_CONTROL"
            }
        }
    ],
    "Count": 2,
    "ScannedCount": 2,
    "ConsumedCapacity": null
}
```

We can see that the information for the two files has been added to the table.

[6] Delete the table

1. Use the following AWS CLI command to delete the table:

```
aws dynamodb delete-table \
> --table-name CloudFiles \
> --endpoint-url http://localhost:8000
```

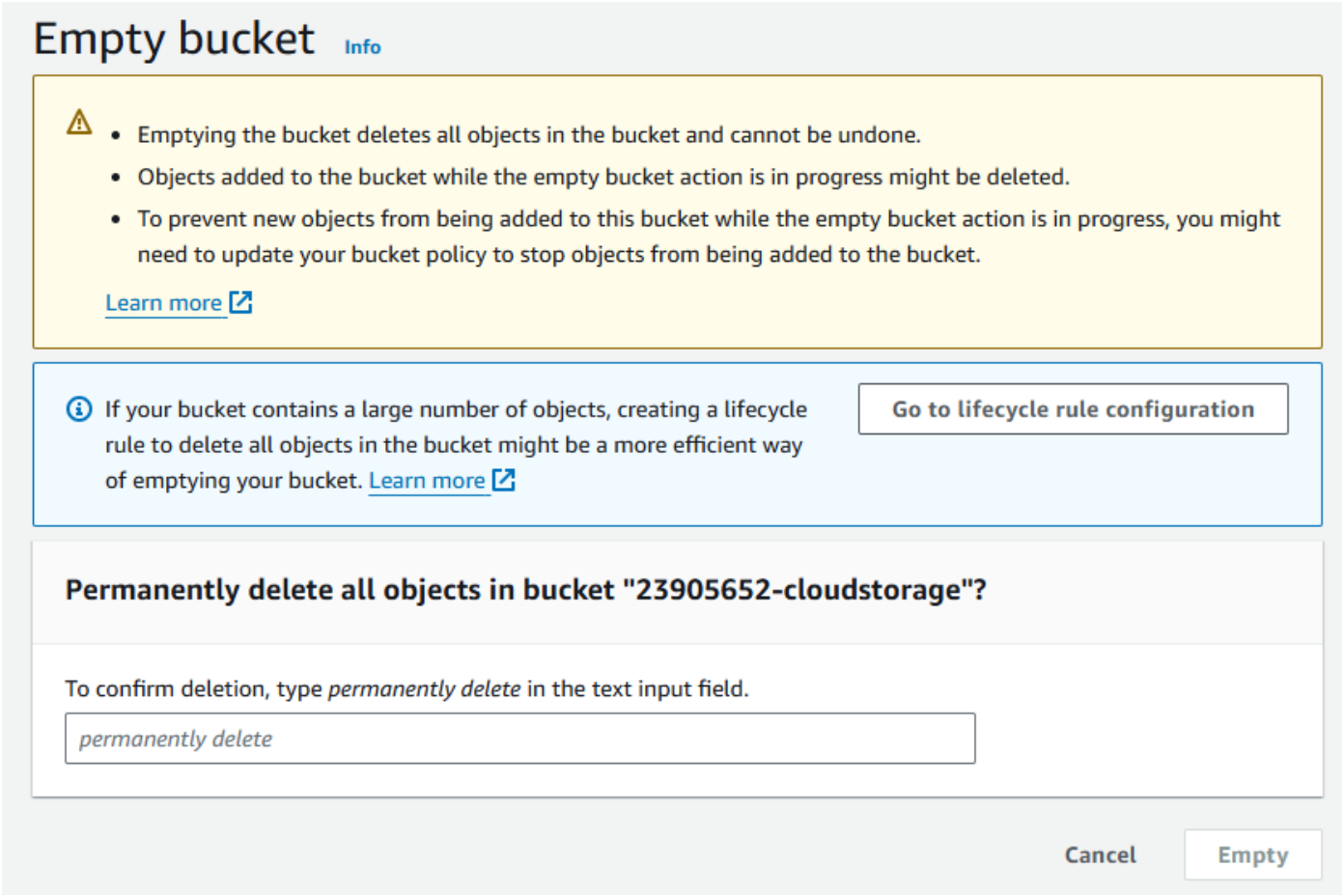
Output:

To confirm that the table has been deleted, we can run the following command:

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab03$ aws dynamodb list-tables --endpoint-url http://localhost:8000
{
    "TableNames": []
}
mayhan@DESKTOP-KEJ3P3J:~/lab/lab03$
```

The table list has been cleared, indicating that the created table has been successfully deleted.

2. Empty and delete the created S3 bucket from the AWS console:



Delete bucket Info

- Deleting a bucket cannot be undone.
- Bucket names are unique. If you delete a bucket, another AWS user can use the name.
- If this bucket is used with a Multi-Region Access Point in an external account, initiate failover before deleting the bucket.
- If this bucket is used with an access point in an external account, the requests made through those access points will fail after you delete this bucket.

Learn more

Delete bucket "23905652-cloudstorage"?

To confirm deletion, enter the name of the bucket in the text input field.

23905652-cloudstorage

Cancel | Delete bucket

Lab 4 Encryption

Apply a policy to restrict permissions on bucket

[1] Write a Python script

To apply the following policy to the S3 bucket to **only allow access to my username**, modifications were made based on the code from Lab 3 that created the S3 bucket.

Policy:

```
{
  "Version": "2012-10-17",
  "Statement": [{
   "Sid": "AllowAllS3ActionsInUserFolderForUserOnly",
    "Effect": "DENY",
    "Principal": "*",
    "Action": "s3:*",
    "Resource": "arn:aws:s3:::23905652-cloudstorage/folder1/folder2/*",
    "Condition": {
      "StringNotLike": {
          "aws:username":"23905652@student.uwa.edu.au"
       }
    }
  }]
}
```

Add the `apply_bucket_policy()` function to apply the policy:

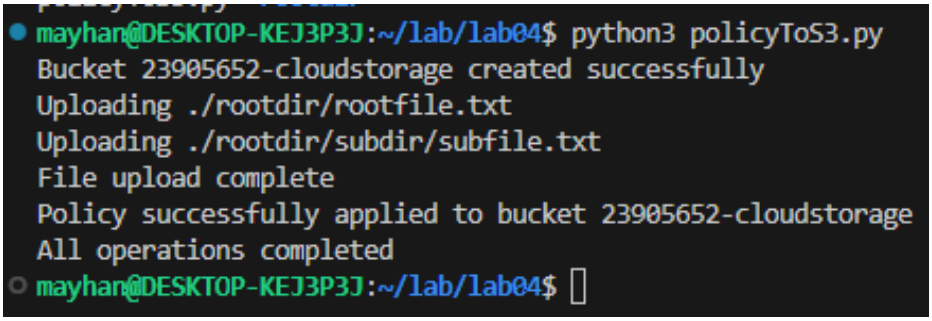
```
ROOT_S3_DIR = '23905652-cloudstorage'

def apply_bucket_policy():
    """
    Apply a bucket policy to restrict access to the S3 bucket.
    This policy denies all S3 actions to everyone except '23905652@student.uwa.edu.au'.
    """
    # Define the bucket policy
    policy = {
        "Version": "2012-10-17",  # Policy language version
        "Statement": [{
            "Sid": "AllowAllS3ActionsInUserFolderForUserOnly",  # Statement identifier
            "Effect": "DENY",  # This policy will deny access
            "Principal": "*",  # Applies to all AWS users
            "Action": "s3:*",  # Applies to all S3 actions
            "Resource": [  # The AWS resources this policy applies to
                f"arn:aws:s3:::{ROOT_S3_DIR}/folder1/folder2/*"
            ],
            "Condition": {  # Conditions for when this policy is in effect
                "StringNotLike": {  # Applies when the following is not true
```

```
                    "aws:username": "23905652@student.uwa.edu.au"  # Specific user exempt
from this policy
                }
            }
        }]
    }

    # Convert the policy dictionary to a JSON-formatted string
    policy_json = json.dumps(policy)

    try:
        # Attempt to apply the policy to the S3 bucket
        s3.put_bucket_policy(Bucket=ROOT_S3_DIR, Policy=policy_json)
        print(f"Policy successfully applied to bucket {ROOT_S3_DIR}")
    except Exception as e:
        # If an error occurs, print the error message
        print(f"Error applying policy: {str(e)}")
```

Keep the other code for creating S3 and uploading files same. After uploading the files, call the `apply_bucket_policy()` function:

```
...

# Same as before, parse directory and upload files
for dir_name, subdir_list, file_list in os.walk(ROOT_DIR, topdown=True):
    if dir_name != ROOT_DIR:
        relative_dir = os.path.relpath(dir_name, ROOT_DIR)
        for fname in file_list:
            file_path = os.path.join(dir_name, fname)
            upload_file(relative_dir, file_path, fname)

print("File upload complete")

# Apply bucket policy
apply_bucket_policy()

print("All operations completed")
```

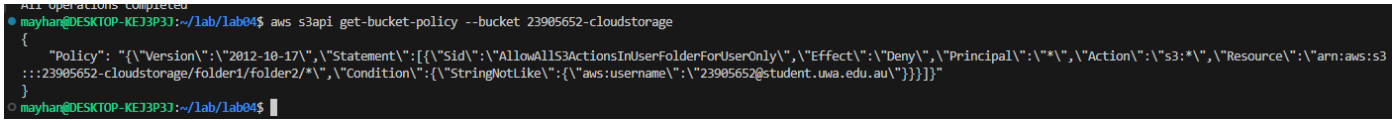
Save the new script as 'policyToS3.py' and **run the script**:



[2] Check whether the script works

1. Use the AWS CLI command to display the policy content:

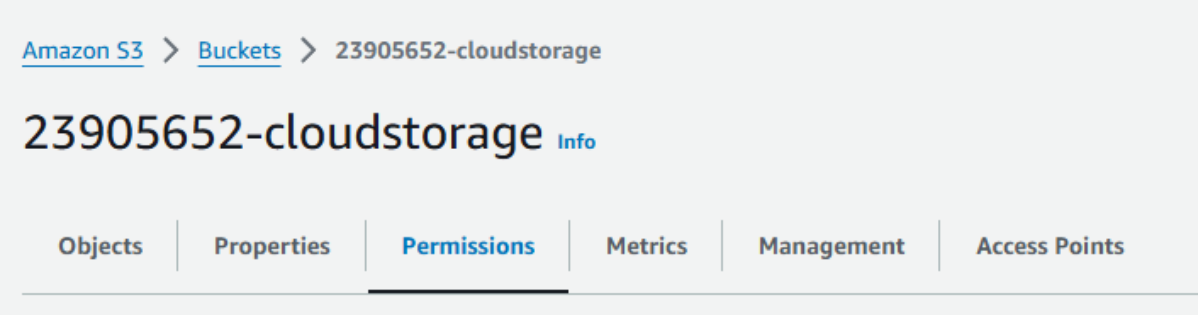
```
aws s3api get-bucket-policy --bucket 23905652-cloudstorage
```



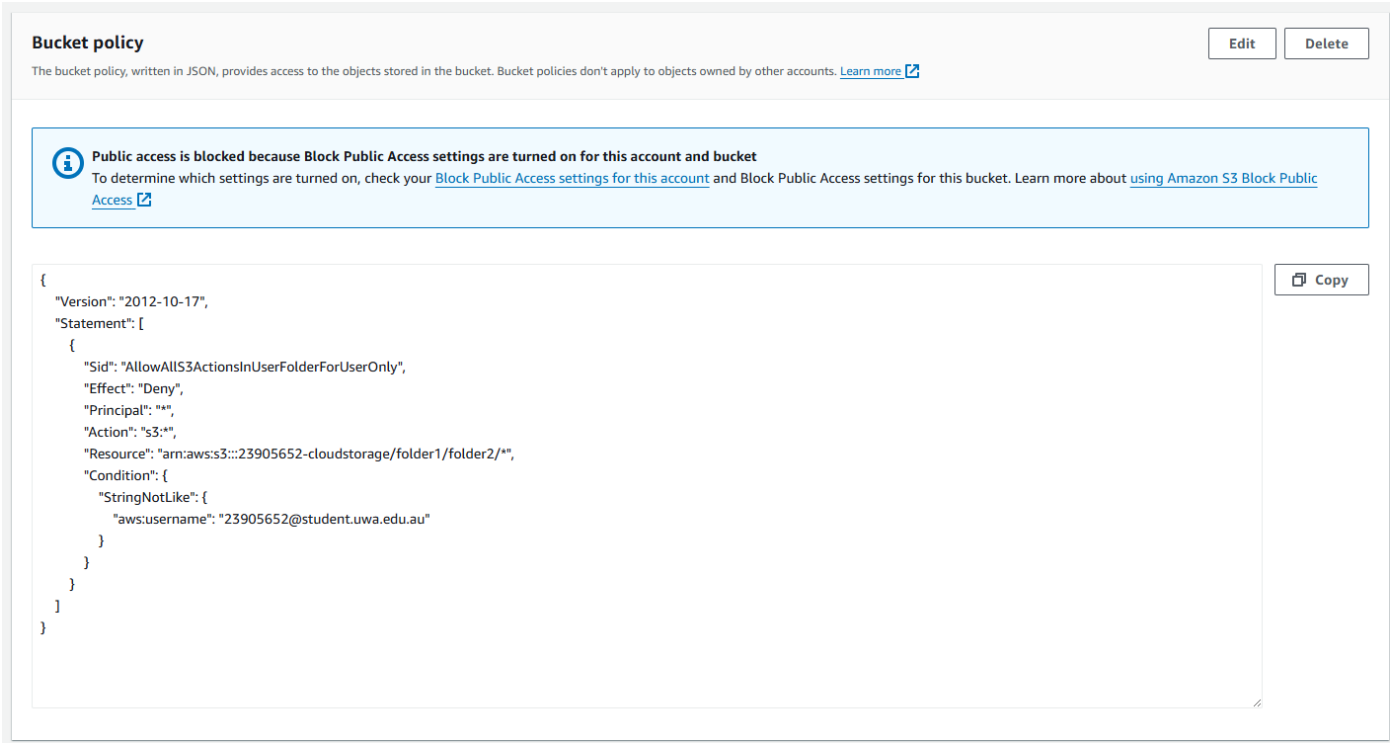
The response is as follows, **matching the expected policy/script policy**:

```
{
    "Policy": "{\"Version\":\"2012-10-17\",\"Statement\":
[{\"Sid\":\"AllowAllS3ActionsInUserFolderForUserOnly\",\"Effect\":\"Deny\",\"Principal\":\
"*\",\"Action\":\"s3:*\",\"Resource\":\"arn:aws:s3:::23905652-
cloudstorage/folder1/folder2/*\",\"Condition\":{\"StringNotLike\":
{\"aws:username\":\"23905652@student.uwa.edu.au\"}}}]}"
}
```

2. Open the AWS S3 console to view the policy. In the S3 details page, select **"Permissions"**:

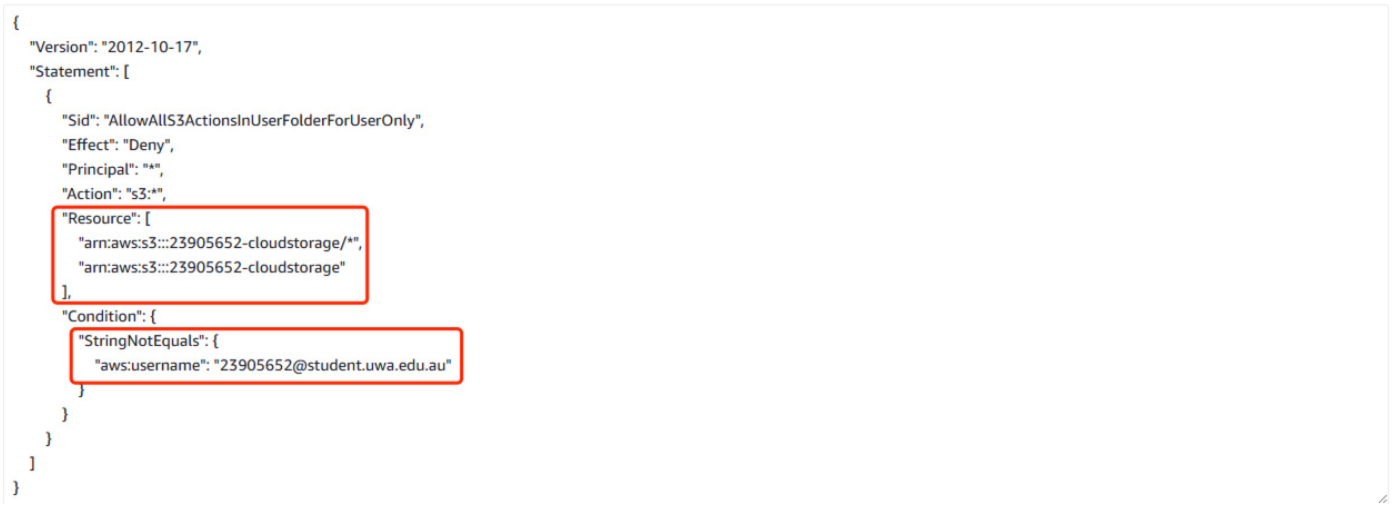


Scroll down to find **"Bucket policy"**:

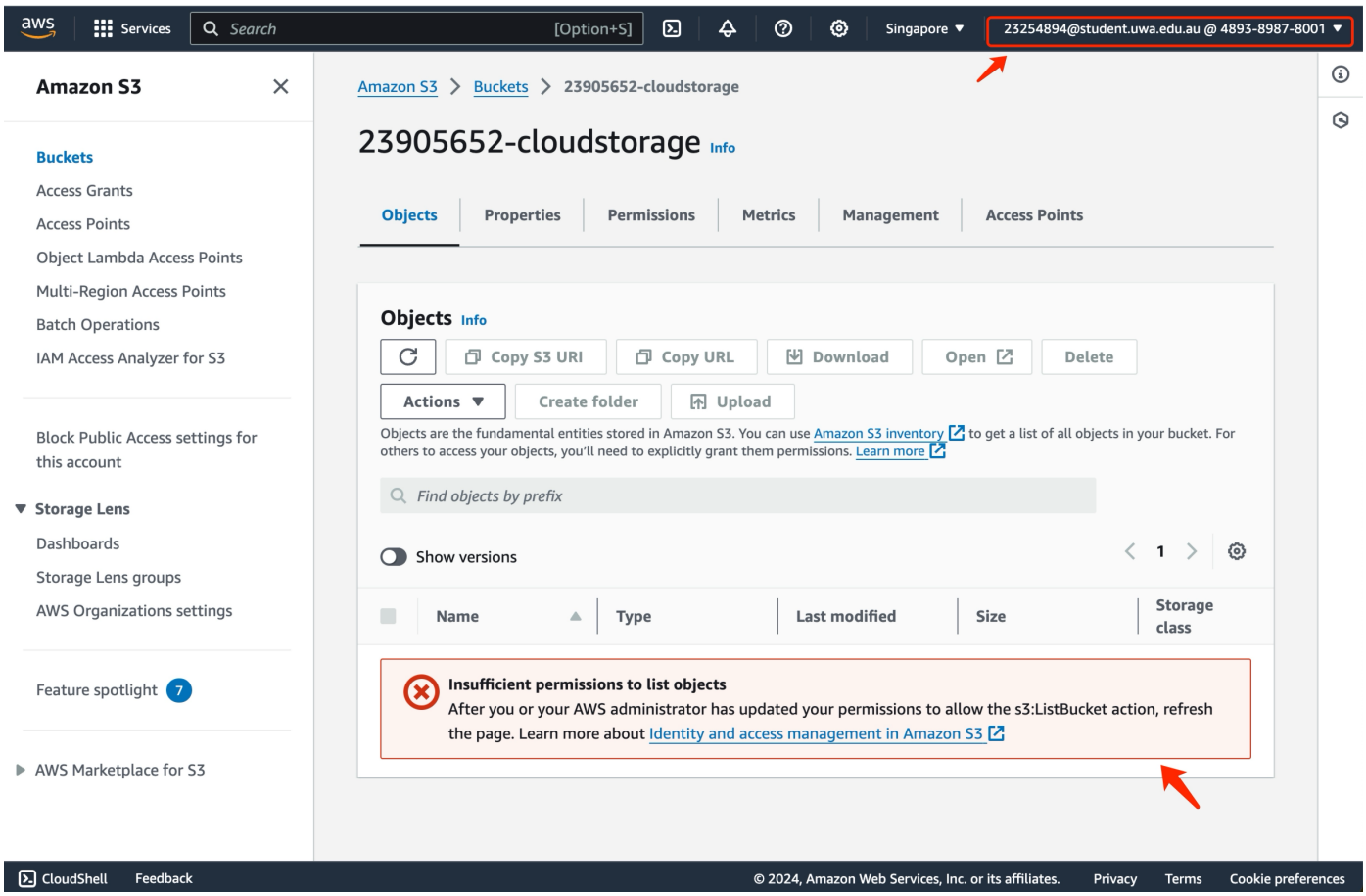


The policy has been successfully applied to the bucket.

3. To test the effectiveness of the policy in AWS Console, we extended the **"Resource"** covered by the policy to the entire bucket and set the **"Condition"** to a strict **"StringNotEquals**:



Attempting to access the bucket with another username (23254894@student.uwa.edu.au) shows the permission restrictions:



AES Encryption using KMS

[1] Create a KMS key

To create a KMS key, a new Python script was written, where the alias for the key is my student number (23905652). The script is attached in the next step combined with the process of attaching the policy .

[2] Attach a policy to the created KMS key

The Python script provided includes the creation of a KMS key and attaching a specified policy to the key. It includes two functions: `create_kms_key()` and `attach_policy_to_key()`. **Detailed explanations are included in the comments of the code**:

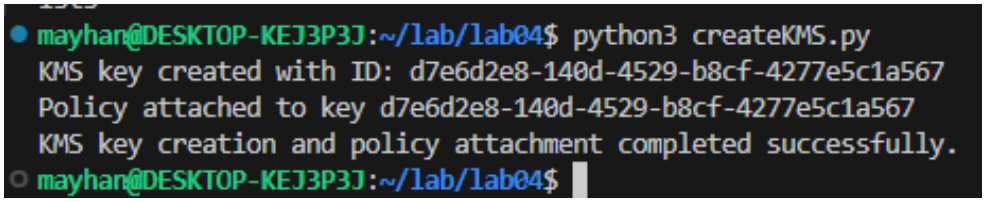
```
import boto3
import json


# Initialize the KMS client, this creates a client for interacting with AWS Key Management Service in the specified region
kms_client = boto3.client('kms', region_name='ap-southeast-1')

# Student number will be used to create an alias for the KMS key
STUDENT_NUMBER = '23905652_2'

# This is the AWS Identity and Access Management username that will be granted permissions to the key
```

```
IAM_USERNAME = '23905652@student.uwa.edu.au'

def create_kms_key():
    """
    Creates a new KMS key and an alias for it.

    Returns:
        str: The ID of the created KMS key
    """
    # Create a new KMS key
    response = kms_client.create_key(
        Description=f'KMS key for student {STUDENT_NUMBER}',  # Description of the key
        KeyUsage='ENCRYPT_DECRYPT',  # Specifies that this key will be used for encryption
and decryption
        Origin='AWS_KMS'  # Indicates that AWS KMS creates and manages the key material
    )

    # Extract the key ID from the response
    key_id = response['KeyMetadata']['KeyId']

    # Create an alias for the key, an alias is a user-friendly name for the key
    kms_client.create_alias(
        AliasName=f'alias/{STUDENT_NUMBER}',  # The alias name, prefixed with 'alias/'
        TargetKeyId=key_id  # The ID of the key to which this alias refers
    )

    print(f"KMS key created with ID: {key_id}")
    return key_id

def attach_policy_to_key(key_id):
    """
    Attaches a policy to the specified KMS key.

    Args:
        key_id (str): The ID of the KMS key to which the policy will be attached
    """

    # Define the policy, this policy defines who can administer and use the key
    policy = {
        "Version": "2012-10-17",
        "Id": "key-consolepolicy-3",
        "Statement": [
            {
                # Allows the root user full access to the key
                "Sid": "Enable IAM User Permissions",
                "Effect": "Allow",
                "Principal": {
                    "AWS": "arn:aws:iam::489389878001:root"
                },
                "Action": "kms:*",
                "Resource": "*"
            },
```

```
            {
                # Allows the specified IAM user to administer the key
                "Sid": "Allow access for Key Administrators",
                "Effect": "Allow",
                "Principal": {
                    "AWS": f"arn:aws:iam::489389878001:user/{IAM_USERNAME}"
                },
                "Action": [
                    # List of administrative actions allowed
                    "kms:Create*", "kms:Describe*", "kms:Enable*",
                    "kms:List*", "kms:Put*", "kms:Update*",
                    "kms:Revoke*", "kms:Disable*", "kms:Get*",
                    "kms:Delete*", "kms:TagResource", "kms:UntagResource",
                    "kms:ScheduleKeyDeletion", "kms:CancelKeyDeletion"
                ],
                "Resource": "*"
            },
            {
                # Allows the specified IAM user to use the key for cryptographic
operations
                "Sid": "Allow use of the key",
                "Effect": "Allow",
                "Principal": {
                    "AWS": f"arn:aws:iam::489389878001:user/{IAM_USERNAME}"
                },
                "Action": [
                    # List of cryptographic operations allowed
                    "kms:Encrypt", "kms:Decrypt", "kms:ReEncrypt*",
                    "kms:GenerateDataKey*", "kms:DescribeKey"
                ],
                "Resource": "*"
            },
            {
                # Allows the specified IAM user to manage grants on the key
                "Sid": "Allow attachment of persistent resources",
                "Effect": "Allow",
                "Principal": {
                    "AWS": f"arn:aws:iam::489389878001:user/{IAM_USERNAME}"
                },
                "Action": [
                    "kms:CreateGrant", "kms:ListGrants", "kms:RevokeGrant"
                ],
                "Resource": "*",
                "Condition": {
                    "Bool": {
                        "kms:GrantIsForAWSResource": "true"
                    }
                }
            }
        ]
    }
```

```
    # Attach the policy to the key
    kms_client.put_key_policy(
        KeyId=key_id,
        PolicyName='default',  # The name of the policy
        Policy=json.dumps(policy)  # The policy document, converted to a JSON string
    )

    print(f"Policy attached to key {key_id}")

def main():
    """
    Main function to create a KMS key and attach a policy to it.
    """
    key_id = create_kms_key()
    attach_policy_to_key(key_id)
    print("KMS key creation and policy attachment completed successfully.")

if __name__ == "__main__":
    main()
```

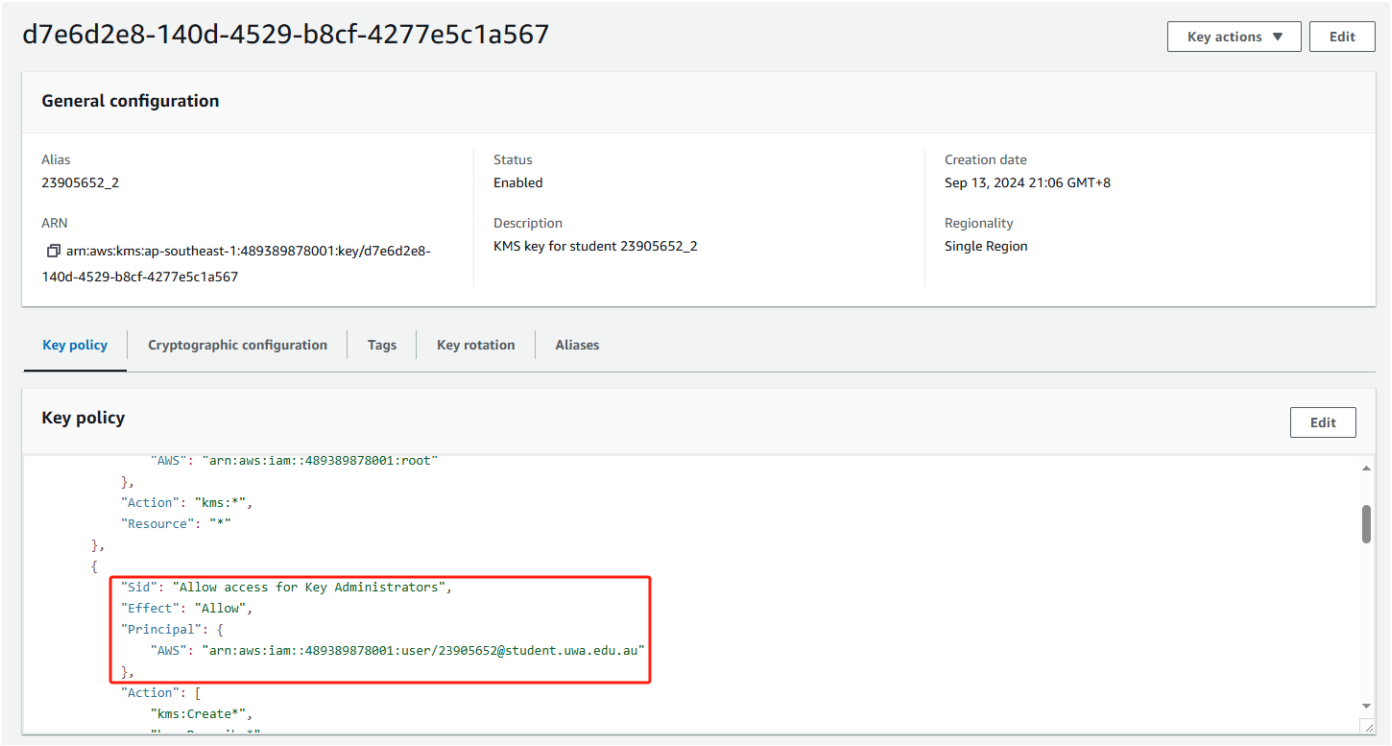
Save the script as “createKMS.py” and run the code:



[3] Check whether the script works

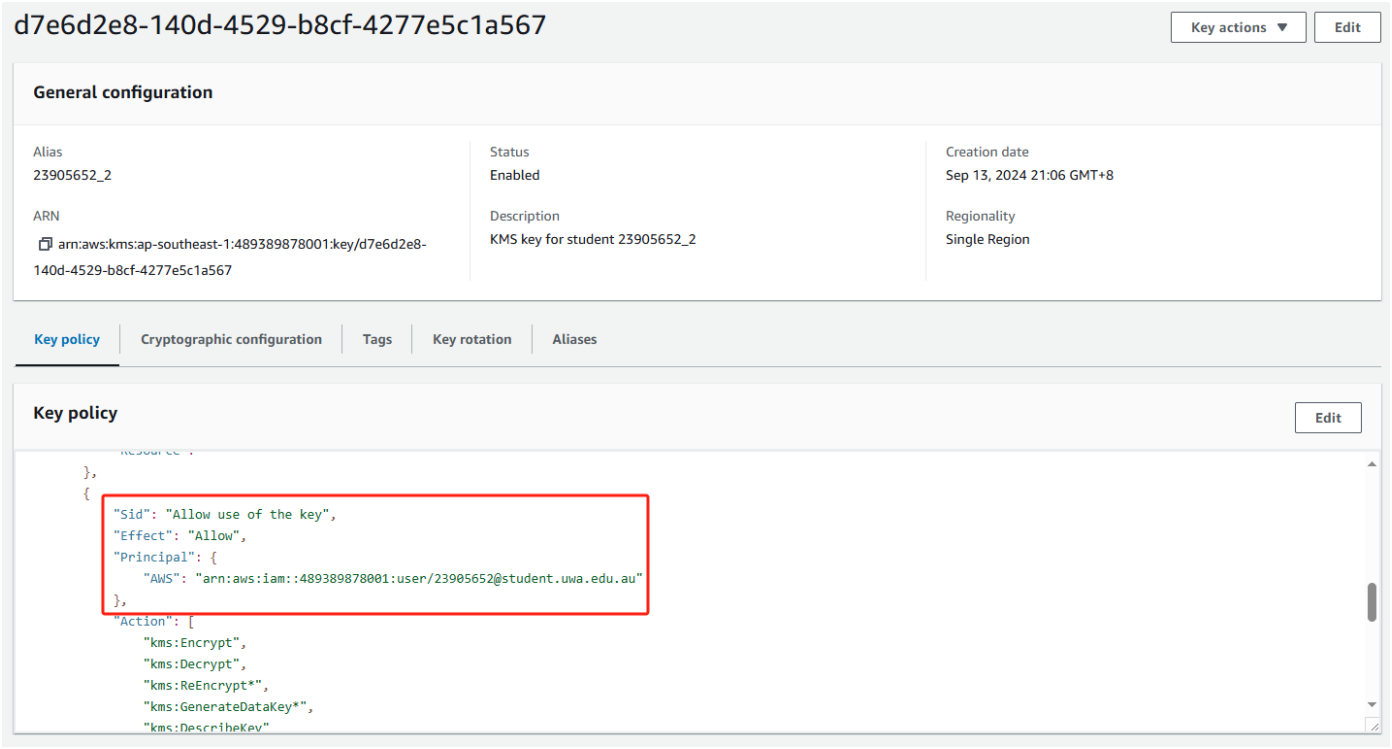
Open the AWS KMS Console and check the policy of the created KMS:

Key administrator:



It can be seen that **the Key Administrator is myself**.

Key user:



It can be seen that **the Key User is myself only**, too.

[4] Use the created KMS key for encryption/decryption

In this step, we handle encryption and decryption separately, starting with encryption.

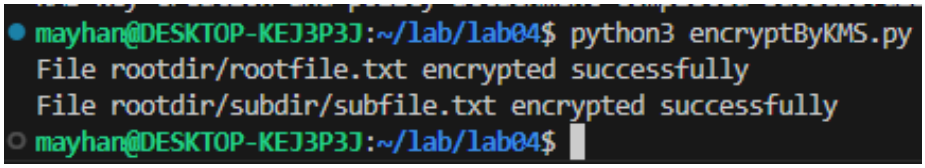
1. **Encryption Script:**

The following script uses the KMS key to encrypt S3 files, defining two functions: `get_kms_key_id()` and `encrypt_file()`:

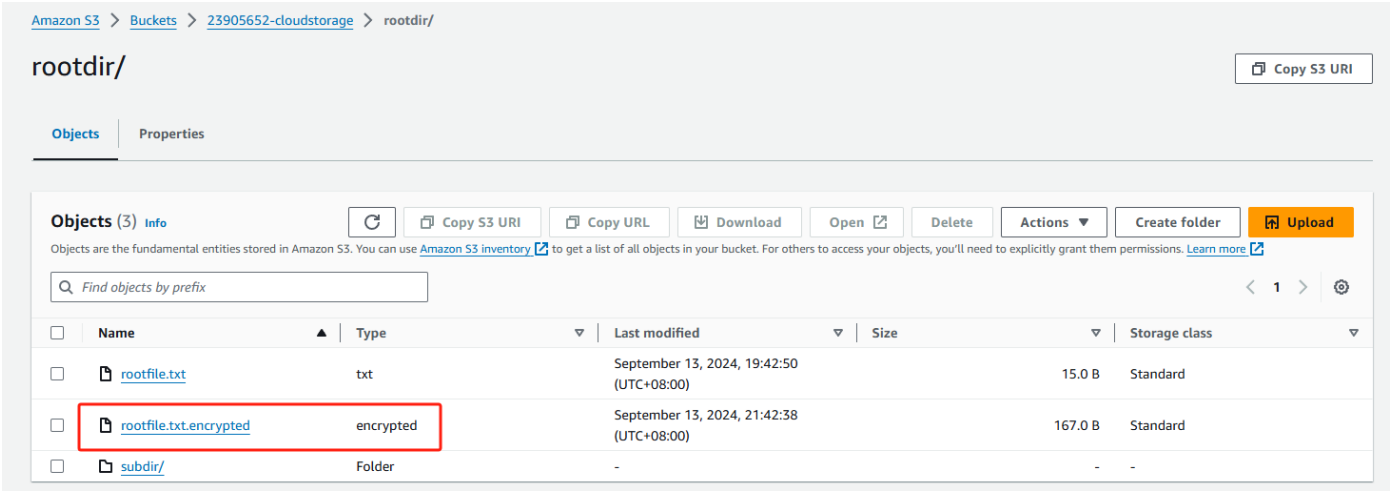
```
import boto3
import os

# Initialize the S3 and KMS clients
# These clients allow interaction with AWS S3 (Simple Storage Service) and KMS (Key
Management Service)
s3 = boto3.client("s3")
kms = boto3.client('kms')

# S3 bucket name and KMS key alias
# These constants define the S3 bucket to work with and the alias of the KMS key to use
for encryption
BUCKET_NAME = '23905652-cloudstorage'
KEY_ALIAS = 'alias/23905652_2'

def get_kms_key_id():
    """
    Retrieve the KMS key ID associated with the specified alias.

    Returns:
        str: The ID of the KMS key
    Raises:
        Exception: If the KMS key with the specified alias is not found
    """
    response = kms.list_aliases()
    for alias in response['Aliases']:
        if alias['AliasName'] == KEY_ALIAS:
            return alias['TargetKeyId']
    raise Exception(f"KMS key with alias {KEY_ALIAS} not found")

def encrypt_file(file_key):
    """
    Download a file from S3, encrypt it using the KMS key, and upload the encrypted
version back to S3.

    Args:
        file_key (str): The key (path) of the file in the S3 bucket
    """
    # Download the file from S3 to the local filesystem
    local_file = os.path.basename(file_key)
    s3.download_file(BUCKET_NAME, file_key, local_file)

    # Read the contents of the downloaded file
    with open(local_file, 'rb') as file:
        file_contents = file.read()

    # Encrypt the file contents using the KMS key
    response = kms.encrypt(KeyId=key_id, Plaintext=file_contents)
    encrypted_contents = response['CiphertextBlob']
```

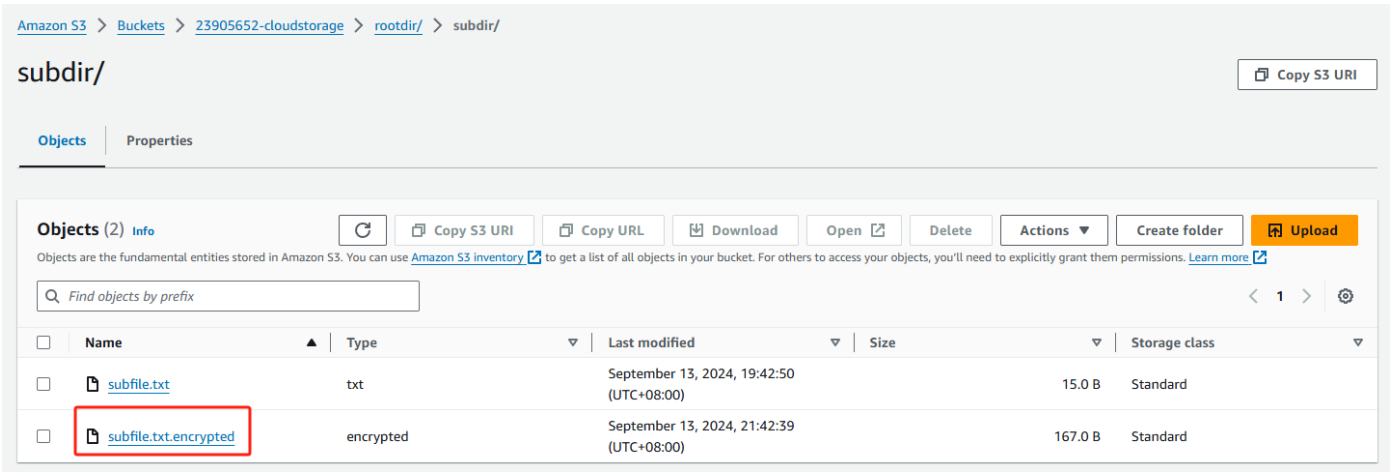
```
    # Write the encrypted contents to a new local file
    encrypted_file = f"{local_file}.encrypted"
    with open(encrypted_file, 'wb') as file:
        file.write(encrypted_contents)

    # Upload the encrypted file back to S3 with a '.encrypted' suffix
    s3.upload_file(encrypted_file, BUCKET_NAME, f"{file_key}.encrypted")

    print(f"File {file_key} encrypted successfully")

def main():
    """
    Main function to encrypt all non-encrypted files in the specified S3 bucket.
    """
    global key_id
    # Retrieve the KMS key ID
    key_id = get_kms_key_id()

    # List all objects in the S3 bucket
    response = s3.list_objects_v2(Bucket=BUCKET_NAME)

    # Iterate through each object in the bucket
    for obj in response.get('Contents', []):
        file_key = obj['Key']
        # Check if the file is not already encrypted (doesn't end with '.encrypted')
        if not file_key.endswith('.encrypted'):
            encrypt_file(file_key)

if __name__ == "__main__":
    main()
```

Save the script as "encryptByKMS.py" and run the code:

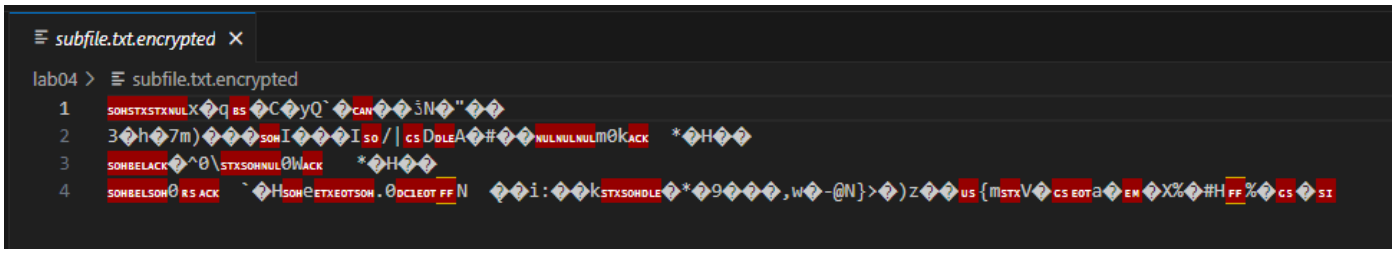


Returning to the **AWS S3 console**, we can see the encrypted file:





Downloading the encrypted file and opening it reveals the ciphertext:



2. **Decryption Script**:

   For the decryption process, we add two more functions `decrypt_file(file_key)` and `compare_files()`:

```
def decrypt_file(file_key):
    """
    Download an encrypted file from S3, decrypt it using the KMS key, and upload the decrypted version back to S3.
```

```
    Args:
        file_key (str): The key (path) of the encrypted file in the S3 bucket
    """
    # Download the encrypted file from S3 to the local filesystem
    local_file = os.path.basename(file_key)
    s3.download_file(BUCKET_NAME, file_key, local_file)

    # Read the contents of the downloaded encrypted file
    with open(local_file, 'rb') as file:
        encrypted_contents = file.read()

    # Decrypt the file contents using the KMS key
    response = kms.decrypt(CiphertextBlob=encrypted_contents, KeyId=key_id)
    decrypted_contents = response['Plaintext']

    # Write the decrypted contents to a new local file
    # The new filename replaces '.encrypted' with '.decrypted'
    decrypted_file = local_file.replace('.encrypted', '.decrypted')
    with open(decrypted_file, 'wb') as file:
        file.write(decrypted_contents)

    # Upload the decrypted file back to S3
    # The S3 key (path) also replaces '.encrypted' with '.decrypted'
    s3.upload_file(decrypted_file, BUCKET_NAME, file_key.replace('.encrypted',
'.decrypted'))

    print(f"File {file_key} decrypted successfully")

def compare_files(original_key, decrypted_key):
    """
    Compare the contents of the original file and its decrypted version in S3.

    Args:
        original_key (str): The key (path) of the original file in S3
        decrypted_key (str): The key (path) of the decrypted file in S3
    """
    # Create unique local filenames for the original and decrypted files
    original_file = 'original_' + os.path.basename(original_key)
    decrypted_file = 'decrypted_' + os.path.basename(decrypted_key)

    # Download both the original and decrypted files from S3
    s3.download_file(BUCKET_NAME, original_key, original_file)
    s3.download_file(BUCKET_NAME, decrypted_key, decrypted_file)

    # Open and read both files, then compare their contents
    with open(original_file, 'rb') as f1, open(decrypted_file, 'rb') as f2:
        if f1.read() == f2.read():
            # If the contents match, the decryption was successful
            print(f"File {original_key} was successfully decrypted and matches the
original!")
        else:
```

```
            # If the contents don't match, there was an error in the
encryption/decryption process
            print(f"Error: {original_key} and its decrypted version do not match.")
```

Modify the `main()` function to perform the decryption process:

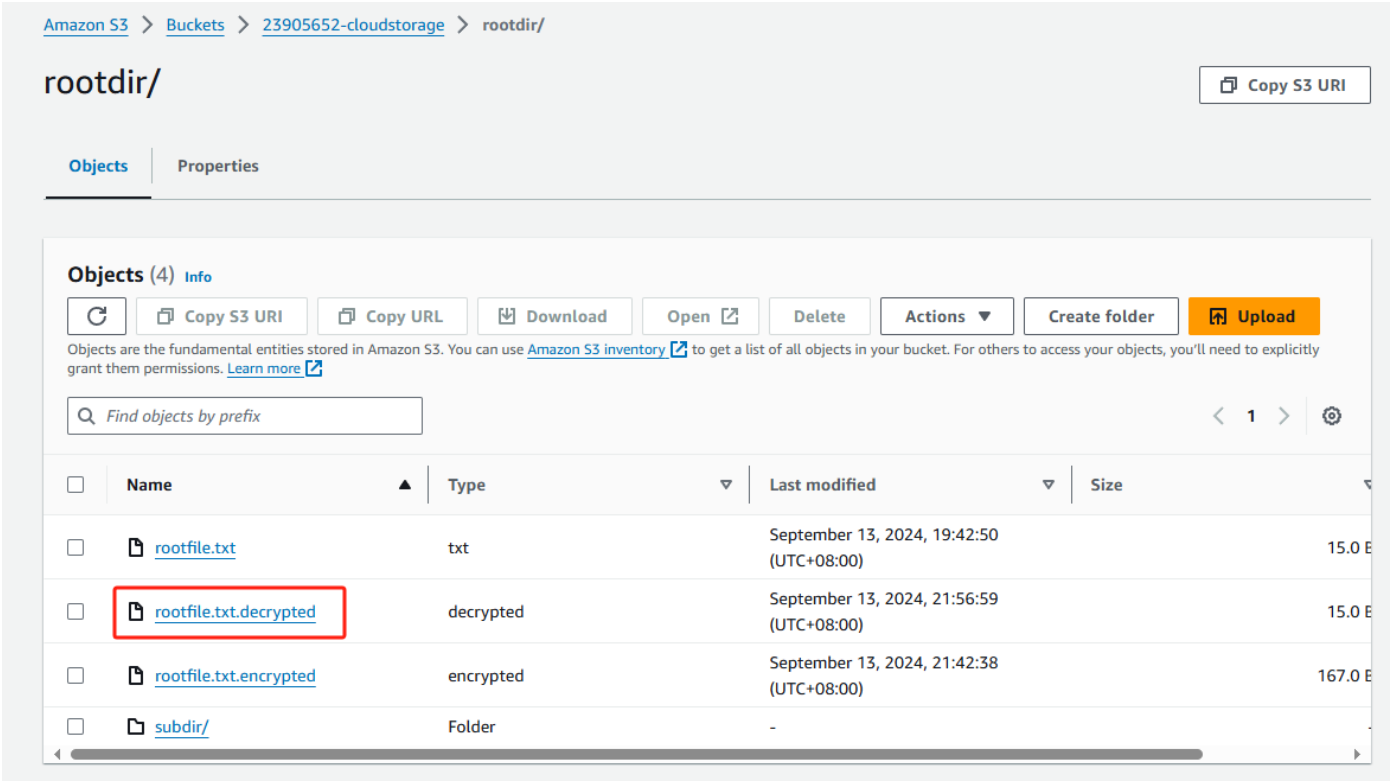
```
def main():
    """
    Main function to decrypt all encrypted files in the specified S3 bucket
    and compare them with their original versions.
    """
    global key_id
    key_id = get_kms_key_id()

    response = s3.list_objects_v2(Bucket=BUCKET_NAME)

    for obj in response.get('Contents', []):
        file_key = obj['Key']

        # Check if the file is an encrypted one (ends with '.encrypted')
        if file_key.endswith('.encrypted'):
            # Decrypt the file
            decrypt_file(file_key)

            # Construct the key for the original (unencrypted) file
            # by removing the '.encrypted' suffix
            original_key = file_key.replace('.encrypted', '')

            # Construct the key for the decrypted file
            # by replacing '.encrypted' with '.decrypted'
            decrypted_key = file_key.replace('.encrypted', '.decrypted')

            # Compare the original file with its decrypted version
            compare_files(original_key, decrypted_key)
```

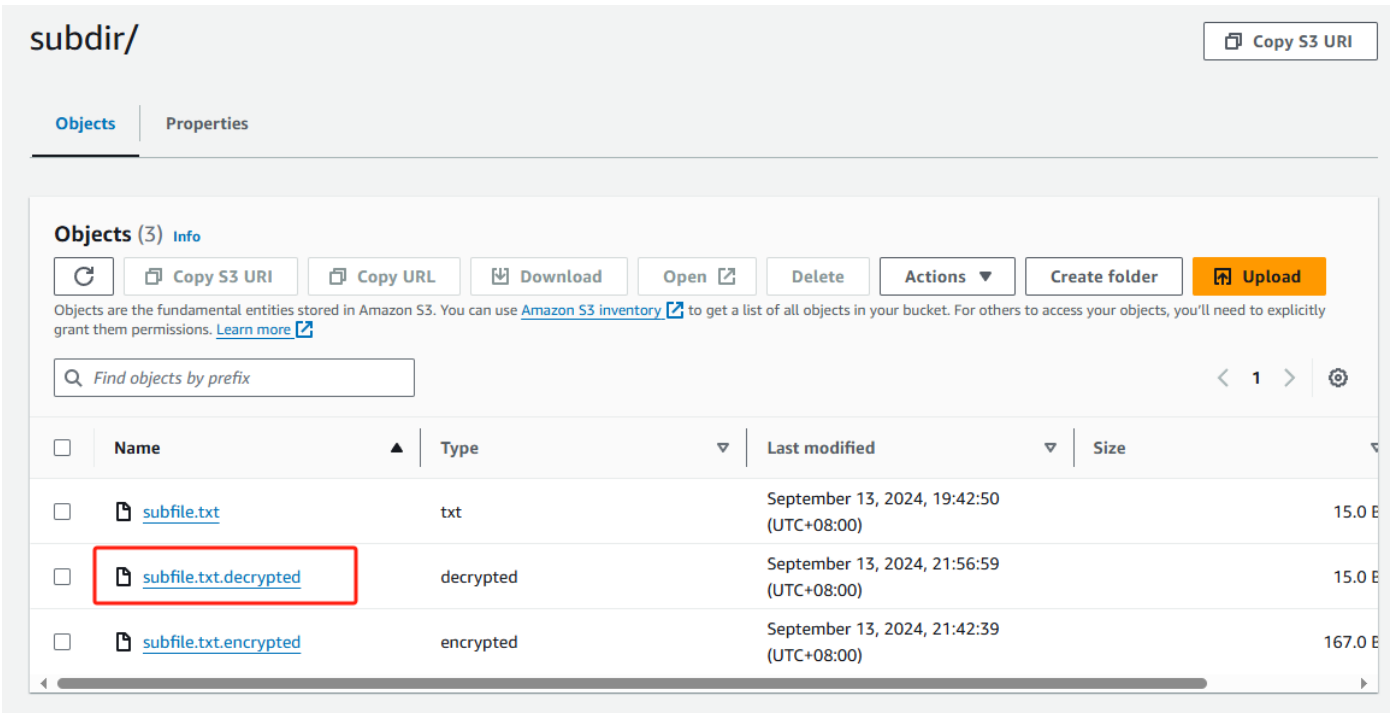
Save the modified script as "decryptByKMS.py" and run the code:

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab04$ python3 decryptByKMS.py
File rootdir/rootfile.txt.encrypted decrypted successfully
File rootdir/rootfile.txt was successfully decrypted and matches the original!
File rootdir/subdir/subfile.txt.encrypted decrypted successfully
File rootdir/subdir/subfile.txt was successfully decrypted and matches the original!
mayhan@DESKTOP-KEJ3P3J:~/lab/lab04$
```

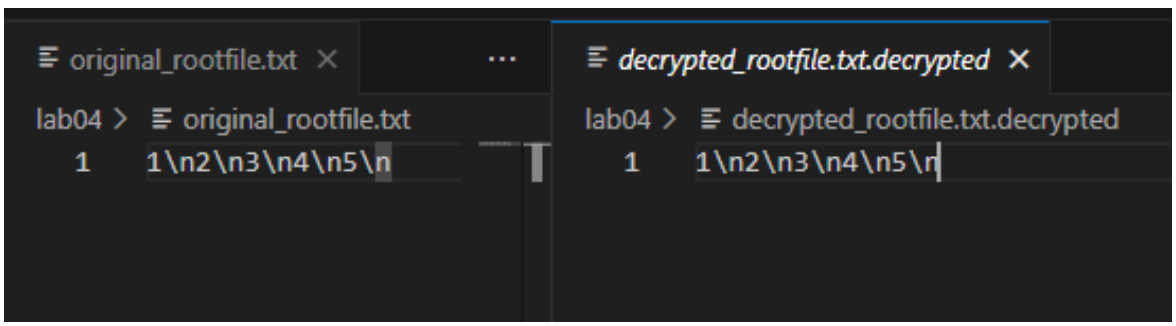
The result shows that **the decrypted file matches the original file**.

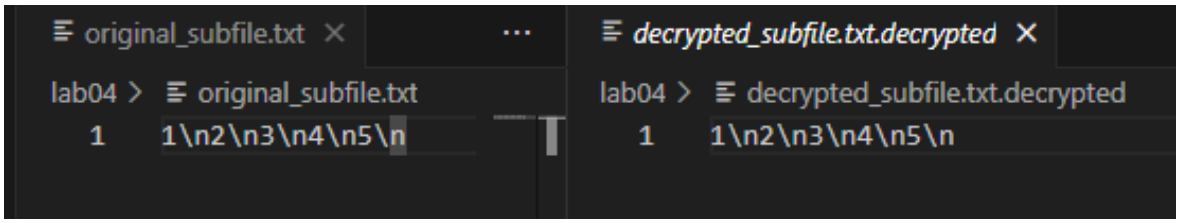
Opening the **AWS S3 Console** reveals the new decrypted files:





Comparing the downloaded decrypted file with the original, matching the original file :





[5] Apply `pycryptodome` for encryption/decryption

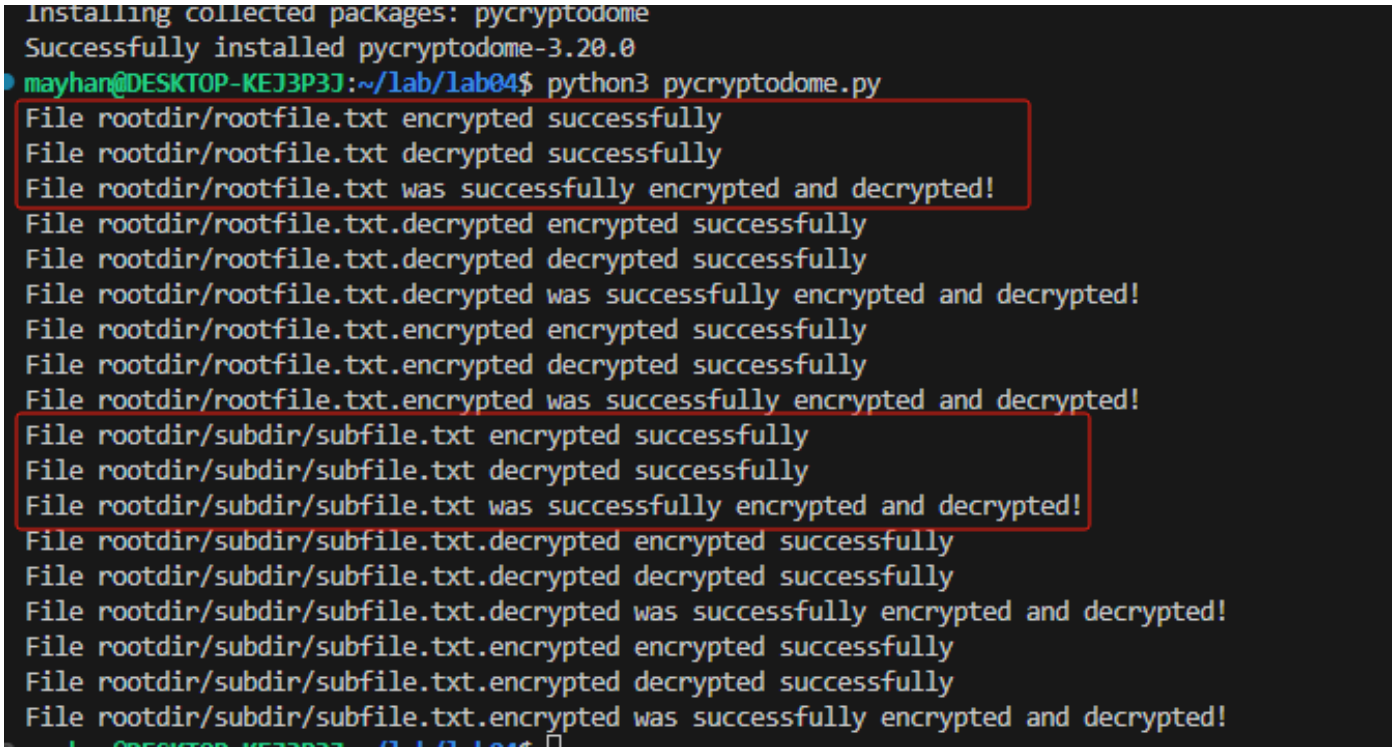
Write another Python script using the `pycryptodome` library to encrypt and decrypt each file in the S3 bucket. The general process is similar to the previous step using KMS key:

```
import os, random, struct
from Crypto.Cipher import AES
from Crypto import Random
import boto3
import base64
import hashlib

s3 = boto3.client('s3', region_name='ap-southeast-1')
BUCKET_NAME = '23905652-cloudstorage'

# Constants for encryption
BLOCK_SIZE = 16  # AES block size
CHUNK_SIZE = 64 * 1024  # Size of chunks to read/write at a time (64KB)

def encrypt_file(password, in_filename, out_filename):
    # Generate a 256-bit key from the password using SHA-256
    key = hashlib.sha256(password.encode("utf-8")).digest()

    # Generate a random 16-byte initialization vector
    iv = Random.new().read(AES.block_size)

    # Create an AES cipher object in CBC mode
    encryptor = AES.new(key, AES.MODE_CBC, iv)

    # Get the size of the input file
    filesize = os.path.getsize(in_filename)

    with open(in_filename, 'rb') as infile:
        with open(out_filename, 'wb') as outfile:
            # Write the original filesize and IV to the output file
            outfile.write(struct.pack('<Q', filesize))
            outfile.write(iv)

            while True:
                # Read the file in chunks
                chunk = infile.read(CHUNK_SIZE)
                if len(chunk) == 0:
                    break
                elif len(chunk) % 16 != 0:
                    # Pad the chunk if it's not a multiple of 16 bytes
```

```
                    chunk += ' '.encode("utf-8") * (16 - len(chunk) % 16)

                # Encrypt and write the chunk
                outfile.write(encryptor.encrypt(chunk))

def decrypt_file(password, in_filename, out_filename):
    # Generate the same 256-bit key from the password
    key = hashlib.sha256(password.encode("utf-8")).digest()

    with open(in_filename, 'rb') as infile:
        # Read the original filesize and IV
        origsize = struct.unpack('<Q', infile.read(struct.calcsize('Q')))[0]
        iv = infile.read(16)

        # Create an AES cipher object for decryption
        decryptor = AES.new(key, AES.MODE_CBC, iv)

        with open(out_filename, 'wb') as outfile:
            while True:
                # Read and decrypt chunks
                chunk = infile.read(CHUNK_SIZE)
                if len(chunk) == 0:
                    break
                outfile.write(decryptor.decrypt(chunk))

            # Truncate the output file to the original size (removes padding)
            outfile.truncate(origsize)

def process_s3_files(password):
    response = s3.list_objects_v2(Bucket=BUCKET_NAME)

    for obj in response.get('Contents', []):
        file_key = obj['Key']
        if not file_key.endswith(('.enc', '.dec')):
            # Download the file from S3
            local_file = os.path.basename(file_key)
            s3.download_file(BUCKET_NAME, file_key, local_file)

            # Encrypt the file
            encrypted_file = local_file + ".enc"
            encrypt_file(password, local_file, encrypted_file)
            # Upload the encrypted file back to S3
            s3.upload_file(encrypted_file, BUCKET_NAME, f"{file_key}.enc")
            print(f"File {file_key} encrypted successfully")

            # Decrypt the file
            decrypted_file = local_file + ".dec"
            decrypt_file(password, encrypted_file, decrypted_file)
            # Upload the decrypted file back to S3
            s3.upload_file(decrypted_file, BUCKET_NAME, f"{file_key}.dec")
            print(f"File {file_key} decrypted successfully")
```

```
            # Compare original and decrypted files to verify integrity
            with open(local_file, 'rb') as f1, open(decrypted_file, 'rb') as f2:
                if f1.read() == f2.read():
                    print(f"File {file_key} was successfully encrypted and decrypted!")
                else:
                    print(f"Error: {file_key} and its decrypted version do not match.")

if __name__ == "__main__":
    password = 'kitty and the kat'  # Password for encryption/decryption
    process_s3_files(password)
```

Save the script as "pycryptodome.py" and run the code:



After running the code, we can find that the program performs encryption and decryption operations on the '.encrypted' and '.decrypted' files from the previous step as well. For effective checking, **we focus only on the original files**.

In the **AWS S3 console**, we can see the newly added encrypted and decrypted files:

rootdir/

Copy S3 URI

Objects | Properties

Objects (10) Info

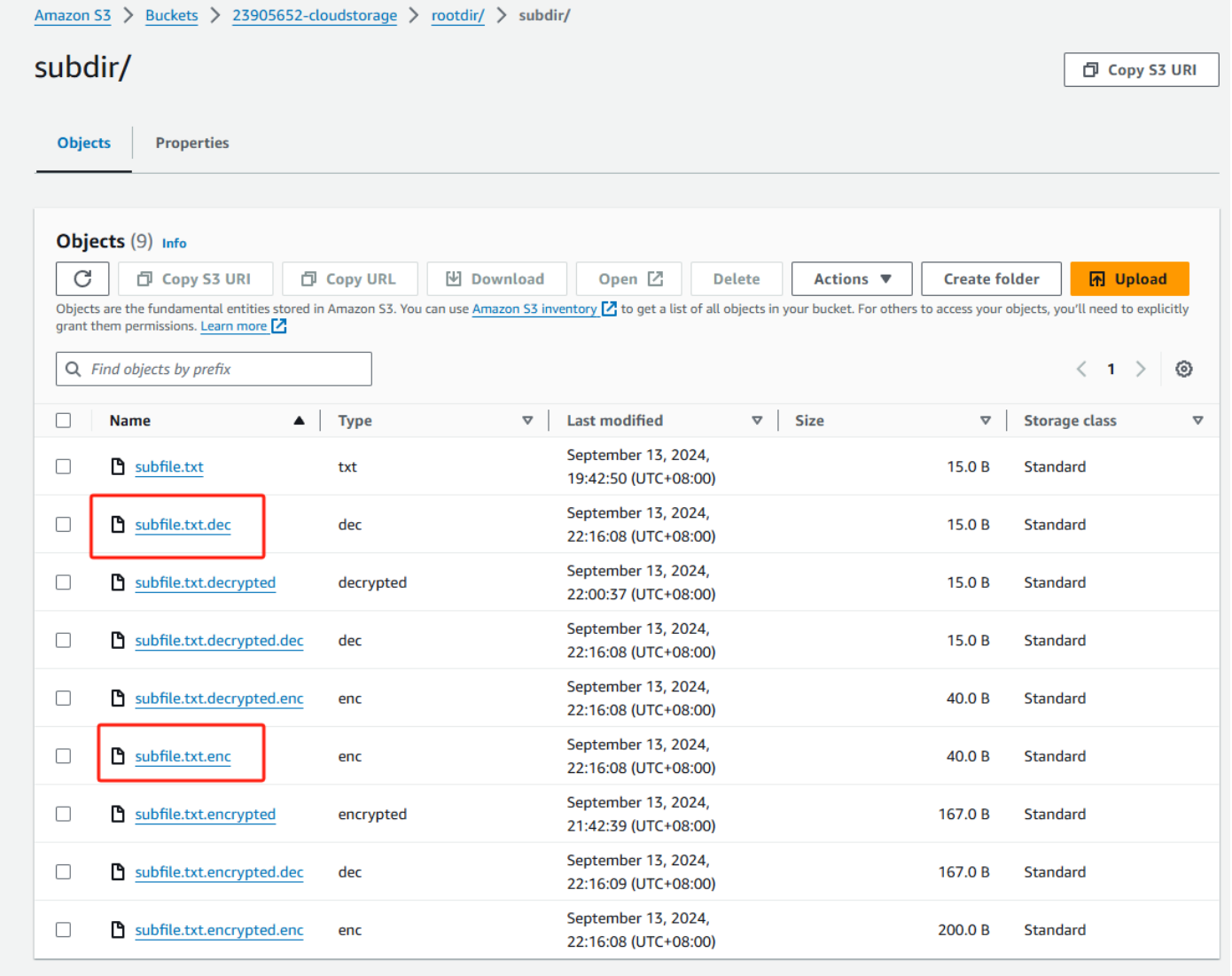
Copy S3 URI | Copy URL | Download | Open | Delete | Actions | Create folder | Upload

Objects are the fundamental entities stored in Amazon S3. You can use Amazon S3 inventory to get a list of all objects in your bucket. For others to access your objects, you'll need to explicitly grant them permissions. Learn more

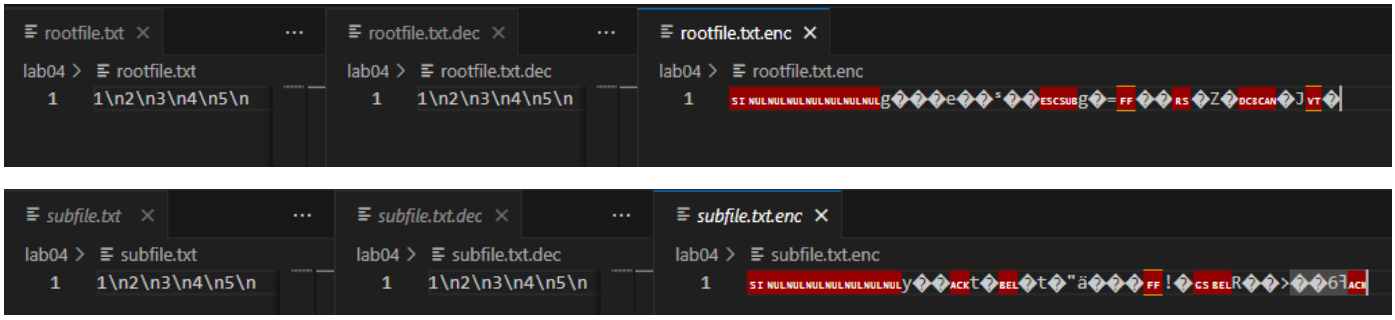
Find objects by prefix

1

Name	Type	Last modified	Size	Storage class
rootfile.txt	txt	September 13, 2024, 19:42:50 (UTC+08:00)	15.0 B	Standard
rootfile.txt.dec	dec	September 13, 2024, 22:16:06 (UTC+08:00)	15.0 B	Standard
rootfile.txt.decrypted	decrypted	September 13, 2024, 22:00:36 (UTC+08:00)	15.0 B	Standard
rootfile.txt.decrypted.dec	dec	September 13, 2024, 22:16:07 (UTC+08:00)	15.0 B	Standard
rootfile.txt.decrypted.enc	enc	September 13, 2024, 22:16:07 (UTC+08:00)	40.0 B	Standard
rootfile.txt.enc	enc	September 13, 2024, 22:16:06 (UTC+08:00)	40.0 B	Standard
rootfile.txt.encrypted	encrypted	September 13, 2024, 21:42:38 (UTC+08:00)	167.0 B	Standard
rootfile.txt.encrypted.dec	dec	September 13, 2024, 22:16:07 (UTC+08:00)	167.0 B	Standard
rootfile.txt.encrypted.enc	enc	September 13, 2024, 22:16:07 (UTC+08:00)	200.0 B	Standard
subdir/	Folder	-	-	-



Download and compare the original file/encrypted file/decrypted file. The decrypted file matches the original one, and the encrypted file shows the ciphertext:



Answer the following question

What is the performance difference between using KMS and using the custom solution?

- Scalability:
  - KMS: Capable of handling a large number of concurrent requests, suitable for high-throughput scenarios.

    - Custom Solution: Limited by local resources, may not perform as well when handling many concurrent requests.
- Network Latency:
    - KMS: Each encryption or decryption operation requires communication with AWS servers, which may introduce network latency.
    - Custom Solution: Executed locally, no additional network latency.
- Large File Handling:
    - KMS: Has a 4KB data size limit, requiring chunking for large files, which may impact performance.
    - Custom Solution: Can handle large files more flexibly, typically more efficient for large file processing.
- Key Management:
    - KMS: Provides automatic key rotation and versioning, but may add some overhead.

      Custom Solution: Key management is your responsibility, potentially faster but less secure.
- Cost:
    - KMS: Charged based on usage, high volume may result in significant costs.
    - Custom Solution: Main cost is computational resources, potentially more economical for high-volume operations.

Lab 5 Networking

Application Load Balancer

[1] Create 2 EC2 instances

Similar to the script created for EC2 in Lab 2, we will write a Python Boto3 script to create a security group to allow inbound HTTP and SSH traffic, and create 2 EC2 instances in two different availability zones, named '-vm1' and '-vm2'. The repeated part of the code from before has not been commented.

```
import boto3
import os

student_number = "23905652"
region = "ap-southeast-1"

ec2 = boto3.client('ec2', region_name=region)

def create_security_group():
    # Create a new security group with a name based on the student number
    response = ec2.create_security_group(
        GroupName=f"{student_number}-sg",
        Description="Security group for ALB lab"
    )
    security_group_id = response['GroupId']

    # Add inbound rules to the security group
    # Allow incoming traffic on port 80 (HTTP) and port 22 (SSH) from any IP address
    ec2.authorize_security_group_ingress(
        GroupId=security_group_id,
        IpPermissions=[
        {
            'IpProtocol': 'tcp',
            'FromPort': 80,
            'ToPort': 80,
            'IpRanges': [{'CidrIp': '0.0.0.0/0'}]
        },
        {
            'IpProtocol': 'tcp',
            'FromPort': 22,
            'ToPort': 22,
            'IpRanges': [{'CidrIp': '0.0.0.0/0'}]
        }
    ]
    )
    print(f"Created Security Group: {security_group_id}")
    return security_group_id

def create_key_pair():
```

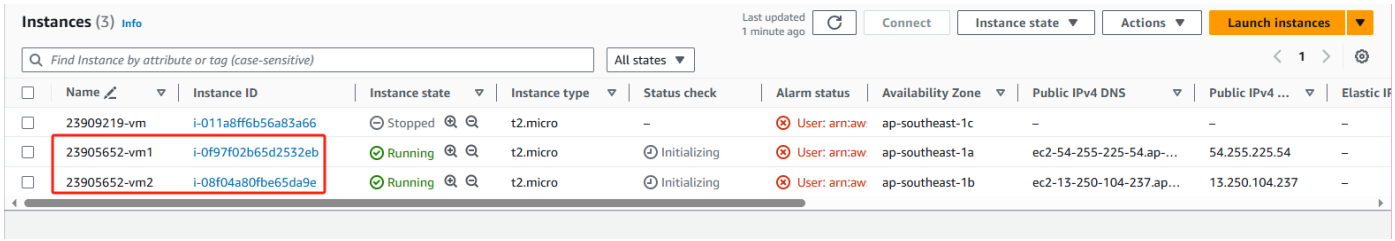
```
    key_name = f"{student_number}-key"
    response = ec2.create_key_pair(KeyName=key_name)
    private_key = response['KeyMaterial']

    private_key_file = f"{key_name}.pem"

    with open(private_key_file, 'w') as key_file:
        key_file.write(private_key)

    os.chmod(private_key_file, 0o400)

    print(f"Private key saved to {private_key_file}")
    return key_name

def get_availability_zones():
    # Retrieves the first two availability zones in the specified region

    # Make an API call to describe availability zones with a filter for "ap-southeast-1"
    response = ec2.describe_availability_zones(
        Filters=[
            {
                'Name': 'region-name',  # Filter by region name
                'Values': [region]      # Use the global 'region' variable defined earlier
            },
        ]
    )
    # Return the 'ZoneName'of the first two zones available zones
    return [az['ZoneName'] for az in response['AvailabilityZones'][:2]]

def create_ec2_instance(security_group_id, key_name, availability_zone, instance_number):
    # Launch a new EC2 instance with specified parameters
    response = ec2.run_instances(
        ImageId="ami-0497a974f8d5dcef8",
        InstanceType="t2.micro",
        KeyName=key_name,
        MaxCount=1,
        MinCount=1,
        SecurityGroupIds=[security_group_id],
        Placement={
            'AvailabilityZone': availability_zone
        },
        TagSpecifications=[
            {
                'ResourceType': 'instance',
                'Tags': [
                    {'Key': 'Name', 'Value': f'{student_number}-vm{instance_number}'}
                ]
            }
        ]
    )
    instance_id = response['Instances'][0]['InstanceId']
    print(f"Created EC2 instance: {instance_id} in {availability_zone}")
```

```
    return instance_id

def main():
    # Create security group
    security_group_id = create_security_group()

    # Create key pair
    key_name = create_key_pair()

    # Get availability zones
    availability_zones = get_availability_zones()

    # Create EC2 instances
    instance_ids = []
    for i, az in enumerate(availability_zones, start=1):
        # Create an EC2 instance in each availability zone
        instance_id = create_ec2_instance(security_group_id, key_name, az, i)
        # Add the new instance ID to our list
        instance_ids.append(instance_id)

    # Wait for instances to be running
    print("Waiting for instances to enter 'running' state...")
    waiter = ec2.get_waiter('instance_running')
    waiter.wait(InstanceIds=instance_ids)
    print("Instances are now running.")

    # Describe instances to get public IP addresses
    for i, instance_id in enumerate(instance_ids, start=1):
        # Retrieve detailed information about each instance
        response = ec2.describe_instances(InstanceIds=[instance_id])
        # Extract the instance details from the response
        instance = response['Reservations'][0]['Instances'][0]
        # Get the public IP address, or 'N/A' if it doesn't exist
        public_ip = instance.get('PublicIpAddress', 'N/A')
        # Get the availability zone where the instance is running
        az = instance['Placement']['AvailabilityZone']
        # Print out the details of each instance
        print(f"Instance {i} (ID: {instance_id}) created in {az} with Public IP:
{public_ip}")

if __name__ == "__main__":
    main()
```

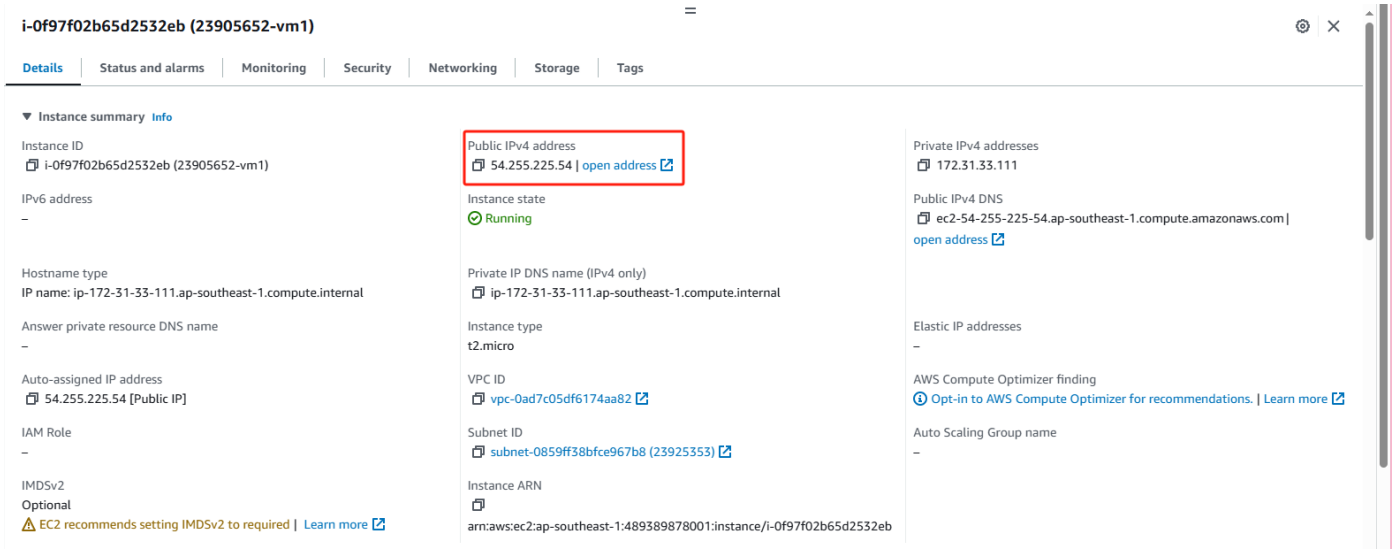
Save the script as "create2EC2.py" and run the code:

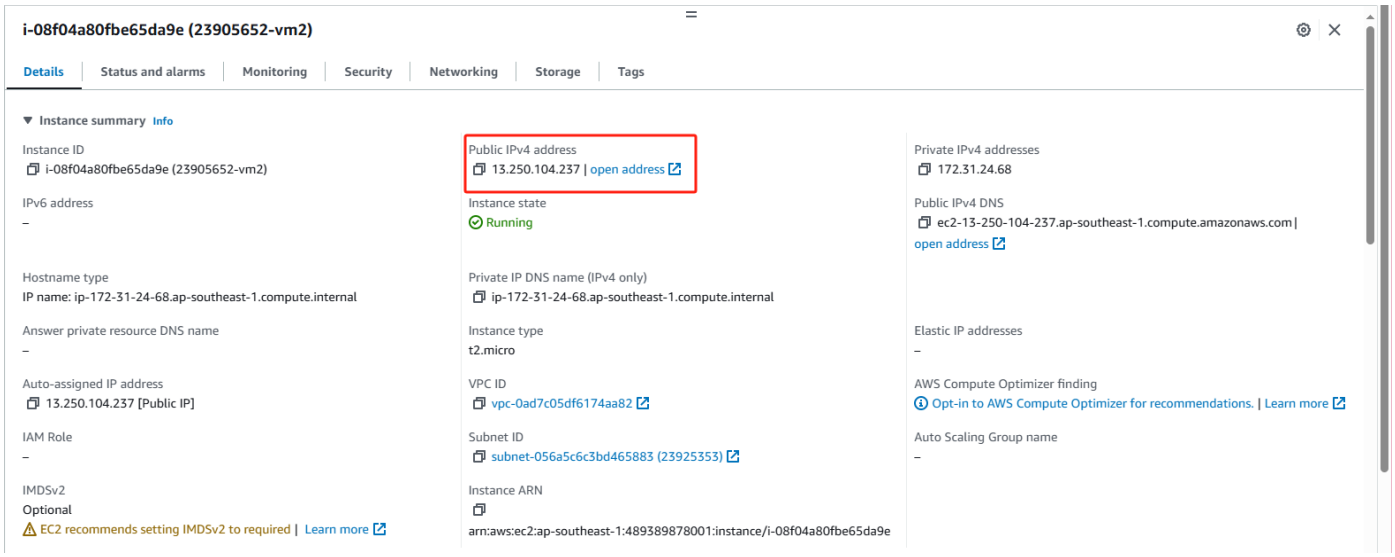
```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab05$ python3 create2EC2.py
Created Security Group: sg-02e38b48c9c59b8f4
Private key saved to 23905652-key.pem
Created EC2 instance: i-0f97f02b65d2532eb in ap-southeast-1a
Created EC2 instance: i-08f04a80fbe65da9e in ap-southeast-1b
Waiting for instances to enter 'running' state...
Instances are now running.
Instance 1 (ID: i-0f97f02b65d2532eb) created in ap-southeast-1a with Public IP: 54.255.225.54
Instance 2 (ID: i-08f04a80fbe65da9e) created in ap-southeast-1b with Public IP: 13.250.104.237
mayhan@DESKTOP-KEJ3P3J:~/lab/lab05$
```

We can check the EC2 instances in the **AWS Console**, named them "23905652-vm1" and "23905652-vm2":



It shows that **the Instance ID matches the output in Terminal.**





Click to view the details of the two instances, and we can find that **the public IP address also matches the output.**

[2] Create an Application Load Balancer

Update the above script to create an application load balancer and load balance HTTP requests to the 2 instances created, using the v2 of the ELB interface. The updates to the script include:

- Create a load balancer, specifying the two subnets and security groups created in the previous step.
- Create a target group using the same VPC used for creating instances.
- Register targets in the target group.
- Create a listener with the default rule protocol: HTTP and port 80 forwarding to the target group.

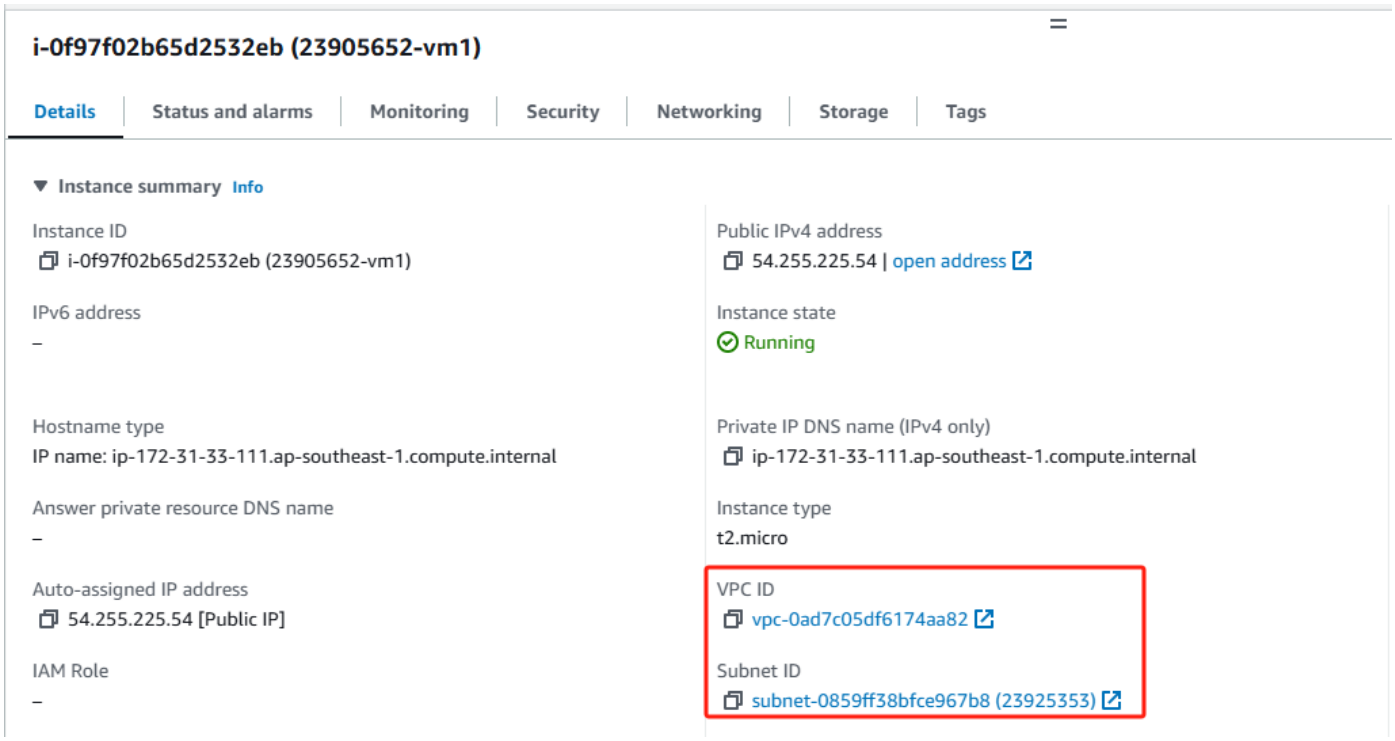
1. To achieve this, we added four functions to the previous script, `create_load_balancer()`, `create_target_group()`, `register_targets()`, `create_listener()`:

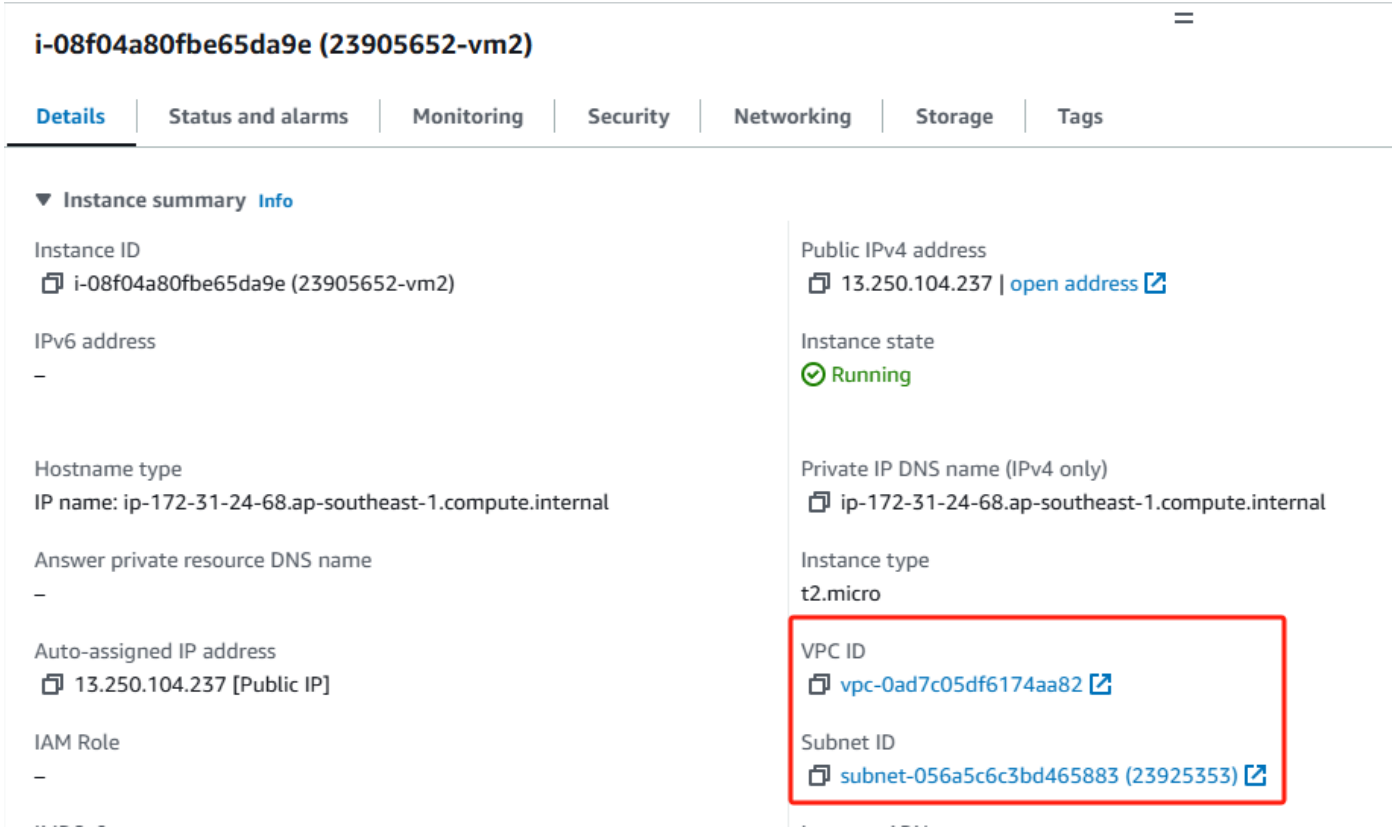
```
import boto3
import botocore
import os

student_number = "23905652"
region = "ap-southeast-1"

# Initialize boto3 clients for EC2 and Elastic Load Balancing v2 services
ec2 = boto3.client('ec2', region_name=region)
elbv2 = boto3.client('elbv2', region_name=region)

def create_load_balancer(security_group_id, subnet_ids):
    # Create an Application Load Balancer (ALB)
    response = elbv2.create_load_balancer(
        Name=f'{student_number}-alb',  # Name the ALB using the student number
        Subnets=subnet_ids,  # Specify subnets where the ALB will be created
        SecurityGroups=[security_group_id],  # Attach a security group to the ALB
        Scheme='internet-facing',  # Make the ALB accessible from the internet
        Type='application',  # Specify that this is an Application Load Balancer
        Tags=[
            {
                'Key': 'Name',
                'Value': f'{student_number}-alb'
            },
        ]  # Tag the ALB for easier identification
    )
    # Return the Amazon Resource Name (ARN) of the created load balancer
    return response['LoadBalancers'][0]['LoadBalancerArn']

def create_target_group(vpc_id):
    # Create a target group for the ALB
    response = elbv2.create_target_group(
        Name=f'{student_number}-tg',  # Name the target group using the student number
        Protocol='HTTP',  # Use HTTP protocol for the target group
        Port=80,  # Set the port to 80 for HTTP traffic
        VpcId=vpc_id,  # Specify the VPC where the target group will be created
        HealthCheckProtocol='HTTP',  # Use HTTP for health checks
```

```
        HealthCheckPath='/',  # Set the health check path to the root
        TargetType='instance'  # Specify that the targets will be EC2 instances
    )
    # Return the ARN of the created target group
    return response['TargetGroups'][0]['TargetGroupArn']

def register_targets(target_group_arn, instance_ids):
    # Register EC2 instances as targets in the target group
    targets = [{'Id': instance_id} for instance_id in instance_ids]  # Create a list of
target dictionaries

    elbv2.register_targets(
        TargetGroupArn=target_group_arn,  # Specify the target group
        Targets=targets  # Register the EC2 instances as targets
    )

def create_listener(load_balancer_arn, target_group_arn):
    # Create a listener for the ALB
    response = elbv2.create_listener(
        LoadBalancerArn=load_balancer_arn,  # Specify the ALB
        Protocol='HTTP',  # Use HTTP protocol for the listener
        Port=80,  # Set the port to 80 for HTTP traffic
        DefaultActions=[
            {
                'Type': 'forward',  # Set the default action to forward traffic
                'TargetGroupArn': target_group_arn  # Specify the target group to forward
traffic to
            }
        ]
    )
    # Return the ARN of the created listener
    return response['Listeners'][0]['ListenerArn']

def main():
    # Main function to process the creation of ALB and related resources

    # Hardcoded resource IDs
    vpc_id = 'vpc-0ad7c05df6174aa82'
    subnet_ids = ['subnet-0859ff38bfce967b8', 'subnet-056a5c6c3bd465883']
    security_group_id = 'sg-02e38b48c9c59b8f4'
    instance_ids = ['i-0f97f02b65d2532eb', 'i-08f04a80fbe65da9e']

    print("Creating Application Load Balancer...")
    load_balancer_arn = create_load_balancer(security_group_id, subnet_ids)
    print(f"Load Balancer created: {load_balancer_arn}")

    print("Creating Target Group...")
    target_group_arn = create_target_group(vpc_id)
    print(f"Target Group created: {target_group_arn}")

    print("Creating listener...")
    listener_arn = create_listener(load_balancer_arn, target_group_arn)
```

```
    print(f"Listener created: {listener_arn}")

    print("Registering targets...")
    register_targets(target_group_arn, instance_ids)
    print("Targets registered")

    print("Setup complete!")

if __name__ == "__main__":
    main()
```

2. In the `main()` function, the **`security_group_id`** and **`instance_ids`** are saved from the previous output, while the **`vpc_id`** and **`subnet_ids`** are found in the details of each instance in the AWS Console and then hardcoded into the program to operate on specific objects:





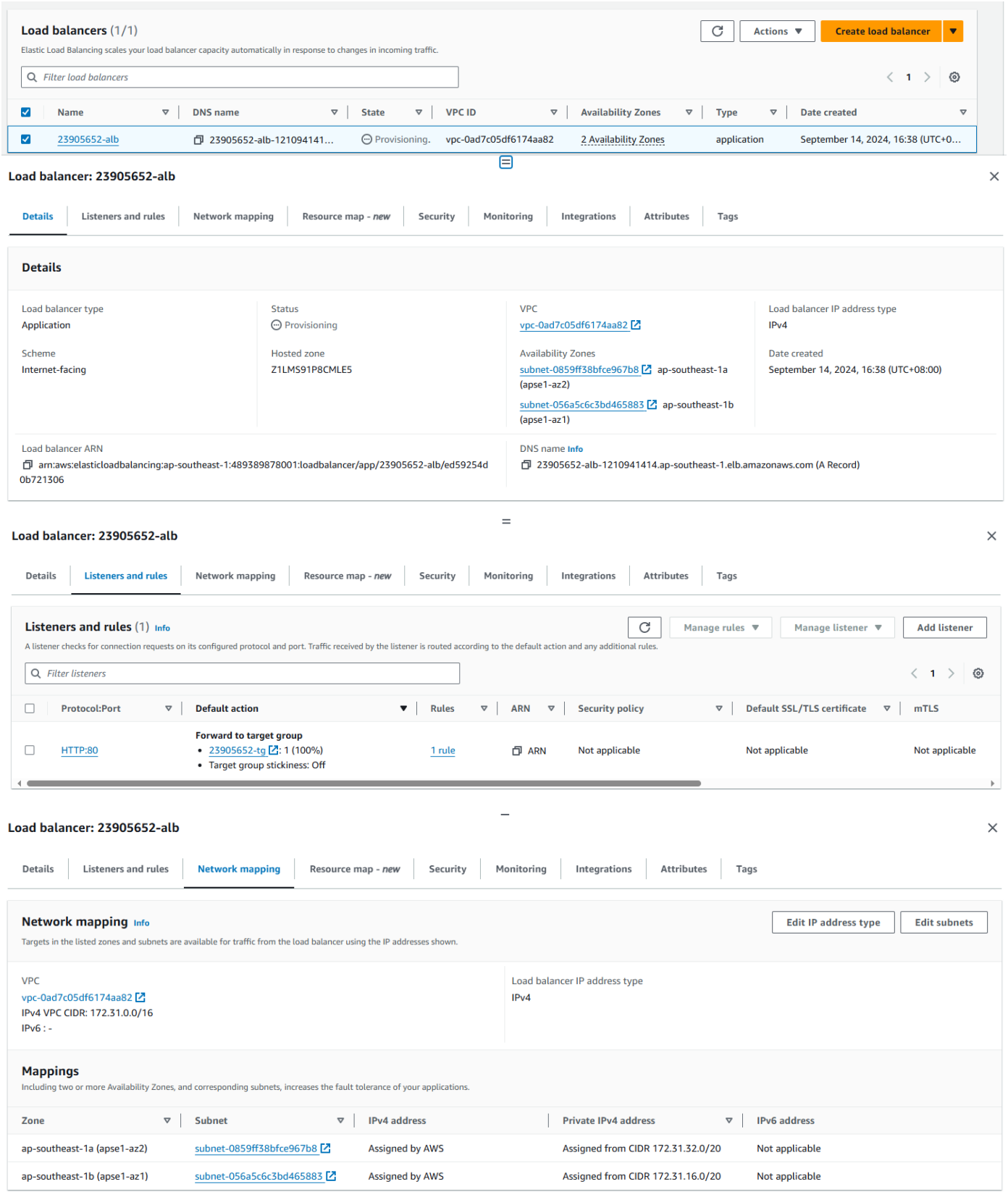
3. Save the script as "createALB.py" and run the code:

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab05$ python3 createALB.py
Creating Application Load Balancer...
Load Balancer created: arn:aws:elasticloadbalancing:ap-southeast-1:489389878001:loadbalancer/app/23905652-alb/ed59254d0b721306
Creating Target Group...
Target Group created: arn:aws:elasticloadbalancing:ap-southeast-1:489389878001:targetgroup/23905652-tg/a34d3644c87dce17
Creating listener...
Listener created: arn:aws:elasticloadbalancing:ap-southeast-1:489389878001:listener/app/23905652-alb/ed59254d0b721306/cdb20af71e4a5170
Registering targets...
Targets registered
Setup complete!
```

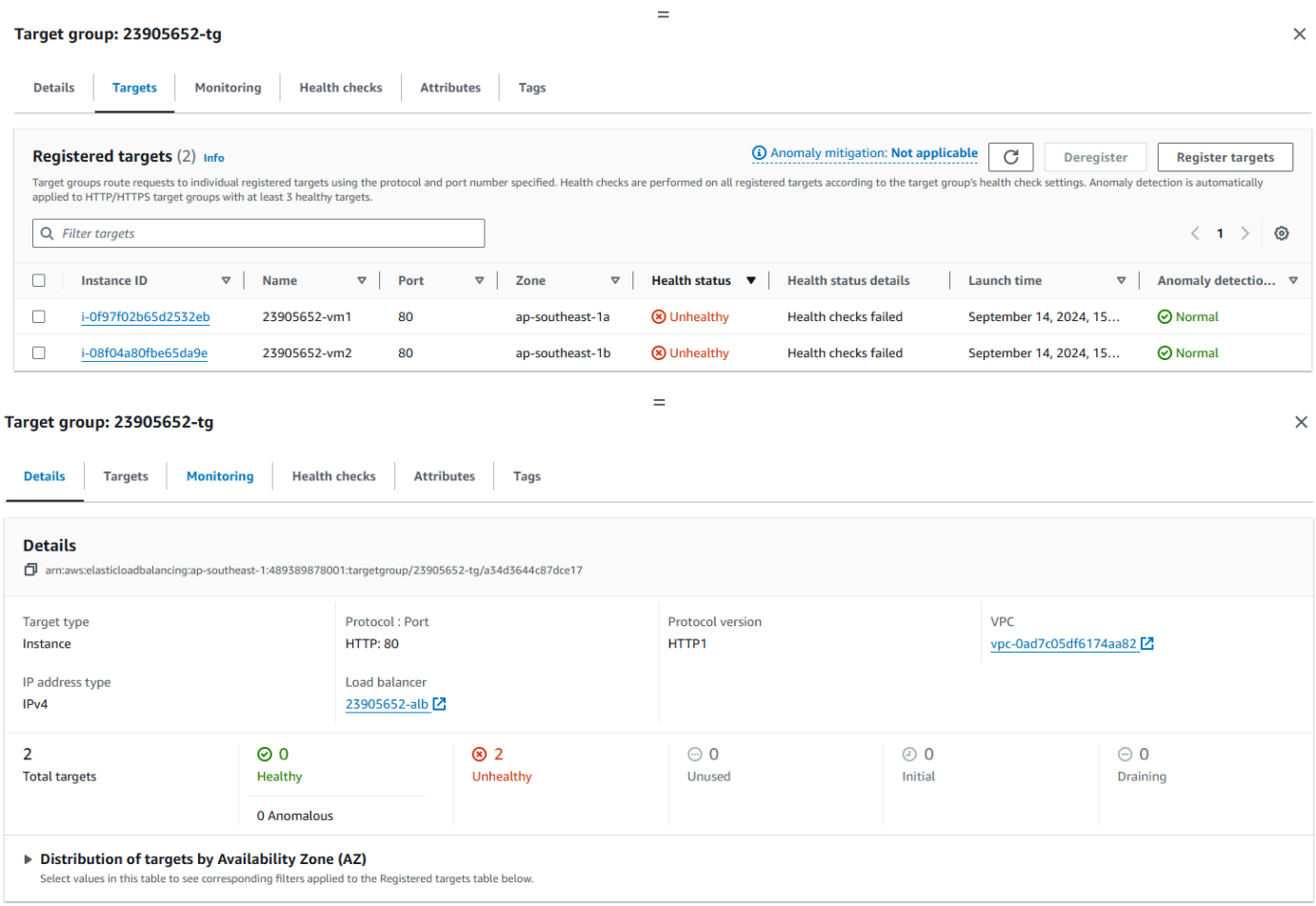
Based on the output, the setup can be considered successful.

4. In the AWS Console, we can see the created Load Balancer and Target Group information:

- **Load balancer**:



- **Target group：**



[3] Test the Application Load Balancer

To test the Application Load Balancer, we will try to access each EC2 instance using its public IP address in a browser.

1. To use ALB, we need to install **Apache 2** on the instances, a popular open-source web server software widely used for hosting websites and web applications across various operating systems.

First, connect to the two instances via SSH (using one of the instances as an example, the other follows the same steps):

```
mayhan@DESKTOP-KEJ3P3J:~/lab/lab05$ ssh -i 23905652-key.pem ubuntu@13.250.104.237
The authenticity of host '13.250.104.237 (13.250.104.237)' can't be established.
ECDSA key fingerprint is SHA256:68/giouYCCrYrHaIs1nNrHWNfp+eih+K4uAVfqIKkBg.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '13.250.104.237' (ECDSA) to the list of known hosts.
Welcome to Ubuntu 22.04.4 LTS (GNU/Linux 6.5.0-1022-aws x86_64)

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

 System information as of Sat Sep 14 08:54:39 UTC 2024

  System load:  0.0               Processes:             97
  Usage of /:   20.7% of 7.57GB   Users logged in:       0
  Memory usage: 21%               IPv4 address for eth0: 172.31.24.68
  Swap usage:   0%
```

Update the instance:

```
ubuntu@ip-172-31-24-68:~$ sudo apt-get update
Hit:1 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy InRelease
Get:2 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy-updates InRelease [128 kB]
Get:3 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy-backports InRelease [127 kB]
Get:4 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/universe amd64 Packages [14.1 MB]
Get:5 http://security.ubuntu.com/ubuntu jammy-security InRelease [129 kB]
Get:6 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/universe Translation-en [5652 kB]
Get:7 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/universe amd64 c-n-f Metadata [286 kB]
Get:8 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/multiverse amd64 Packages [217 kB]
Get:9 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/multiverse Translation-en [112 kB]
Get:10 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy/multiverse amd64 c-n-f Metadata [8372 B]
Get:11 http://ap-southeast-1.ec2.archive.ubuntu.com/ubuntu jammy-updates/main amd64 Packages [2023 kB]
```

Install apache2:

```
ubuntu@ip-172-31-24-68:~$ sudo apt install apache2
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  apache2-bin apache2-data apache2-utils bzip2 libapr1 libaprutil1 libaprutil1-dbd-sqlite3 libaprutil1-ldap liblua5.3-0 mailcap mime-support ssl-cert
Suggested packages:
  apache2-doc apache2-suexec-pristine | apache2-suexec-custom www-browser bzip2-doc
The following NEW packages will be installed:
  apache2 apache2-bin apache2-data apache2-utils bzip2 libapr1 libaprutil1 libaprutil1-dbd-sqlite3 libaprutil1-ldap liblua5.3-0 mailcap mime-support ssl-cert
0 upgraded, 13 newly installed, 0 to remove and 69 not upgraded.
Need to get 2141 kB of archives.
After this operation, 8524 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
```

2. Use the following command to edit the `<title>` tags in the `/var/www/html/index.html` file to display the instance name:

```
sudo nano /var/www/html/index.html
```

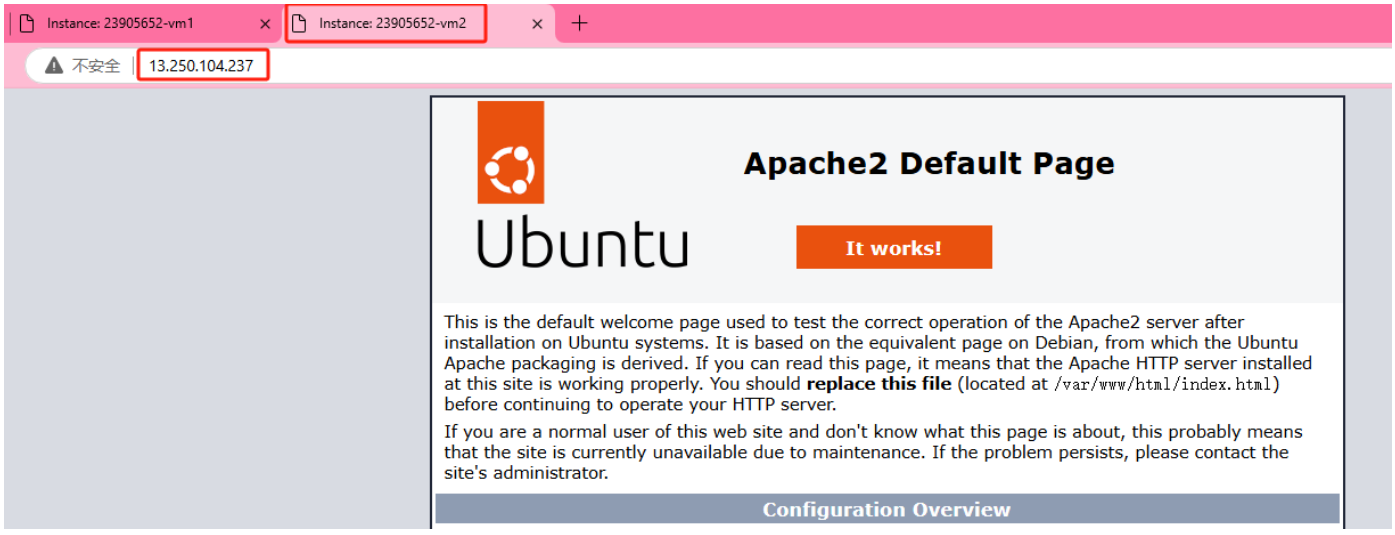
```
 GNU nano 6.2                                                    /var/www/html/index.html *
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <!--
    Modified from the Debian original for Ubuntu
    Last updated: 2022-03-22
    See: https://launchpad.net/bugs/1966004
  -->
  <head>
    <meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />
    <title>Instance: 23905652-vm2</title>
    <style type="text/css" media="screen">
  * {
    margin: 0px 0px 0px 0px;
    padding: 0px 0px 0px 0px;
  }
```

Save and exit according to the prompt. For the other instance, follow the same steps and change the title to “23905652-vm1”.

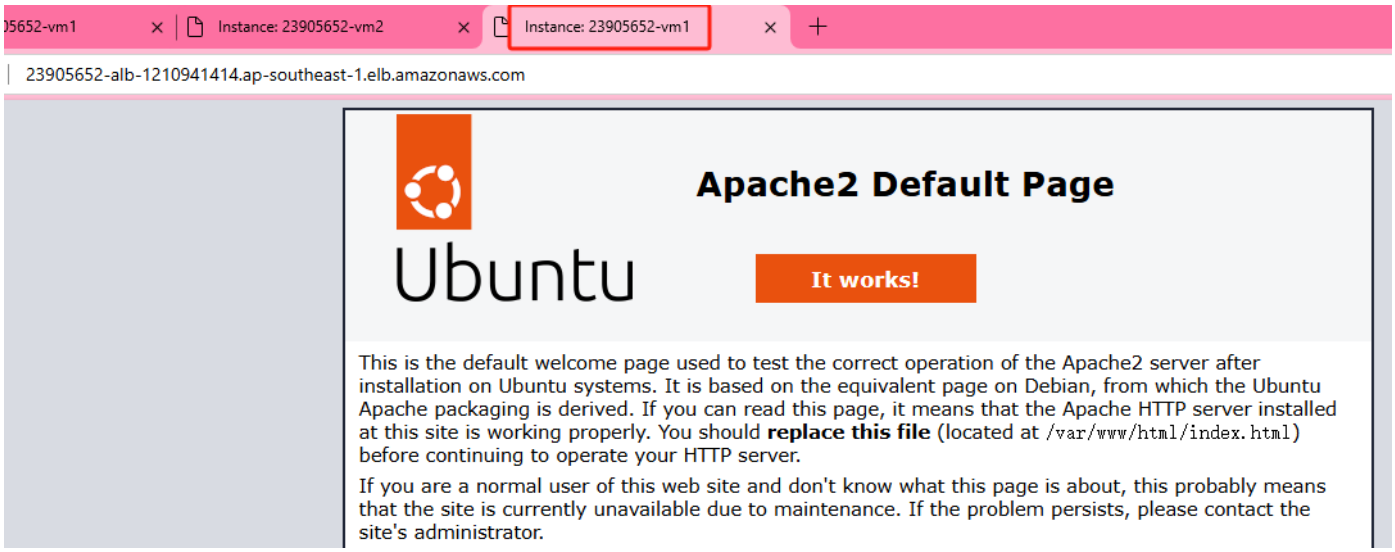
3. Open a browser and access each instance using their respective **IP addresses** to see the default Apache webpage with their respective titles:

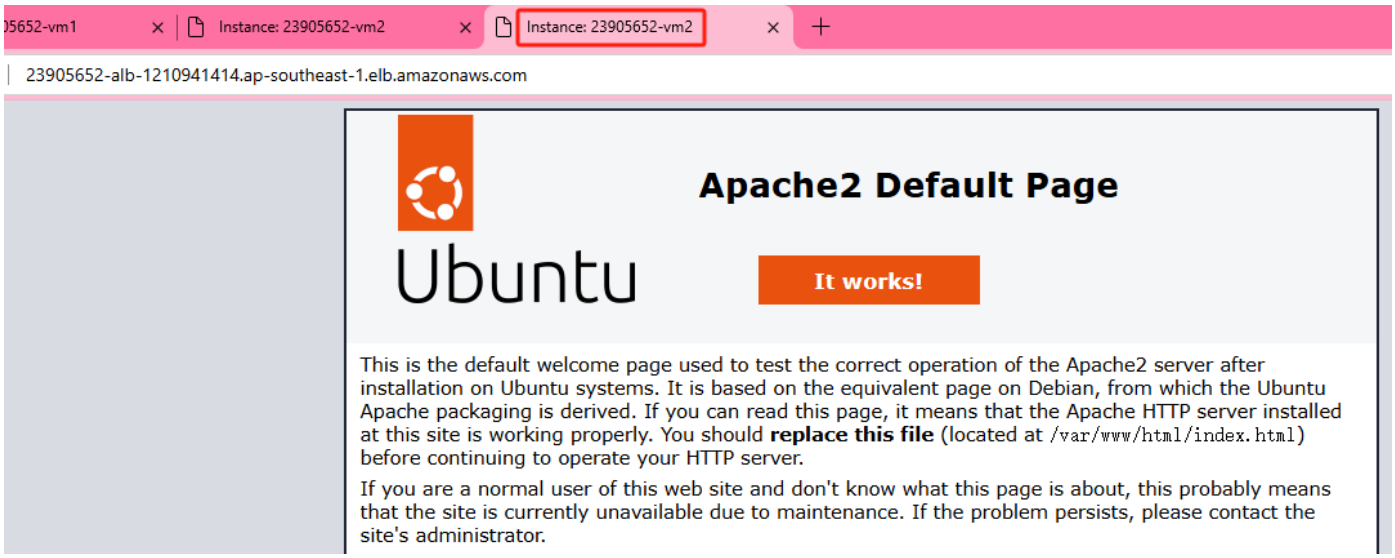
   http://54.255.225.54/（**23905652-vm1**）：

   http://13.250.104.237/（**23905652-vm2**）：



4. To verify the ALB, we access its **DNS name** http://23905652-alb-1210941414.ap-southeast-1.elb.amazonaws.com/ in a browser and perform **several refreshes to test accessing different instances**:


5652-vm1
Instance: 23905652-vm2
Instance: 23905652-vm1
23905652-alb-1210941414.ap-southeast-1.elb.amazonaws.com
Apache2 Default Page
Ubuntu
It works!
This is the default welcome page used to test the correct operation of the Apache2 server after installation on Ubuntu systems. It is based on the equivalent page on Debian, from which the Ubuntu Apache packaging is derived. If you can read this page, it means that the Apache HTTP server installed at this site is working properly. You should replace this file (located at /var/www/html/index.html) before continuing to operate your HTTP server.
If you are a normal user of this web site and don't know what this page is about, this probably means that the site is currently unavailable due to maintenance. If the problem persists, please contact the site's administrator.


5652-vm1
Instance: 23905652-vm2
Instance: 23905652-vm2
23905652-alb-1210941414.ap-southeast-1.elb.amazonaws.com
Apache2 Default Page
Ubuntu
It works!
This is the default welcome page used to test the correct operation of the Apache2 server after installation on Ubuntu systems. It is based on the equivalent page on Debian, from which the Ubuntu Apache packaging is derived. If you can read this page, it means that the Apache HTTP server installed at this site is working properly. You should replace this file (located at /var/www/html/index.html) before continuing to operate your HTTP server.
If you are a normal user of this web site and don't know what this page is about, this probably means that the site is currently unavailable due to maintenance. If the problem persists, please contact the site's administrator.