# Lab 1

## Installing UTM and Kali Linux

### Step 1:

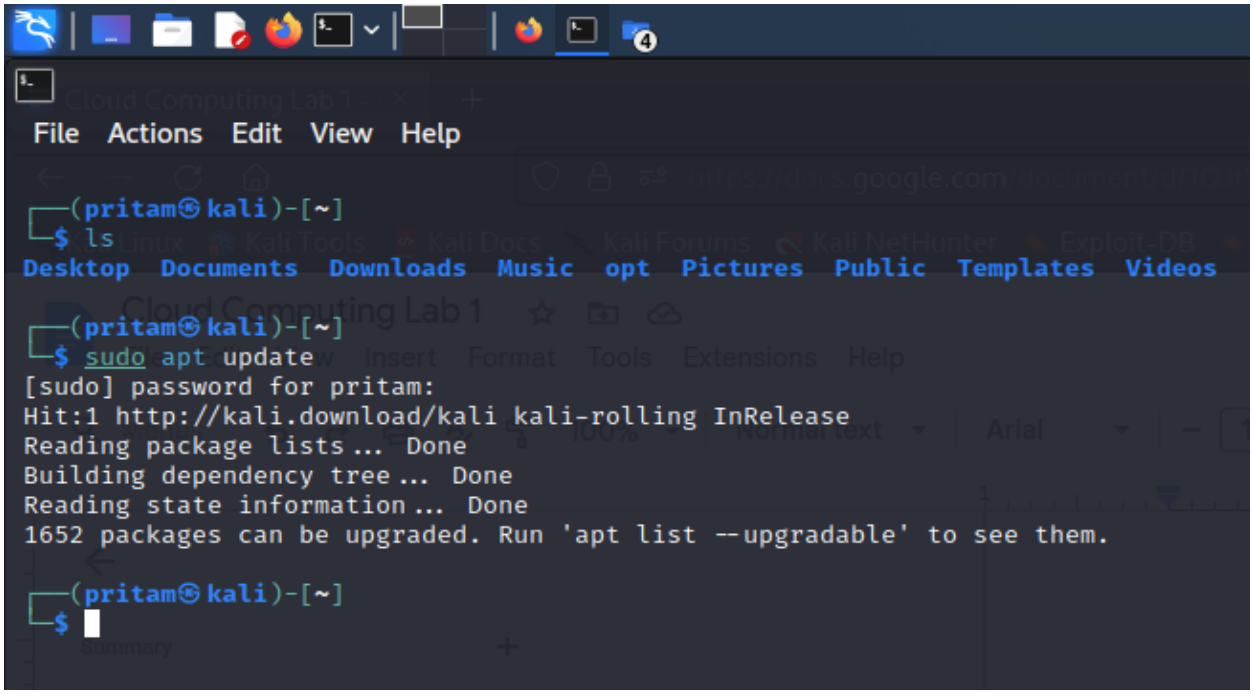
Since my OS was macOS with an M1 chip, I followed the instructions provided in the link below. https://www.kali.org/docs/virtualization/install-utm-guest-vm/ to set up UTM and Kali Linux on my machine.

UTM is a full-featured system emulator and virtual machine host for iOS and macOS. It is based on QEMU (Quick Emulator) which is a free and open-source emulator. In short, it allows you to run Windows, Linux, and more on your Mac, iPhone, and iPad. More information at https://getutm.app/ and https://mac.getutm.app/

### Step 2:

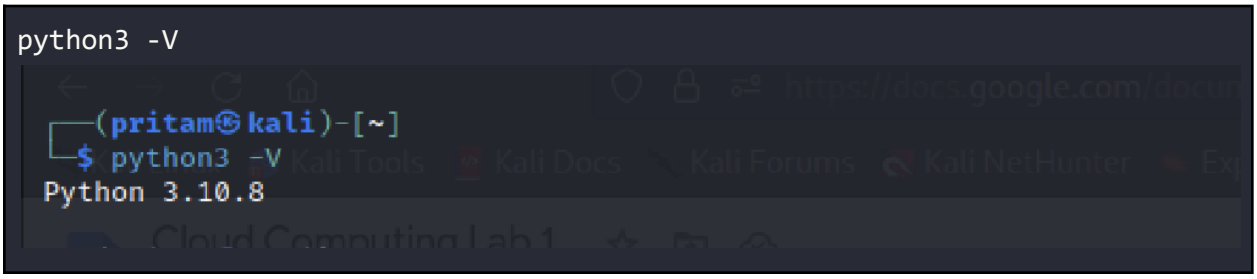
Updated the OS with the following command to make sure all the system packages are updated. Running `**sudo apt update**` fetches the latest package information for software repositories on your Linux system, ensuring security patches, bug fixes, and new features are available. This step is vital before installing or upgrading software with accurate dependencies. It maintains system security, stability, and functionality.

```
sudo apt update
```




Step 3:

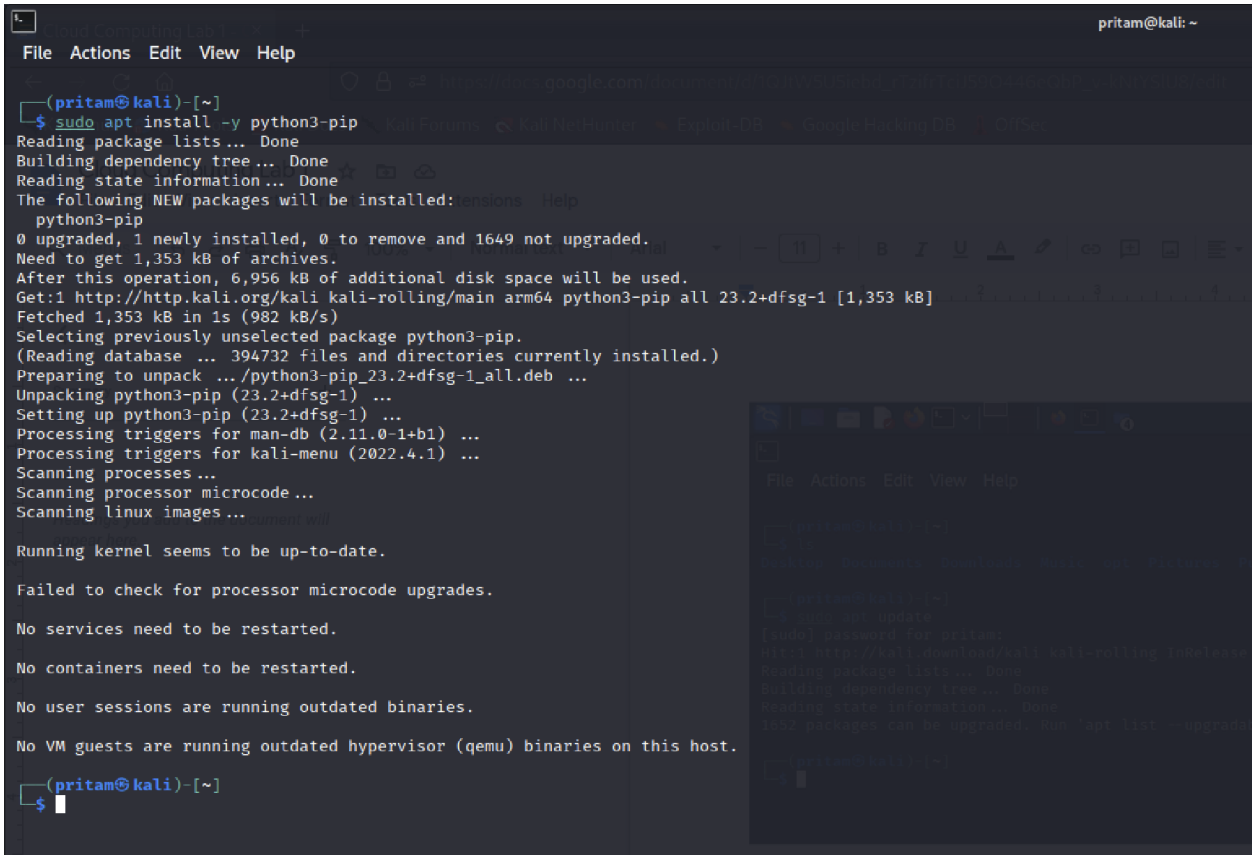
Checked Python version with the following command.




Step 4:

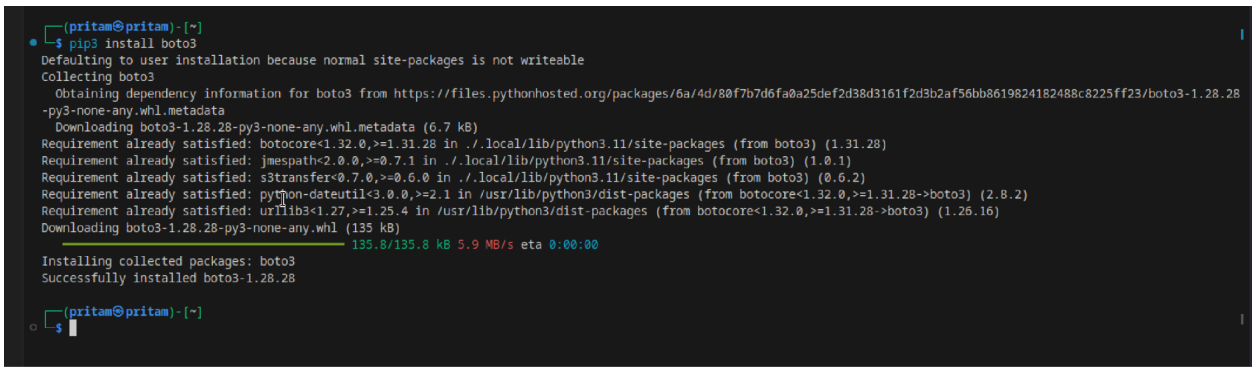
Since the Python version was 3.10.8, I installed pip3 which is a Python package manager. `**pip3**` is a package installer for Python, allowing you to easily download, manage, and install external Python packages. It's essential as it simplifies adding libraries, tools, and modules, enhancing functionality and saving development time. With `pip3`, you can efficiently expand Python capabilities and share code dependencies.

**Note**: The usage of `pip3` instead of `pip` is mainly relevant when working with multiple versions of Python installed on your system. `pip3` is associated with Python 3, ensuring that packages are installed for the correct Python version. Using `pip` alone could refer to the default `pip` associated with Python 2, potentially causing compatibility issues if you're primarily using Python 3. It's a way to maintain version-specific package management.



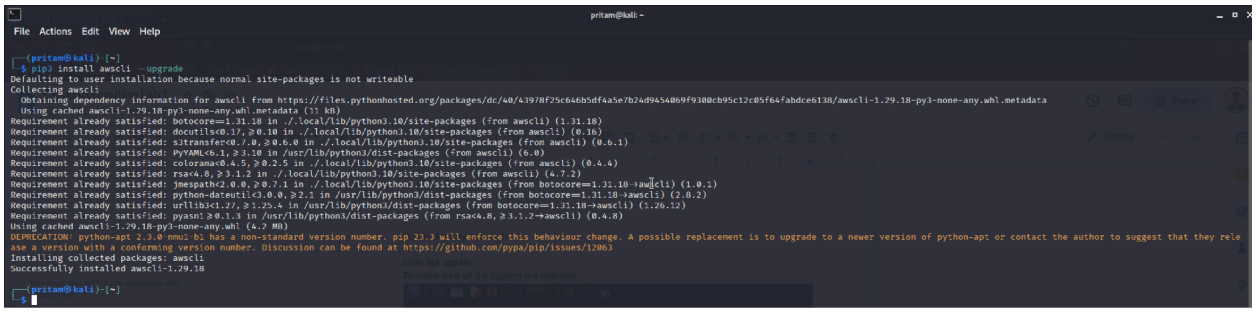

Step 5:

Installed boto3 which is a Python SDK for AWS. `**boto3**` is a Python library developed by Amazon Web Services (AWS) that provides an interface to interact with AWS services programmatically. It allows developers to write Python code to automate and manage various AWS services, such as Amazon S3 (Simple Storage Service), Amazon EC2 (Elastic Compute Cloud), Amazon DynamoDB, and more. With `boto3`, you can create, configure, and manage AWS resources, and perform actions like uploading files to S3, launching EC2 instances, and accessing data stored in AWS services.



Step 6:

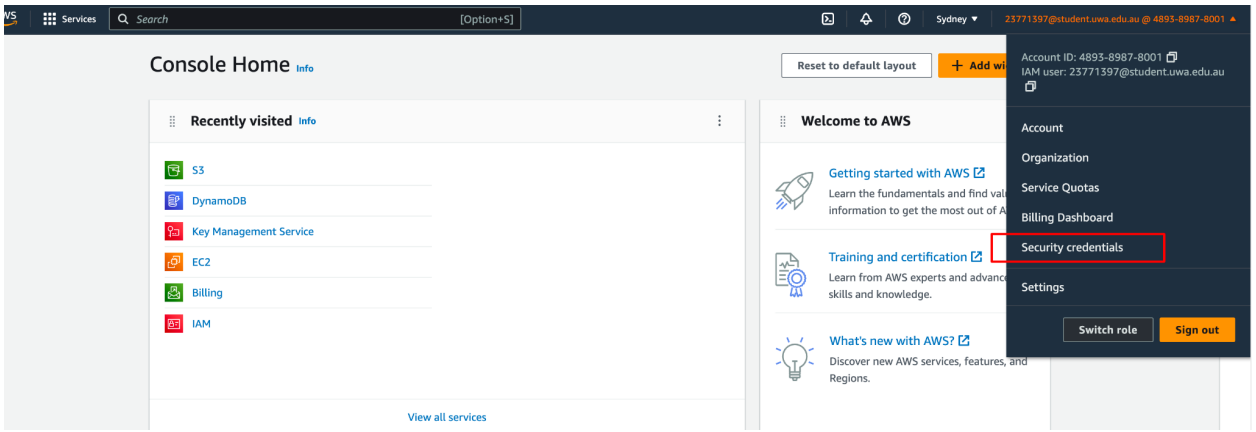
Installed **aswcli** which is a command line interface to interact with AWS. “AWS CLI," stands for Amazon Web Services Command Line Interface. It is a command-line tool provided by AWS that allows users to interact with AWS services using commands in the terminal or command prompt. The AWS CLI enables you to manage and configure AWS resources, and perform tasks such as creating and managing EC2 instances, S3 buckets, and more, all from the command line. It provides an alternative to using the AWS Management Console web interface for interacting with AWS services.




**Steps to create access key using AWS Management Console**

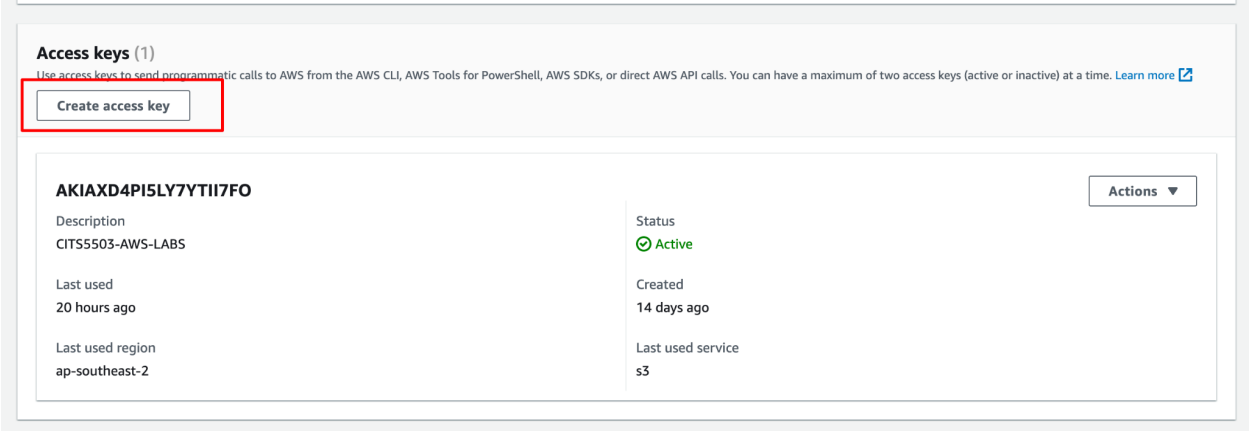
Step 6a:

Click on the Security Credentials tab to open security details page.



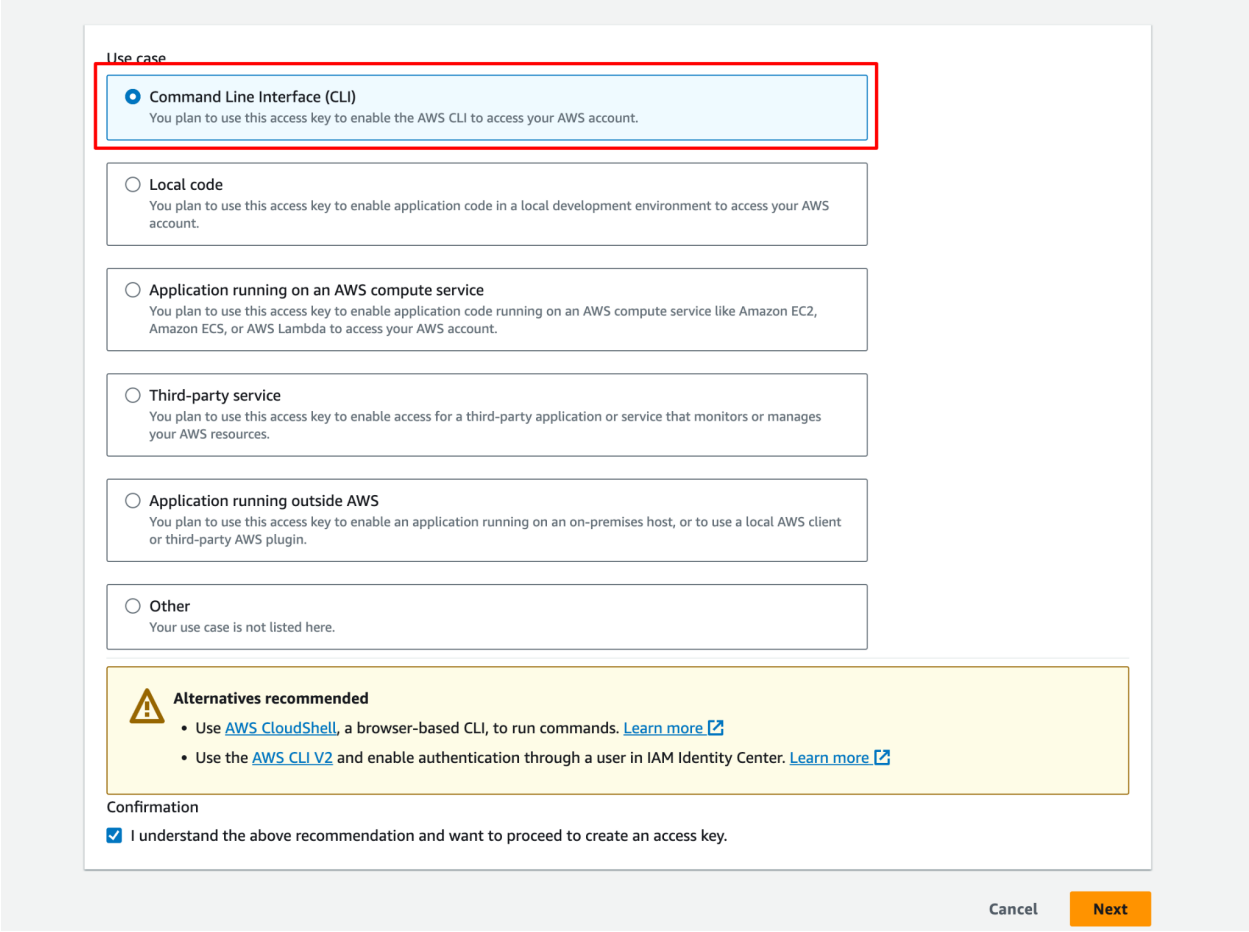

Step 6b:

Choose ‘Create Access key’



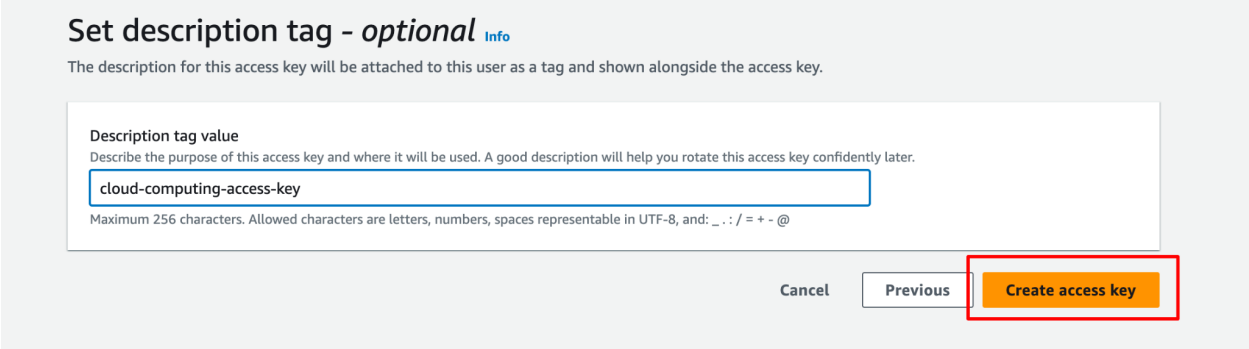

Step 6c:

Select CLI option to use access key for awscli



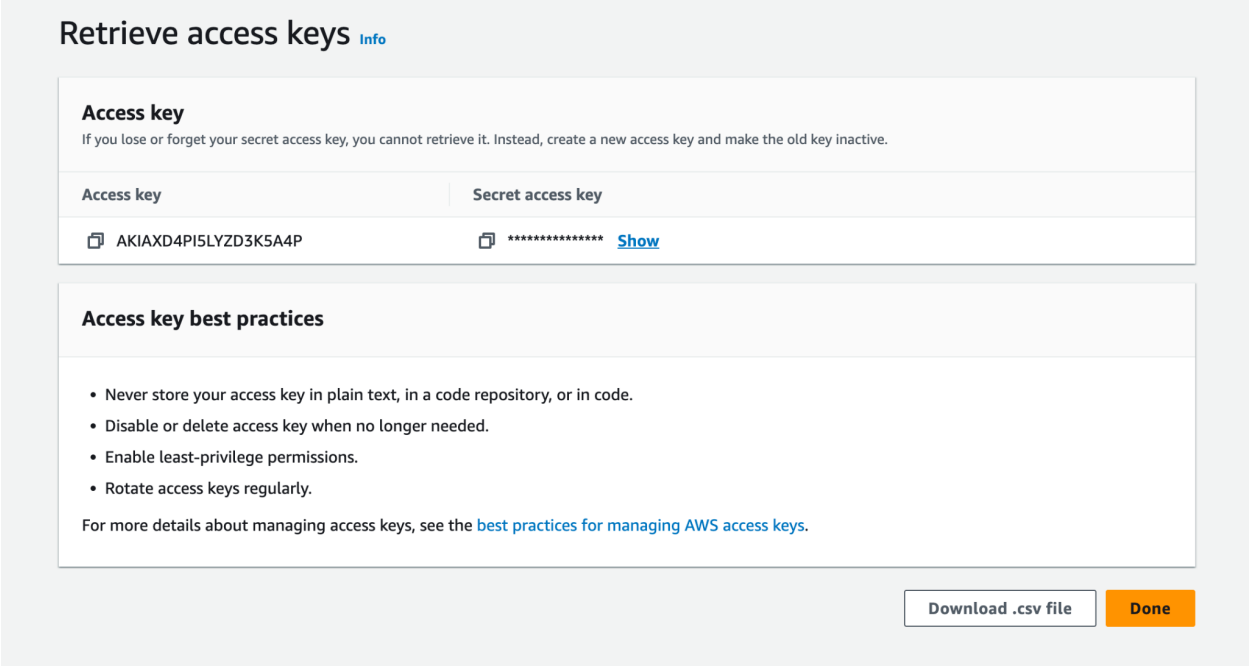

Step 6d:

Add tag to remember and manage access key




Step 6e:

Download .csv file for future reference.




Step 7:

Configured AWS CLI with Access key and Secret key. Access Key ID acts as username and secret Key acts as password for the aws cli. These should never be shared and stored securely. The command `**aws configure**` is used to set up the configuration for the AWS CLI (Command Line Interface) on our local machine. When we run this command, we be prompted to provide our AWS Access Key ID, Secret Access Key, default region, and output format preferences. These credentials are used by the AWS CLI to authenticate your interactions with AWS services. Once configured, we can use the AWS CLI to manage and interact with your AWS resources using command-line commands.

```
┌──(pritam㉿kali)-[~]
└─$ aws configure
AWS Access Key ID [None]: [redacted]
AWS Secret Access Key [None]: [redacted]
Default region name [None]: ap-southeast-2
Default output format [None]: json

┌──(pritam㉿kali)-[~]
└─$
```

Step 8:

Tested the AWS environment by running:

Using the command `**aws ec2 describe-regions --output table**` in your AWS environment retrieves a list of available regions for Amazon EC2 instances and displays them in a tabular format. This command provides us with information about the various regions where we can deploy our EC2 instances, helping us understand the geographical options for hosting our resources. It's a useful way to explore and test your AWS environment's regional availability using the AWS CLI.

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

```
┌──(aws-env)─(pritam㉿kali)-[~/Desktop/aws-env]
└─$ 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      ||
|+-----------------------------------------+-----------------------+-----------------+|
```

In AWS, an "endpoint" refers to the URL or network address that we use to access a specific AWS service within a particular region. Each AWS service has its own endpoint in each region.

The endpoint is used to make API requests and interact with that specific service in the chosen region.

A "region" in AWS is a geographic area where AWS has data centers. Each region is composed of multiple availability zones, which are essentially separate data centers within that region. AWS offers a variety of services in each region, and resources (like EC2 instances, S3 buckets, etc.) are provisioned within a chosen region.

### Step 9:

Tested python environment by running the following in python interpreter.

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

```
ec2 = boto3.client('ec2'):

This line creates an EC2 (Elastic Compute Cloud) client using the boto3 library. The ec2 object will be used to make API requests to EC2 services.

response = ec2.describe_regions():

This line sends an API request to the EC2 service to retrieve information about available regions. The describe_regions() method returns a response containing details about the regions.
```

This will create an un-tabulated response which can be formatted by writing a Python script. I tabulated the output to have 2 columns with Endpoint and RegionName. I installed the tabulate library for formatting using the following command.

```
pip3 install tabulate
```

```python
import boto3

from tabulate import tabulate

ec2 = boto3.client('ec2')

response = ec2.describe_regions()

# print(response)

table = []


for region in response['Regions']:
    table.append([region['Endpoint'], region['RegionName']])


print(tabulate(table, headers=["Endpoint", "RegionName"]))
```

Output of the above python script.

```
┌──(aws-env)─(pritam㉿kali)-[~/Desktop/aws-labs]
└─$ python3 tabulate-regions.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

┌──(aws-env)─(pritam㉿kali)-[~/Desktop/aws-labs]
└─$
```

# Lab 2:

## Create an EC2 instance using awscli

### Step 1: Create a security group

An AWS security group is a virtual firewall that controls inbound and outbound traffic to and from AWS resources. It operates based on rule-based access control, where you define rules specifying allowed or denied traffic based on IP address ranges and protocols. They are associated with AWS instances and provide instance-level security, allowing us to customize rules for different instances. By default, security groups have no inbound rules, and they employ an implicit deny rule for traffic types not explicitly allowed, helping enhance the security of your AWS resources.

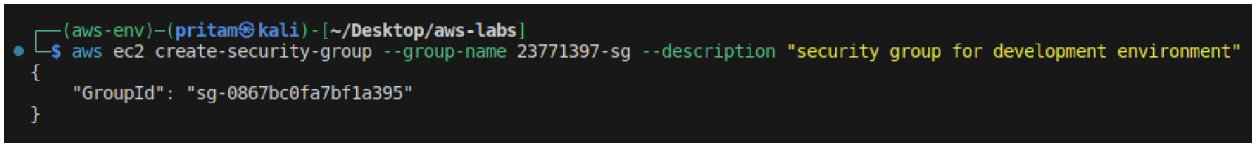
```
aws ec2 create-security-group --group-name <student number>-sg
--description "security group for development environment"
```

Here's what each part of the command does:

- **aws**: This is the AWS Command Line Interface executable.
- **ec2**: This specifies that we are working with Amazon EC2, which is the Elastic Compute Cloud service for managing virtual servers in the AWS cloud.
- **create-security-group:** This is the command to create a new security group.
- **--group-name <student number>-sg**: This is where we should replace `<student number>` with an actual value, like our student number or any unique identifier. It's used as the name of the security group we're creating. The `-sg` suffix indicates that it's a security group.
- **--description "security group for development environment"**: This is where you provide a description for the security group you're creating. It's a human-readable explanation of what the security group is used for.

Putting it all together, the command is used to create a new security group in Amazon EC2 with a specific name and description. Security groups act as virtual firewalls for your instances, controlling inbound and outbound traffic. They are used to define rules that allow or deny traffic based on protocols, ports, and IP ranges.

**Output**: The **GroupId** is a unique identifier assigned by AWS to represent a security group, which is a virtual firewall controlling inbound and outbound traffic for Amazon EC2 instances.




### Step 2: Authorise inbound traffic for ssh

```
aws ec2 authorize-security-group-ingress --group-name <student number>-sg
--protocol tcp --port 22 --cidr 0.0.0.0/0
```

Here's what each part of the command does:

- **authorize-security-group-ingress**: This is the command to add a rule that allows inbound traffic to a security group.
- **--group-name <student number>-sg**: We should replace `<student number>` with our actual identifier. This specifies the name of the security group to which you want to add the rule.
- **--protocol tcp**: Specifies the protocol for which we're allowing traffic. In this case, TCP is used, which is the protocol commonly used for many types of network communication.
- **--port 22**: Specify the port number that you want to allow traffic on. Port 22 is typically used for SSH (Secure Shell) connections, which are used for remote access to instances.
- **--cidr 0.0.0.0/0**: CIDR (Classless Inter-Domain Routing) notation specifies the range of IP addresses that are allowed to access the port. In this case, `0.0.0.0/0` means that traffic from any IP address is allowed.

The command authorizes inbound TCP traffic on port 22 (SSH) from any source IP address to the specified security group. This means that anyone can potentially access instances associated with this security group using SSH, which might be useful for development or administration purposes. However, allowing traffic from any IP address might also pose security risks in a production environment. It's generally recommended to restrict access to only trusted IP addresses or ranges.

**Output:** It gives the summary of all the things specified in the above command.

```
┌──(aws-env)─(pritam㉿kali)-[~/Desktop/aws-labs]
└─$ aws ec2 authorize-security-group-ingress --group-name 23771397-sg --protocol tcp --port 22 --cidr 0.0.0.0/0
{
    "Return": true,
    "SecurityGroupRules": [
        {
            "SecurityGroupRuleId": "sgr-0bcfbcbfdb6087cb1",
            "GroupId": "sg-0867bc0fa7bf1a395",
            "GroupOwnerId": "489389878001",
            "IsEgress": false,
            "IpProtocol": "tcp",
            "FromPort": 22,
            "ToPort": 22,
            "CidrIpv4": "0.0.0.0/0"
        }
    ]
}
```

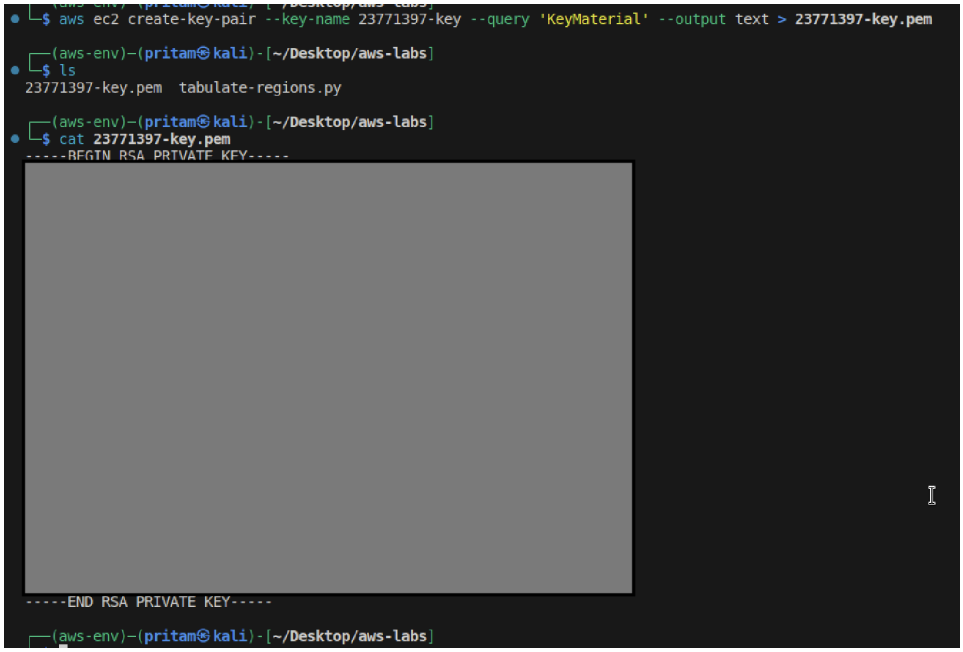
Step 3: Create a key pair that will allow you to ssh to the EC2 instance

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

- **create-key-pair**: This is the command to create a new key pair, which is used for secure authentication to EC2 instances.
- **--key-name <student number>-key**: We should replace `<student number>` with our actual identifier. This specifies the name of the key pair that we want to create. The `-key` suffix is commonly added to indicate that it's a key pair.
- **--query 'KeyMaterial'**: This specifies that we want to retrieve the private key material of the newly created key pair. The query expression `KeyMaterial` is used to extract the private key.
- **--output text**: This specifies the output format. In this case, we're requesting the output to be in plain text format.
- **`> <student number>-key.pem**: This part of the command directs the output (the private key material) to a file named `<student number>-key.pem`. The `>` symbol is used for output redirection.

The command creates a new key pair with the specified name, retrieves the private key material, and saves it to a file named `<student number>-key.pem`. This private key file is used for securely connecting to EC2 instances, particularly when using SSH to authenticate.

**Output**: The private key should not be shared




To use this key on Linux, we should copy the file to a directory ~/.ssh and change the permissions to:

```
chmod 400 <student number>-key.pem
```

The command **chmod 400 <student number>-key.pem** is used to change the permissions of the private key file <student number>-key.pem to make it more secure. The chmod command is used to modify the file permissions on Unix-like systems.

- chmod: Stands for "change mode," and it's a command to change the permissions of files or directories.
- 400: This is a numeric value representing the file permissions. In this case, it sets read permission only for the owner of the file (4 corresponds to read permission in octal notation). The file's owner has full read access to the private key.
- <student number>-key.pem: This should be replaced with the actual filename.

### Step 4: Create the instance and note the instance id

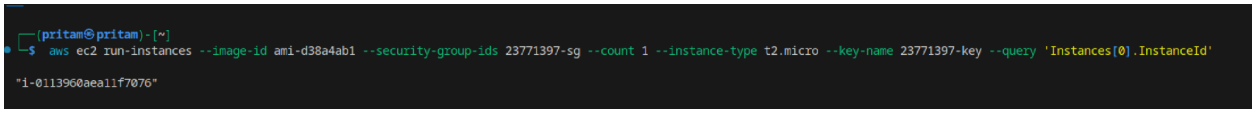
```
 aws ec2 run-instances --image-id ami-d38a4ab1 --security-group-ids
<student number>-sg --count 1 --instance-type t2.micro --key-name <student
number>-key --query 'Instances[0].InstanceId'
```

- **aws ec2 run-instances**: This is the AWS CLI command to launch new EC2 instances.

- **--image-id ami-d38a4ab1**: Specifies the ID of the Amazon Machine Image (AMI) we want to use for the instance.
- **--security-group-ids <student number>-sg**: Specifies the security group ID or name (<student number>-sg) to associate with the instance. This controls inbound and outbound traffic.
- **--count 1**: Indicates the number of instances to launch. In this case, it's set to 1.
- **--instance-type t2.micro:** Specifies the instance type, in this case, t2.micro, which is a small and cost-effective instance type.
- **--key-name <student number>-key:** Specifies the name of the key pair to use for SSH access to the instance.
- **--query 'Instances[0].InstanceId':** Uses JMESPath query language to extract the instance ID of the launched instance. This will be the output of the command, representing the unique identifier of the instance.

Running this command will launch a single EC2 instance with the specified configuration. The instance will be associated with the security group you've specified, allowing incoming traffic based on the security group rules.

**Output:** It gives the id of the ec2 instance running




Step 5: Get the public IP address

```
aws ec2 describe-instances --instance-ids i-<instance id from above>
--query 'Reservations[0].Instances[0].PublicIpAddress'
```

- **aws ec2 describe-instances**: This is the AWS CLI command to describe details of EC2 instances.
- **--instance-ids i-<instance id from above>**: Specifies the instance ID of the EC2 instance we want to describe. Replace <instance id from above> with the actual instance ID obtained from the previous command.
- **--query 'Reservations[0].Instances[0].PublicIpAddress':** Uses JMESPath query language to extract the public IP address of the instance from the response.

Running this command will return the public IP address associated with the specified EC2 instance, allowing you to access the instance remotely using SSH or other protocols.

**Output:** "3.25.60.149". Gives the public IP address of the ec2 instance running.


### Step 6: Connect to the instance

```
ssh -i <student number>-key.pem ubuntu@<IP Address>
```

- **ssh**: This is the command to initiate an SSH connection.
- **-i <student number>-key.pem**: Specifies the private key file (<student number>-key.pem) to use for authentication.
- **ubuntu**: This is the default username for Ubuntu instances on AWS EC2.
- **@<IP Address>**: Replace <IP Address> with the actual public IP address of the EC2 instance you want to connect to.

By executing this command, we'll be connecting to the EC2 instance using SSH, and the private key will be used for authentication. This allows us to access and manage the instance remotely through the terminal.

```
┌──(pritam㉿pritam)-[~/.ssh]
└─$ ssh -i 23771397-key.pem ubuntu@3.25.60.149
The authenticity of host '3.25.60.149 (3.25.60.149)' can't be established.
ED25519 key fingerprint is SHA256:ndj24B3mvvur5F7IQK2O2lqILpcNCTNy31TMDvJ6LX4.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '3.25.60.149' (ED25519) to the list of known hosts.
Welcome to Ubuntu 16.04.4 LTS (GNU/Linux 4.4.0-1052-aws x86_64)

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

  Get cloud support with Ubuntu Advantage Cloud Guest:
    http://www.ubuntu.com/business/services/cloud

0 packages can be updated.
0 updates are security updates.



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

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

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

ubuntu@ip-172-31-12-202:~$
```

## Create an EC2 instance with Python Boto script

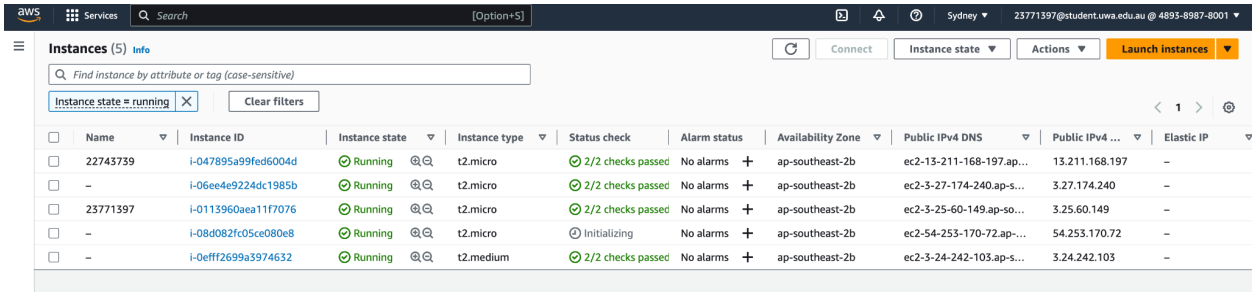
```python
import boto3

# Replace these with your actual credentials and region
aws_access_key = 'AKIAXD4PIXXXXXXXX'
aws_secret_key = 'XXXXX+XXXXXXXXX/Zw0Rt3Bxzo3XXXXX'
region_name = 'ap-southeast-2'

# Create a Boto3 EC2 client
ec2_client = boto3.client(
   'ec2',
```

```
    aws_access_key_id=aws_access_key,
    aws_secret_access_key=aws_secret_key,
    region_name=region_name
)

# Specify the parameters for the instance
instance_params = {
    'ImageId': 'ami-d38a4ab1',  # Replace with the desired Amazon Machine Image
(AMI) ID
    'InstanceType': 't2.micro',           # Replace with the desired instance
type
    'KeyName': '23771397-key',      # Replace with the key pair name you want to
use
    'MinCount': 1,
    'MaxCount': 1
}

# Create the instance
response = ec2_client.run_instances(**instance_params)

# Print the instance ID
instance_id = response['Instances'][0]['InstanceId']
print(f"Instance created with ID: {instance_id}")
```

Output: Running the above script creates an instance with the following id. It's easier to make changes with the **boto3** script than writing awscli commands.

```
┌──(pritam㉿pritam)-[~/Desktop/aws-labs/Lab-3]
└─$ python3 aws-boto-script.py
Instance created with ID: i-08d082fc05ce080e8
```

Creation of instance on the AWS Management Console with above script.



# AWS CLI Commands vs Boto3 Scripts (Python SDK):

**AWS CLI Commands:**

- **Syntax**: AWS CLI commands are entered directly into the command line interface.
- **Ease of Use**: Ideal for quick tasks and one-off operations that can be easily typed in.
- **Interactivity**: Provides a simple and interactive way to interact with AWS services.
- **Scripting**: Suitable for simple scripting and automation of straightforward tasks.

**Boto3 Scripts (Python SDK):**

- **Syntax**: Boto3 scripts are written in Python and use the Boto3 library.
- **Customization**: Offers extensive customization and control over AWS operations.
- **Complex Operations**: Well-suited for complex automation, handling dynamic conditions, and performing batch operations.
- **Modularity**: Code can be organized into functions and modules for reuse and maintainability.
- **Error Handling**: Provides robust error handling and retries in case of failures.

# Termination of EC2 Instance

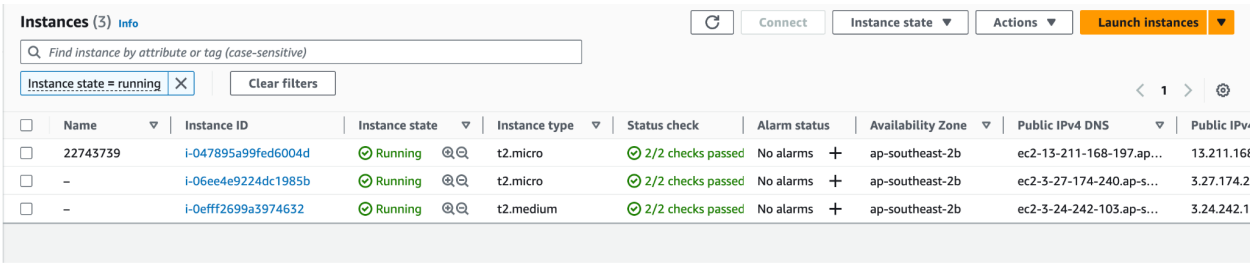
```
aws ec2 terminate-instances --instance-ids i-<your instance id>
```

- **aws ec2 terminate-instances**: This is the AWS CLI command to terminate EC2 instances.
- **--instance-ids i-<your instance id>**: Specifies the instance ID of the EC2 instance you want to terminate.

Executing this command will initiate the termination process for the specified EC2 instance. The instance will be shut down and eventually removed from the AWS account. We should be cautious when using this command, as terminated instances cannot be recovered, and their associated data may be lost.

```
┌──(pritam㉿pritam)-[~/Desktop/aws-labs/Lab-3]
└─$ aws ec2 terminate-instances --instance-ids i-08d082fc05ce080e8
{
    "TerminatingInstances": [
        {
            "CurrentState": {
                "Code": 32,
                "Name": "shutting-down"
            },
            "InstanceId": "i-08d082fc05ce080e8",
            "PreviousState": {
                "Code": 16,
                "Name": "running"
            }
        }
    ]
}
```

The instance is removed from the list of running instances



# Lab 3

An Amazon S3 (Simple Storage Service) bucket is a scalable and secure cloud storage container provided by Amazon Web Services (AWS). It is designed to store and manage vast amounts of data, including files, images, videos, backups, and more. S3 buckets act as global namespaces, and each bucket has a unique name across the entire AWS platform. Users can configure access controls and permissions to manage who can upload, download, or modify the stored data. S3 buckets offer features like versioning, encryption, lifecycle policies, and integration with other AWS services, making them a versatile and reliable solution for storing, archiving, and distributing data in the cloud.

## Step 1: Preparation and Save files to the S3 bucket.

First, we will create a local folder structure as follows:

```
rootdir
├── rootfile.txt
└── subdir
    └── subfile.txt
```

## Step 2: Save to S3 bucket

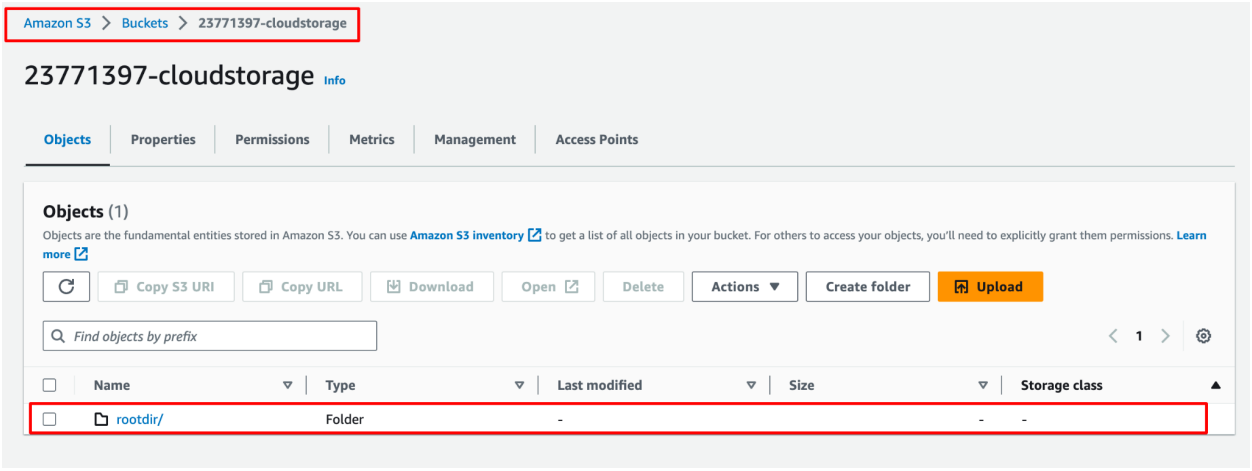
The following script scans a directory and uploads all of the files found in the directory to an S3 bucket, preserving the path information

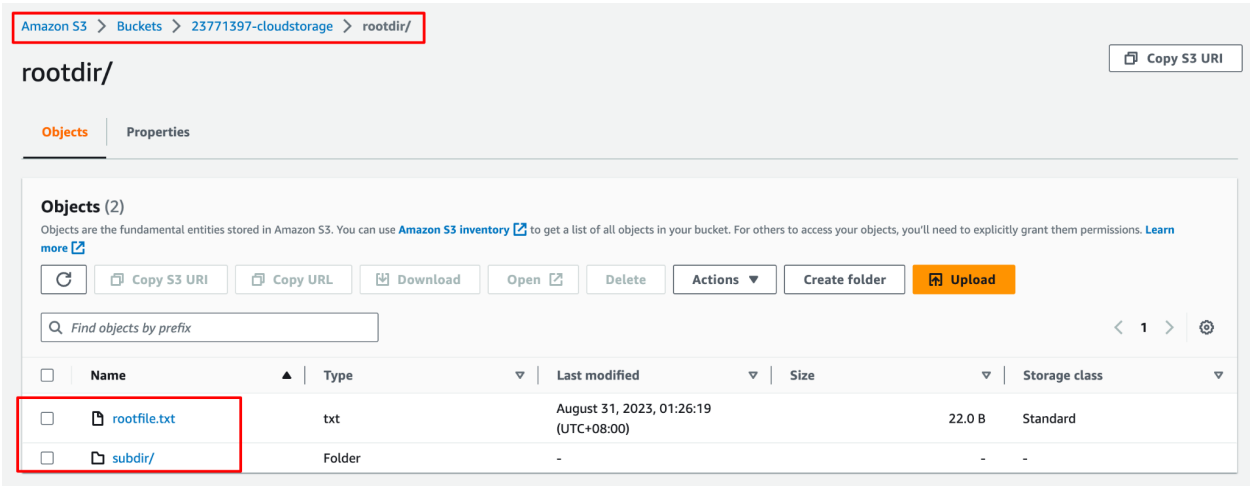
```python
import os
import boto3
import base64

# Constants
ROOT_DIR = '.'  # local root directory

bucket_name = '23771397-cloudstorage'  # S3 bucket name

s3 = boto3.client("s3")
bucket_config = {'LocationConstraint': 'ap-southeast-2'}

# Create the S3 bucket if it doesn't exist
try:
```

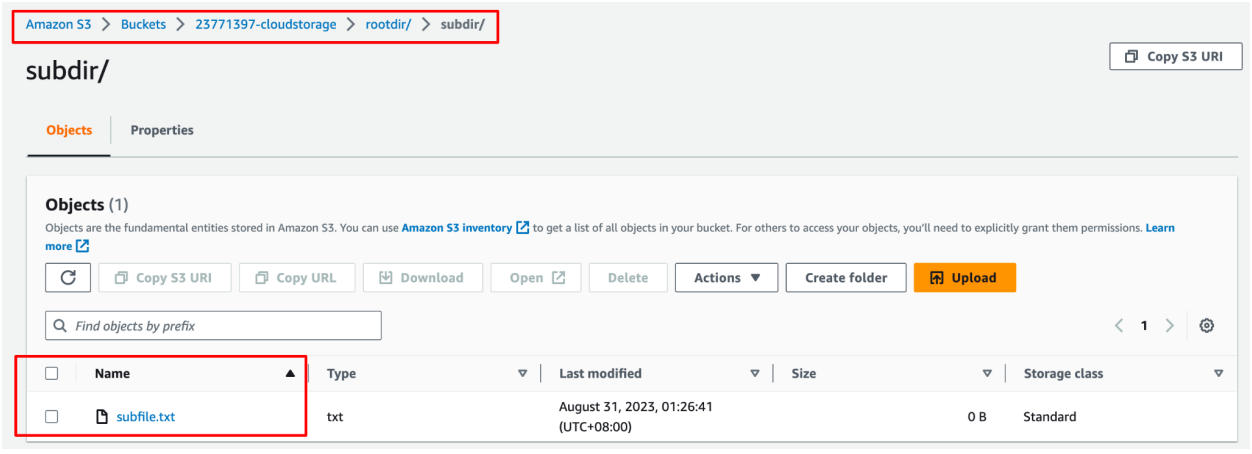
```
  s3.create_bucket(Bucket=bucket_name,
CreateBucketConfiguration=bucket_config)
except Exception as error:
  print("Bucket creation error:", error)


def upload_file(local_path, file_name):
  s3_path = f"{local_path}/{file_name}"
  local_file_path = os.path.join(local_path, file_name)
   print("Uploading", local_file_path, "to", s3_path)
   s3.upload_file(local_file_path, bucket_name, s3_path)


# Parse directory and upload files
for dir_name, subdir_list, file_list in os.walk(ROOT_DIR, topdown=True):
  if dir_name != ROOT_DIR:
      for fname in file_list:
          upload_file(dir_name[2:], fname)  # Remove the first two
characters from dir_name

print("done")
```

The provided Python script uses the Boto3 library to interact with Amazon S3. It creates an S3 bucket named '**23771397-cloudstorage**' in the **ap-southeast-2** region if it doesn't exist. The script then **recursively** traverses a local directory, uploading all files to the S3 bucket. It strips the first two characters from the local directory name before creating an S3 path to maintain the directory structure. Thus, the script automates the process of uploading local files to an S3 bucket while preserving the folder structure.

**Output**: In the AWS Management Console, we can find the same folder structure being preserved as the local folder structure. Refer to the following screenshots.




## Step 3: Restore from S3

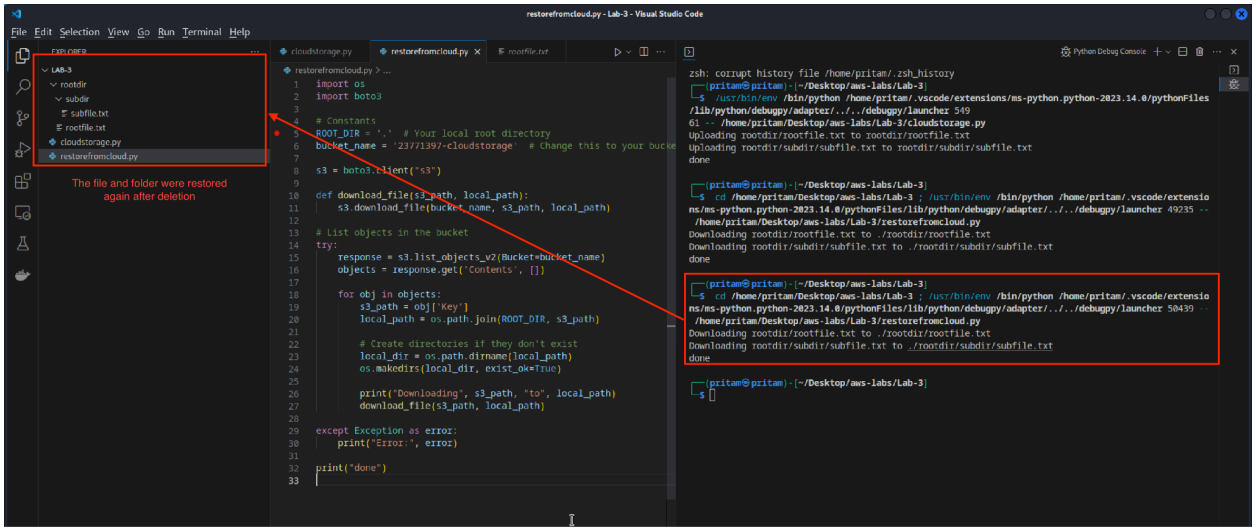
```
import os
import boto3

# Constants
ROOT_DIR = '.'  # Local root directory where files will be downloaded
bucket_name = '23771397-cloudstorage'  # S3 bucket name

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

def download_file(s3_path, local_path):
    """ Download a file from S3 to the local path."""
    s3.download_file(bucket_name, s3_path, local_path)

try:
    # List objects in the S3 bucket
    response = s3.list_objects_v2(Bucket=bucket_name)
    objects = response.get('Contents', [])

    for obj in objects:
        s3_path = obj['Key']
        local_path = os.path.join(ROOT_DIR, s3_path)

        # Create directories if they don't exist
        local_dir = os.path.dirname(local_path)
        os.makedirs(local_dir, exist_ok=True)

        # Download and save the file from S3 to the local path
        print("Downloading", s3_path, "to", local_path)
        download_file(s3_path, local_path)

except Exception as error:
    print("Error:", error)

print("done")
```

**Breakdown of the script:**

- The script sets the **ROOT_DIR** variable to the local directory where files will be downloaded and define the bucket_name for the S3 bucket.
- The S3 client is initialized using the boto3 library.
- The **download_file** function is defined to download a file from S3 to a local path.

- The script lists objects in the S3 bucket using the **list_objects_v2** method and iterates through each object.
- For each object, it constructs the **S3 path** and the **corresponding local path**.
- It creates directories on the local machine if they don't exist using **os.makedirs**.
- The script then downloads the file from S3 to the local path using the **download_file** function.
- If any exceptions occur during the process, they are caught and an error message is printed.

**Output**: After deleting the existing folder structure, the above script will download it again.



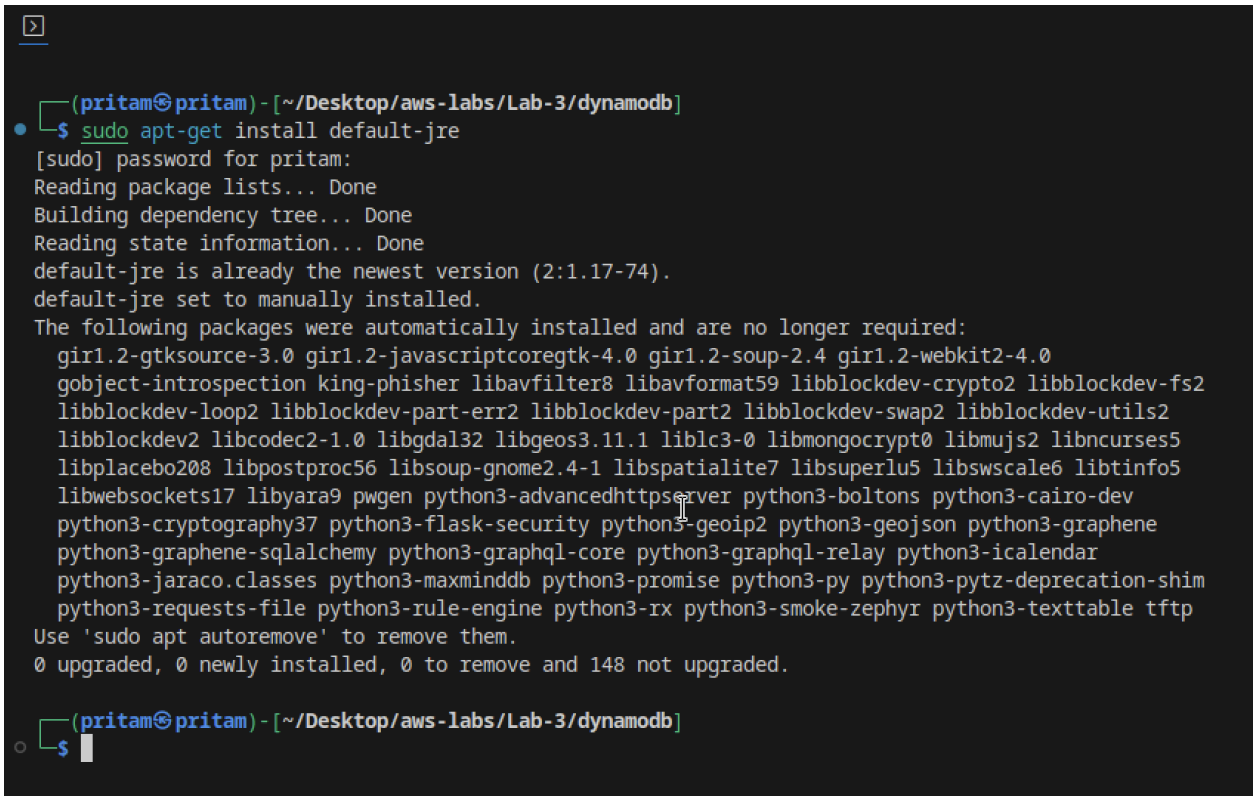

## Step 4: Write information about files to DynamoDB

Amazon DynamoDB is a fully managed NoSQL database service provided by Amazon Web Services (AWS). It is designed to deliver low-latency and high-performance access to data at any scale. DynamoDB offers features like automatic scaling, data replication, and seamless handling of read and write traffic fluctuations. It's suitable for a wide range of applications, including web and mobile apps, gaming, IoT, and more, where flexible and highly available database solutions are required.

### Step 4a: Installing JRE

```
sudo apt-get install default-jre
```

The command `**sudo apt-get install default-jre**` is used to install the default Java Runtime Environment (JRE) on a Debian-based Linux system. The JRE is necessary to run Java applications without the need for compiling source code.




Step 4b:

The provided commands download the latest version of Amazon DynamoDB Local—a local development and testing version of DynamoDB—using `wget`, and then start the DynamoDB Local server locally with shared in-memory databases for testing and development purposes using the Java Runtime Environment (JRE).

```
wget
https://s3-ap-northeast-1.amazonaws.com/dynamodb-local-tokyo/dynamodb_local
_latest.tar.gz
java -Djava.library.path=./DynamoDBLocal_lib -jar DynamoDBLocal.jar
-sharedDb
```

- **wget https://s3-ap-northeast-1.amazonaws.com/dynamodb-local-tokyo/dynamodb_local_latest.tar.gz**: This command uses the wget utility to download the latest version of the Amazon DynamoDB Local package as a compressed tarball (tar.gz) from the specified

URL. DynamoDB Local is a downloadable version of DynamoDB that runs locally for development and testing purposes.

- **java -Djava.library.path=./DynamoDBLocal_lib -jar DynamoDBLocal.jar –sharedDb:** This command starts the DynamoDB Local server using the Java Runtime Environment (JRE). The options and arguments used in this command are as follows:
    - **-Djava.library.path=./DynamoDBLocal_lib:** Sets the library path for DynamoDB Local dependencies.
    - **-jar DynamoDBLocal.jar:** Launches the DynamoDB Local JAR file.
    - **–sharedDb:** Specifies that multiple clients (connections) share the same in-memory database instance. This can be useful for local testing and development.

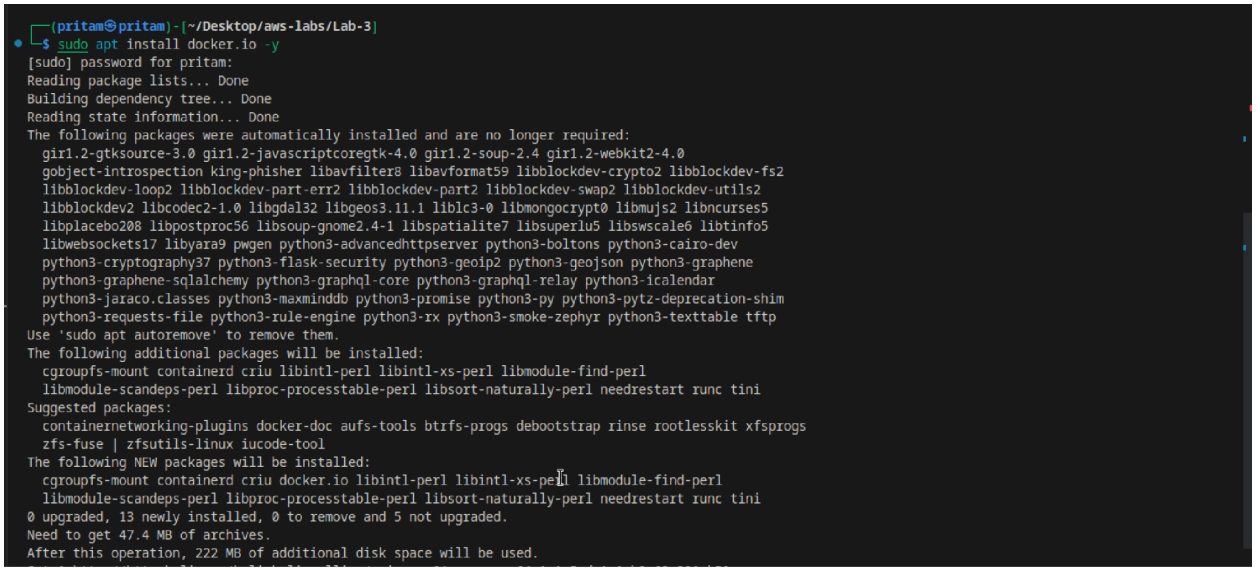
Step 5:

**The above code didn't work in my case. So, I used docker instead.**

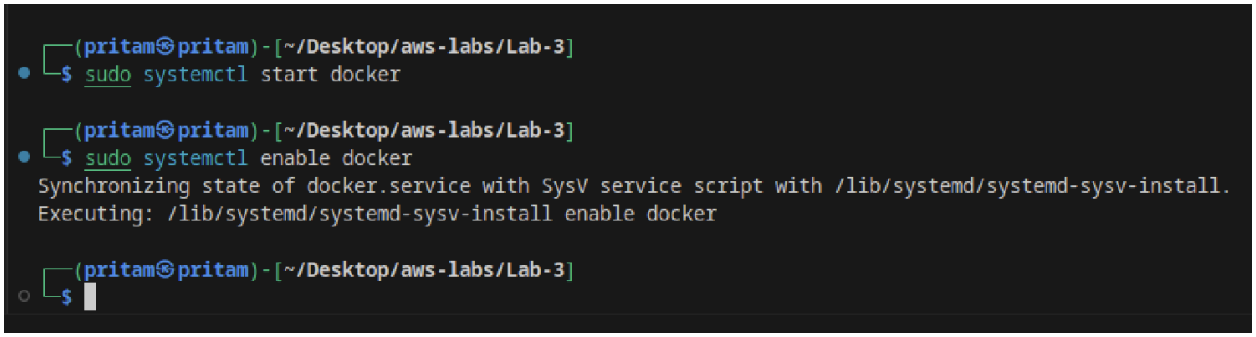
Step 5a: Installing and Managing Docker

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

The command sudo apt install docker.io -y is used to install Docker on a Debian-based Linux system.

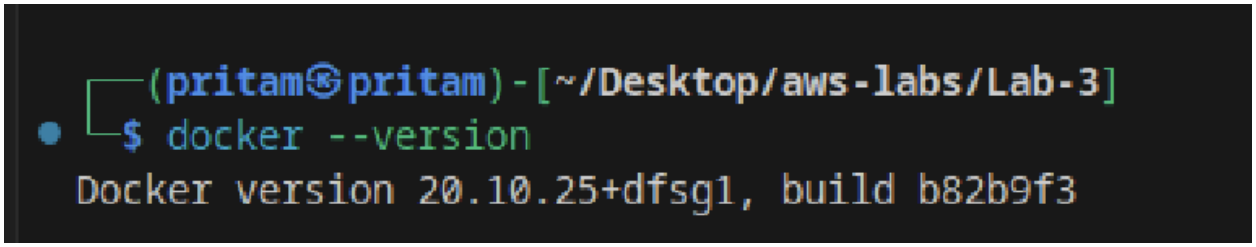


- **sudo systemctl start docker**: This command starts the Docker service immediately. The start action initializes the Docker daemon and allows us to use Docker commands.
- **sudo systemctl enable docker**: This command enables the Docker service to start automatically on system boot. The enable action ensures that Docker starts automatically whenever the system is started or restarted.




### Step 5b: Checking docker version

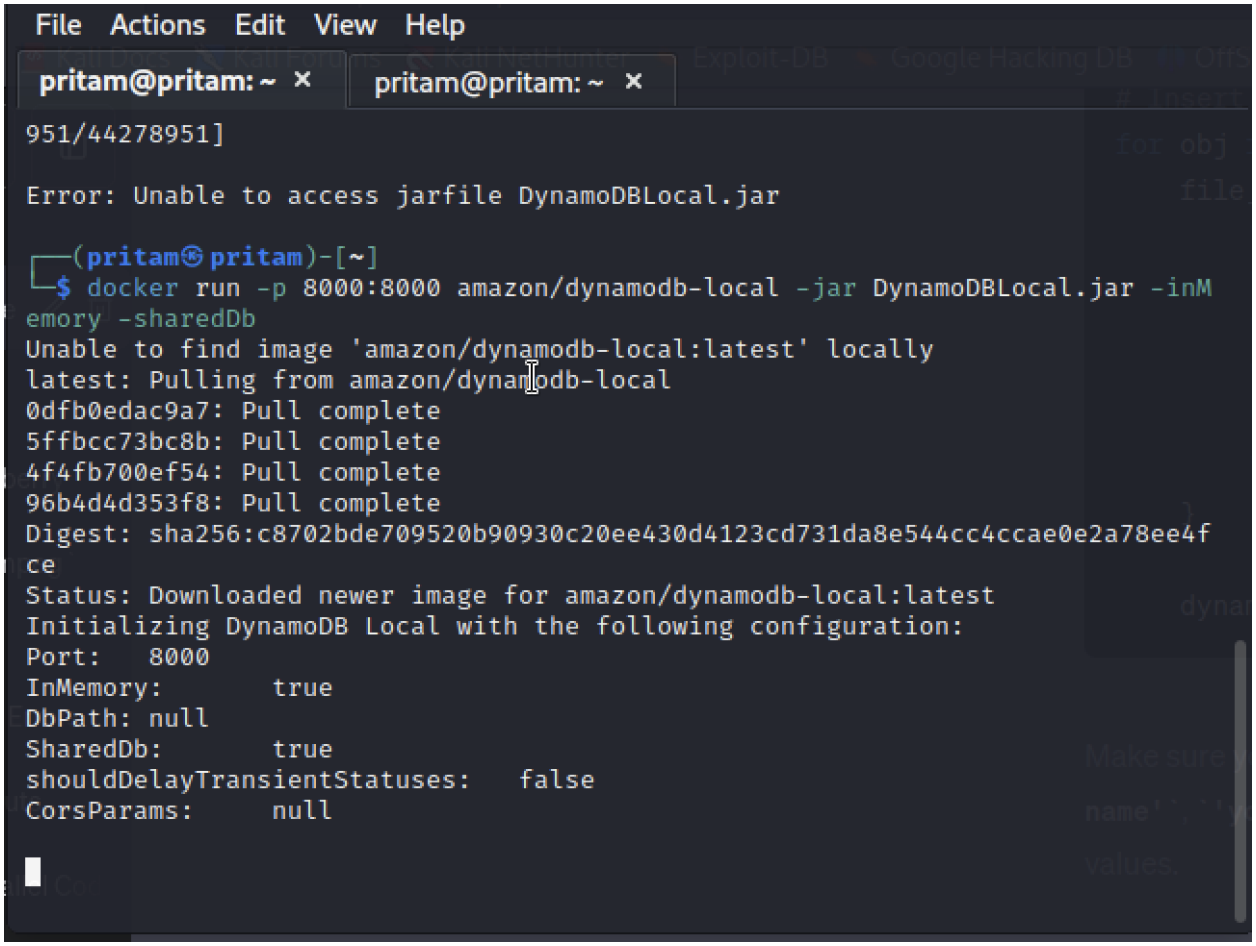
The command `**docker --version**` is used to display the version of the Docker software that is currently installed on your system. When you execute this command, it will provide the version information for Docker, which includes the version number and potentially additional details about the build and release. This helps us to verify the installed version and ensure compatibility with other tools and resources.




### Step 6: Running Amazon DynamoDB Local

```
docker run -p 8000:8000 amazon/dynamodb-local -jar DynamoDBLocal.jar
-inMemory -sharedDb
```

The `**docker run**` command starts a Docker container running Amazon DynamoDB Local, exposing port 8000 on the host machine for communication with the container's port 8000. The `**-jar DynamoDBLocal.jar -inMemory -sharedDb**` arguments configure DynamoDB Local to run in-memory with a shared database configuration, suitable for local testing and development.




Step 7: Create a table on local DynamoDB with the key userId

```python
import boto3

# Initialize DynamoDB client
dynamodb = boto3.resource('dynamodb')

# Table name
table_name = '23771397-CloudFiles'

# Create the table if it doesn't exist
def create_table():
    # Define the table schema and attributes
    table = dynamodb.create_table(
        TableName=table_name,

        # Define the primary key attributes (userId as HASH, fileName as RANGE)
```

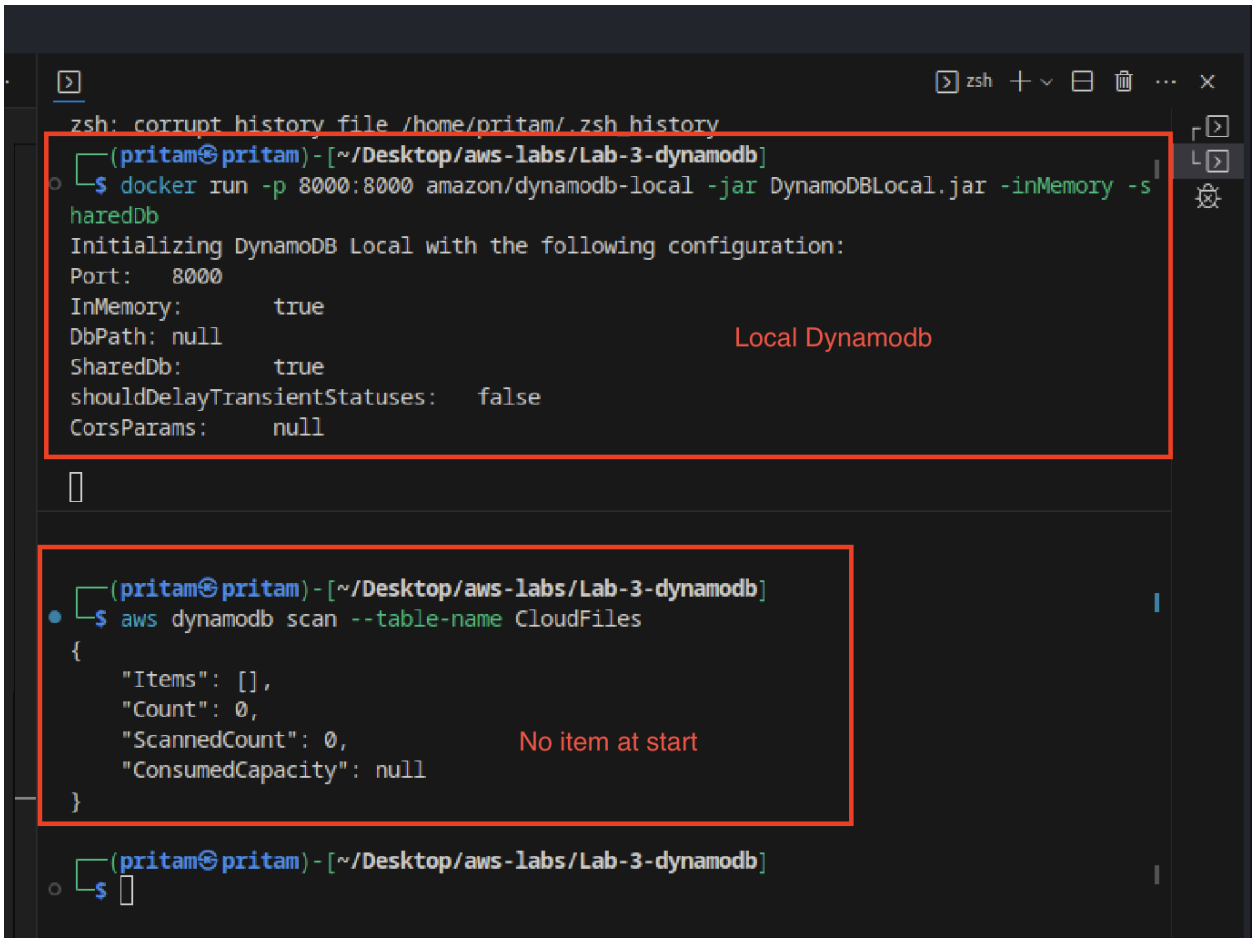
```
        KeySchema=[
            {
                'AttributeName': 'userId',
                'KeyType': 'HASH'
            },
            {
                'AttributeName': 'fileName',
                'KeyType': 'RANGE'
            }
        ],

        # Define the data types of the primary key attributes
        AttributeDefinitions=[
            {
                'AttributeName': 'userId',
                'AttributeType': 'S'  # String type
            },
            {
                'AttributeName': 'fileName',
                'AttributeType': 'S'  # String type
            }
        ],

        # Set the read and write capacity units
        ProvisionedThroughput={
            'ReadCapacityUnits': 5,
            'WriteCapacityUnits': 5
        }
    )

    # Wait for the table to be created before proceeding
    table.meta.client.get_waiter('table_exists').wait(TableName=table_name)

if __name__ == "__main__":
    # Call the create_table function when the script is directly executed
    create_table()
    print("Table creation done")
```

The script initializes a Boto3 DynamoDB resource client to interact with DynamoDB.

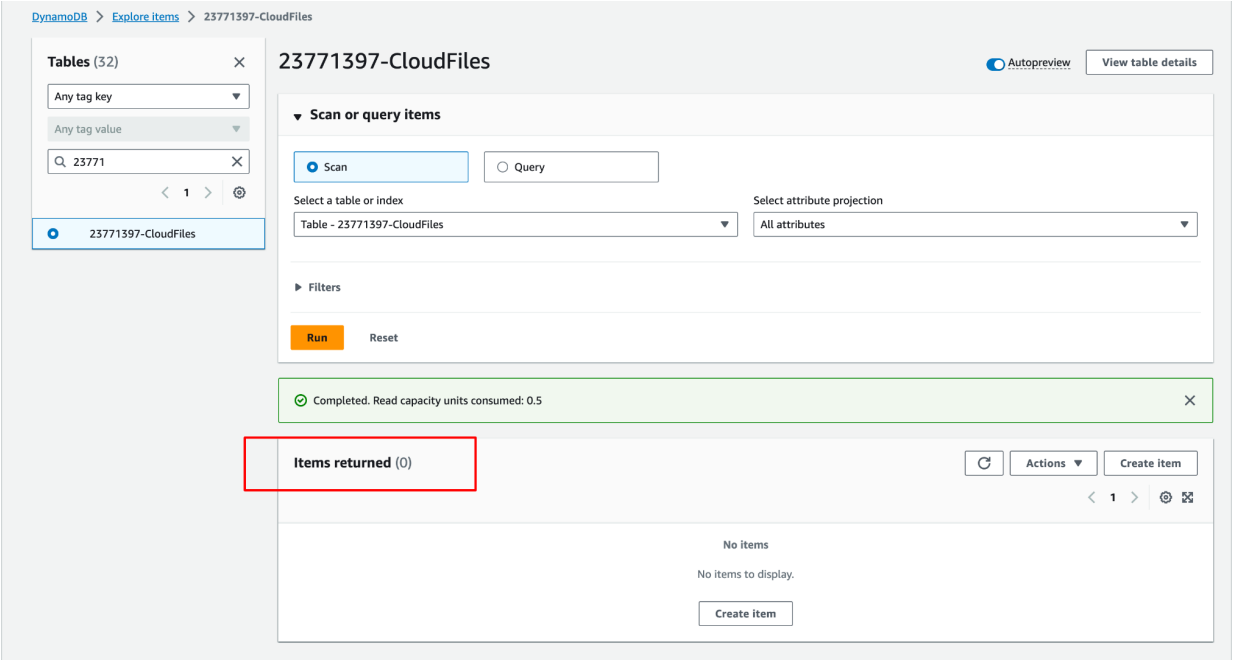
- A constant **table_name** is set to '23771397-CloudFiles'.
- The **create_table** function is defined to create a DynamoDB table with the specified schema and attributes.
- Inside **create_table**, **dynamodb.create_table** is called with:
    - TableName set to **table_name**.

    - KeySchema defining the primary key attributes: **'userId'** as HASH and **'fileName'** as RANGE.
    - **AttributeDefinitions** specifying the data types of the primary key attributes.
    - **ProvisionedThroughput** setting read and write capacity units.
- The script waits for the table to be created using **get_waiter('table_exists').wait()**.
- If the script is directly executed (using __name__), the create_table function is called, and a message is printed indicating that table creation is done.

Output: The following screenshot shows that the table has been created with zero items initially.



Step 7b: Created table on AWS Management Console as well




Step 8: Store information S3 Object information in Dynamodb table

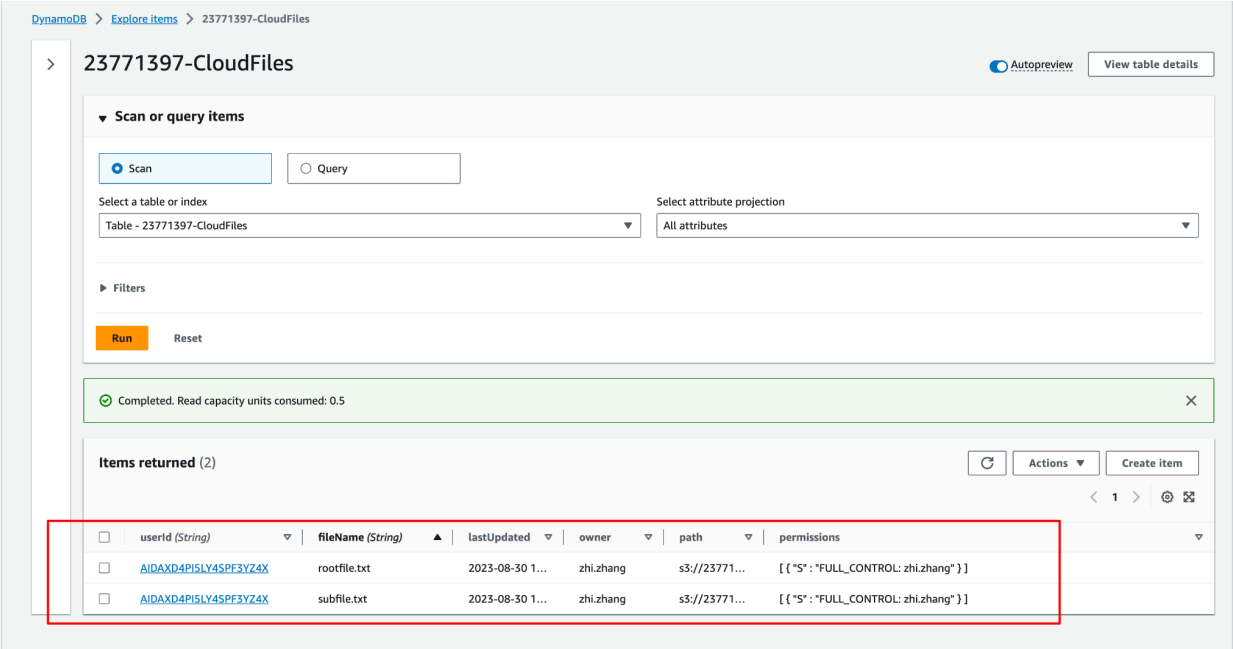
```
import os
import boto3
from datetime import datetime

# Initialize AWS clients
s3 = boto3.client('s3', region_name='ap-southeast-2')  # S3 client
dynamodb = boto3.resource('dynamodb')  # DynamoDB resource client
table = dynamodb.Table('23771397-CloudFiles')  # DynamoDB table
bucket_name = '23771397-cloudstorage'  # S3 bucket name
iam = boto3.client('iam')  # IAM client

# Get information about the IAM user
response = iam.get_user()
user_id = response['User']['UserId']  # Extract user ID

# List objects in the S3 bucket
objects = s3.list_objects(Bucket=bucket_name)

# Loop through S3 objects
for obj in objects.get('Contents', []):
    file_key = obj['Key']
```

```
    file_name = os.path.basename(file_key)  # Extract file name from object key
    file_path = f"s3://{bucket_name}/{file_key}"  # Formulate S3 object path
    last_updated = obj['LastModified'].strftime('%Y-%m-%d %H:%M:%S')  # Convert
last modified timestamp to formatted string
    owner = obj['Owner']['DisplayName']  # Extract owner's display name

    # Fetch object ACLs
    object_acl = s3.get_object_acl(Bucket=bucket_name, Key=file_key)
    permissions = []
    for grant in object_acl['Grants']:
        permission = grant['Permission']
        grantee = grant['Grantee']['DisplayName']
        permissions.append(f"{permission}: {grantee}")  # Store permission and
grantee information

    # Insert data into DynamoDB
    item = {
        'userId': user_id,
        'fileName': file_name,
        'path': file_path,
        'lastUpdated': last_updated,
        'owner': owner,
        'permissions': permissions  # Store permissions information
    }
    table.put_item(Item=item)  # Put item into DynamoDB table
    print(f"Inserted item for '{file_name}' into DynamoDB.")

print("Data insertion complete.")
```

The script interacts with AWS services (S3, DynamoDB, and IAM) to process and insert data about S3 objects into a DynamoDB table.

- It initializes the AWS clients for S3, DynamoDB, and IAM, sets the table name and bucket name, and gets the IAM user's ID.
- The script lists objects in the S3 bucket and loops through each object.
- For each object, it extracts the file name, creates an S3 object path, formats the last modified timestamp, and fetches the object's ACLs.
- Inside the ACL loop, it extracts permission and grantee information and stores them in a permissions list.
- It assembles the data into a dictionary (item) and uses table.put_item() to insert the item into the DynamoDB table.
- Information about the inserted item is printed to the console.

- Once all objects are processed, a message is printed indicating the completion of data insertion.




**Note**: Make sure to add sort key as well as partition key .Otherwise, the useid would be same and was being overwritten by new item everytime

# Lab 4

A bucket policy in AWS is a JSON-based access control configuration that allows you to define fine-grained permissions for an Amazon S3 bucket. It specifies who can access the bucket and what actions they can perform on the objects within it. Bucket policies can grant or deny permissions to AWS accounts, IAM users, or even make objects publicly accessible. These policies are a powerful way to control access to your S3 resources and are commonly used for tasks like setting up cross-account access, enabling public website hosting, or enforcing data retention policies.

## Step 1: Apply policy to restrict permissions on bucket

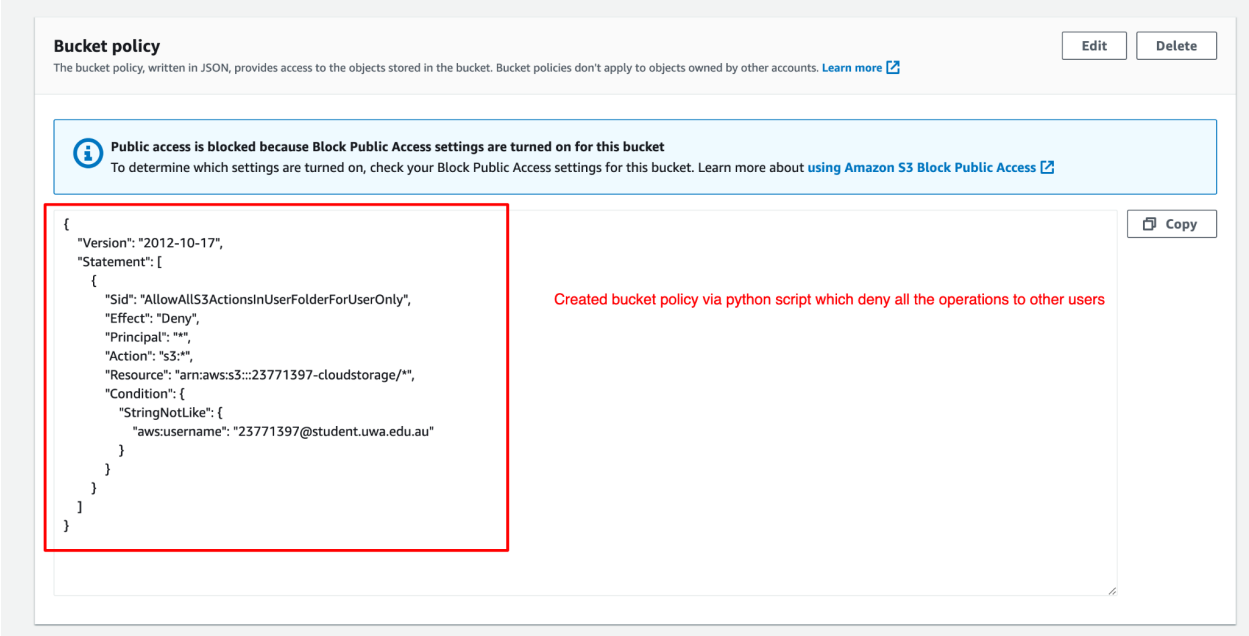
```
import boto3
import json

# Replace these values with your actual values
bucket_name = "23771397-cloudstorage"
username = "23771397@student.uwa.edu.au"

# Policy dictionary
policy = {
    "Version": "2012-10-17",
    "Statement": {
        "Sid": "AllowAllS3ActionsInUserFolderForUserOnly",
        "Effect": "DENY",
        "Principal": "*",
        "Action": "s3:*",
        "Resource": f"arn:aws:s3:::{bucket_name}/*",
        "Condition": {
            "StringNotLike": {
                "aws:username": username
            }
        }
    }
}

# Convert policy dictionary to JSON
policy_json = json.dumps(policy)

# Initialize the S3 client
s3 = boto3.client('s3')

# Apply the policy to the bucket
```

```
s3.put_bucket_policy(
    Bucket=bucket_name,
    Policy=policy_json
)
print("Policy applied successfully.")
```

The script uses Boto3 to apply a bucket policy to an S3 bucket.

- It defines a policy dictionary with a policy statement that **denies** all S3 actions for users other than **the specified username.**
- The S3 client is initialized, and **s3.put_bucket_policy()** is used to apply the policy to the specified bucket.

In S3 bucket, the above code will add the following policy as attached on screenshot.




When other IAM user try to access the bucket, they will get following error message.

## Step 2:  AES Encryption using KMS

AWS Key Management Service (KMS) is a managed service that enables the creation and control of cryptographic keys for securing sensitive data. It provides centralized management of encryption keys used to encrypt and decrypt data within AWS services and applications. KMS offers features like key rotation, audit logging, and integration with various AWS services, making it easier to enforce encryption best practices. It helps ensure the security and privacy of data by allowing users to manage encryption keys without the complexity of manual key management.

### Step 2a: Creating KMS Policy

```
import boto3
import json

# Replace these with your actual values
alias_name = "23771397-t"
username = "23771397@student.uwa.edu.au"


kms_policy = {
   "Version": "2012-10-17",
   "Id": "key-consolepolicy-3",
   "Statement": [
       {
           "Sid": "Enable IAM User Permissions",
           "Effect": "Allow",
           "Principal": {
               "AWS": "arn:aws:iam::489389878001:root"
           },
           "Action": "kms:*",
           "Resource": "*"
       },
       {
           "Sid": "Allow access for Key Administrators",
           "Effect": "Allow",
           "Principal": {
               "AWS": f"arn:aws:iam::489389878001:user/{username}"
           },
           "Action": [
               "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": "*"
        },
        {
            "Sid": "Allow use of the key",
            "Effect": "Allow",
            "Principal": {
                "AWS": f"arn:aws:iam::489389878001:user/{username}"
            },
            "Action": [
                "kms:Encrypt",
                "kms:Decrypt",
                "kms:ReEncrypt*",
                "kms:GenerateDataKey*",
                "kms:DescribeKey"
            ],
            "Resource": "*"
        },
        {
            "Sid": "Allow attachment of persistent resources",
            "Effect": "Allow",
            "Principal": {
                "AWS": f"arn:aws:iam::489389878001:user/{username}"
            },
            "Action": [
                "kms:CreateGrant",
                "kms:ListGrants",
                "kms:RevokeGrant"
            ],
            "Resource": "*",
            "Condition": {
                "Bool": {
                    "kms:GrantIsForAWSResource": "true"
                }
            }
```

```
        }
    ]
}


print(kms_policy)

# Create KMS client
kms_client = boto3.client('kms')

# Create KMS key
key_response = kms_client.create_key()

key_id = key_response['KeyMetadata']['KeyId']

# Create alias for the key
kms_client.create_alias(
    AliasName=f'alias/{alias_name}',
    TargetKeyId=key_id
)

# Attach policy to the key
# policy = json.loads(policy_json)
kms_client.put_key_policy(
    KeyId=key_id,
    PolicyName='default',
    Policy=json.dumps(kms_policy)
)

print(f"KMS Key created with ID: {key_id}")
print(f"Alias '{alias_name}' created for the key")
print("Policy attached to the key")
```

The script uses Boto3 to automate the creation and configuration of an AWS KMS key.

- The **kms_policy** dictionary defines a comprehensive policy specifying permissions and actions for the KMS key.
- It initializes a KMS client using **boto3.client('kms').**
- A KMS key is created using **kms_client.create_key(),** and the **key_id** is extracted from the response.

- An alias for the key is created using **kms_client.create_alias(),** associating the alias with the generated key.
- The script attaches the defined kms_policy to the key using **kms_client.put_key_policy().**

## Step 3: Encrypt and decrypt the files using the KMS Client

```
import boto3

# Create an S3 client
s3_client = boto3.client('s3')

# Define your S3 bucket name
bucket_name = '23771397-cloudstorage'

def encrypt_file(file_path, kms_alias):
    with open(file_path, 'rb') as file:
        file_contents = file.read()

    kms_client = boto3.client('kms')
    response = kms_client.describe_key(KeyId=kms_alias)
    kms_key_id = response['KeyMetadata']['KeyId']

    encrypted_data = kms_client.encrypt(
        KeyId=kms_key_id,
        Plaintext=file_contents
    )

    return encrypted_data['CiphertextBlob']

def decrypt_data(encrypted_data, kms_alias):
    kms_client = boto3.client('kms')
    response = kms_client.describe_key(KeyId=kms_alias)
    kms_key_id = response['KeyMetadata']['KeyId']

    decrypted_data = kms_client.decrypt(
        KeyId=kms_key_id,
        CiphertextBlob=encrypted_data
    )

    return decrypted_data['Plaintext']

# Upload a file to S3
```

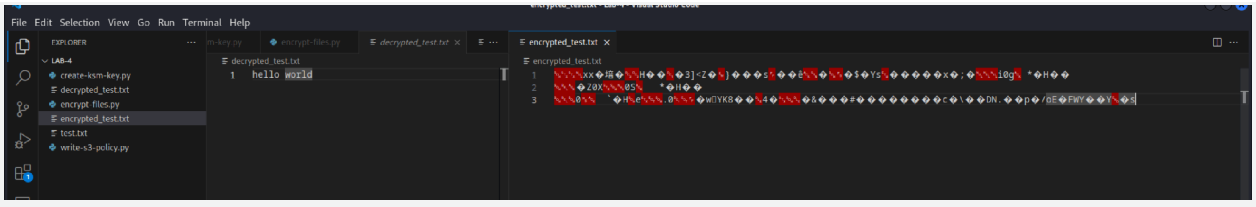
```
def upload_file_to_s3(file_path, s3_key):
    with open(file_path, 'rb') as file:
        s3_client.upload_fileobj(file, bucket_name, s3_key)

# Download a file from S3
def download_file_from_s3(s3_key, local_path):
    with open(local_path, 'wb') as file:
        s3_client.download_fileobj(bucket_name, s3_key, file)

# Usage
file_path = 'test.txt'
encrypted_file_path = 'encrypted_test.txt'
decrypted_file_path = 'decrypted_test.txt'
kms_alias = 'alias/23771397-t'

# Encrypt and upload the file
encrypted_data = encrypt_file(file_path, kms_alias)
s3_client.put_object(
    Bucket=bucket_name,
    Key=encrypted_file_path,
    Body=encrypted_data
)
print(f"Encrypted file uploaded to S3:
s3://{bucket_name}/{encrypted_file_path}")

# Download and decrypt the file
download_file_from_s3(encrypted_file_path, encrypted_file_path)
decrypted_data = decrypt_data(encrypted_data, kms_alias)

with open(decrypted_file_path, 'wb') as file:
    file.write(decrypted_data)

print(f"Decrypted file saved locally: {decrypted_file_path}")
```

The script initializes an S3 client and defines the bucket_name where files will be stored.

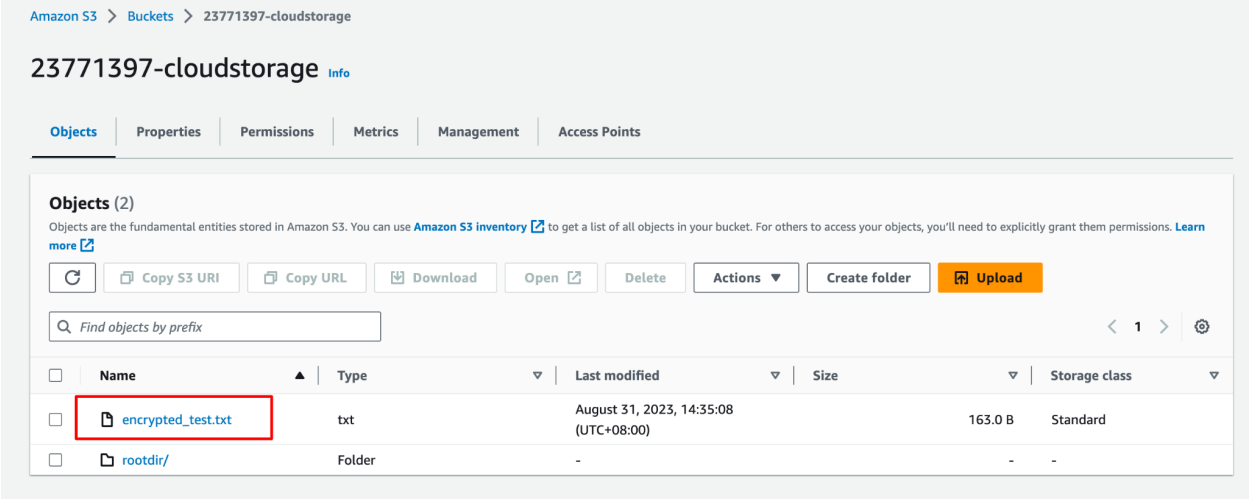
- Two functions, **encrypt_file** and **decrypt_data**, are defined to perform encryption and decryption using KMS.
- Additional functions, **upload_file_to_s3** and **download_file_from_s3**, are created to handle file uploads and downloads using the S3 client.
- The **encrypt_file** function is called to encrypt the contents of a file.
- The encrypted data is uploaded to the S3 bucket using **put_object**.
- The **download_file_from_s3** function is called to download the encrypted file.
- The **decrypt_data** function is used to decrypt the downloaded data.
- The decrypted data is written to a local file.

This script demonstrates how to securely upload, store, and manage encrypted files in an S3 bucket using KMS for encryption and decryption operations.

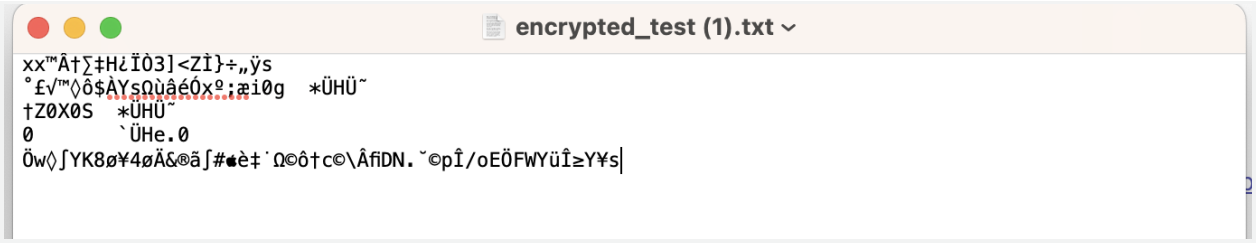
**Output**: Encrypted and decrypted file using KMS Client.




Encrypted file that has been uploaded to S3 bucket.




The contents of encrypted file.




## Step 4: AES Encryption using pycryptodome

```
import os, struct
from Crypto.Cipher import AES
from Crypto import Random
```

```python
import boto3
import hashlib


# Initialize the S3 client
s3_client = boto3.client('s3')

# Define your S3 bucket name
bucket_name = '23771397-cloudstorage'

# Define the chunk size for reading and writing files
CHUNK_SIZE = 64 * 1024

# Function to encrypt a file before uploading to S3 using AES
def encrypt_file(password, local_path, encrypted_path):
   # Generate a key from the password using SHA-256
   key = hashlib.sha256(password.encode("utf-8")).digest()

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

   with open(local_path, 'rb') as infile:
       with open(encrypted_path, 'wb') as outfile:
           # Write the original file size and IV to the encrypted file
           outfile.write(struct.pack('<Q', os.path.getsize(local_path)))
           outfile.write(iv)

           # Create an AES encryptor
           encryptor = AES.new(key, AES.MODE_CBC, iv)

           while True:
               chunk = infile.read(CHUNK_SIZE)
               if len(chunk) == 0:
                   break
               elif len(chunk) % 16 != 0:
                   # Pad the chunk if its size is not a multiple of 16 bytes
                   chunk += b' ' * (16 - len(chunk) % 16)

               outfile.write(encryptor.encrypt(chunk))

# Function to decrypt a file after downloading from S3 using AES
def decrypt_file(password, encrypted_path, decrypted_path):
   # Generate a key from the password using SHA-256
   key = hashlib.sha256(password.encode("utf-8")).digest()
```

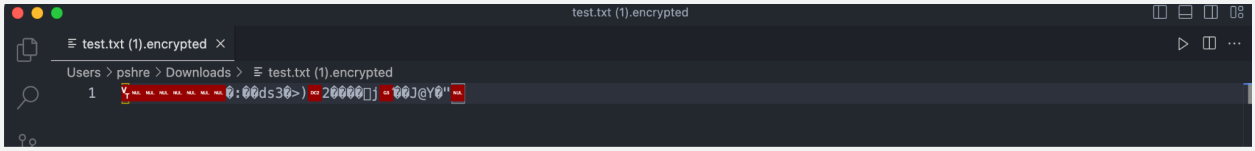
```
    with open(encrypted_path, 'rb') as infile:
        # Read the original file size and IV from the encrypted file
        origsize = struct.unpack('<Q', infile.read(struct.calcsize('Q')))[0]
        iv = infile.read(16)

        # Create an AES decryptor
        decryptor = AES.new(key, AES.MODE_CBC, iv)

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

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

# Example usage
password = 'kitty and the kat'
local_file_path = './test.txt'
s3_file_path = 'rootdir/test.txt.encrypted'

# Encrypt and upload the file to S3
encrypted_path = local_file_path + '.encrypted'
encrypt_file(password, local_file_path, encrypted_path)
s3_client.upload_file(encrypted_path, bucket_name, s3_file_path)
os.remove(encrypted_path)  # Remove the encrypted temporary file

# Download and decrypt the file from S3
downloaded_file_path = local_file_path + '.decrypted'
local_encrypted_path = local_file_path + '.encrypted'
s3_client.download_file(bucket_name, s3_file_path, local_encrypted_path)
decrypt_file(password, local_encrypted_path, downloaded_file_path)
os.remove(local_encrypted_path)  # Remove the downloaded encrypted file

print("File Uploaded")
```

Above is a Python script that uses the Crypto library for AES encryption and decryption, along with Boto3 for interacting with AWS S3. Here's an explanation of what this script does:

- It initializes the S3 client and defines the bucket_name where files will be stored in Amazon S3.
- The script defines a **CHUNK_SIZE** constant for reading and writing files in chunks.

- **encrypt_file**: This function takes a password, the local path of a file, and the desired path for the encrypted file. It encrypts the file using AES encryption with CBC mode and writes the encrypted content to the specified file path. It also prepends the original file size and an initialization vector (IV) to the encrypted file.
- decrypt_file: This function takes the same password, the path to the encrypted file, and the desired path for the decrypted file. It reads the encrypted file, extracts the original file size and IV, decrypts the content, and writes it to the specified decrypted file path.
- The example usage section demonstrates how to use these functions:
- A password is provided for encryption and decryption.
- A **local_file_path** points to the file we want to encrypt and upload to S3.
- An **s3_file_path** specifies the S3 destination for the encrypted file.
- The script encrypts the file using the encrypt_file function, uploads it to S3 using **s3_client.upload_file**, and then removes the temporary encrypted file.
- It also demonstrates downloading the encrypted file from S3, decrypting it using the **decrypt_file** function, and removing the downloaded encrypted file.

Encrypted File downloaded from AWS Management Console.




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

The performance difference between using AWS Key Management Service (KMS) and a custom encryption solution can vary depending on several factors, including the complexity of the encryption algorithm, the size of the data being encrypted, and the specific use case. Here are some considerations:

**KMS Performance:**

- **Managed Service**: KMS is a fully managed service provided by AWS. It is designed for high availability, scalability, and low latency. AWS manages the infrastructure and operations, ensuring consistent and reliable performance.

- **Hardware Acceleration**: AWS KMS uses hardware security modules (HSMs) for key storage and cryptographic operations. These HSMs are optimized for encryption and decryption tasks, which can result in high performance.
- **Integration**: KMS seamlessly integrates with various AWS services, making it easy to encrypt and decrypt data within the AWS ecosystem.

**Custom Encryption Solution Performance:**

- **Algorithm Choice**: The performance of a custom encryption solution depends on the encryption algorithm used. Some algorithms are computationally more intensive than others. AES (Advanced Encryption Standard) is a commonly used and efficient encryption algorithm.
- **Implementation**: The quality of the custom encryption implementation can significantly impact performance. Well-optimized code and parallelization techniques can improve speed.
- **Key Management:** Managing encryption keys securely in a custom solution can add complexity. If not handled properly, it can impact both security and performance.

**Performance Comparison:**

- For small to moderately-sized files, the performance difference between KMS and a well-optimized custom solution may not be significant.
- However, as the size of data and the number of encryption/decryption operations increase, KMS can often provide more consistent and predictable performance due to its optimized hardware and infrastructure.
- Custom solutions may offer more flexibility but require careful optimization to match KMS performance, especially at scale.