AWS Data Lake

This document goes through the AWS setup required to facilitate uploading of files and its subsequent insertion into a PostgreSQL database instance over AWS cloud services.

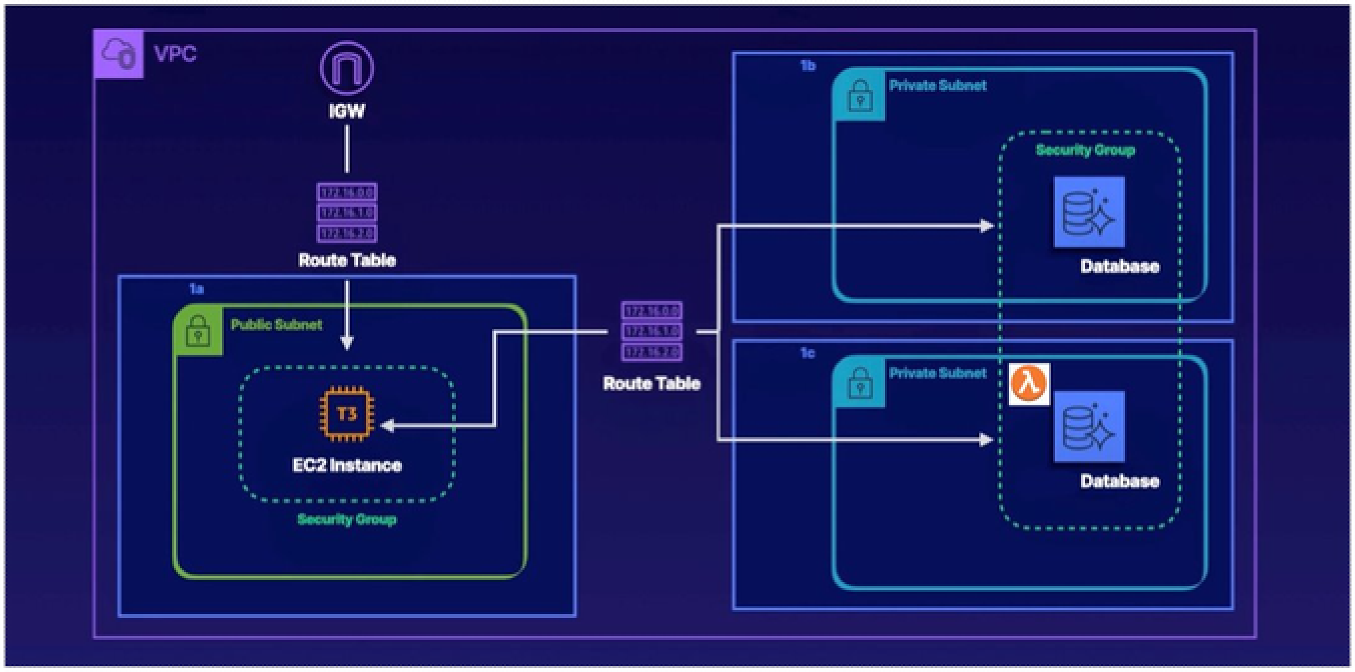
Login Page

Amazon Web Services Sign-In

Permissions

- Ensure that your AWS account has access to the following services:
  - S3
  - RDS
  - Lambda
  - SQS
  - IAM

Overall Architecture



We are going to setup an environment with the following components to host EC2 and databases for public access:

1. VPC (Virtual Private Cloud)
2. Subnets
   a. One public
   b. Two private
3. Internet Gateway
4. Route tables
5. Security Groups

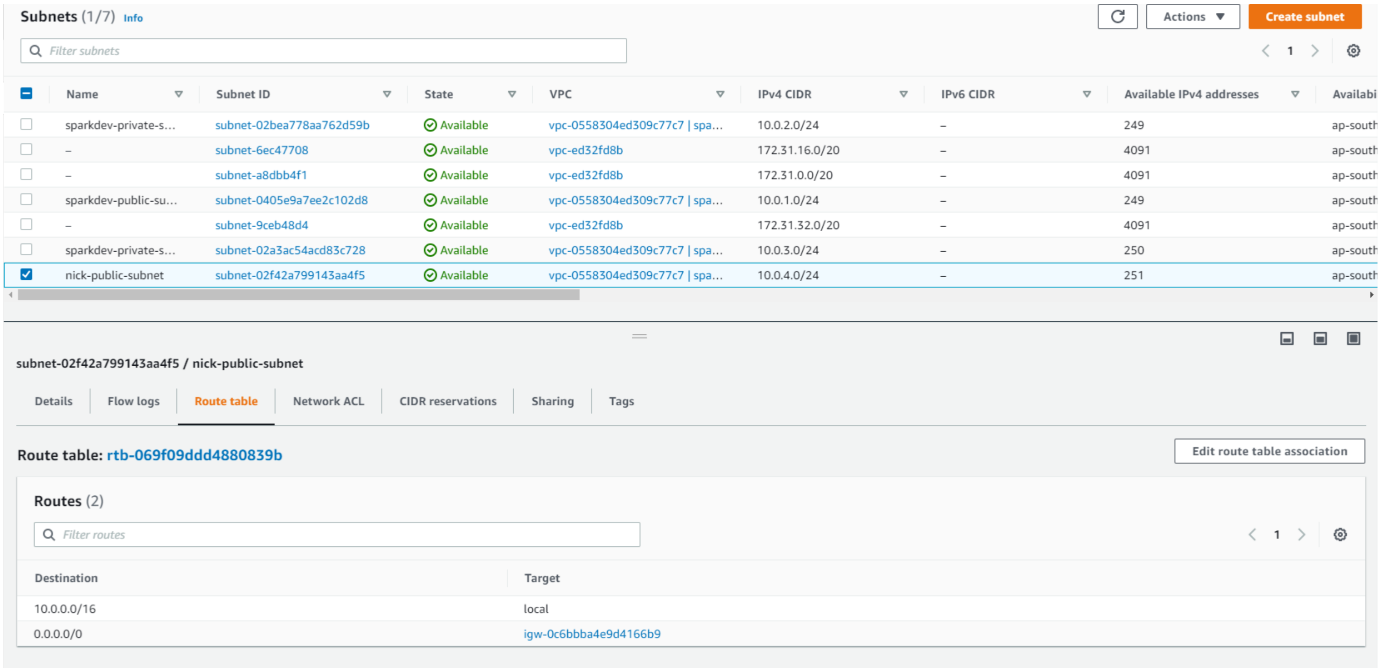
Creating VPC and Subnets

- Navigate to **VPC** page in the AWS management console
- Click on **Create VPC**
- Input a name (eg. sparkdev-vpc-01) and under IPv4 CIDR input 10.0.0.0/16
- Navigate to **Subnets** sub-directory on the left-hand side of the **VPC** page
- Click on **Create subnet** and specify the following details:

    - **VPC ID:** Select the VPC previously created (i.e. sparkdev-vpc-01)
    - **Subnet name:** This will be used as the public subnet, give it a valid name eg. sparkdev-public-subnet-1
    - **Availability zone:** Asia Pacific (Singapore) / ap-southeast-1a
    - **IPv4 Block:** 10.0.1.0/24
- Instead of creating subnet, we select the **Add new subnet** option
    - Name should include “private-subnet-1”
    - **Availability zone:** Asia Pacific (Singapore) / ap-southeast-1b
    - **IPv4 Block:** 10.0.2.0/24
- Select **Add new subnet** to create the final subnet
    - Name should include “private-subnet-2”
    - **Availability zone:** Asia Pacific (Singapore) / ap-southeast-1c
    - **Pv4 Block:** 10.0.3.0/24
- Click on the **Create subnet** option at the bottom right

Configuring subnets' route tables

- Navigate to **Internet gateways** in the **VPC** page, click **Create gateway**, give it a name
- Once created, click **Options** and attach to the **VPC** previously created
- Navigate to the public subnet created previously (**VPC Subnets sparkdev-public-subnet-1**)
- Click **Actions Modify auto-assign IP Enable auto-assign IPv4** then save
- Click on **Route table** and select the route table to enter the route table page
- Under **Routes**, click on **Edit routes**.
- Add route with destination 0.0.0.0/0 and target the internet gateway just created
- Go back to public subnet page, and click on **Network ACL**, then click on network id
- Edit **Inbound rules** and **Outbound rules** by changing the first rule (the Allow rule) to **Type: All TCP**
- Go to **Route table** page and click **Create route table**
- Give it a name eg. sparkdev-private-route-table, and create
- Go to both of the private subnets previously created **Route table Edit route table associations**
- Under **Route table ID,** select the sparkdev-private-route-table previously created and **Save**



Subnets (1/7)

	Name	Subnet ID	State	VPC	IPv4 CIDR	IPv6 CIDR	Available IPv4 addresses	Availabi
□	sparkdev-private-s...	subnet-02bea778aa762d59b	✓ Available	vpc-0558304ed309c77c7 | spa...	10.0.2.0/24	–	249	ap-south
□	–	subnet-6ec47708	✓ Available	vpc-ed32fd8b	172.31.16.0/20	–	4091	ap-south
□	–	subnet-a8dbb4f1	✓ Available	vpc-ed32fd8b	172.31.0.0/20	–	4091	ap-south
□	sparkdev-public-su...	subnet-0405e9a7ee2c102d8	✓ Available	vpc-0558304ed309c77c7 | spa...	10.0.1.0/24	–	249	ap-south
□	–	subnet-9ceb48d4	✓ Available	vpc-ed32fd8b	172.31.32.0/20	–	4091	ap-south
□	sparkdev-private-s...	subnet-02a3ac54acd83c728	✓ Available	vpc-0558304ed309c77c7 | spa...	10.0.3.0/24	–	250	ap-south
☑	nick-public-subnet	subnet-02f42a799143aa4f5	✓ Available	vpc-0558304ed309c77c7 | spa...	10.0.4.0/24	–	251	ap-south

subnet-02f42a799143aa4f5 / nick-public-subnet

Route table: rtb-069f09ddd4880839b

Routes (2)

Destination	Target
10.0.0.0/16	local
0.0.0.0/0	igw-0c6bbba4e9d4166b9

Note: The Internet gateway (igw-0c6bbba4e9d4166b9) is added in the table.

Configuring security groups

- Navigate to **Security Groups** page under **VPC > Security**

- Create a security group (eg name. Postgres-SG) with VPC specified as the one created above (i.e. sparkdev-vpc). Add an inbound rule with **Type:** PostgreSQL and **Source:** 10.0.0.0/16
- Create another security group (eg name. SSH-SG) with the same VPC as above and add an inbound rule with **Type:** SSH and **Source:** 0.0.0.0/0

Creating EC2 instance

- Navigate to **EC2** page in the AWS management console
- Select instances and **Launch instance** with the following specifications:
    - AMI - Amazon Linux 2 (Free Tier)
    - Instance type - Free Tier option then click on **Configure Instance Details**
    - Network - Select VPC previously created (i.e. sparkdev-vpc)
    - Subnet - Select the public subnet with internet gateway attached
    - Leave as default the next few pages, and under configure security groups, choose **Select an existing security group** and select the SSH-SG previously created
    - Select **Review and Launch > Launch**
    - When prompted with Key-Pair window, select **Create new key pair,** give it a name and click download key pair
    - **Save** your key pair file (required to access EC2 instance)
    - **Launch instance**

Creating RDS database instance

- Navigate to **RDS** page in the AWS management console
- First, on the left hand side of the page, click on **Subnet groups**
- Click on **Create DB subnet group** with the following specifications:
    - Name: Something appropriate (eg. PostgreSQL-RDS)
    - VPC: The VPC created previously (i.e. sparkdev-vpc)
    - Availability zones: The zones assigned to the private subnets (ap-southeast-1b and 1c)
    - Subnets: Both private subnets
- Now, navigate back to **Databases** in the **RDS** page
- Click on **Create Database**
- In the creation page, specify the following details:
    - **Choose a database creation method:** Standard create
    - **Engine options:** PostgreSQL
    - **Version:** Specify according to requirements, or just leave it as the default value
    - **Templates:** Free tier, unless otherwise needed
    - **Settings:** Specify details as needed. Store master username, password safely
    - **DB instance class:** Burstable classes (db.t2.micro), unless otherwise needed
    - **Storage:** default, unless otherwise needed
    - **Connectivity:**
        - VPC: The VPC created previously (i.e. sparkdev-vpc)
        - Subnet group: The group that was just created (i.e. PostgreSQL-RDS)
        - No public access
        - VPC Security group: De-select default and select the one previously created (i.e. Postgres-SG)
    - **Database authentication:** Password, unless otherwise needed.
    - **Additional configuration:** Include some database name, unless otherwise needed.

Connecting to RDS instance with DBeaver

- Open DBeaver Database New Database Connection
- Specify the following details for secure connection:
    - Host: Insert the rds database endpoint obtained from the RDS AWS management console page
    - Database: Some name, or the name specified when creating RDS instance (postgres etc.)
    - Username + Password: The master user and pass set during RDS creation (user: sparkdev, pass: Welcome2021!)
- Next, click the SSH header and specify the following:
    - Host/IP: Insert the public IPv4 address or the public IPv4 DNS
    - Username: Insert “ec2-user”
    - Authentication method: Public key and provide path to .pem file (default one below) created earlier for ec2 instance

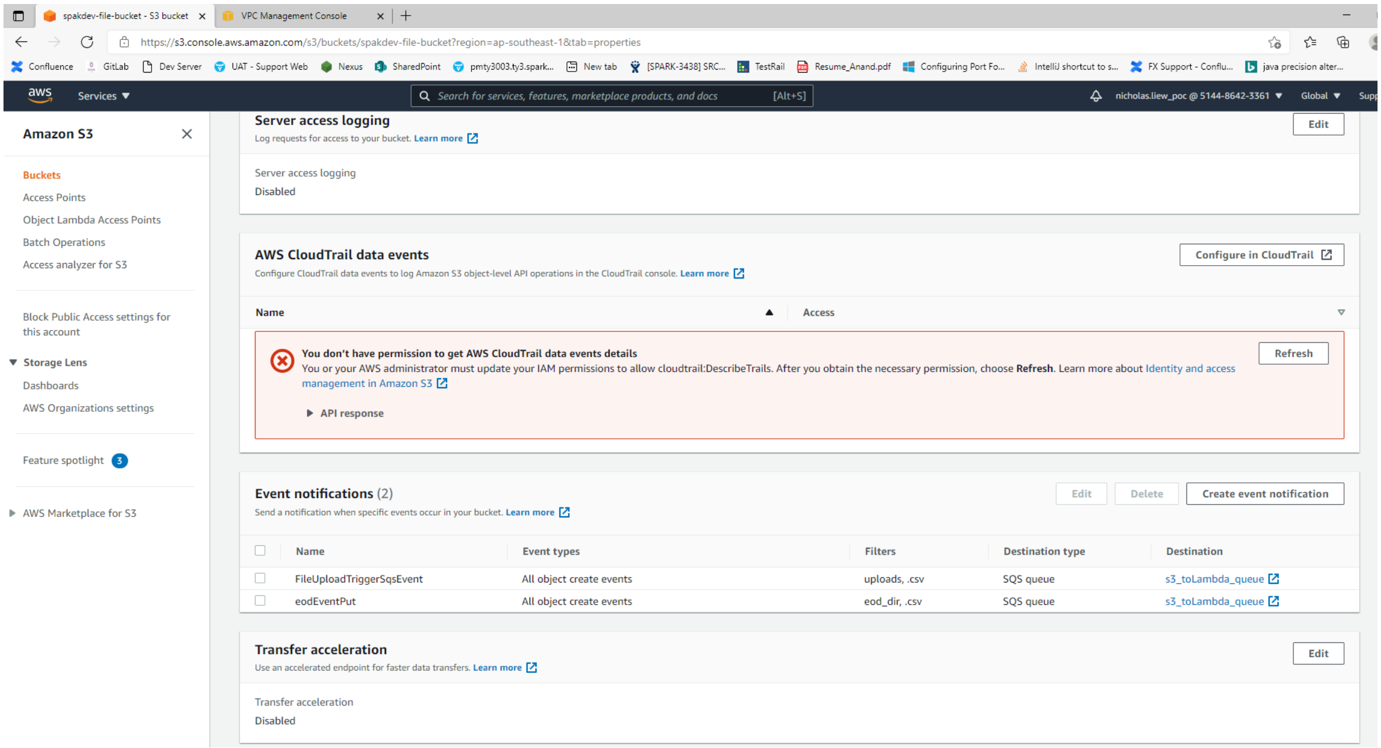
- Click OK and the database should be available in the DBeaver platform

Creating SQS queue

- Navigate to **SQS** page in the AWS management console
- Click on **Create queue**
- In the creation page, add in a queue name (eg. s3_toLambda_queue) and leave the other specifications as default

Creating S3 bucket

- Navigate to **S3** page in the AWS management console
- Click on **Create bucket**
- Give the bucket a name, and choose the desired region, eg. Asia Pacific (Singapore)ap-southeast-1
- Click **Create/ Save**
- Select the newly created bucket, and navigate to **Objects > Create folder**
- Create 3 folders, **uploads, processed** and **errors** to store files that have been uploaded and subsequently processed, or failed to process by the lambda respectively



Server access logging Edit

Log requests for access to your bucket. Learn more

Server access logging
Disabled

AWS CloudTrail data events Configure in CloudTrail

Configure CloudTrail data events to log Amazon S3 object-level API operations in the CloudTrail console. Learn more

Name	Access

You don't have permission to get AWS CloudTrail data events details Refresh

You or your AWS administrator must update your IAM permissions to allow cloudtrail:DescribeTrails. After you obtain the necessary permission, choose **Refresh**. Learn more about Identity and access management in Amazon S3

▶ API response

Event notifications (2) Edit Delete Create event notification

Send a notification when specific events occur in your bucket. Learn more

□	Name	Event types	Filters	Destination type	Destination
□	FileUploadTriggerSqsEvent	All object create events	uploads, .csv	SQS queue	s3_toLambda_queue
□	eodEventPut	All object create events	eod_dir, .csv	SQS queue	s3_toLambda_queue

Transfer acceleration Edit

Use an accelerated endpoint for faster data transfers. Learn more

Transfer acceleration
Disabled

Note: Event notification to queue (SQS)

Configuring SQS permissions and access policy

- Navigate to **SQS** page in the AWS management console
- Click on the previously created queue, and navigate to the **Access policy** tab
- Add in the necessary permissions for S3-SQS access permissions or use the following template:

```
{
  "Version": "2008-10-17",
  "Id": "__default_policy_ID",
  "Statement": [
    {
      "Sid": "__owner_statement",
      "Effect": "Allow",
      "Principal": {
        "AWS": "arn:aws:iam::<INSERT ACCOUNT ID>:root"
      },
      "Action": "SQS:*",
      "Resource": "<INSERT SQS QUEUE ARN>"
    },
    {
      "Sid": "__sender_statement",
      "Effect": "Allow",
      "Principal": {
        "AWS": [
          "arn:aws:iam::<INSERT ACCOUNT ID>:root",
          "arn:aws:iam::<INSERT ACCOUNT ID>:user/<INSERT IAM USERNAME>"
        ]
      },
      "Action": "SQS:SendMessage",
      "Resource": "<INSERT SQS QUEUE ARN>"
    },
    {
      "Sid": "__receiver_statement",
      "Effect": "Allow",
      "Principal": {
        "AWS": [
          "arn:aws:iam::<INSERT ACCOUNT ID>:root",
          "arn:aws:iam::<INSERT ACCOUNT ID>:user/<INSERT IAM USERNAME>"
        ]
      },
      "Action": [
        "SQS:ChangeMessageVisibility",
        "SQS:DeleteMessage",
        "SQS:ReceiveMessage"
      ],
      "Resource": "<INSERT SQS QUEUE ARN>"
    },
    {
      "Sid": "example-statement-ID",
      "Effect": "Allow",
      "Principal": {
        "Service": "s3.amazonaws.com"
      },
      "Action": "SQS:SendMessage",
      "Resource": "<INSERT SQS QUEUE ARN>",
      "Condition": {
        "ArnLike": {
          "aws:SourceArn": "<INSERT S3 BUCKET ARN>"
        }
      }
    }
  ]
}
```

Configuring S3 Event Notification to SQS

- Navigate back to **S3** page in the AWS management console, click on the bucket name
- In the upper half of the page, change to the **Properties** tab
- Scroll down and under **Event notifications**, select **Create event notification**
- In the creation page, specify the following details:
  - Give the event some meaningful name eg. “FileUploadTriggerSqsEvent”
  - **Prefix:** uploads
  - **Suffix:** .csv
  - **Event types:** tick the “All object create events” box
  - **Destination:** Click SQS queue, then from the dropdown, select your previously created queue

Creating IAM Execution Role for Lambda

- Navigate to **IAM** page in the AWS management console
- Click on **Roles > Create Role**
- Click on **Lambda > Next: Permissions**
- Add AWSLambdaVPCAccessExecutionRole, AWSLambdaSQSQueueExecutionRole and AmazonS3FullAccess
- Click **Next > Next** and give the role a name eg. lambda-vpc-execution-role and **Create role**

Creating Lambda function

Specified below are two different approaches to configure the AWS Lambda function. Choose either.

Python

- On your local environment, create a folder and give it a name eg. py-postgres
- In the folder, create a file db_util.py
- Open the folder and paste the following code, substituting the “<>” with the appropriate parameters:

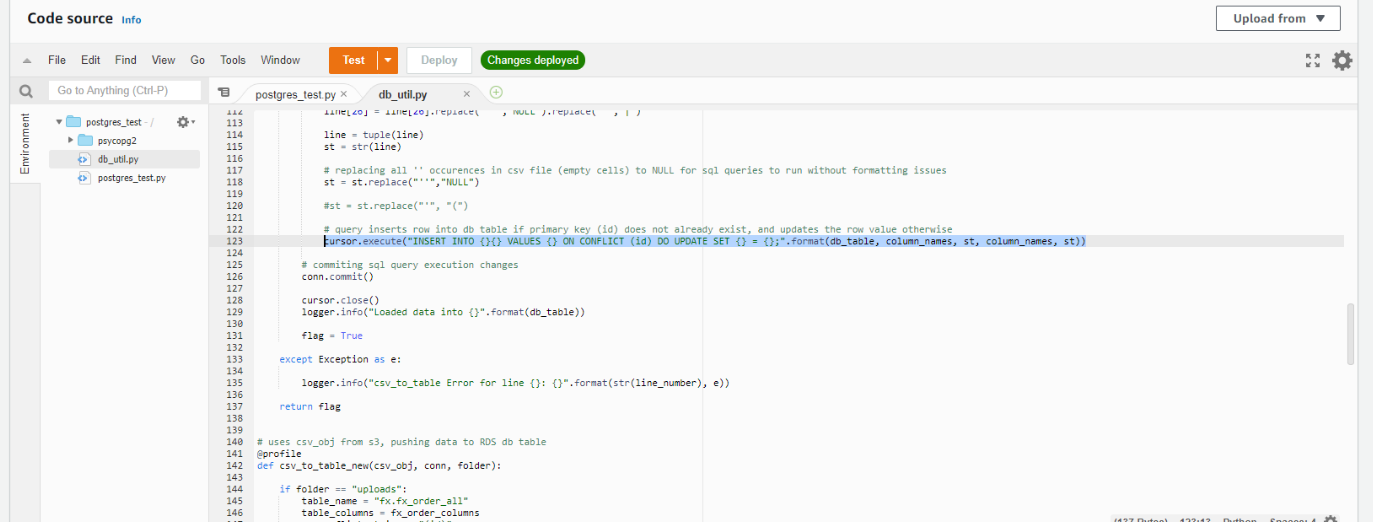
```
import psycopg2
import csv
import logging
import datetime
import json
import boto3
import time
from functools import wraps

db_host = "<INSERT RDS ENDPOINT HERE>""
db_port = 5432
db_name = "<INSERT DB NAME>"
db_user = "<INSERT MASTER USERNAME>"
db_pass = "<INSERT MASTER PASSWORD>"
db_table = "fx.fx_order" # or any other table name
column_names = "<COLUMN_1, COLUMN_2, .... etc>" # in order of table
columns


# sets up  postgres connection with RDS db instance using psycopg2
module
def make_conn():

    conn = None

    try:

        conn = psycopg2.connect("dbname='%s' user='%s' host='%s'
password='%s'" % (db_name, db_user, db_host, db_pass))

    except Exception as e:

        print("I am unable to connect to the database" + str(e))

    return conn

# executes query and fetches server response to query
def fetch_data(conn, query):

    result = []
    print("Now executing: %s" % (query))
    cursor = conn.cursor()
    cursor.execute(query)

    # subclass JSONEncoder - changes to datetime to str during fetch
    class DateTimeEncoder(json.JSONEncoder):
        #Override the default method
        def default(self, obj):
            if isinstance(obj, (datetime.date, datetime.datetime)):
                return obj.isoformat()

    raw = cursor.fetchall()
    cursor.close()

    for line in raw:
        line = DateTimeEncoder().encode(line)
        result.append(line)

    return result

# creates a profile for a method to display its execution time
def profile(fn):

    @wraps(fn)
    def inner(*args, **kwargs):
        fn_kwargs_str = ', '.join(f'{k}={v}' for k, v in kwargs.items())
        print(f'\n{fn.__name__}({fn_kwargs_str})')

        # Measure time
        t = time.perf_counter()
        retval = fn(*args, **kwargs)
        elapsed = time.perf_counter() - t
        print(f'Time   {elapsed:0.4}')

        return retval

    return inner

# uses csv_obj from s3, pushing data to RDS db table
@profile
def csv_to_table(csv_obj, conn):

    body = csv_obj['Body']

    flag = False

    try:

        cursor = conn.cursor()

        # converts data to readable format
        data = (body.read().decode('utf-8').splitlines())
        lines = csv.reader(data)

        # removes header column
        next(lines)

        for line in lines:

            line = tuple(line)
            st = str(line)

            # replacing all '' occurences in csv file (empty cells) to
NULL for sql queries to run without formatting issues
            st = st.replace("''","NULL")
            # query inserts row into db table if primary key (id) does
not already exist, and updates the row value otherwise
            cursor.execute("INSERT INTO {}{} VALUES {} ON CONFLICT (id)
DO UPDATE SET {} = {};".format(db_table, column_names, st,
column_names, st))

        # commiting sql query execution changes
        conn.commit()

        cursor.close()
        logger.info("Loaded data into {}".format(db_table))

        flag = True

    except Exception as e:

        logger.info("csv_to_table Error: {}".format(str(e)))

    return flag
```

- In the same folder, create another file postgres_test.py and paste the following code:

```
import sys
import logging
import psycopg2

import boto3
import requests
import os
import csv
import json
import ast

s3_client = boto3.client('s3')
s3_resource = boto3.resource('s3')
logger = logging.getLogger()
logger.setLevel(logging.INFO)

from db_util import make_conn, fetch_data, csv_to_table, db_table

# handles events passed from SQS trigger
def lambda_handler(event, context):

    return 1
    # connecting to the RDS db instance
    conn = make_conn()

    if event:
        try:

            print(str(event))

            # transforming event parameter and extracting s3 bucket
name and key path
            record = event['Records'][0]
            body = record['body']

            # using ast module to transform 'body' in event from str to
dict
            body_contents_in_dict_format = ast.literal_eval(body)
['Records'][0]

            bucket = body_contents_in_dict_format['s3']['bucket']
['name']
            key_path = body_contents_in_dict_format['s3']['object']
['key']

            # using boto3 s3 client to extract s3.Object
            csv_obj = s3_client.get_object(Bucket=bucket, Key=key_path)

            # pusing data to rds
            is_pushed_successfully = csv_to_table(csv_obj, conn)

            # retrieving csv file name
            object_name = key_path[8:]

            if pushed_successfully:

                # moving csv_file from /uploads folder to /processed
folder in S3 once processed
                s3_resource.Object(bucket,'processed/{}'.format
(object_name)).copy_from(CopySource='/{}/uploads/{}'.format(bucket,
object_name))
                s3_resource.Object(bucket,'uploads/{}'.format
(object_name)).delete()

            else:

                # moving csv_file to /errors if data not pushed
successfully
                s3_resource.Object(bucket,'errors/{}'.format
(object_name)).copy_from(CopySource='/{}/uploads/{}'.format(bucket,
object_name))
                s3_resource.Object(bucket,'uploads/{}'.format
(object_name)).delete()

            #s3_client.copy_object(Bucket=bucket, CopySource=key_path,
Key="/{}/processed/{}".format(bucket, object_name))
```

```
            #s3_client.delete_object(Bucket=bucket, Key=key_path)

        except Exception as e:

            logger.info("lambda_handler has exception:  {}".format(str
(e)))

    else:

        logger.info('No event')

    query_cmd = 'select count(*) from fx.fx_order'
    result = fetch_data(conn, query_cmd)

    conn.close()

    return result
```

- Next, we need to add in the psycopg2 module to connect to the postgres database since AWS Lambda does not provide local access to some modules
- Go to https://github.com/jkehler/awslambda-psycopg2 and download the appropriate psycopg2 folder depending on the python version you plan to use. For reference, we use the psycopg2-3.7 for python 3.7 in this example
- Download the psycopg2-3.7 (or otherwise) and rename it to psycopg2 before placing it into the local folder (i.e. py-postgres) created earlier
- ZIP the folder
- Return to AWS management console and navigate to the **Lambda** page
- Click **Create function > Author from scratch**
- Choose a python runtime (eg. Python 3.7 in this case)
- Expand **Permissions** tab, select **Use an existing role** and select the previously created role i.e. lambda-vpc-execution-role
- Under **Advanced settings**, select the VPC previously created i.e. sparkdev-vpc-01
- Specify the 2 private subnets, and the PostgreSQL security group created earlier
- Click **Create function**
- Wait for function to be successfully created, then under the **Code** section from within the function page, click on the **Upload from** button on the right hand side, select .zip and choose the zipped folder (i.e. py-postgres.zip) created earlier
- Change the handler to <INSERT .py file name>.<INSERT function name> eg. (postgres_test.lambda_handler)
- Next go to the lambda function page created > configuration > change visibility timeout to 5 minutes (or otherwise). This is due to the fact that AWS Lambda will auto re-process the event given its processing is not complete within timeout duration. Thus, for bigger CSVs (>20mb), a lower timeout time may cause repeated processing (which wont affect db but will invoke additional memory costs for running the lambda unnecessarily)



```
            line = tuple(line)
            st = str(line)

            # replacing all '' occurences in csv file (empty cells) to NULL for sql queries to run without formatting issues
            st = st.replace("''","NULL")

            #st = st.replace("'", "(")

            # query inserts row into db table if primary key (id) does not already exist, and updates the row value otherwise
            cursor.execute("INSERT INTO {}{} VALUES {} ON CONFLICT (id) DO UPDATE SET {} = {};".format(db_table, column_names, st, column_names, st))

        # commiting sql query execution changes
        conn.commit()

        cursor.close()
        logger.info("Loaded data into {}".format(db_table))

        flag = True

    except Exception as e:

        logger.info("csv_to_table Error for line {}: {}".format(str(line_number), e))

    return flag


# uses csv_obj from s3, pushing data to RDS db table
@profile
def csv_to_table_new(csv_obj, conn, folder):

    if folder == "uploads":
        table_name = "fx.fx_order_all"
        table_columns = fx_order_columns
```

```
        on_conflict_string = "(id)"
    elif folder == "eod_dir":
        table_name = "fx_eod_spot_rate"
```

Note: We use the ON CONFLICT to either insert or update

Configure VPC Endpoint for Lambda to access S3

- Navigate to **VPC > Endpoints > Create endpoint** in the AWS management console
- Tick AWS services, search for s3 and click on the gateway option
- Select the sparkdev-vpc in the vpc dropdown and select the route table that is associated with the 2 private subnets (where the lambda is situated)
- Grant full access unless otherwise needed and click **Create endpoint**