Operationalizing an AWS ML Project

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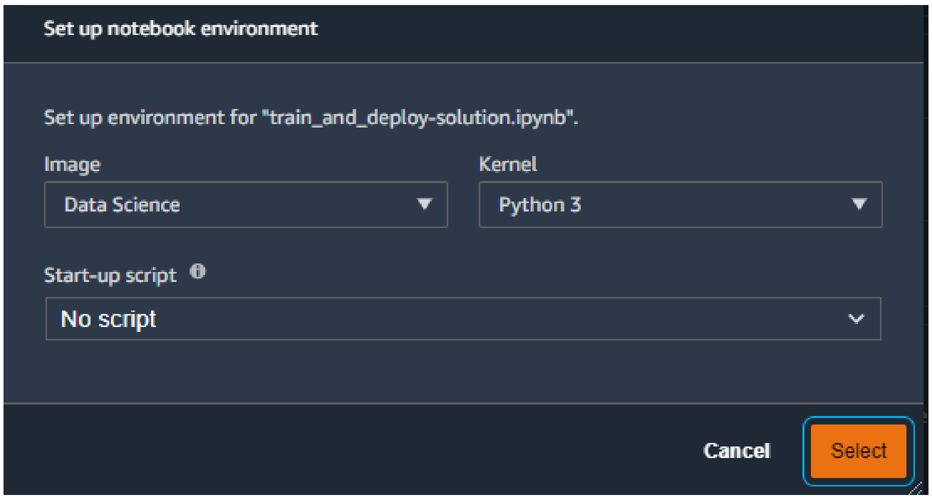
1. Initial Setup:

ml.t3.medium instance type was chosen for the notebook because of it's fast-launch,Moreover they are designed specifically for tasks that result in moderate usage of CPU with temporary spikes.Despite the higher cost as compared to ml.t2.medium it has extra CPU credits which proves to be more beneficial in terms of performance.
Kernel: Python3
Image:Data Science


Set up notebook environment

Set up environment for "train_and_deploy-solution.ipynb".

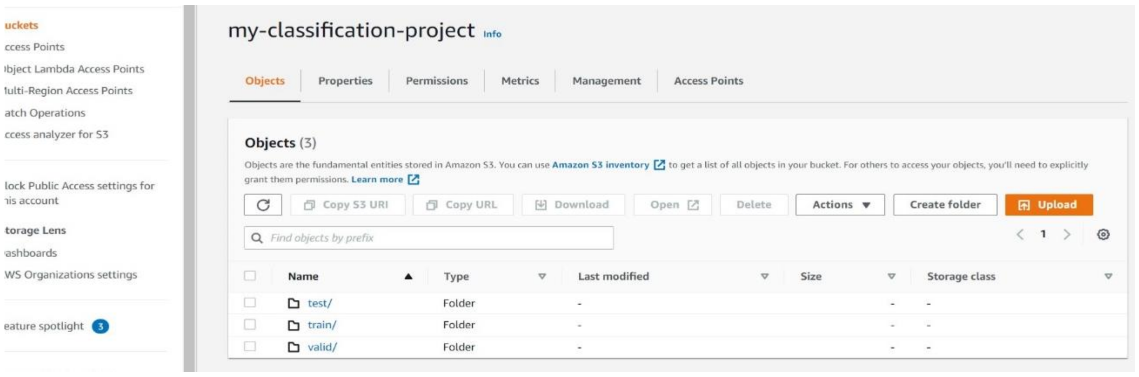
Image: Data Science

Kernel: Python 3

Start-up script: No script

Figure 1 – Setting up Notebook environment in JupyterLab

The dog-breed dataset downloaded and unzipped after which it was successfully uploaded to s3 bucket via !aws s3 cp dogImages s3://my-classification-project/ --recursive command


my-classification-project

Objects (3)

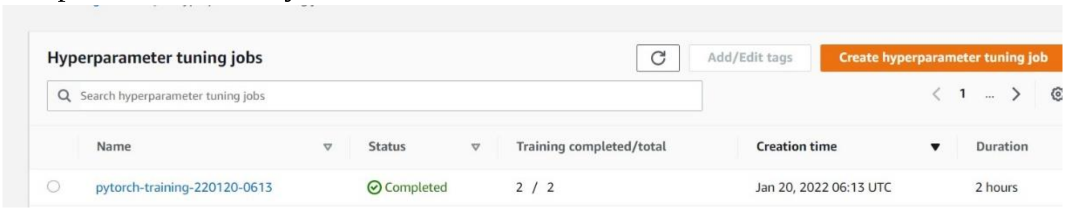
Objects are the fundamental entities stored in Amazon S3. You can use Amazon S3 inventory to get a list of all objects in your bucket. For others to access your objects, you'll need to explicitly grant them permissions. Learn more

Name	Type	Last modified	Size	Storage class
test/	Folder	-	-	-
train/	Folder	-	-	-
valid/	Folder	-	-	-

Figure 2 – S3 bucket holding the dog-breed dataset

2. SageMaker Training and Deployment:

For hyperparameter tuning I used “ml.m5.xlarge” instance_type ,as it’s computational performance seemed sufficient for the current Image classification project.Hyperparameter tuning job (**max_jobs = 2, max_parallel_jobs = 2**) was completed successfully:

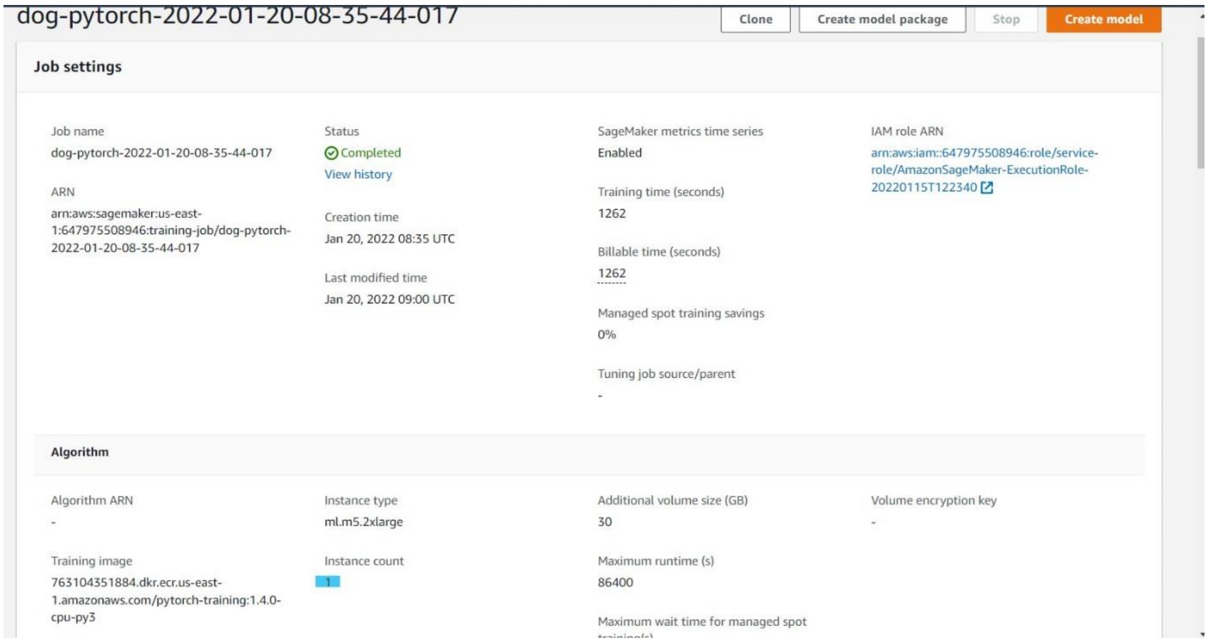

Add/Edit tags
Create hyperparameter tuning job
Search hyperparameter tuning jobs

Hyperparameter tuning jobs

Name	Status	Training completed/total	Creation time	Duration
pytorch-training-220120-0613	Completed	2 / 2	Jan 20, 2022 06:13 UTC	2 hours

Figure 3 – Hyperparameter Tuning Jobs

After completion of tuning jobs we had to create single and multi-instance training jobs as shown in the figures below



dog-pytorch-2022-01-20-08-35-44-017

Job settings

Job name
dog-pytorch-2022-01-20-08-35-44-017

ARN
arn:aws:sagemaker:us-east-1:647975508946:training-job/dog-pytorch-2022-01-20-08-35-44-017

Status
Completed
View history

Creation time
Jan 20, 2022 08:35 UTC

Last modified time
Jan 20, 2022 09:00 UTC

SageMaker metrics time series
Enabled

Training time (seconds)
1262

Billable time (seconds)
1262

Managed spot training savings
0%

Tuning job source/parent
-

IAM role ARN
arn:aws:iam::647975508946:role/service-role/AmazonSageMaker-ExecutionRole-20220115T122340

Algorithm

Algorithm ARN
-

Training image
763104351884.dkr.ecr.us-east-1.amazonaws.com/pytorch-training:1.4.0-cpu-py3

Instance type
ml.m5.2xlarge

Instance count
1

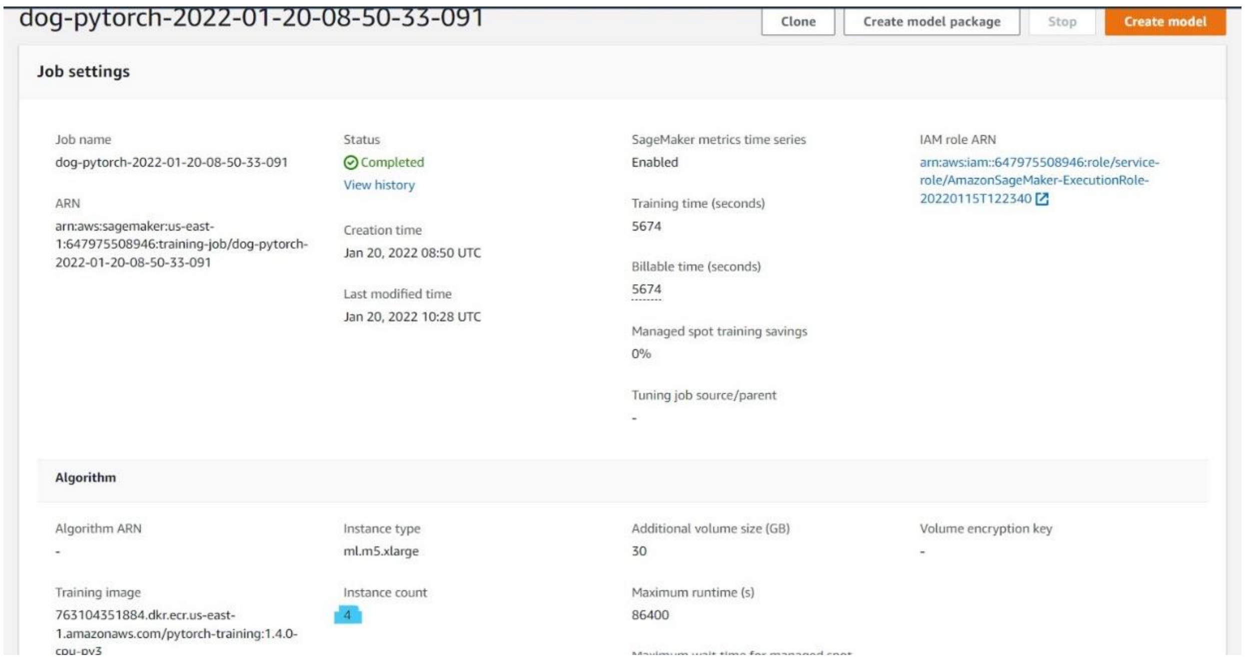
Additional volume size (GB)
30

Maximum runtime (s)
86400

Maximum wait time for managed spot

Volume encryption key
-

Figure 4 – Single Instance training job



dog-pytorch-2022-01-20-08-50-33-091

Clone | Create model package | Stop | Create model

Job settings

Job name
dog-pytorch-2022-01-20-08-50-33-091

ARN
arn:aws:sagemaker:us-east-1:647975508946:training-job/dog-pytorch-2022-01-20-08-50-33-091

Status
Completed
View history

Creation time
Jan 20, 2022 08:50 UTC

Last modified time
Jan 20, 2022 10:28 UTC

SageMaker metrics time series
Enabled

Training time (seconds)
5674

Billable time (seconds)
5674

Managed spot training savings
0%

Tuning job source/parent
-

IAM role ARN
arn:aws:iam::647975508946:role/service-role/AmazonSageMaker-ExecutionRole-20220115T122340

Algorithm

Algorithm ARN
-

Training image
763104351884.dkr.ecr.us-east-1.amazonaws.com/pytorch-training:1.4.0-cpu-py3

Instance type
ml.m5.xlarge

Instance count
4

Additional volume size (GB)
30

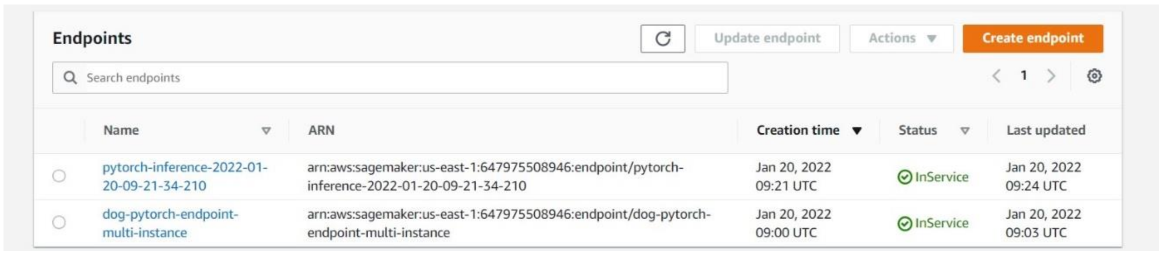
Maximum runtime (s)
86400

Volume encryption key
-

Figure 5– Multi-instance training job

Deployed Endpoints to invoke the model and receive the outputs:

- Single instance deployed endpoint: “pytorch-inference-2022-01-20-09-21-34-210”
- Multi instance deployed endpoint: “dog-pytorch-endpoint-multi-instance”



Endpoints

Update endpoint | Actions | Create endpoint

Search endpoints

Name	ARN	Creation time	Status	Last updated
pytorch-inference-2022-01-20-09-21-34-210	arn:aws:sagemaker:us-east-1:647975508946:endpoint/pytorch-inference-2022-01-20-09-21-34-210	Jan 20, 2022 09:21 UTC	InService	Jan 20, 2022 09:24 UTC
dog-pytorch-endpoint-multi-instance	arn:aws:sagemaker:us-east-1:647975508946:endpoint/dog-pytorch-endpoint-multi-instance	Jan 20, 2022 09:00 UTC	InService	Jan 20, 2022 09:03 UTC

Figure 6 – Deployed Endpoints

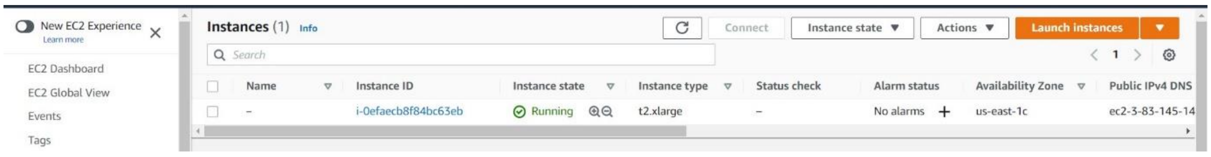
3. EC2 Instance

- I used the **t2.xlarge** instance and the **Deep Learning AMI (Amazon Linux 2) Version 55.0**. as I wanted a moderate performance which was not on the high end in terms of cost for a mere Image classification model
- Moreover t2.xlarge has a baseline performance of **90%** with **4 vCPU’s** along with 16 GiB of memory just at the charge of **$0.188** per hour which is considerably lower than sagemaker notebook instances.

Difference between ec2train1.py (EC2 script) and train_and_deploy solution.ipynb (SageMaker scripts)

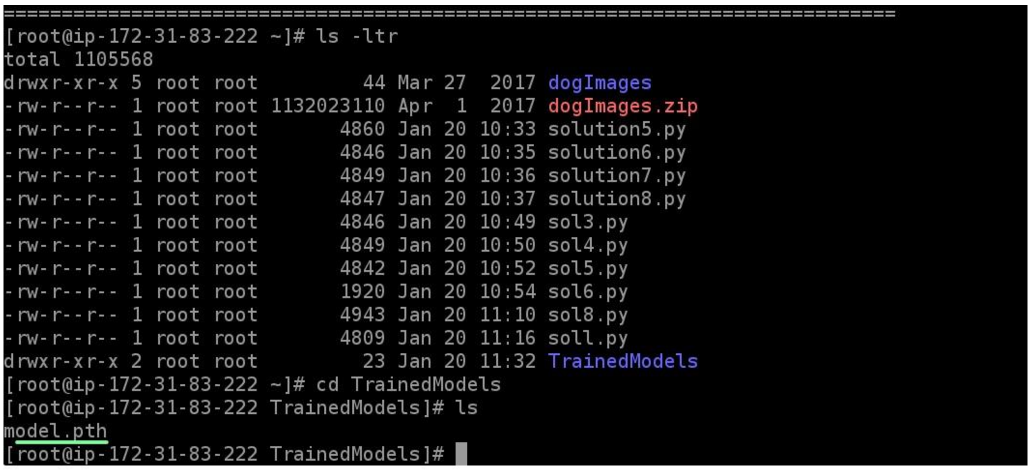
1. In the EC2 training script, all the hyperparameters are mentioned within the script and there is no need for **argparse** unlike SageMaker scripts.

2. In EC2 ,the training happens on the server where you write the code,the screen just hangs in there till your model finishes training ,there is no way to know the progress of your training,but in SageMaker you can employ several training jobs and also keep a track of it's progress via SageMaker dashboard.
3. You cannot directly deploy an endpoint using EC2 trained model as opposed to the ease of creation of an endpoint using SageMaker Trained models
4. Moreover ,writing code in EC2 is similar to a command-line terminal which does not have a user friendly interface as opposed to the well structured interface provided via SageMaker scripts which is easier to navigate and edit.
5. It is harder to edit code on EC2 instances ,it requires one to remember certain codes such as**:** :wq! **(**for saving) , :qa! (for exiting). Even upwards traversal through your code changes spacing which leads to syntax error.hence it's not convenient for larger projects unlike sagemaker scripts



	Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zone	Public IPv4 DNS
	–	i-0efaecb8f84bc63eb	Running	t2.xlarge	–	No alarms	us-east-1c	ec2-3-83-145-14

Figure 7 – EC2 Instance snapshot

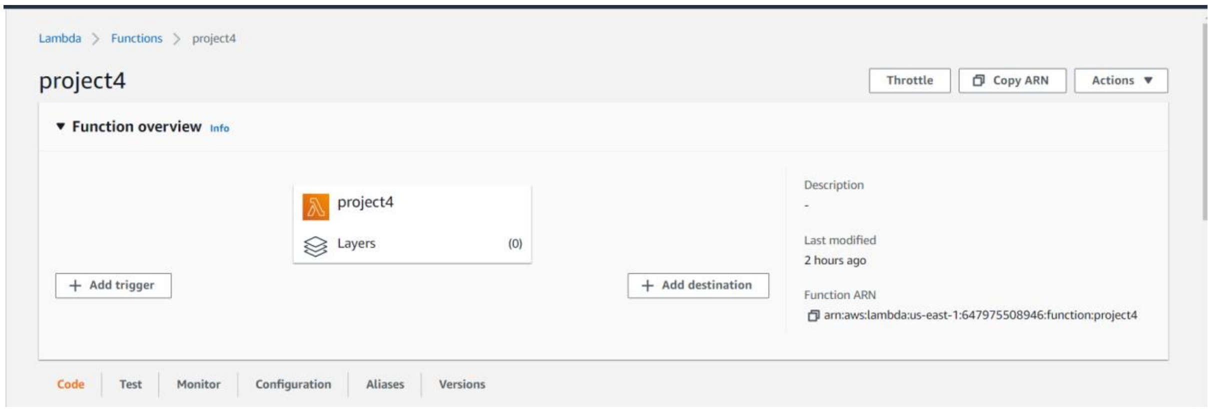


```
============================================================================
[root@ip-172-31-83-222 ~]# ls -ltr
total 1105568
drwxr-xr-x 5 root root         44 Mar 27  2017 dogImages
-rw-r--r-- 1 root root 1132023110 Apr  1  2017 dogImages.zip
-rw-r--r-- 1 root root       4860 Jan 20 10:33 solution5.py
-rw-r--r-- 1 root root       4846 Jan 20 10:35 solution6.py
-rw-r--r-- 1 root root       4849 Jan 20 10:36 solution7.py
-rw-r--r-- 1 root root       4847 Jan 20 10:37 solution8.py
-rw-r--r-- 1 root root       4846 Jan 20 10:49 sol3.py
-rw-r--r-- 1 root root       4849 Jan 20 10:50 sol4.py
-rw-r--r-- 1 root root       4842 Jan 20 10:52 sol5.py
-rw-r--r-- 1 root root       1920 Jan 20 10:54 sol6.py
-rw-r--r-- 1 root root       4943 Jan 20 11:10 sol8.py
-rw-r--r-- 1 root root       4809 Jan 20 11:16 soll.py
drwxr-xr-x 2 root root         23 Jan 20 11:32 TrainedModels
[root@ip-172-31-83-222 ~]# cd TrainedModels
[root@ip-172-31-83-222 TrainedModels]# ls
model.pth
[root@ip-172-31-83-222 TrainedModels]#
```

Figure 8– EC2 Training saved model.pth

4. Lambda Functions

I have used a previously deployed endpoint named ""dog-pytorch-endpoint-multi-instance" to invoke my endpoint which had been deployed using the model that was created earlier in the project to classify dog breeds.


Lambda > Functions > project4

project4

Function overview

Function ARN: arn:aws:lambda:us-east-1:647975508946:function:project4

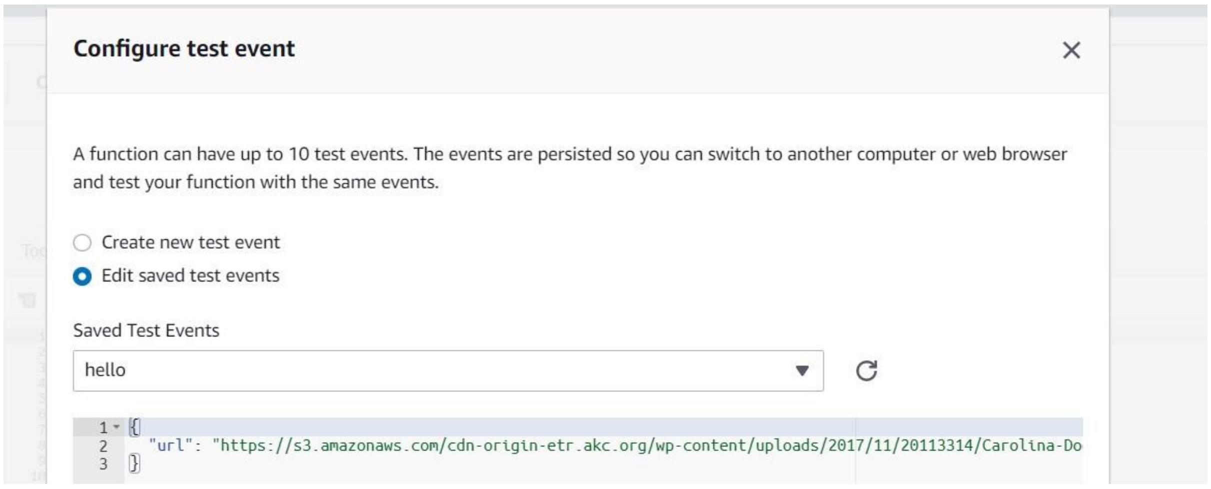
Last modified: 2 hours ago

Figure 9 – Lambda Function

5.Security and Testing

Lambda functions respond to events that have been passed to it by invoking an earlier deployed endpoint. Hence it allows us to perform serverless computing by accessing S3 buckets and inference endpoints via managed policies.

- We had created a new role for this lambda functions with **"SageMakerFullAccess"**(without which it leads to **Invocation Error**)
- We had to use the below test event to test our Lambda function: It's a JSON object which on being passed returns a 200 status code along with an output array.


Configure test event

A function can have up to 10 test events. The events are persisted so you can switch to another computer or web browser and test your function with the same events.

Create new test event [✓ Edit saved test events]

Saved Test Events: hello

```
{
  "url": "https://s3.amazonaws.com/cdn-origin-etr.akc.org/wp-content/uploads/2017/11/20113314/Carolina-Do
}
```

Figure 10 – Lambda Function Test Event

Response from Lambda Function:

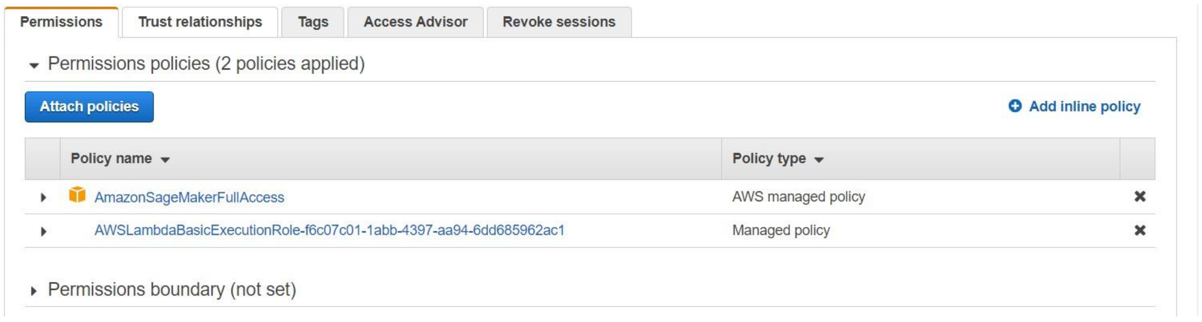
```
{
 "statusCode": 200,
 "headers": {
  "Content-Type": "text/plain",
  "Access-Control-Allow-Origin": "*"
 },
  "type-result": "<class 'str'>",

  "COntent-Type-In": "LambdaContext([aws_request_id=c6dae78f-40b0-46ca-a44a-
58d7b1cdca4b,log_group_name=/aws/lambda/project4,log_stream_name=2022/01/20/[$LATEST]c
ac131cc588742a0a203734c6298d530,function_name=project4,memory_limit_in_mb=128,function_
version=$LATEST,invoked_function_arn=arn:aws:lambda:us-east-
1:647975508946:function:project4,client_context=None,identity=CognitoIdentity([cognito_identity_
id=None,cognito_identity_pool_id=None])])",

  "body": "[[-8.509687423706055, -7.77571964263916, -2.675638198852539, -
2.3557212352752686, -6.151639938354492, -7.035409927368164, -3.780886173248291, -
2.774186134338379, -8.81319522857666, -1.3065375089645386, 1.6190638542175293, -
5.865751266479492, -3.352370023727417, 0.33569395542144775, -7.82021427154541, -
3.9492571353912354, -8.446880340576172, -2.839498996734619, -4.651222229003906,
1.0388201475143433, -7.5899882316589355, -3.5086326599121094, -9.712128639221191, -
8.360410690307617, -8.240933418273926, -13.016434669494629, -5.23638391494751, -
7.427854537963867, -6.946070194244385, -2.703977108001709, -7.135708332061768, -
5.68403434753418, -11.949724197387695, -4.561254024505615, -11.778522491455078, -
8.986464500427246, -7.212772369384766, -3.3191754817962646, -1.1046655178070068, -
6.461777687072754, -5.033671855926514, -2.7278974056243896, -0.9936132431030273, -
6.044423580169678, -1.883324384689331, -9.649934768676758, -3.4763667583465576, -
1.0421169996261597, -2.717921257019043, -3.589296817779541, -5.795350551605225, -
7.381248474121094, -8.431464195251465, -7.530313491821289, -8.174006462097168, -
3.8078136444091797, -6.326535701751709, -8.39573860168457, -2.9995415210723877, -
5.429052829742432, -10.660608291625977, -9.486539840698242, -11.510260581970215, -
6.826721668243408, -6.756300449371338, -14.48521614074707, -1.6789501905441284, -
9.15797233581543, -2.646780490875244, -1.1237974166870117, -0.6023721694946289, -
6.902181148529053, -5.664377689361572, -8.664715766906738, -7.221043586730957, -
3.847078323364258, -13.318488121032715, -4.377753257751465, -4.632699489593506, -
6.257696151733398, -1.2542197704315186, -10.409688949584961, -2.2787129878997803, -
1.0235614776611328, -8.419547080993652, -8.682510375976562, -2.885606527328491, -
10.519001960754395, -4.825105667114258, -2.1089701652526855, -8.725203514099121, -
5.307856559753418, -5.575226783752441, -9.437766075134277, -5.222029685974121, -
4.098916053771973, -6.385500431060791, -7.366503715515137, -7.367201805114746, -
6.432024002075195, -7.426565170288086, -1.6843739748001099, -7.017165184020996, -
5.080165863037109, -8.466792106628418, -14.218036651611328, -4.277678966522217, -
0.39628297090530396, -1.378735899925232, -3.197972536087036, -2.170497179031372, -
3.1416969299316406, -8.856181144714355, -6.239938259124756, -7.6649956703186035, -
1.4355008602142334, -6.978602409362793, -1.5712144374847412, -4.779670715332031, -
1.2244170904159546, -3.855419397354126, -6.736294746398926, -5.722675800323486, -
6.578609943389893, -12.074214935302734, -5.719165802001953, -4.999317169189453, -
2.3081724643707275, -5.571413516998291, -9.936185836791992, -8.904071807861328, -
4.077090263366699, -7.278857231140137]]"

}
```

Security: I believe that in an industrial set up granting **FullAccess** policies may do more harm than good when the task requires just the invocation of a single component as in this project,wherein without SageMakerFullAccess policy,the lambda function kept throwing invocation error.
It would be considered a better practice to create **IAM customer managed policies** that provide your team members with permission which is required to perform the task at hand.



Permissions | Trust relationships | Tags | Access Advisor | Revoke sessions

Permissions policies (2 policies applied)

Attach policies — Add inline policy

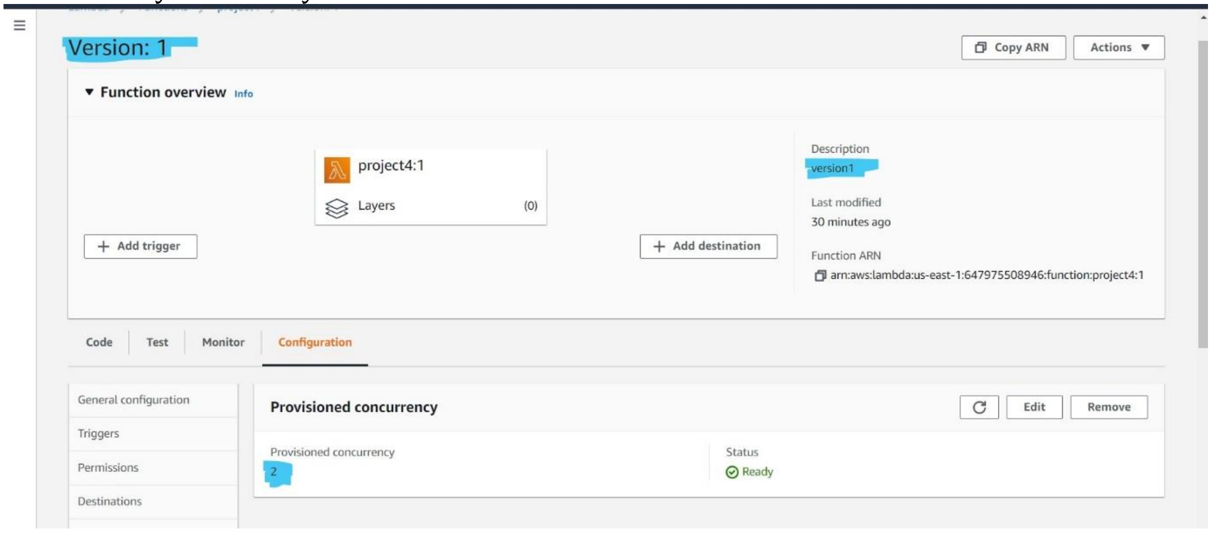
Policy name	Policy type
AmazonSageMakerFullAccess	AWS managed policy
AWSLambdaBasicExecutionRole-f6c07c01-1abb-4397-aa94-6dd685962ac1	Managed policy

Permissions boundary (not set)

Figure 11- Permission Policies

6.Concurrency and AutoScaling

- We were first asked to create a different version for our lambda function after which we were supposed to add concurrency to it.As seen below I have added a provisioned concurrency of 2 to my first version.



Version: 1

Function overview

project4:1
Layers (0)

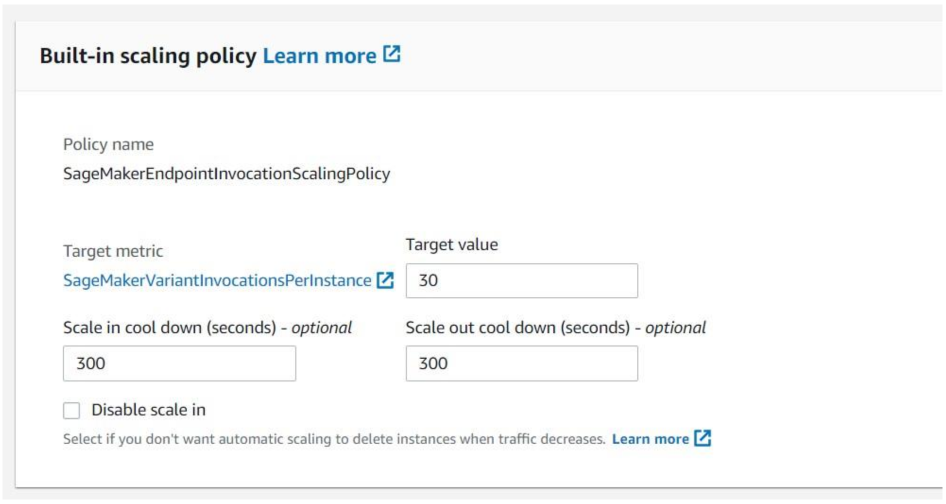
Description: version1
Last modified: 30 minutes ago
Function ARN: arn:aws:lambda:us-east-1:647975508946:function:project4:1

Provisioned concurrency
Provisioned concurrency: 2
Status: Ready

Figure 12- Version(1): Provisioned Concurrency

- I have set up **Provisioned Concurrency** because it creates instances that are always on and can reply to all traffic without requiring a wait for start-up times.
- Provisioned concurrency has a higher cost than reserved concurrency but since it turns on instances that are always ready to respond to traffic, it can achieve low latency even in very high traffic scenarios.

Autoscaling: Setting the target value to be 30 along with default values of 300 seconds for scale in and scale down seemed to sufficient for the current scenario as it would efficiently deal with the traffic



Built-in scaling policy Learn more

Policy name
SageMakerEndpointInvocationScalingPolicy

Target metric
SageMakerVariantInvocationsPerInstance

Target value
30

Scale in cool down (seconds) - *optional*
300

Scale out cool down (seconds) - *optional*
300

☐ Disable scale in
Select if you don't want automatic scaling to delete instances when traffic decreases. Learn more

Figure 13- AutoScale Configuration