

Configuration Manual

MSc Research Project
Cloud Computing

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Project Submission Sheet
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Configuration Manual

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1 Introduction

In our initial setup in the development of this Thesis Project an Amazon SageMaker Notebook has been created to assist us with data preprocessing and preparation stages. In this notebook, various libraries were imported to support data analysis and manipulation. After that, Lambda function was developed to integrate it with the model endpoint that has been created. This Lambda function plays an important role in serving the model inference requests. Finally to allow external access to the model, an API Gateway was introduced, acting as an interface from the virtual network to trigger the lambda function.

2 Amazon SageMaker AI

2.1 NoteBook Creation

Below figure presents the successful creation of SageMaker Notebook with a sufficient computing resources. Figure 1.

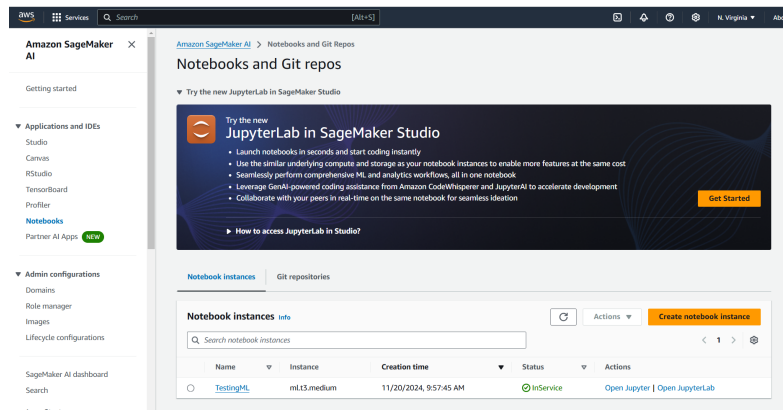


Figure 1: SageMaker Notebook.

2.2 Data Collection

The dataset was collected from our Virtual Network and can be accessed through below GitHub link.

<https://github.com/Abdu-AJ/ORAN.git>

2.3 Data Exploration

All the Python libraries required to implement the entire project are listed in below figure Figure 2 and s3 bucket name.

Figure 2.

```
In [1]: import numpy as np
        from sagemaker import get_execution_role
        import sagemaker
        from sklearn.model_selection import train_test_split
        from sklearn.preprocessing import LabelEncoder, StandardScaler, OneHotEncoder
        import datetime
        import time
        import tarfile
        import boto3
        import pandas as pd
        from imblearn.over_sampling import SMOTE
        from sklearn.ensemble import RandomForestClassifier
        from sklearn.metrics import accuracy_score, classification_report, confusion_matrix, precision_score, recall_score, f1_score,
        roc_curve, auc
        import sklearn
        import joblib
        import pathlib
        from io import StringIO
        import argparse
        import os
        from sagemaker.sklearn.estimator import SKLearn
        from sagemaker.sklearn.model import SKLearnModel
        from time import gmtime, strftime

        sm_boto3 = boto3.client("sagemaker")
        sess = sagemaker.Session()
        region = sess.boto_session.region_name
        bucket = 'bucket-sagemaker-ml'
```

Figure 2: Required Libraries.

2.4 Data Preprocessing and Preparation for SageMaker

Below photos represent data preprocessing workflow. Where the dataset was split into features and target labels, then divided into training and testing sets using an 80-20 split. After that to address class imbalance, SMOTE (Synthetic Minority Oversampling Technique) is applied to the training data. Finally resampled training and testing datasets are saved as CSV files and uploaded to Amazon S3, making them accessible for SageMaker training Figure 3 Figure 4.

```
In [5]: label_encoder = LabelEncoder()
        df['Day_Type'] = df['Day_Type'].map({'weekday': 0, 'weekend': 1})
        df['Area'] = df['Area'].map({'office': 0, 'residential': 1, 'garden_mall': 2})
        df['RU_Type'] = df['RU_Type'].map({'macro': 0, 'micro': 1})
        df['RU_Power'] = df['RU_Power'].map({'idle': 0, 'reduced': 1, 'full': 2})
        df = df.drop(columns=['RU_id', 'RU_x', 'RU_y'])
        print(df.head())

        Day_Type  Hour  Area  RU_Type  Capacity  Current_Load  Load_Percentage \
0      0      0      0      0      200      0.0      0.0
1      0      0      0      0      200      10.0      5.0
2      0      0      0      0      200      5.0      2.5
3      0      0      0      0      200      21.0      10.5
4      0      0      0      0      200      24.0      12.0

        RU_Power
0      0
1      1
2      1
3      1
4      1

In [6]: df.columns
Out[6]: Index(['Day_Type', 'Hour', 'Area', 'RU_Type', 'Capacity', 'Current_Load',
              'Load_Percentage', 'RU_Power'],
              dtype='object')
```

```
In [9]: features = list(df.columns)
        features

Out[9]: ['Day_Type',
        'Hour',
        'Area',
        'RU_Type',
        'Capacity',
        'Current_Load',
        'Load_Percentage',
        'RU_Power']

In [10]: label = features.pop(-1)
         print(label)

        RU_Power

In [11]: x = df[features].copy()
         y = df[label]
```

Figure 3: Data Preprocessing and Preparation.

2.5 Random Forest Model Training and Deployment Script

The script uses the provided data set to train a Random Forest Classifier using hyperparameters and save the trained model for deployment. The steps followed in this script were to preprocesses the data, train the model, evaluate its performance on test data,

```

X_train, X_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_state=0, shuffle=True)

smote = SMOTE(random_state=42)
X_train_resampled, y_train_resampled = smote.fit_resample(X_train, y_train)

trainX = pd.DataFrame(X_train_resampled, columns=features)
trainX[label] = y_train_resampled

testX = pd.DataFrame(X_test, columns=features)
testX[label] = y_test

trainx.to_csv("train-v-1.csv", index = False)
testx.to_csv("test-v-1.csv", index = False)

# send data to S3, SageMaker will take training data from s3
sk_prefix = "sagemaker/ml-power-classification/sklearncontainer"
trainpath = sess.upload_data(
    path="train-v-1.csv", bucket=bucket, key_prefix=sk_prefix
)

testpath = sess.upload_data(
    path="test-v-1.csv", bucket=bucket, key_prefix=sk_prefix
)

```

Figure 4: Data Preprocessing and Preparation.

and provide key metrics such as accuracy and classification report. These steps were implemented by the example provided in Spidy20 (2023)

Our Project Version can be found on—<https://github.com/Abdu-AJ/ORAN.git>

2.6 Configuring and Launching a SageMaker Training Job

Configuring and launching a SageMaker training job using the Scikit-learn framework by specifying the training script. Additionally, the job trains the model in the cloud using the provided training and testing data from S3 Figure 5.

```

In [30]: FRAMEWORK_VERSION = "1.2-1"

sklearn_estimator = SKLearn(
    entry_point="script.py",
    role=get_execution_role(),
    instance_count=1,
    instance_type="ml.m5.large",
    framework_version=FRAMEWORK_VERSION,
    base_job_name="custom-sklearn",
    hyperparameters={
        "n_estimators": 100,
        "random_state": 0,
    },
    use_spot_instances = True,
    max_wait = 7200,
    max_run = 3600
)

In [31]: # launch training job, with asynchronous call
sklearn_estimator.fit({"train": trainpath, "test": testpath}, wait=True)

```

Figure 5: SageMaker Training Job.

2.7 Model Retrieval, Deployment, and Endpoint Creation in SageMaker

Below final steps are used to handle the model being trained in SageMaker. Firstly, it retrieves the model, then creates a SageMaker model using this artifact. Finally, the model is deployed to a SageMaker endpoint to serve the model real-time predictions Figure 6.

```

In [32]: sklearn_estimator.latest_training_job.wait(logs="None")
artifact = sm_boto3.describe_training_job(
    TrainingJobName=sklearn_estimator.latest_training_job.name
)["ModelArtifacts"]["S3ModelArtifacts"]
print("Model artifact persisted at " + artifact)

2024-11-28 12:36:47 Starting - Preparing the instances for training
2024-11-28 12:36:47 Downloading - Downloading the training image
2024-11-28 12:36:47 Training - Training image download completed. Training in progress.
2024-11-28 12:36:47 Uploading - Uploading generated training model
2024-11-28 12:36:47 Completed - Training job completed
Model artifact persisted at s3://sagemaker-us-east-1-423623834574/custom-sklearn-2024-11-28-12-34-28-279/output/model.tar.gz

In [33]: model_name = "Custom-sklearn-model-" + strftime("%Y-%m-%d-%H-%M-%S", gmtime())
model = SKLearnModel(
    name = model_name,
    model_data=artifact,
    role=get_execution_role(),
    entry_point="script.py",
    framework_version=FRAMEWORK_VERSION,
)

In [34]: endpoint_name = "Custom-sklearn-model-" + strftime("%Y-%m-%d-%H-%M-%S", gmtime())
print("EndpointName={}".format(endpoint_name))

predictor = model.deploy(
    initial_instance_count=1,
    instance_type="ml.m4.xlarge",
    endpoint_name=endpoint_name,
)

EndpointName=Custom-sklearn-model-2024-11-28-12-38-00

```

Figure 6: Model retrieval, creation, and deployment.

3 Lambda

3.1 Lambda Function Creation

First chose the suitable Lambda Function name after that chose python 3.12 version as show in below Figure 7.

The screenshot shows the AWS Lambda 'Create function' page. At the top, there are three tabs: 'Author from scratch' (selected), 'Use a blueprint', and 'Container image'. Below these, the 'Basic information' section contains a 'Function name' field with the value 'RU_Power_Lambd'. The 'Runtime' is set to 'Python 3.12'. The 'Architecture' is set to 'x86_64'. The 'Permissions' section shows a link to 'Change default execution role'. At the bottom right, there are 'Cancel' and 'Create function' buttons.

Figure 7: Lambda Function Creation

3.2 Updating Lambda Function Role

First we have to find the Role that is being used by our lambda function as shown in Figure 8. Then under the IAM role section select the role and press the policy as shown below Figure 9. Finally, edit it Figure 10 as advised by Amazon's official website Amazon Web Services (2024) Figure 11.

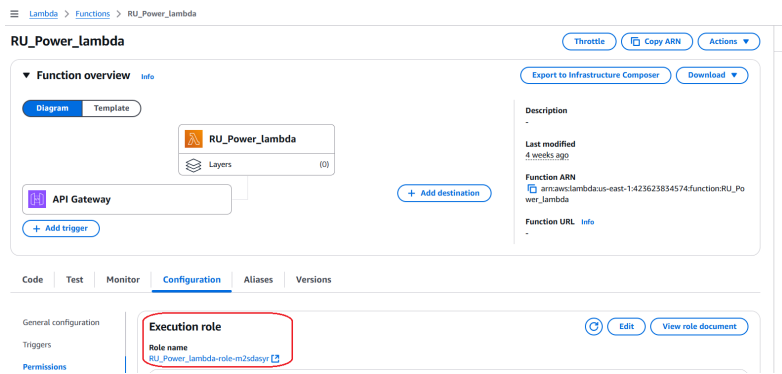


Figure 8: Lambda Role Update

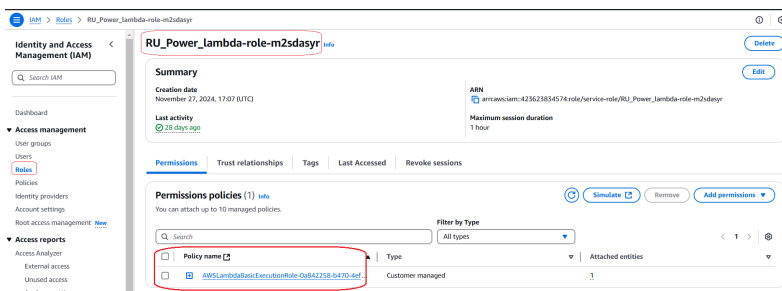


Figure 9: IAM Role Update

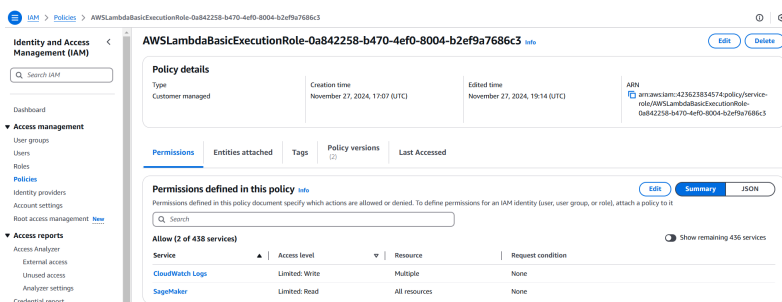


Figure 10: IAM Role Update

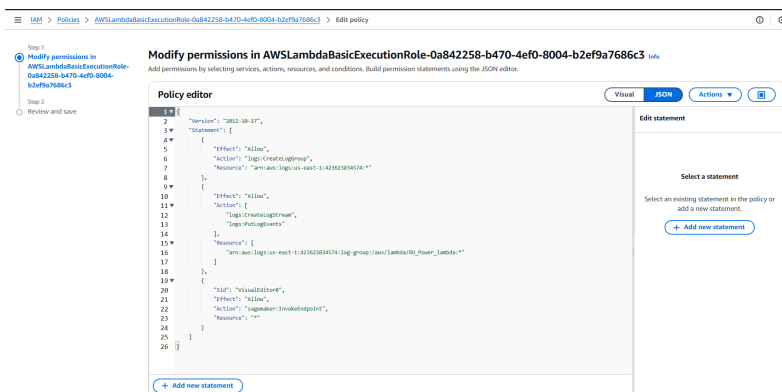


Figure 11: IAM Role Update

4 API Gateway

4.1 API Creation

REST API Creation Figure 12.

The screenshot shows the 'Create REST API' form in the AWS API Gateway console. The breadcrumb trail is 'API Gateway > APIs > Create API > Create REST API'. The form is titled 'Create REST API'. Under 'API details', there are four radio buttons: 'New API' (selected), 'Clone existing API', 'Import API', and 'Example API'. Below this, there is a text input for 'API name' with the value 'RU_Power_API', a text input for 'Description - optional', and a dropdown for 'API endpoint type' set to 'Regional'. At the bottom right, there are 'Cancel' and 'Create API' buttons.

Figure 12: API Creation

4.2 Resource, Method and Deploying Creation

First we have to create a resource Figure 13 then a POST method under this resource. We don't have to forget to connect it to the lambda function as shown in Figure 14. Finally we have to deploy it so we would be able to trigger it Figure 15.

The screenshot shows the 'Create resource' form in the AWS API Gateway console. The breadcrumb trail is 'API Gateway > APIs > Resources - RU_Power_API [pdddw8ll] > Create resource'. The form is titled 'Create resource'. Under 'Resource details', there is a radio button for 'Proxy resource' (selected) and a text input for 'Resource path' with the value '/'. To the right, there is a text input for 'Resource name' with the value 'api-ml-model'. At the bottom right, there are 'Cancel' and 'Create resource' buttons.

Figure 13: Resource Creation

The screenshot shows the 'Create method' form in the AWS API Gateway console. The breadcrumb trail is 'API Gateway > APIs > Resources - RU_Power_API [pdddw8ll] > Create method'. The form is titled 'Create method'. Under 'Method details', there is a dropdown for 'Method type'. Below this, there are several radio buttons for 'Integration type': 'Lambda function' (selected), 'HTTP', 'Mock', 'AWS service', and 'VPC link'. At the bottom, there is a section for 'Lambda proxy integration' with a text input for 'Lambda function' containing 'arn:aws:lambda:us-east-1:423623834574:function:RU_Power_lambd'. At the bottom right, there are 'Cancel' and 'Create method' buttons.

Figure 14: Method Creation

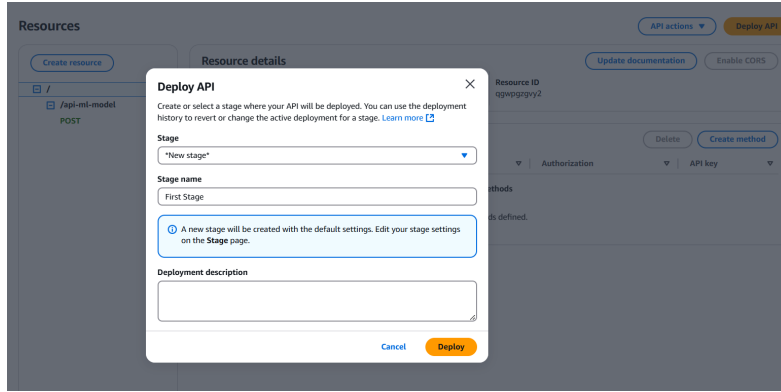


Figure 15: Deployment

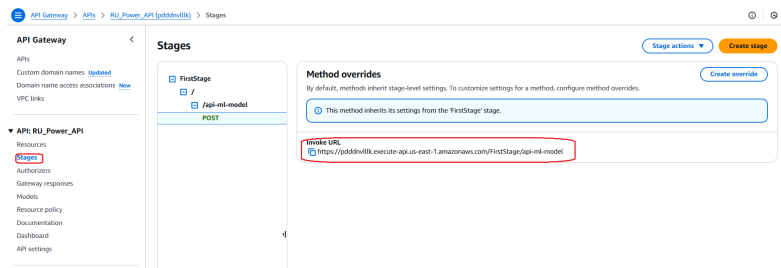


Figure 16: API GateWay URL

5 Virtual ORAN Network

The Virtual Open RAN network simulation code can be found at this link—<https://github.com/Abdu-AJ/ORAN.git>

References

Amazon Web Services (2024). *Amazon SageMaker Documentation: SageMaker Roles*.

URL: <https://docs.aws.amazon.com/sagemaker/latest/dg/sagemaker-roles.html>

Spidy20 (2023). Sagemaker tutorials - tutorial 1: Sagemaker sklearn custom script mode, <https://github.com/Spidy20/Sagemaker-Tutorials/tree/master/Tutorial%20-%201%20Sagemaker%20SKLearn%20Custom%20Script%20Mode>.