Build, Train and Deploy a Machine Learning Model

SageMaker AWS Demo : XGBoost

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- Demo content: As a machine learning developer for the marketing department of a bank you need to predict if a customer will enroll for certificate of deposit. Your marketing dataset contains bank information on customer demographics, response to marketing events, and external environment factors. The data is labeled, meaning there is a column in the dataset that identifies whether the customer is enrolled for a product offered by the bank. For this example scenario, you will use a publicly-available dataset from the ML repository curated by the University of California, Irvine.

In [1]:

```
# import libraries
import boto3, re, sys, math, json, os, sagemaker, urllib.request
from sagemaker import get_execution_role
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image
from IPython.display import display
from time import gmtime, strftime
from sagemaker.predictor import csv_serializer

# Define IAM role
role = get_execution_role()
prefix = 'sagemaker/DEMO-xgboost-dm'
containers = {'us-west-2': '433757028032.dkr.ecr.us-west-2.amazonaws.com/xgboost:latest',
              'us-east-1': '811284229777.dkr.ecr.us-east-1.amazonaws.com/xgboost:latest',
              'us-east-2': '825641698319.dkr.ecr.us-east-2.amazonaws.com/xgboost:latest',
              'eu-west-1': '685385470294.dkr.ecr.eu-west-1.amazonaws.com/xgboost:latest'} # each region has its XGBoost container
my_region = boto3.session.Session().region_name # set the region of the instance
print("Success - the MySageMakerInstance is in the " + my_region + " region. You will use the " + containers[my_region] + " container for your SageMaker endpoint.")
```

```
Success - the MySageMakerInstance is in the eu-west-1 region. You will use
the 685385470294.dkr.ecr.eu-west-1.amazonaws.com/xgboost:latest container
for your SageMaker endpoint.
```

In [2]:

```
# Create S3 bucket
bucket_name = 'nasirbucketxgboostdemo' # <--- change this variable to a unique name for
your bucket
s3 = boto3.resource('s3')
try:
    if  my_region == 'us-east-1':
      s3.create_bucket(Bucket=bucket_name)
    else:
      s3.create_bucket(Bucket=bucket_name, CreateBucketConfiguration={ 'LocationConstra
int': my_region })
    print('S3 bucket created successfully')
except Exception as e:
    print('S3 error: ',e)
```

```
S3 bucket created successfully
```

In [3]:

```
# Download the dateset
try:
  urllib.request.urlretrieve ("https://d1.awsstatic.com/tmt/build-train-deploy-machine-
learning-model-sagemaker/bank_clean.27f01fbbdf43271788427f3682996ae29ceca05d.csv", "ban
k_clean.csv")
  print('Success: downloaded bank_clean.csv.')
except Exception as e:
  print('Data load error: ',e)

try:
  model_data = pd.read_csv('./bank_clean.csv',index_col=0)
  print('Success: Data loaded into dataframe.')
except Exception as e:
    print('Data load error: ',e)
```

```
Success: downloaded bank_clean.csv.
Success: Data loaded into dataframe.
```

In [8]:

```
# see head of model_data
model_data.head()
```

Out[8]:

	age	campaign	pdays	previous	no_previous_contact	not_working	job_admin.	job_blue-collar
0	56	1	999	0	1	0	0	0
1	57	1	999	0	1	0	0	0
2	37	1	999	0	1	0	0	0
3	40	1	999	0	1	0	1	0
4	56	1	999	0	1	0	0	0

5 rows × 61 columns

In [4]:

```
# Shuffle & split data
train_data, test_data = np.split(model_data.sample(frac=1, random_state=1729), [int(0.7
* len(model_data))])
print(train_data.shape, test_data.shape)
```

```
(28831, 61) (12357, 61)
```

In [5]:

```
# Reformat and load data for SageMaker pre-built XGBoost model
pd.concat([train_data['y_yes'], train_data.drop(['y_no', 'y_yes'], axis=1)], axis=1).to
_csv('train.csv', index=False, header=False)
boto3.Session().resource('s3').Bucket(bucket_name).Object(os.path.join(prefix, 'train/t
rain.csv')).upload_file('train.csv')
s3_input_train = sagemaker.s3_input(s3_data='s3://{}/{}/train'.format(bucket_name, pref
ix), content_type='csv')
```

In [6]:

```
# Set up SageMaker session and defince hyperparameter
sess = sagemaker.Session()
xgb = sagemaker.estimator.Estimator(containers[my_region],role, train_instance_count=1,
train_instance_type='ml.m4.xlarge',output_path='s3://{}/{}/output'.format(bucket_name,
prefix),sagemaker_session=sess)
xgb.set_hyperparameters(max_depth=5,eta=0.2,gamma=4,min_child_weight=6,subsample=0.8,si
lent=0,objective='binary:logistic',num_round=100)
```

In [7]:

```
# Train the model using gradiant optimization
xgb.fit({'train': s3_input_train})
```

```
2019-06-24 08:03:55 Starting - Starting the training job...
2019-06-24 08:03:57 Starting - Launching requested ML instances......
2019-06-24 08:05:01 Starting - Preparing the instances for training......
2019-06-24 08:06:26 Downloading - Downloading input data
2019-06-24 08:06:26 Training - Downloading the training image...
2019-06-24 08:06:50 Uploading - Uploading generated training model
Arguments: train
[2019-06-24:08:06:45:INFO] Running standalone xgboost training.
[2019-06-24:08:06:45:INFO] Path /opt/ml/input/data/validation does not exi
st!
[2019-06-24:08:06:45:INFO] File size need to be processed in the node: 3.3
8mb. Available memory size in the node: 8440.03mb
[2019-06-24:08:06:45:INFO] Determined delimiter of CSV input is ','
[08:06:45] S3DistributionType set as FullyReplicated
[08:06:45] 28831x59 matrix with 1701029 entries loaded from /opt/ml/input/
data/train?format=csv&label_column=0&delimiter=,
[08:06:45] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 14 pruned nodes, max_depth=5
[0]#011train-error:0.100482
[08:06:45] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 28 ext
ra nodes, 16 pruned nodes, max_depth=5
[1]#011train-error:0.099858
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 32 ext
ra nodes, 18 pruned nodes, max_depth=5
[2]#011train-error:0.099476
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 32 ext
ra nodes, 14 pruned nodes, max_depth=5
[3]#011train-error:0.099025
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 18 pruned nodes, max_depth=5
[4]#011train-error:0.099476
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 32 ext
ra nodes, 8 pruned nodes, max_depth=5
[5]#011train-error:0.099372
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 28 ext
ra nodes, 12 pruned nodes, max_depth=5
[6]#011train-error:0.09906
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 20 pruned nodes, max_depth=5
[7]#011train-error:0.099025
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 24 pruned nodes, max_depth=5
[8]#011train-error:0.099164
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 12 pruned nodes, max_depth=5
[9]#011train-error:0.098817
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 30 pruned nodes, max_depth=5
[10]#011train-error:0.098817
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 22 pruned nodes, max_depth=5
[11]#011train-error:0.098817
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 22 pruned nodes, max_depth=5
[12]#011train-error:0.098852
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 28 ext
ra nodes, 16 pruned nodes, max_depth=5
[13]#011train-error:0.098574
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 28 ext
ra nodes, 18 pruned nodes, max_depth=5
[14]#011train-error:0.098609
```

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[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 32 ext
ra nodes, 8 pruned nodes, max_depth=5
[15]#011train-error:0.098401
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 26 pruned nodes, max_depth=5
[16]#011train-error:0.098401
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 20 pruned nodes, max_depth=5
[17]#011train-error:0.098297
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 18 pruned nodes, max_depth=5
[18]#011train-error:0.098054
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 14 pruned nodes, max_depth=5
[19]#011train-error:0.098158
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 8 pruned nodes, max_depth=5
[20]#011train-error:0.098193
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 36 ext
ra nodes, 8 pruned nodes, max_depth=5
[21]#011train-error:0.098193
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 28 ext
ra nodes, 22 pruned nodes, max_depth=5
[22]#011train-error:0.098124
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 16 pruned nodes, max_depth=5
[23]#011train-error:0.098124
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 20 pruned nodes, max_depth=5
[24]#011train-error:0.097881
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 34 ext
ra nodes, 4 pruned nodes, max_depth=5
[25]#011train-error:0.097777
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 14 pruned nodes, max_depth=5
[26]#011train-error:0.097742
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 20 pruned nodes, max_depth=5
[27]#011train-error:0.097707
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 22 pruned nodes, max_depth=5
[28]#011train-error:0.097291
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 32 ext
ra nodes, 4 pruned nodes, max_depth=5
[29]#011train-error:0.097152
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 14 ext
ra nodes, 6 pruned nodes, max_depth=5
[30]#011train-error:0.097256
[08:06:46] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 24 pruned nodes, max_depth=5
[31]#011train-error:0.097083
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 10 pruned nodes, max_depth=5
[32]#011train-error:0.097083
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 24 pruned nodes, max_depth=5
[33]#011train-error:0.097083
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 8 pruned nodes, max_depth=5
[34]#011train-error:0.097152
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
```

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ra nodes, 28 pruned nodes, max_depth=5
[35]#011train-error:0.097256
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 22 pruned nodes, max_depth=5
[36]#011train-error:0.097187
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 26 pruned nodes, max_depth=5
[37]#011train-error:0.097118
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 20 pruned nodes, max_depth=5
[38]#011train-error:0.097152
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 20 pruned nodes, max_depth=5
[39]#011train-error:0.096736
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 4 extr
a nodes, 14 pruned nodes, max_depth=2
[40]#011train-error:0.09691
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 14 pruned nodes, max_depth=5
[41]#011train-error:0.096736
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 16 pruned nodes, max_depth=5
[42]#011train-error:0.096771
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 12 pruned nodes, max_depth=0
[43]#011train-error:0.096806
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 16 pruned nodes, max_depth=5
[44]#011train-error:0.096736
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 4 extr
a nodes, 14 pruned nodes, max_depth=2
[45]#011train-error:0.096806
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 24 pruned nodes, max_depth=5
[46]#011train-error:0.096459
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 26 pruned nodes, max_depth=5
[47]#011train-error:0.096424
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 12 ext
ra nodes, 16 pruned nodes, max_depth=4
[48]#011train-error:0.096528
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 14 pruned nodes, max_depth=5
[49]#011train-error:0.096563
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 38 pruned nodes, max_depth=5
[50]#011train-error:0.096597
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 14 ext
ra nodes, 14 pruned nodes, max_depth=5
[51]#011train-error:0.096528
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 30 pruned nodes, max_depth=5
[52]#011train-error:0.096112
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 14 pruned nodes, max_depth=5
[53]#011train-error:0.096077
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 16 pruned nodes, max_depth=5
[54]#011train-error:0.09632
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 8 extr
a nodes, 16 pruned nodes, max_depth=3
```

```
[55]#011train-error:0.09632
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 12 ext
ra nodes, 30 pruned nodes, max_depth=4
[56]#011train-error:0.096147
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 16 pruned nodes, max_depth=5
[57]#011train-error:0.09632
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 24 pruned nodes, max_depth=5
[58]#011train-error:0.096112
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 12 ext
ra nodes, 34 pruned nodes, max_depth=5
[59]#011train-error:0.096042
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 28 pruned nodes, max_depth=5
[60]#011train-error:0.096008
[08:06:47] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 26 ext
ra nodes, 14 pruned nodes, max_depth=5
[61]#011train-error:0.096042
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 30 pruned nodes, max_depth=5
[62]#011train-error:0.096077
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 6 extr
a nodes, 30 pruned nodes, max_depth=3
[63]#011train-error:0.096147
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 18 pruned nodes, max_depth=5
[64]#011train-error:0.096216
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 12 pruned nodes, max_depth=5
[65]#011train-error:0.09632
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 10 pruned nodes, max_depth=5
[66]#011train-error:0.096181
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 20 pruned nodes, max_depth=4
[67]#011train-error:0.095904
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 16 ext
ra nodes, 24 pruned nodes, max_depth=5
[68]#011train-error:0.096008
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 26 pruned nodes, max_depth=0
[69]#011train-error:0.096042
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 22 ext
ra nodes, 12 pruned nodes, max_depth=5
[70]#011train-error:0.096077
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 8 pruned nodes, max_depth=5
[71]#011train-error:0.095938
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 30 pruned nodes, max_depth=0
[72]#011train-error:0.095938
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 4 extr
a nodes, 28 pruned nodes, max_depth=2
[73]#011train-error:0.096008
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 12 pruned nodes, max_depth=0
[74]#011train-error:0.095869
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 34 pruned nodes, max_depth=0
[75]#011train-error:0.095938
```

```
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 24 pruned nodes, max_depth=0
[76]#011train-error:0.095904
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 12 ext
ra nodes, 14 pruned nodes, max_depth=5
[77]#011train-error:0.0958
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 6 extr
a nodes, 14 pruned nodes, max_depth=3
[78]#011train-error:0.09573
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 18 pruned nodes, max_depth=4
[79]#011train-error:0.095765
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 14 ext
ra nodes, 12 pruned nodes, max_depth=5
[80]#011train-error:0.095834
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 20 pruned nodes, max_depth=5
[81]#011train-error:0.095592
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 22 pruned nodes, max_depth=4
[82]#011train-error:0.095557
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 6 extr
a nodes, 26 pruned nodes, max_depth=3
[83]#011train-error:0.095557
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 32 pruned nodes, max_depth=5
[84]#011train-error:0.095453
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 8 pruned nodes, max_depth=4
[85]#011train-error:0.095453
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 24 pruned nodes, max_depth=0
[86]#011train-error:0.095453
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 24 pruned nodes, max_depth=0
[87]#011train-error:0.095453
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 20 ext
ra nodes, 16 pruned nodes, max_depth=5
[88]#011train-error:0.095349
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 4 extr
a nodes, 30 pruned nodes, max_depth=2
[89]#011train-error:0.095037
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 14 pruned nodes, max_depth=0
[90]#011train-error:0.095106
[08:06:48] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 42 pruned nodes, max_depth=0
[91]#011train-error:0.095037
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 0 extr
a nodes, 30 pruned nodes, max_depth=0
[92]#011train-error:0.095106
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 10 ext
ra nodes, 14 pruned nodes, max_depth=5
[93]#011train-error:0.095314
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 24 ext
ra nodes, 30 pruned nodes, max_depth=5
[94]#011train-error:0.095314
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 6 extr
a nodes, 24 pruned nodes, max_depth=3
[95]#011train-error:0.095314
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 12 ext
```

```
ra nodes, 30 pruned nodes, max_depth=5
[96]#011train-error:0.095279
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 18 ext
ra nodes, 12 pruned nodes, max_depth=5
[97]#011train-error:0.094828
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 4 extr
a nodes, 22 pruned nodes, max_depth=2
[98]#011train-error:0.094863
[08:06:49] src/tree/updater_prune.cc:74: tree pruning end, 1 roots, 30 ext
ra nodes, 12 pruned nodes, max_depth=5
[99]#011train-error:0.094759

2019-06-24 08:06:57 Completed - Training job completed
Billable seconds: 52
```

Deploy the model

- deploy the trained model to en endpoint, reformat then load the CSV data, then run the model to create predictions.

In [9]:

```
# Deploy the model on a server and create an endpoint
xgb_predictor = xgb.deploy(initial_instance_count=1,instance_type='ml.m4.xlarge')
```

```
-----------------------------------------------------------------------
--------------!
```

In [10]:

```
# To predict whether customers in the test data enrolled for the bank product or not
# prediction array shape
test_data_array = test_data.drop(['y_no', 'y_yes'], axis=1).as_matrix() #load the data
 into an array
xgb_predictor.content_type = 'text/csv' # set the data type for an inference
xgb_predictor.serializer = csv_serializer # set the serializer type
predictions = xgb_predictor.predict(test_data_array).decode('utf-8') # predict!
predictions_array = np.fromstring(predictions[1:], sep=',') # and turn the prediction i
nto an array
print(predictions_array.shape)
```

```
/home/ec2-user/anaconda3/envs/python3/lib/python3.6/site-packages/ipykerne
l/__main__.py:2: FutureWarning: Method .as_matrix will be removed in a fut
ure version. Use .values instead.
  from ipykernel import kernelapp as app

(12357,)
```

In [13]:

```
## Evaluate model performance
cm = pd.crosstab(index=test_data['y_yes'], columns=np.round(predictions_array), rownames=['Observed'], colnames=['Predicted'])
tn = cm.iloc[0,0]; fn = cm.iloc[1,0]; tp = cm.iloc[1,1]; fp = cm.iloc[0,1]; p = (tp+tn)/(tp+tn+fp+fn)*100
print("\n{0:<20}{1:<4.1f}%\n".format("Overall Classification Rate: ", p))
print("{0:<15}{1:<15}{2:>8}".format("Predicted", "No Purchase", "Purchase"))
print("Observed")
print("{0:<15}{1:<2.0f}% ({2:<}){3:>6.0f}% ({4:<})".format("No Purchase", tn/(tn+fn)*100,tn, fp/(tp+fp)*100, fp))
print("{0:<16}{1:<1.0f}% ({2:<}){3:>7.0f}% ({4:<}) \n".format("Purchase", fn/(tn+fn)*100,fn, tp/(tp+fp)*100, tp))
```

```
Overall Classification Rate: 89.5%

Predicted      No Purchase    Purchase
Observed
No Purchase    90% (10785)    35% (151)
Purchase        10% (1143)     65% (278)
```

- original paper: http://media.salford-systems.com/video/tutorial/2015/targeted_marketing.pdf (http://media.salford-systems.com/video/tutorial/2015/targeted_marketing.pdf)
- We can conclude that we predicted the outcome accurately for 90% of customers in the test data, with a precision of 65% (278/429) for enrolled and 90% (10,785/11,928) for didn't enroll. The model could now be fined tuned, but this performance is already better than in the original paper.

In [ ]:

```
# Terminate the resources
"""
sagemaker.Session().delete_endpoint(xgb_predictor.endpoint)
bucket_to_delete = boto3.resource('s3').Bucket(bucket_name)
bucket_to_delete.objects.all().delete()
"""
```