Overview

This notebook will show you how to create and query a table or DataFrame that you uploaded to DBFS. DBFS (https://docs.databricks.com/user-guide/dbfs-databricks-file-system.html) is a Databricks File System that allows you to store data for querying inside of Databricks. This notebook assumes that you have a file already inside of DBFS that you would like to read from.

This notebook is written in **Python** so the default cell type is Python. However, you can use different languages by using the `%LANGUAGE` syntax. Python, Scala, SQL, and R are all supported.

In [1]:

```
from pyspark.sql import SparkSession
from pyspark import HiveContext
from pyspark.sql.functions import monotonically_increasing_id
from pyspark.ml.linalg import Vectors
from pyspark.ml.feature import VectorAssembler
from pyspark.ml.evaluation import RegressionEvaluator
from pyspark.ml.classification import LogisticRegression, LogisticRegressionModel
from pyspark.mllib.evaluation import BinaryClassificationMetrics as metric
from pyspark.ml.feature import OneHotEncoder, StringIndexer, VectorAssembler,OneHotEnco
from pyspark.ml.classification import RandomForestClassifier, RandomForestClassificatio
from pyspark.mllib.evaluation import BinaryClassificationMetrics as metric
from pyspark.ml import Pipeline
```

In [2]:

```
spark.sparkContext._conf.getAll()
```

Out[2]:

```
[('spark.sql.catalogImplementation', 'hive'),
 ('spark.rdd.compress', 'True'),
 ('spark.driver.host', '10.30.30.21'),
 ('spark.serializer.objectStreamReset', '100'),
 ('spark.driver.port', '44127'),
 ('spark.master', 'local[*]'),
 ('spark.executor.id', 'driver'),
 ('spark.submit.deployMode', 'client'),
 ('spark.app.id', 'local-1559696620353'),
 ('spark.app.name', 'PySparkShell')]
```

In [3]:

```
conf = spark.sparkContext._conf.setAll([
    ("hive.metastore.uris", "thrift://localhost:9083")])
```

In [4]:

```
spark.stop()
```

In [5]:

```
sc = SparkContext()
```

In [6]:

```
spark = SparkSession.builder.config(conf=conf).getOrCreate()
```

In [7]:

```
spark.sparkContext._conf.getAll()
```

Out[7]:

```
[('spark.sql.catalogImplementation', 'hive'),
 ('spark.rdd.compress', 'True'),
 ('spark.driver.host', '10.30.30.21'),
 ('hive.metastore.uris', 'thrift://localhost:9083'),
 ('spark.serializer.objectStreamReset', '100'),
 ('spark.driver.port', '44127'),
 ('spark.master', 'local[*]'),
 ('spark.executor.id', 'driver'),
 ('spark.submit.deployMode', 'client'),
 ('spark.app.id', 'local-1559696620353'),
 ('spark.app.name', 'PySparkShell')]
```

In [8]:

```
df = spark.sql("SHOW TABLES")
df.show()
```

```
+--------+--------------+-----------+
|database|     tableName|isTemporary|
+--------+--------------+-----------+
| default|boosting_output|      false|
| default|  movieratings|      false|
+--------+--------------+-----------+
```

In [9]:

```
# Load File from HDFS
# file_location = "/FileStore/tables/bank_additional_full_no_header-a99ad.csv"
file_location = 'hdfs:///user/labdata/marketing/bank-additional-full.csv'
file_type = "csv"

# CSV options
infer_schema = "true"
first_row_is_header = "false"
delimiter = ";"

# The applied options are for CSV files. For other file types, these will be ignored.
df_marketing_data = spark.read.format(file_type) \
  .option("inferSchema", infer_schema) \
  .option("header", first_row_is_header) \
  .option("sep", delimiter) \
  .load(file_location)
```

In [11]:

```
# Rename Column Names to the Original Header
DefColumnNames=df_marketing_data.schema.names
HeaderNames=['age','job','marital','education','default','housing','loan','contact','mo

for Idx in range(0,21):
    df_marketing_data=df_marketing_data.withColumnRenamed(DefColumnNames[Idx],HeaderNam
df_marketing_data = df_marketing_data.drop ('duration')
df_marketing_data.printSchema()
```

```
root
 |-- age: integer (nullable = true)
 |-- job: string (nullable = true)
 |-- marital: string (nullable = true)
 |-- education: string (nullable = true)
 |-- default: string (nullable = true)
 |-- housing: string (nullable = true)
 |-- loan: string (nullable = true)
 |-- contact: string (nullable = true)
 |-- month: string (nullable = true)
 |-- day_of_week: string (nullable = true)
 |-- campaign: integer (nullable = true)
 |-- pdays: integer (nullable = true)
 |-- previous: integer (nullable = true)
 |-- poutcome: string (nullable = true)
 |-- emp_var_rate: double (nullable = true)
 |-- cons_price_idx: double (nullable = true)
 |-- cons_conf_idx: double (nullable = true)
 |-- euribor3m: double (nullable = true)
 |-- nr_employed: double (nullable = true)
 |-- deposit: string (nullable = true)
```

In [12]:

```
categoricalColumns = []
numericCols = []
for i in df_marketing_data.dtypes:
    if i[1]=='string':
        categoricalColumns  += [i[0]]
    elif i[1]=='int' or i[1]=='double':
        numericCols  += [i[0]]

print(categoricalColumns)
print(numericCols)
```

```
['job', 'marital', 'education', 'default', 'housing', 'loan', 'contact',
'month', 'day_of_week', 'poutcome', 'deposit']
['age', 'campaign', 'pdays', 'previous', 'emp_var_rate', 'cons_price_id
x', 'cons_conf_idx', 'euribor3m', 'nr_employed']
```

In [13]:

```
# Handling Categorical Columns using StringIndex/Encoder
#categoricalColumns = ['job', 'marital', 'education', 'default', 'housing', 'loan', 'co

stages = []
for categoricalCol in categoricalColumns:
  stringIndexer = StringIndexer(inputCol=categoricalCol, outputCol=categoricalCol+"Inde
  encoder = OneHotEncoder(inputCol=categoricalCol+"Index", outputCol=categoricalCol+"cl
  stages += [stringIndexer, encoder]

#numericCols = ['age', 'balance', 'duration', 'campaign', 'pdays', 'previous']
label_stringIdx = StringIndexer(inputCol = "deposit", outputCol = "label")
stages += [label_stringIdx]
```

In [14]:

```
## Assembler Inputs
assemblerInputs = ['jobclassVec', 'maritalclassVec', 'educationclassVec', 'defaultclass
assembler = VectorAssembler(inputCols=assemblerInputs, outputCol="features")
stages += [assembler]
```

In [15]:

```
## PipeLine
pipeline = Pipeline(stages=stages)
pipelineModel = pipeline.fit(df_marketing_data)
df_marketing_data_prep = pipelineModel.transform(df_marketing_data)
df_marketing_data_prep.printSchema()
```

```
root
 |-- age: integer (nullable = true)
 |-- job: string (nullable = true)
 |-- marital: string (nullable = true)
 |-- education: string (nullable = true)
 |-- default: string (nullable = true)
 |-- housing: string (nullable = true)
 |-- loan: string (nullable = true)
 |-- contact: string (nullable = true)
 |-- month: string (nullable = true)
 |-- day_of_week: string (nullable = true)
 |-- campaign: integer (nullable = true)
 |-- pdays: integer (nullable = true)
 |-- previous: integer (nullable = true)
 |-- poutcome: string (nullable = true)
 |-- emp_var_rate: double (nullable = true)
 |-- cons_price_idx: double (nullable = true)
 |-- cons_conf_idx: double (nullable = true)
 |-- euribor3m: double (nullable = true)
 |-- nr_employed: double (nullable = true)
 |-- deposit: string (nullable = true)
 |-- jobIndex: double (nullable = true)
 |-- jobclassVec: vector (nullable = true)
 |-- maritalIndex: double (nullable = true)
 |-- maritalclassVec: vector (nullable = true)
 |-- educationIndex: double (nullable = true)
 |-- educationclassVec: vector (nullable = true)
 |-- defaultIndex: double (nullable = true)
 |-- defaultclassVec: vector (nullable = true)
 |-- housingIndex: double (nullable = true)
 |-- housingclassVec: vector (nullable = true)
 |-- loanIndex: double (nullable = true)
 |-- loanclassVec: vector (nullable = true)
 |-- contactIndex: double (nullable = true)
 |-- contactclassVec: vector (nullable = true)
 |-- monthIndex: double (nullable = true)
 |-- monthclassVec: vector (nullable = true)
 |-- day_of_weekIndex: double (nullable = true)
 |-- day_of_weekclassVec: vector (nullable = true)
 |-- poutcomeIndex: double (nullable = true)
 |-- poutcomeclassVec: vector (nullable = true)
 |-- depositIndex: double (nullable = true)
 |-- depositclassVec: vector (nullable = true)
 |-- label: double (nullable = true)
 |-- features: vector (nullable = true)
```

In [16]:

```
df_marketing_data_prep.take(5)
```

Out[16]:

```
[Row(age=56, job='housemaid', marital='married', education='basic.4y', de
fault='no', housing='no', loan='no', contact='telephone', month='may', da
y_of_week='mon', campaign=1, pdays=999, previous=0, poutcome='nonexisten
t', emp_var_rate=1.1, cons_price_idx=93.994, cons_conf_idx=-36.4, euribor
3m=4.857, nr_employed=5191.0, deposit='no', jobIndex=8.0, jobclassVec=Spa
rseVector(11, {8: 1.0}), maritalIndex=0.0, maritalclassVec=SparseVector
(3, {0: 1.0}), educationIndex=4.0, educationclassVec=SparseVector(7, {4:
1.0}), defaultIndex=0.0, defaultclassVec=SparseVector(2, {0: 1.0}), housi
ngIndex=1.0, housingclassVec=SparseVector(2, {1: 1.0}), loanIndex=0.0, lo
anclassVec=SparseVector(2, {0: 1.0}), contactIndex=1.0, contactclassVec=S
parseVector(1, {}), monthIndex=0.0, monthclassVec=SparseVector(9, {0: 1.
0}), day_of_weekIndex=1.0, day_of_weekclassVec=SparseVector(4, {1: 1.0}),
poutcomeIndex=0.0, poutcomeclassVec=SparseVector(2, {0: 1.0}), depositInd
ex=0.0, depositclassVec=SparseVector(1, {0: 1.0}), label=0.0, features=Sp
arseVector(52, {8: 1.0, 11: 1.0, 18: 1.0, 21: 1.0, 24: 1.0, 25: 1.0, 28:
1.0, 38: 1.0, 41: 1.0, 43: 56.0, 44: 1.0, 45: 999.0, 47: 1.1, 48: 93.994,
49: -36.4, 50: 4.857, 51: 5191.0})),
 Row(age=57, job='services', marital='married', education='high.school',
default='unknown', housing='no', loan='no', contact='telephone', month='m
ay', day_of_week='mon', campaign=1, pdays=999, previous=0, poutcome='none
xistent', emp_var_rate=1.1, cons_price_idx=93.994, cons_conf_idx=-36.4, e
uribor3m=4.857, nr_employed=5191.0, deposit='no', jobIndex=3.0, jobclassV
ec=SparseVector(11, {3: 1.0}), maritalIndex=0.0, maritalclassVec=SparseVe
ctor(3, {0: 1.0}), educationIndex=1.0, educationclassVec=SparseVector(7,
{1: 1.0}), defaultIndex=1.0, defaultclassVec=SparseVector(2, {1: 1.0}), h
ousingIndex=1.0, housingclassVec=SparseVector(2, {1: 1.0}), loanIndex=0.
0, loanclassVec=SparseVector(2, {0: 1.0}), contactIndex=1.0, contactclass
Vec=SparseVector(1, {}), monthIndex=0.0, monthclassVec=SparseVector(9,
{0: 1.0}), day_of_weekIndex=1.0, day_of_weekclassVec=SparseVector(4, {1:
1.0}), poutcomeIndex=0.0, poutcomeclassVec=SparseVector(2, {0: 1.0}), dep
ositIndex=0.0, depositclassVec=SparseVector(1, {0: 1.0}), label=0.0, feat
ures=SparseVector(52, {3: 1.0, 11: 1.0, 15: 1.0, 22: 1.0, 24: 1.0, 25: 1.
0, 28: 1.0, 38: 1.0, 41: 1.0, 43: 57.0, 44: 1.0, 45: 999.0, 47: 1.1, 48:
93.994, 49: -36.4, 50: 4.857, 51: 5191.0})),
 Row(age=37, job='services', marital='married', education='high.school',
default='no', housing='yes', loan='no', contact='telephone', month='may',
day_of_week='mon', campaign=1, pdays=999, previous=0, poutcome='nonexiste
nt', emp_var_rate=1.1, cons_price_idx=93.994, cons_conf_idx=-36.4, euribo
r3m=4.857, nr_employed=5191.0, deposit='no', jobIndex=3.0, jobclassVec=Sp
arseVector(11, {3: 1.0}), maritalIndex=0.0, maritalclassVec=SparseVector
(3, {0: 1.0}), educationIndex=1.0, educationclassVec=SparseVector(7, {1:
1.0}), defaultIndex=0.0, defaultclassVec=SparseVector(2, {0: 1.0}), housi
ngIndex=0.0, housingclassVec=SparseVector(2, {0: 1.0}), loanIndex=0.0, lo
anclassVec=SparseVector(2, {0: 1.0}), contactIndex=1.0, contactclassVec=S
parseVector(1, {}), monthIndex=0.0, monthclassVec=SparseVector(9, {0: 1.
0}), day_of_weekIndex=1.0, day_of_weekclassVec=SparseVector(4, {1: 1.0}),
poutcomeIndex=0.0, poutcomeclassVec=SparseVector(2, {0: 1.0}), depositInd
ex=0.0, depositclassVec=SparseVector(1, {0: 1.0}), label=0.0, features=Sp
arseVector(52, {3: 1.0, 11: 1.0, 15: 1.0, 21: 1.0, 23: 1.0, 25: 1.0, 28:
1.0, 38: 1.0, 41: 1.0, 43: 37.0, 44: 1.0, 45: 999.0, 47: 1.1, 48: 93.994,
49: -36.4, 50: 4.857, 51: 5191.0})),
 Row(age=40, job='admin.', marital='married', education='basic.6y', defau
lt='no', housing='no', loan='no', contact='telephone', month='may', day_o
f_week='mon', campaign=1, pdays=999, previous=0, poutcome='nonexistent',
emp_var_rate=1.1, cons_price_idx=93.994, cons_conf_idx=-36.4, euribor3m=
4.857, nr_employed=5191.0, deposit='no', jobIndex=0.0, jobclassVec=Sparse
Vector(11, {0: 1.0}), maritalIndex=0.0, maritalclassVec=SparseVector(3,
{0: 1.0}), educationIndex=5.0, educationclassVec=SparseVector(7, {5: 1.
0}), defaultIndex=0.0, defaultclassVec=SparseVector(2, {0: 1.0}), housing
Index=1.0, housingclassVec=SparseVector(2, {1: 1.0}), loanIndex=0.0, loan
classVec=SparseVector(2, {0: 1.0}), contactIndex=1.0, contactclassVec=Spa
rseVector(1, {}), monthIndex=0.0, monthclassVec=SparseVector(9, {0: 1.
0}), day_of_weekIndex=1.0, day_of_weekclassVec=SparseVector(4, {1: 1.0}),
poutcomeIndex=0.0, poutcomeclassVec=SparseVector(2, {0: 1.0}), depositInd
ex=0.0, depositclassVec=SparseVector(1, {0: 1.0}), label=0.0, features=Sp
arseVector(52, {0: 1.0, 11: 1.0, 19: 1.0, 21: 1.0, 24: 1.0, 25: 1.0, 28:
1.0, 38: 1.0, 41: 1.0, 43: 40.0, 44: 1.0, 45: 999.0, 47: 1.1, 48: 93.994,
49: -36.4, 50: 4.857, 51: 5191.0})),
 Row(age=56, job='services', marital='married', education='high.school',
default='no', housing='no', loan='yes', contact='telephone', month='may',
day_of_week='mon', campaign=1, pdays=999, previous=0, poutcome='nonexiste
nt', emp_var_rate=1.1, cons_price_idx=93.994, cons_conf_idx=-36.4, euribo
r3m=4.857, nr_employed=5191.0, deposit='no', jobIndex=3.0, jobclassVec=Sp
arseVector(11, {3: 1.0}), maritalIndex=0.0, maritalclassVec=SparseVector
(3, {0: 1.0}), educationIndex=1.0, educationclassVec=SparseVector(7, {1:
1.0}), defaultIndex=0.0, defaultclassVec=SparseVector(2, {0: 1.0}), housi
ngIndex=1.0, housingclassVec=SparseVector(2, {1: 1.0}), loanIndex=1.0, lo
anclassVec=SparseVector(2, {1: 1.0}), contactIndex=1.0, contactclassVec=S
parseVector(1, {}), monthIndex=0.0, monthclassVec=SparseVector(9, {0: 1.
0}), day_of_weekIndex=1.0, day_of_weekclassVec=SparseVector(4, {1: 1.0}),
poutcomeIndex=0.0, poutcomeclassVec=SparseVector(2, {0: 1.0}), depositInd
ex=0.0, depositclassVec=SparseVector(1, {0: 1.0}), label=0.0, features=Sp
arseVector(52, {3: 1.0, 11: 1.0, 15: 1.0, 21: 1.0, 24: 1.0, 26: 1.0, 28:
1.0, 38: 1.0, 41: 1.0, 43: 56.0, 44: 1.0, 45: 999.0, 47: 1.1, 48: 93.994,
49: -36.4, 50: 4.857, 51: 5191.0}))]
```

In [17]:

```python
# Divisão dos Dados de Teste e Treino
(marketing_model_treino, marketing_model_teste) = df_marketing_data_prep.randomSplit([0
```

In [18]:

```python
# Definindo Numero de Arvores
modelo =  RandomForestClassifier(featuresCol="features").setNumTrees(100)
```

In [19]:

```
# Preparing Training
modelo_fit = modelo.fit(marketing_model_treino)
print (modelo_fit.featureImportances)
```

```
(52,[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,
26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,5
0,51],[0.0006705108661640729,0.002161657683086589,0.0005734176579959931,
0.0004262521511439382,0.0005186550150947832,0.001876269949621637,0.000338
06297497945874,0.0005254846541944077,0.00012914979216743438,0.00018249836
39196838,0.0023019694594873055,0.0004320687255771988,0.000642822639894107
1,0.0004608657755694816,0.0010400789947641192,0.0010018396582272740,0.000
6372179396928386,0.0007021327845227091,0.00037192484910320196,0.000438009
3705322684,0.0007737548377592699,0.0014062012698582776,0.0022709792853826
427,0.0004719181364820079,0.0006020418280617020,0.0005487355084603763,0.00
05126693404563093,0.01474685246495978,0.014061021017010305,0.000980850736
765406,0.0014174951207774685,0.0015541973495046399,0.0005814000024891434,
0.01029875114058305,0.01624305623314624,0.0013857150078692812,0.011632603
748333394,0.0017271708463932555,0.002833802140712272,0.000788531055694688
2,0.0008713998360729534,0.01901655745488842,0.025731806162645927,0.013634
316129580574,0.004854727303084206,0.1399633981542219,0.02555218598119692
4,0.09473716833953227,0.0365672135065326,0.0826844962431634,0.21581014853
43889,0.2403079459782541])
```

In [21]:

```
# Saving Model HDFS
hdfs_path = "/user/labdata/modelo_RFT"
modelo_fit.write().overwrite().save(hdfs_path)
```

In [22]:

```
modelo_salvo = RandomForestClassificationModel.load(hdfs_path)
```

In [23]:

```
# Running Prediction
predict = modelo_salvo.transform(marketing_model_treino)
```

In [16]:

```
predict.show()
```

```
+---+-------+-------+-----------+-------+-------+-------+---------+-----+-----------+--------+--------+-----
+--------+-----------+------------+-------------+-------------+---------+-----------+-------+--------+---------
------+------------+--------------+-------------+----------------+-----------+--------------+------------+--
-------------+---------+-------------+-----------+--------------+----------+-------------+---------------+----
---------------+------------+---------------+-----------+--------------+-----+------------------+----------
----------+-------------------+----------+ age| job|marital| education|default|housing| loan|
contact|month|day_of_week|duration|campaign|pdays|previous|
poutcome|emp_var_rate|cons_price_idx|cons_conf_idx|euribor3m|nr_employed|deposit|jobInc
jobclassVec|maritalIndex|maritalclassVec|educationIndex|educationclassVec|defaultIndex|defa
loanclassVec|contactIndex|contactclassVec|monthIndex|monthclassVec|day_of_weekIndex|day
features| rawPrediction| probability|prediction| +---+-------+-------+-----------+-------+-------+------
-+---------+-----+-----------+--------+--------+-----+--------+-----------+-----------+-------------+--------
-----+---------+-----------+-------+--------+--------------+-----------+--------------+-------------+-------
----------+-----------+--------------+-----------+--------------+---------+------------+-----------+-------
--------+----------+------------+---------------+------------------+------------+---------------+-----------
-+--------------+-----+-------------------+-------------------+-------------------+----------+ 18|student|
single| basic.4y| no| no| no| cellular| apr| thu| 108| 1| 999| 0|nonexistent| -1.8| 93.075| -47.1|
1.365| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 4.0| (7,[4],[1.0])| 0.0| (2,[0],[1.0])| 1.0|
(2,[1],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 0.0| (4,[0],[1.0])| 0.0| (2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,18,21,...|[89.0701043154089...|[0.89070104315408...|
0.0| 18|student| single| basic.4y| no| yes| yes| cellular| apr| thu| 184| 2| 999| 0|nonexistent|
-1.8| 93.075| -47.1| 1.365| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 4.0| (7,[4],[1.0])|
0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 1.0|(2,[1],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 0.0| (4,[0],
[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,18,21,...|[88.1614910545486...|
[0.88161491054548...| 0.0| 18|student| single|high.school| no| no| no|telephone| nov| thu| 75|
1| 999| 0|nonexistent| -0.1| 93.2| -42.0| 4.245| 5195.8| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],
[1.0])| 1.0| (7,[1],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (2,[1],[1.0])| 0.0|(2,[0],[1.0])| 1.0| (1,[],[])| 4.0|(9,
[4],[1.0])| 0.0| (4,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,15,21,...|
[93.5213641872117...|[0.93521364187211...| 0.0| 18|student| single|high.school| no| yes|
yes| cellular| mar| tue| 103| 1| 999| 0|nonexistent| -1.8| 92.843| -50.0| 1.687| 5099.1| no|
10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 1.0| (7,[1],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 1.0|
(2,[1],[1.0])| 0.0| (1,[0],[1.0])| 8.0|(9,[8],[1.0])| 3.0| (4,[3],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],
[1.0])| 0.0|(53,[10,12,15,21,...|[81.2251155137767...|[0.81225115513776...| 0.0| 19|student|
single| basic.4y| no| no| yes| cellular| apr| wed| 371| 2| 999| 0|nonexistent| -1.8| 93.075|
-47.1| 1.405| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 4.0| (7,[4],[1.0])| 0.0| (2,[0],
[1.0])| 1.0| (2,[1],[1.0])| 1.0|(2,[1],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 2.0| (4,[2],[1.0])| 0.0|
(2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,18,21,...|[87.3896261662517...|
[0.87389626166251...| 0.0| 19|student| single| basic.6y| no| no| no| cellular| mar| tue| 136| 1|
999| 0|nonexistent| -1.8| 92.843| -50.0| 1.556| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],
[1.0])| 5.0| (7,[5],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (2,[1],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])|
8.0|(9,[8],[1.0])| 3.0| (4,[3],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,19,21,...|
[79.7554866896712...|[0.79755486689671...| 0.0| 19|student| single| basic.9y| no| no| no|
cellular| apr| thu| 165| 3| 999| 0|nonexistent| -1.8| 93.075| -47.1| 1.41| 5099.1| no| 10.0|(11,
[10],[1.0])| 1.0| (3,[1],[1.0])| 2.0| (7,[2],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (2,[1],[1.0])| 0.0|(2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 0.0| (4,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],[1.0])|
0.0|(53,[10,12,16,21,...|[89.2963410747740...|[0.89296341074774...| 0.0| 19|student| single|
basic.9y|unknown| yes| no| cellular| jul| mon| 87| 4| 999| 0|nonexistent| 1.4| 93.918| -42.7|
4.96| 5228.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 2.0| (7,[2],[1.0])| 1.0| (2,[1],[1.0])| 0.0|
(2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 1.0|(9,[1],[1.0])| 1.0| (4,[1],[1.0])| 0.0| (2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,16,22,...|[94.3982232569771...|[0.9439822325697 7...|
0.0| 19|student| single|high.school|unknown| no| yes| cellular| may| tue| 106| 4| 999|
0|nonexistent| -1.8| 92.893| -46.2| 1.344| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])|
1.0| (7,[1],[1.0])| 1.0| (2,[1],[1.0])| 1.0| (2,[1],[1.0])| 1.0|(2,[1],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(9,[0],
[1.0])| 3.0| (4,[3],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,15,22,...|
[92.2052782437938...|[0.92205278243793...| 0.0| 19|student| single|high.school|unknown|
yes| no| cellular| may| tue| 338| 4| 999| 0|nonexistent| -1.8| 92.893| -46.2| 1.344| 5099.1| no|
10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 1.0| (7,[1],[1.0])| 1.0| (2,[1],[1.0])| 0.0| (2,[0],[1.0])| 0.0|
(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(9,[0],[1.0])| 3.0| (4,[3],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],
[1.0])| 0.0|(53,[10,12,15,22,...|[91.3175301264966...|[0.91317530126496...| 0.0| 19|student|
single| unknown| no| no| no| cellular| apr| fri| 108| 5| 999| 0|nonexistent| -1.8| 93.075| -47.1|
1.405| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 1.0|
(2,[1],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 4.0| (4,[],[])| 0.0| (2,[0],[1.0])|
0.0| (1,[0],[1.0])| 0.0|(53,[10,12,20,21,...|[89.2747510601574...|[0.89274751060157...| 0.0|
19|student| single| unknown| no|unknown|unknown| cellular| apr| mon| 213| 3| 999|
0|nonexistent| -1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])|
6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 2.0| (2,[],[])| 2.0| (2,[],[])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])|
1.0| (4,[1],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,20,21,...|[88.1474968068203...|
[0.88147496806820...| 0.0| 19|student| single| unknown| no| yes| no| cellular| apr| fri| 156| 1|
999| 0|nonexistent| -1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],
[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])|
5.0|(9,[5],[1.0])| 4.0| (4,[],[])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,20,21,...|
[89.0206095437437...|[0.89020609543743...| 0.0| 19|student| single| unknown| no| yes| no|
cellular| apr| fri| 452| 3| 999| 0|nonexistent| -1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|(11,
[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 4.0| (4,[],[])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,
[10,12,20,21,...|[85.4610755949567...|[0.85461075594956...| 0.0| 19|student| single|
unknown| no| yes| no| cellular| apr| mon| 104| 3| 999| 0|nonexistent| -1.8| 93.075| -47.1|
1.405| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0|
(2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 1.0| (4,[1],[1.0])| 0.0| (2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,20,21,...|[89.1915898782313...|[0.89191589878231...|
0.0| 19|student| single| unknown| no| yes| no| cellular| apr| mon| 159| 2| 999| 0|nonexistent|
-1.8| 93.075| -47.1| 1.405| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])|
0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 1.0| (4,[1],
[1.0])| 0.0| (2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,20,21,...|[89.0206095437437...|
[0.89020609543743...| 0.0| 19|student| single| unknown| no| yes| no| cellular| apr| mon| 205|
1| 999| 1| failure| -1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],
[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])|
5.0|(9,[5],[1.0])| 1.0| (4,[1],[1.0])| 1.0| (2,[1],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,20,21,...|
[88.4492933790718...|[0.88449293379071...| 0.0| 19|student| single| unknown| no| yes| no|
cellular| apr| mon| 438| 1| 999| 0|nonexistent| -1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|
(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 5.0|(9,[5],[1.0])| 1.0| (4,[1],[1.0])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,
[10,12,20,21,...|[85.4610755949567...|[0.85461075594956...| 0.0| 19|student| single|
unknown| no| yes| no| cellular| may| mon| 121| 5| 999| 0|nonexistent| -1.8| 92.893| -46.2|
1.354| 5099.1| no| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])| 0.0| (2,[0],[1.0])| 0.0|
(2,[0],[1.0])| 0.0|(2,[0],[1.0])| 0.0| (1,[0],[1.0])| 0.0|(9,[0],[1.0])| 1.0| (4,[1],[1.0])| 0.0| (2,[0],
[1.0])| 0.0| (1,[0],[1.0])| 0.0|(53,[10,12,20,21,...|[92.0128568629496...|[0.92012856862949...|
0.0| 19|student| single| unknown| no| yes| no|telephone| apr| tue| 396| 3| 999| 0|nonexistent|
-1.8| 93.075| -47.1| 1.405| 5099.1| yes| 10.0|(11,[10],[1.0])| 1.0| (3,[1],[1.0])| 6.0| (7,[6],[1.0])|
0.0| (2,[0],[1.0])| 0.0| (2,[0],[1.0])| 0.0|(2,[0],[1.0])| 1.0| (1,[],[])| 5.0|(9,[5],[1.0])| 3.0| (4,[3],
```

[1.0])| 0.0| (2,[0],[1.0])| 1.0| (1,[],[])| 1.0|(53,[10,12,20,21,...|[87.5248539650293...|
[0.87524853965029...| 0.0| +---+-------+-------+-----------+-------+-------+-------+---------+-----+---
--------+--------+--------+-----+--------+-----------+------------+--------------+-------------+---------+------
-----+-------+--------+--------------+------------+--------------+--------------+-----------------+------------
+---------------+------------+---------------+---------+-------------+------------+---------------+----------+--
-----------+----------------+------------------+-------------+----------------+------------+---------------+----
-+--------------------+--------------------+--------------------+----------+ only showing top 20 rows

In [24]:

```
exibe_colunas = predict.select(['age','probability','label','prediction'])
```

In [25]:

```
exibe_colunas.show()
```

```
+---+--------------------+-----+----------+
|age|         probability|label|prediction|
+---+--------------------+-----+----------+
| 18|[0.77454038145034...|  0.0|       0.0|
| 18|[0.77126954811700...|  0.0|       0.0|
| 18|[0.93229045760570...|  0.0|       0.0|
| 18|[0.69587427804269...|  0.0|       0.0|
| 19|[0.80773746982928...|  1.0|       0.0|
| 19|[0.66840544485366...|  1.0|       0.0|
| 19|[0.81160853535051...|  0.0|       0.0|
| 19|[0.80833780760600...|  1.0|       0.0|
| 19|[0.68527055498378...|  1.0|       0.0|
| 19|[0.93690136560285...|  0.0|       0.0|
| 19|[0.80784561318732...|  1.0|       0.0|
| 19|[0.80784550759851...|  1.0|       0.0|
| 19|[0.80614291425943...|  1.0|       0.0|
| 19|[0.80614280867061...|  0.0|       0.0|
| 19|[0.87714957827532...|  0.0|       0.0|
| 19|[0.80844698062204...|  0.0|       0.0|
| 19|[0.80739235232994...|  1.0|       0.0|
| 19|[0.80866507726509...|  0.0|       0.0|
| 19|[0.80614291425943...|  1.0|       0.0|
| 20|[0.94200469061399...|  0.0|       0.0|
+---+--------------------+-----+----------+
only showing top 20 rows
```

In [26]:

```
##
results = predict.select(['probability', 'label'])
```

In [27]:

```
# Persiste Modelo Na Base
import pyspark
df_writer = pyspark.sql.DataFrameWriter(predict)
df_writer.saveAsTable('default.random_forest_output', format='parquet', mode='overwrite
```

In [28]:

```
#
spark.sql("SELECT * FROM default.boosting_output").show()
```

```
+---+-------+-------+-----------+-------+-------+----+---------+-----+-
----------+--------+-----+--------+----------+-----------+----------
---+-------------+---------+-----------+---+--------+---------------+--
----------+--------------+-------------+---------------+-----------
-+---------------+------------+--------------+---------+-------------+
------------+--------------+---------+------------+---------------+
-------------------+------------+---------------+------+-------------
+-----+-------------------+--------------------+-------------------+-
---------+
|age|    job|marital|  education|default|housing|loan|  contact|month|d
ay_of_week|campaign|pdays|previous|   poutcome|emp_var_rate|cons_price_
idx|cons_conf_idx|euribor3m|nr_employed|  y|jobIndex|    jobclassVec|ma
ritalIndex|maritalclassVec|educationIndex|educationclassVec|defaultInde
x|defaultclassVec|housingIndex|housingclassVec|loanIndex| loanclassVec|
contactIndex|contactclassVec|monthIndex|monthclassVec|day_of_weekIndex|
day_of_weekclassVec|poutcomeIndex|poutcomeclassVec|yIndex|    yclassVec
|label|            features|       rawPrediction|         probability|p
rediction|
+---+-------+-------+-----------+-------+-------+----+---------+-----+-
```

In [29]:

```
results_collect = results.collect()
results_list = [(float(i[0][0]), 1.0-float(i[1])) for i in results_collect]
scoreAndLabels = sc.parallelize(results_list)
```

In [30]:

```
metrics = metric(scoreAndLabels)
print("AUC (numTrees=100): ", metrics.areaUnderROC)
```

```
AUC (numTrees=100):  0.8040772169758128
```

In [31]:

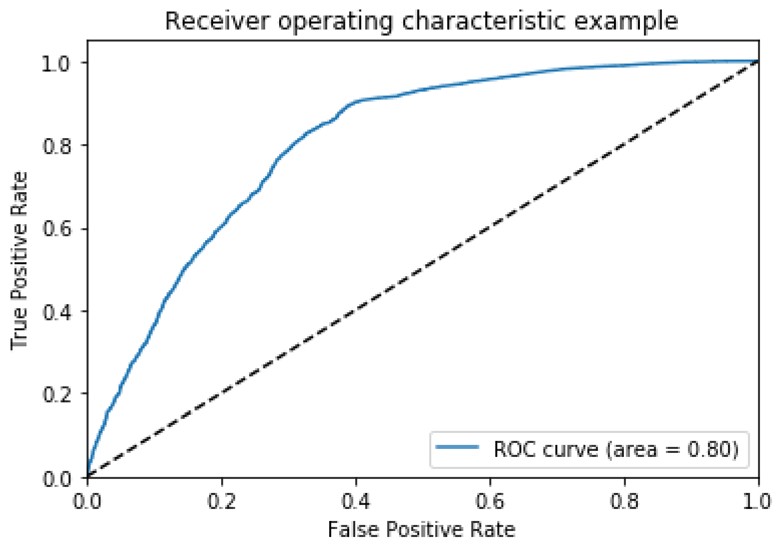
```
from sklearn.metrics import roc_curve, auc
from matplotlib import pyplot as plt

fpr = dict()
tpr = dict()
roc_auc = dict()

y_test = [i[1] for i in results_list]
y_score = [i[0] for i in results_list]

fpr, tpr, _ = roc_curve(y_test, y_score)
roc_auc = auc(fpr, tpr)

get_ipython().run_line_magic('matplotlib', 'inline')
plt.figure()
plt.plot(fpr, tpr, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], 'k--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic example')
plt.legend(loc="lower right")
plt.show()
display()
```



In [32]:

```
import pyspark.sql.functions as func
pred_results = predict.withColumn('compara', func.when(func.col("label") == func.col("p
print("Taxa de Acerto: ", round(pred_results[pred_results['compara']=='Y'].count() / pr
```

```
Taxa de Acerto:  90.01 %
```

In [ ]: