Sparkify

May 29, 2021

1 Sparkify Project Workspace

This workspace contains a tiny subset (128MB) of the full dataset available (12GB). Feel free to use this workspace to build your project, or to explore a smaller subset with Spark before deploying your cluster on the cloud. Instructions for setting up your Spark cluster is included in the last lesson of the Extracurricular Spark Course content.

You can follow the steps below to guide your data analysis and model building portion of this project.

In [75]:
```
# import libraries
from pyspark.sql import SparkSession, SQLContext , Window
from pyspark.sql.functions import avg, col, concat, desc, explode, lit, min, max, split
from pyspark.sql.types import IntegerType
from pyspark.ml.classification import LogisticRegression, RandomForestClassifier, GBTCl
from pyspark.ml.feature import StandardScaler,RegexTokenizer, StringIndexer, CountVecto
from pyspark.ml import Pipeline
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder
from pyspark.ml.evaluation import BinaryClassificationEvaluator , MulticlassClassificat
from time import time

import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

import numpy as np
import pandas as pd
```

In [76]:
```
# create a Spark session
spark = SparkSession.builder.master("local").appName("Capstone_Project").getOrCreate()
```

2 Load and Clean Dataset

In this workspace, the mini-dataset file is `mini_sparkify_event_data.json`. Load and clean the dataset, checking for invalid or missing data - for example, records without userids or sessionids.

In [77]:
```
# load data into spark DataFrame
```

```
mydata = spark.read.json("./mini_sparkify_event_data.json")

mydata.printSchema()
```

```
root
 |-- artist: string (nullable = true)
 |-- auth: string (nullable = true)
 |-- firstName: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- itemInSession: long (nullable = true)
 |-- lastName: string (nullable = true)
 |-- length: double (nullable = true)
 |-- level: string (nullable = true)
 |-- location: string (nullable = true)
 |-- method: string (nullable = true)
 |-- page: string (nullable = true)
 |-- registration: long (nullable = true)
 |-- sessionId: long (nullable = true)
 |-- song: string (nullable = true)
 |-- status: long (nullable = true)
 |-- ts: long (nullable = true)
 |-- userAgent: string (nullable = true)
 |-- userId: string (nullable = true)
```

2.1 Clean Data

In [78]:
```
#Clean Dataset

# temp view of the data frame

mydata.createOrReplaceTempView('data_tbl')
```

In [79]:
```
# check if there are nulls in sessionId column

spark.sql("""
            SELECT COUNT(userId) as UserId
            FROM data_tbl
            WHERE sessionId IS NULL
        """).show()
```

```
+------+
|UserId|
+------+
|     0|
+------+
```

In [80]:
```
# check if there are empty sessionIds

spark.sql("""
            SELECT COUNT(userId) as UserId
            FROM data_tbl
            WHERE sessionId == ''
        """).show()
```

```
+------+
|UserId|
+------+
|     0|
+------+
```

In [81]:
```
# check if there are nulls in userId column

spark.sql("""
            SELECT COUNT(userId) as UserId
            FROM data_tbl
            WHERE userId IS NULL
        """).show()
```

```
+------+
|UserId|
+------+
|     0|
+------+
```

In [82]:
```
# check if there are empty UserIDs

spark.sql("""
            SELECT COUNT(userId) as UserId
            FROM data_tbl
            WHERE userId == ''
        """).show()
```

```
+------+
|UserId|
+------+
|  8346|
+------+
```

In [83]:
```
# remove the invalid user IDs from the dataset
```

```
mydata = spark.sql("""
                    SELECT *
                    FROM data_tbl
                    WHERE userId != ''
                """)
```

```
In [84]: # temporary view of the data frame

         mydata.createOrReplaceTempView('data_tbl')
```

3 Exploratory Data Analysis

When you're working with the full dataset, perform EDA by loading a small subset of the data and doing basic manipulations within Spark. In this workspace, you are already provided a small subset of data you can explore.

3.0.1 Define Churn

Once you've done some preliminary analysis, create a column `Churn` to use as the label for your model. I suggest using the `Cancellation Confirmation` events to define your churn, which happen for both paid and free users. As a bonus task, you can also look into the `Downgrade` events.

```
In [85]: page = mydata.select("page").dropDuplicates().show()
```

```
+--------------------+
|                page|
+--------------------+
|              Cancel|
|    Submit Downgrade|
|         Thumbs Down|
|                Home|
|           Downgrade|
|         Roll Advert|
|              Logout|
|       Save Settings|
|Cancellation Conf...|
|               About|
|            Settings|
|     Add to Playlist|
|          Add Friend|
|            NextSong|
|           Thumbs Up|
|                Help|
|             Upgrade|
|               Error|
|      Submit Upgrade|
+--------------------+
```

```
In [86]: # create churn user list

         mydata = spark.sql("""
                           SELECT *,
                                  CASE
                                       WHEN page == 'Cancellation Confirmation' THEN 1
                                       ELSE 0 END as Churned
                           FROM data_tbl
                       """)

         mydata.createOrReplaceTempView('data_tbl')

         Churned = spark.sql("""
                                   SELECT DISTINCT userID
                                   FROM data_tbl
                                   WHERE Churned = 1
                               """).toPandas().values

         Churned = [user[0] for user in Churned]
```

```
In [87]: #show churned and non-churned user in dataset

         spark.sql("""
                   SELECT
                       Churned,
                       count(distinct userId)
                     FROM
                         data_tbl
                     GROUP BY
                         Churned
                     """)
```

```
Out[87]: DataFrame[Churned: int, count(DISTINCT userId): bigint]
```

```
In [88]: #create churn table

         churn = spark.sql("""
                   SELECT
                       distinct userId,
                       Churned
                     FROM
                         data_tbl

                     """)
         churn.createOrReplaceTempView('churn')
```

```
In [89]: # show  churn in gender

         spark.sql("""
```

```
            SELECT distinct
                gender,
                Churned,
                count(distinct userId) as DistinctUsers
              FROM
                  data_tbl
              GROUP BY
                  gender,Churned
              order by Churned desc
              """)
```

```
Out[89]: DataFrame[gender: string, Churned: int, DistinctUsers: bigint]
```

3.0.2 Explore Data

Once you've defined churn, perform some exploratory data analysis to observe the behavior for users who stayed vs users who churned. You can start by exploring aggregates on these two groups of users, observing how much of a specific action they experienced per a certain time unit or number of songs played.

```
In [90]: explore_data = mydata.toPandas()
```

```
In [125]: explore_data.drop('Churned',axis='columns', inplace=True)
```

```
In [126]: explore_data.head()
```

```
Out[126]:                   artist       auth firstName gender  itemInSession  \
          0   Sleeping With Sirens  Logged In  Darianna      F              0
          1  Francesca Battistelli  Logged In  Darianna      F              1
          2                 Brutha  Logged In  Darianna      F              2
          3                   None  Logged In  Darianna      F              3
          4            Josh Ritter  Logged In  Darianna      F              4

              lastName     length level                         location method  \
          0  Carpenter  202.97098  free  Bridgeport-Stamford-Norwalk, CT    PUT
          1  Carpenter  196.54485  free  Bridgeport-Stamford-Norwalk, CT    PUT
          2  Carpenter  263.13098  free  Bridgeport-Stamford-Norwalk, CT    PUT
          3  Carpenter        NaN  free  Bridgeport-Stamford-Norwalk, CT    PUT
          4  Carpenter  316.23791  free  Bridgeport-Stamford-Norwalk, CT    PUT

                  page   registration  sessionId  \
          0   NextSong  1538016340000         31
          1   NextSong  1538016340000         31
          2   NextSong  1538016340000         31
          3  Thumbs Up  1538016340000         31
          4   NextSong  1538016340000         31

                                              song  status             ts  \
          0  Captain Tyin Knots VS Mr Walkway (No Way)     200  1539003534000
```

```
1              Beautiful_ Beautiful (Album)     200  1539003736000
2                               She's Gone     200  1539003932000
3                                     None     307  1539003933000
4                           Folk Bloodbath     200  1539004195000

                                          userAgent  userId  churn
0  "Mozilla/5.0 (iPhone; CPU iPhone OS 7_1_2 like...  100010      0
1  "Mozilla/5.0 (iPhone; CPU iPhone OS 7_1_2 like...  100010      0
2  "Mozilla/5.0 (iPhone; CPU iPhone OS 7_1_2 like...  100010      0
3  "Mozilla/5.0 (iPhone; CPU iPhone OS 7_1_2 like...  100010      0
4  "Mozilla/5.0 (iPhone; CPU iPhone OS 7_1_2 like...  100010      0
```

In [127]: explore_data.describe()

Out[127]:

```
       itemInSession         length  registration      sessionId  \
count  278154.000000  228108.000000  2.781540e+05  278154.000000
mean      114.899182     249.117182  1.535359e+12    1042.561624
std       129.851729      99.235179  3.291322e+09     726.501036
min         0.000000       0.783220  1.521381e+12       1.000000
25%        27.000000     199.888530  1.533522e+12     338.000000
50%        70.000000     234.500770  1.536664e+12    1017.000000
75%       157.000000     277.158730  1.537672e+12    1675.000000
max      1321.000000    3024.665670  1.543247e+12    2474.000000

              status            ts          churn
count  278154.000000  2.781540e+05  278154.000000
mean      209.103216  1.540959e+12       0.161292
std        30.151389  1.506829e+09       0.367801
min       200.000000  1.538352e+12       0.000000
25%       200.000000  1.539699e+12       0.000000
50%       200.000000  1.540934e+12       0.000000
75%       200.000000  1.542268e+12       0.000000
max       404.000000  1.543799e+12       1.000000
```

In [128]: explore_data.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 278154 entries, 0 to 278153
Data columns (total 19 columns):
artist           228108 non-null object
auth             278154 non-null object
firstName        278154 non-null object
gender           278154 non-null object
itemInSession    278154 non-null int64
lastName         278154 non-null object
length           228108 non-null float64
level            278154 non-null object
location         278154 non-null object
method           278154 non-null object
```

```
page              278154 non-null object
registration      278154 non-null int64
sessionId         278154 non-null int64
song              228108 non-null object
status            278154 non-null int64
ts                278154 non-null int64
userAgent         278154 non-null object
userId            278154 non-null object
churn             278154 non-null int64
dtypes: float64(1), int64(6), object(12)
memory usage: 40.3+ MB
```

In [129]:
```
# from checking if there are empty UserIDs above
# we will drop empty values
explore_data = explore_data.filter(explore_data.userId != '')
```

In [130]:
```
cancelation_flag = udf(lambda x: 1 if x == "Cancellation Confirmation" else 0, Integer
```

In [131]:
```
explore_data = mydata.withColumn("churn", cancelation_flag("page"))
window_value = Window.partitionBy("userId").rangeBetween(Window.unboundedPreceding, Wi
```

In [132]:
```
explore_data = explore_data.withColumn("churn", Fsum("churn").over(window_value))
```

In [133]:
```
explore_data = explore_data.toPandas()
```

In [142]:
```
explore_data.sample(10)
```

Out[142]:
```
                       artist       auth  firstName gender  itemInSession  \
187258                 The xx  Logged In      Elias      M             30
52080                    None  Logged In    Brayden      M             30
207939      Carl Dobkins_ Jr.  Logged In  Alexander      M             92
270649                   None  Logged In     Jayden      M             35
202384                   None  Logged In      Micah      M             67
187651              Lifehouse  Logged In     Andrew      M            161
250710              The Verve  Logged In       Saul      M              4
129529                   P!nk  Logged In    Michael      M            270
17678                  Rytmus  Logged In      Sadie      F            217
219436  Violadores del Verso  Logged In     Lauren      F            177

       lastName     length level                              location method  \
187258     Love  313.39057  paid                           Salinas, CA    PUT
52080    Thomas        NaN  paid    Los Angeles-Long Beach-Anaheim, CA    GET
207939   Garcia  120.21506  paid      Indianapolis-Carmel-Anderson, IN    PUT
270649   Santos        NaN  free       Dallas-Fort Worth-Arlington, TX    GET
202384     Long        NaN  paid        Boston-Cambridge-Newton, MA-NH    GET
187651    Poole  259.89179  paid              Greensboro-High Point, NC    PUT
250710  Johnson  360.25424  paid  Houston-The Woodlands-Sugar Land, TX    PUT
129529   Miller  227.02975  paid            Phoenix-Mesa-Scottsdale, AZ    PUT
```

```
17678     Jones  254.24934  paid           Denver-Aurora-Lakewood, CO    PUT
219436    Boone  325.72036  paid                     St. Louis, MO-IL    PUT

            page  registration  sessionId  \
187258  NextSong  1532696273000        348
52080       Home  1534133898000        734
207939  NextSong  1536817381000        508
270649      Help  1533812833000         67
202384  Settings  1538331630000       2334
187651  NextSong  1541223737000       1719
250710  NextSong  1531804365000       1763
129529  NextSong  1537014411000       1400
17678   NextSong  1537054553000       2065
219436  NextSong  1534859694000         76

                                             song  status             ts  \
187258                                   Infinity     200  1542409487000
52080                                        None     200  1539320124000
207939                    My Heart Is An Open Book     200  1539325590000
270649                                       None     200  1539075198000
202384                                       None     200  1543319750000
187651                      The End Has Only Begun     200  1541744505000
250710                       Bitter Sweet Symphony     200  1542011203000
129529                          Glitter In The Air     200  1541019841000
17678   Ani jeden skurvy me nezastavi (Explicit)     200  1542832017000
219436                                   Nada mas     200  1539279730000

                                                userAgent  userId  Churned  \
187258  "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebK...  200025        0
52080   "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_4...      85        0
207939  Mozilla/5.0 (Windows NT 6.1; WOW64; rv:31.0) G...     105        0
270649  "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_10)...  100018        0
202384  "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebK...       9        0
187651  "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebK...     153        0
250710  Mozilla/5.0 (Windows NT 6.1; WOW64; rv:31.0) G...      62        0
129529  Mozilla/5.0 (Macintosh; Intel Mac OS X 10.8; r...      60        0
17678   "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_4...     132        0
219436  "Mozilla/5.0 (Windows NT 6.1; WOW64) AppleWebK...  300009        0

        churn
187258      0
52080       0
207939      1
270649      0
202384      0
187651      0
250710      0
129529      0
```

```
17678       0
219436      0
```

In [135]:
```
# check churned and non churned users

explore_data.drop_duplicates(subset='userId').groupby(['churn'])['userId'].count()
```

Out[135]:
```
churn
0    173
1     52
Name: userId, dtype: int64
```

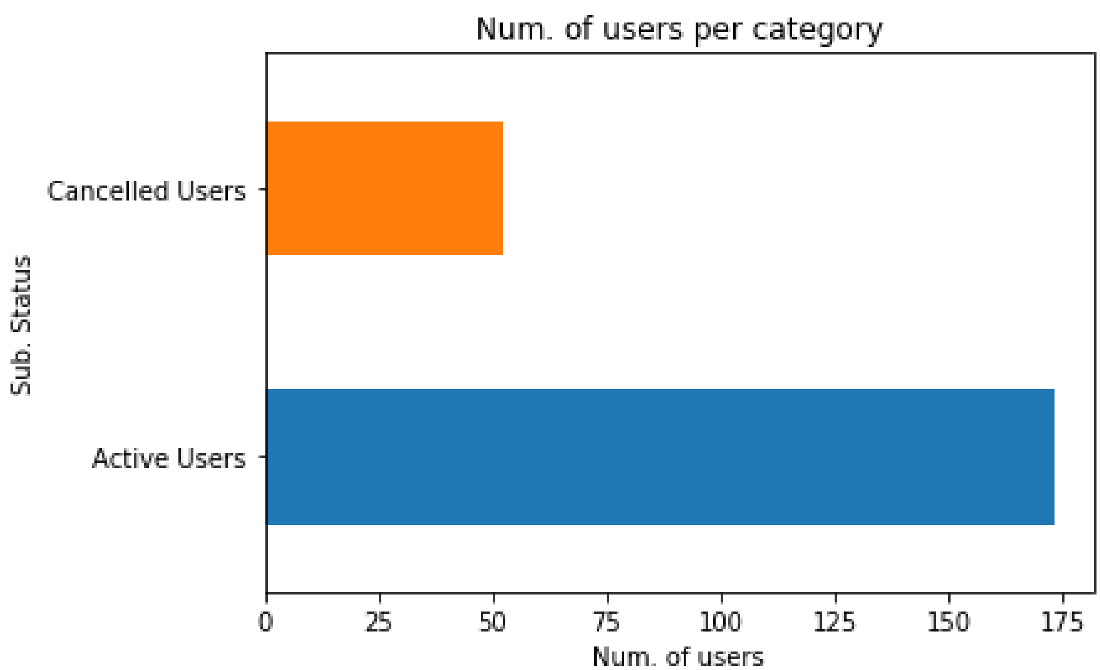
In [136]:
```
# Plot function to visualize some Data

def plot(subset, group, labels, x_title="Num. of users", y_title="Sub. Status"):

    ax = explore_data.drop_duplicates(subset=subset).groupby(group)['userId'].count().

    ax.set_xlabel(x_title)
    ax.set_yticklabels(labels)
    ax.set_ylabel(y_title)
```

In [137]:
```
plot(subset = ['userId'], group = ['churn'], labels = ['Active Users', 'Cancelled User
```

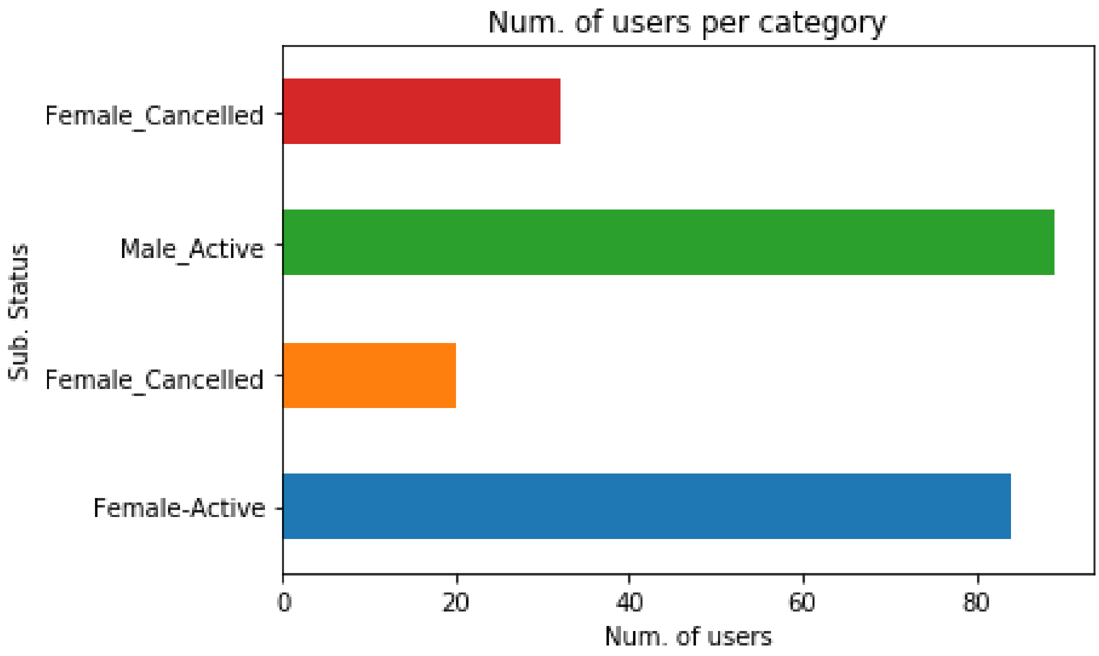


In [138]: # check churned and non churned users by Gender

```
explore_data.drop_duplicates(subset='userId').groupby(['gender', 'churn'])['gender'].c
```

Out[138]:
```
gender  churn
F       0        84
        1        20
M       0        89
        1        32
Name: gender, dtype: int64
```

In [139]:
```
plot(subset=['userId', 'gender'], group = ['gender', 'churn'], labels = ['Female-Activ
```

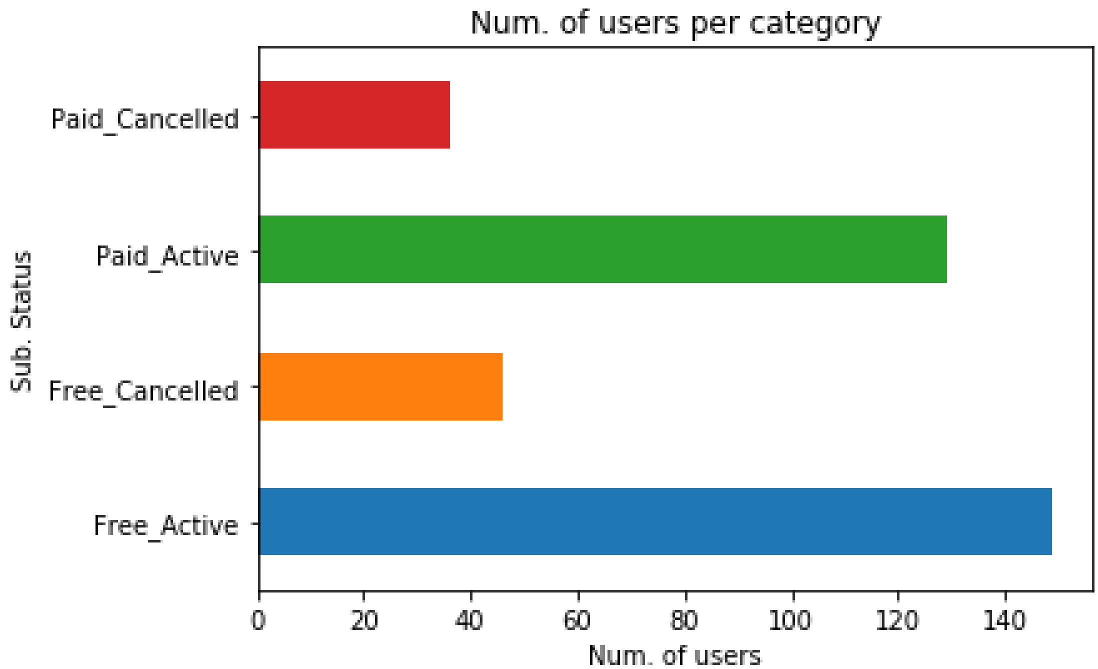


In [140]: # check churned and non churned users by Payment

```
explore_data.drop_duplicates(subset='userId').groupby(['level', 'churn'])['level'].cou
```

Out[140]:
```
level  churn
free   0        133
       1         44
paid   0         40
       1          8
Name: level, dtype: int64
```

In [141]:
```
plot(subset=['userId', 'level'], group=['level', 'churn'], labels=['Free_Active', 'Fre
```



4 Feature Engineering

Once you've familiarized yourself with the data, build out the features you find promising to train your model on. To work with the full dataset, you can follow the following steps. - Write a script to extract the necessary features from the smaller subset of data - Ensure that your script is scalable, using the best practices discussed in Lesson 3 - Try your script on the full data set, debugging your script if necessary

If you are working in the classroom workspace, you can just extract features based on the small subset of data contained here. Be sure to transfer over this work to the larger dataset when you work on your Spark cluster.

In [106]:
```
#gender feature " replace str by int values"


gender = mydata.dropDuplicates(['userId']).sort('userId').select(['userId','gender'])
gender = gender.replace(['F','M'], ['1', '0'], 'gender')
gender = gender.withColumn('gender', gender.gender.cast("int"))

gender.createOrReplaceTempView('gender')
```

In [107]:
```
#number of songs played per user

songs = mydata.where(mydata.song!='null').groupby('userId')
songs= songs.agg(count(mydata.song).alias('Played_Songs')).orderBy('userId')
```

```
songs = songs.select(['userId','Played_Songs'])

songs.createOrReplaceTempView('songs')
```

In [108]:
```
# number of listened singers per user

listened_singers_per_user = mydata.dropDuplicates(['userId','artist']).groupby('userId
listened_singers_per_user = listened_singers_per_user.agg(count(mydata.artist).alias('
listened_singers_per_user = listened_singers_per_user.select(['userId','Listened_Singe

listened_singers_per_user.createOrReplaceTempView('listened_singers_per_user')
```

In [109]:
```
#thumbs_Down

thumbs_Down = mydata.where(mydata.page=='Thumbs Down').groupby(['userId'])
thumbs_Down = thumbs_Down.agg(count(col('page')).alias('thumbs_down')).orderBy('userId
thumbs_Down = thumbs_Down.select(['userId','thumbs_down'])

thumbs_Down.createOrReplaceTempView('thumbs_Down')
```

In [110]:
```
#thumbs_Up

thumbs_Up = mydata.where(mydata.page=='Thumbs Up').groupby(['userId'])
thumbs_Up = thumbs_Up.agg(count(col('page')).alias('thumbs_Up')).orderBy('userId')
thumbs_Up = thumbs_Up.select(['userId','thumbs_Up'])

thumbs_Up.createOrReplaceTempView('thumbs_Up')
```

5 Modeling

Split the full dataset into train, test, and validation sets. Test out several of the machine learning methods you learned. Evaluate the accuracy of the various models, tuning parameters as necessary. Determine your winning model based on test accuracy and report results on the validation set. Since the churned users are a fairly small subset, I suggest using F1 score as the metric to optimize.

In [111]:
```
# join features

Data = churn.dropDuplicates(['userId']).sort('userId').select(['userId','Churned'])
for selected_features in [ gender, songs, listened_singers_per_user, thumbs_Up, thumbs
    Data = Data.join(selected_features,'userId')
```

In [112]:
```
# convert data type into float
for selected_features in Data.columns[1:]:
    Data = Data.withColumn(selected_features,Data[selected_features].cast('float'))
```

In [113]:
```
Data.dtypes
```

Out[113]: [('userId', 'string'),
 ('Churned', 'float'),
 ('gender', 'float'),
 ('Played_Songs', 'float'),
 ('Listened_Singers', 'float'),
 ('thumbs_Up', 'float'),
 ('thumbs_down', 'float')]

In [114]:
```
# split our data into train and test sets

train_set, test_set = Data.randomSplit([0.8, 0.2])
```

In [115]:
```
assembler = VectorAssembler(inputCols=Data.columns[2:],outputCol='featuresassemble')
scaler = StandardScaler(inputCol="featuresassemble", outputCol="features")
indexer = StringIndexer(inputCol="Churned", outputCol="label")
stringIndexer = StringIndexer(inputCol="label", outputCol="indexed")
RandomForestClassifier = RandomForestClassifier(numTrees=3, maxDepth=2, labelCol="inde
LogisticRegression =  LogisticRegression(maxIter=100, regParam=0.0, elasticNetParam=0)
```

In [116]:
```
LogisticRegression_pipeline = Pipeline(stages=[assembler, scaler, indexer, LogisticReg

paramGrid_LogisticRegression = ParamGridBuilder().addGrid(LogisticRegression.regParam,

CrossValidator_LogisticRegression = CrossValidator(estimator=LogisticRegression_pipeli
                                    evaluator=MulticlassClassificationEvaluator(metric

start_time = time()
CrossValidator_LogisticRegression_Model = CrossValidator_LogisticRegression.fit(train_
end_time = time()

print('The training process take {} seconds'.format(end_time - start_time))

CrossValidator_LogisticRegression_Model.avgMetrics
```

The training process take 923.1168491840363 seconds

Out[116]: [0.8297728719764362, 0.8256805908727608, 0.8256805908727608]

In [117]:
```
RandomForest_pipeline = Pipeline(stages=[assembler, scaler, indexer, stringIndexer, Ra

paramGrid_RandomForest = ParamGridBuilder().addGrid(RandomForestClassifier.numTrees,[1

CrossValidator_RandomForest = CrossValidator(estimator=RandomForest_pipeline,estimator
                              evaluator=MulticlassClassificationEvaluator(metricName =

start_time = time()
CrossValidator_RandomForest_Model = CrossValidator_RandomForest.fit(train_set)
end_time = time()
```

```
print('The training process take {} seconds'.format(end_time - start_time))

CrossValidator_RandomForest_Model.avgMetrics
```

```
The training process take 617.9057967662811 seconds
```

```
Out[117]: [0.8256805908727608, 0.8256805908727608]
```

6 Performance of models

```
In [120]: def performance(model, test_data, metric = 'f1'):

              """

              this function to Evaluate model performance

                  Input:
                      model - trained model
                      metric - used metric to evaluate performance
                      data - test set that performance measurement should be performed

                  Output:
                      evaluated_score
              """

              evaluator = BinaryClassificationEvaluator(metricName = 'areaUnderROC')

              predictions = model.transform(test_data)

              # evaluated_score
              evaluated_score = evaluator.evaluate(predictions)

              return evaluated_score
```

```
In [121]: model_RandomForest_fitted = RandomForest_pipeline.fit(train_set)
          model_LogisticRegression_fitted = LogisticRegression_pipeline.fit(train_set)
```

```
In [122]: performance(model_RandomForest_fitted, test_set)
```

```
Out[122]: 0.49107142857142855
```

```
In [123]: performance(model_LogisticRegression_fitted, test_set)
```

```
Out[123]: 0.7202380952380952
```

7 Final Steps

Clean up your code, adding comments and renaming variables to make the code easier to read and maintain. Refer to the Spark Project Overview page and Data Scientist Capstone Project Rubric to make sure you are including all components of the capstone project and meet all expectations. Remember, this includes thorough documentation in a README file in a Github repository, as well as a web app or blog post.

```
In [ ]:
```