Exploratory Data Analysis Using PYSPARK and Machine Learning models

In [1]:
```
!python3 --version
```
```
Python 3.10.6
```

In [2]:
```
!jupyter --version
```
```
Selected Jupyter core packages...
IPython          : 7.31.1
ipykernel        : 6.7.0
ipywidgets       : 6.0.0
jupyter_client   : 7.1.2
jupyter_core     : 4.9.1
jupyter_server   : not installed
jupyterlab       : not installed
nbclient         : 0.5.6
nbconvert        : 6.4.0
nbformat         : 5.1.3
notebook         : 6.4.8
qtconsole        : not installed
traitlets        : 5.1.1
```

In [3]:
```
pip install -U notebook-as-pdf
```
```
Defaulting to user installation because normal site-packages is not writeable
Collecting notebook-as-pdf
  Downloading notebook_as_pdf-0.5.0-py3-none-any.whl (6.5 kB)
Collecting PyPDF2
  Downloading pypdf2-2.11.2-py3-none-any.whl (220 kB)
     220.6/220.6 KB 846.1 kB/s eta 0:00:00[36m0:00:01[36m0:00:01
Requirement already satisfied: nbconvert in /usr/lib/python3/dist-packages (from notebook-as-pdf) (6.4.0)
Collecting pyppeteer
  Downloading pyppeteer-1.0.2-py3-none-any.whl (83 kB)
     83.4/83.4 KB 5.5 MB/s eta 0:00:00
Requirement already satisfied: importlib-metadata>=1.4 in /usr/lib/python3/dist-packages (from pyppeteer->note
book-as-pdf) (4.6.4)
Collecting websockets<11.0,>=10.0
  Downloading websockets-10.4-cp310-cp310-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_2_17_x86_64.manyl
ux2014_x86_64.whl (106 kB)
     106.8/106.8 KB 1.1 MB/s eta 0:00:00 MB/s eta 0:00:01
Collecting certifi>=2021
  Downloading certifi-2022.12.7-py3-none-any.whl (155 kB)
     155.3/155.3 KB 2.3 MB/s eta 0:00:00m eta 0:00:01
Collecting tqdm<5.0.0,>=4.42.1
  Downloading tqdm-4.64.1-py2.py3-none-any.whl (78 kB)
     78.5/78.5 KB 661.0 kB/s eta 0:00:0031m19.1 MB/s eta 0:00:01
Collecting pyee<9.0.0,>=8.1.0
  Downloading pyee-8.2.2-py2.py3-none-any.whl (12 kB)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in /usr/lib/python3/dist-packages (from pyppeteer->noteb
ook-as-pdf) (1.4.4)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in /usr/lib/python3/dist-packages (from pyppeteer->noteb
ook-as-pdf) (1.26.5)
Installing collected packages: pyee, websockets, tqdm, PyPDF2, certifi, pyppeteer, notebook-as-pdf
Successfully installed PyPDF2-2.11.2 certifi-2022.12.7 notebook-as-pdf-0.5.0 pyee-8.2.2 pyppeteer-1.0.2 tqdm-
4.64.1 websockets-10.4
Note: you may need to restart the kernel to use updated packages.
```

In [3]:
```
pip install pyppeteer
```
```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pyppeteer in ./.local/lib/python3.10/site-packages (1.0.2)
Requirement already satisfied: tqdm<5.0.0,>=4.42.1 in ./.local/lib/python3.10/site-packages (from pyppeteer) (4.64.1)
Requirement already satisfied: importlib-metadata>=1.4 in /usr/lib/python3/dist-packages (from pyppeteer) (4.6.4)
Requirement already satisfied: appdirs<2.0.0,>=1.4.3 in /usr/lib/python3/dist-packages (from pyppeteer) (1.4.4)
Requirement already satisfied: certifi>=2021 in ./.local/lib/python3.10/site-packages (from pyppeteer) (2022.12.7)
Requirement already satisfied: pyee<9.0.0,>=8.1.0 in ./.local/lib/python3.10/site-packages (from pyppeteer) (8.2.2)
Requirement already satisfied: websockets<11.0,>=10.0 in ./.local/lib/python3.10/site-packages (from pyppeteer) (10.4)
Requirement already satisfied: urllib3<2.0.0,>=1.25.8 in /usr/lib/python3/dist-packages (from pyppeteer) (1.26.5)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:
```
pip install pyspark
```
```
Defaulting to user installation because normal site-packages is not writeable
Collecting pyspark
  Downloading pyspark-3.3.1.tar.gz (281.4 MB)
     281.4/281.4 MB 345.2 kB/s eta 0:00:00m eta 0:00:01[36m0:00:02
  Preparing metadata (setup.py) ... done
Collecting py4j==0.10.9.5
  Downloading py4j-0.10.9.5-py2.py3-none-any.whl (199 kB)
     199.7/199.7 KB 2.5 MB/s eta 0:00:00[36m0:00:01
Building wheels for collected packages: pyspark
  Building wheel for pyspark (setup.py) ... done
  Created wheel for pyspark: filename=pyspark-3.3.1-py2.py3-none-any.whl size=281845509 sha256=42a4eaf1d47c87b
f716487d9df82438c8b2e30ef5a5e4821bba8eee8d64b72
  Stored in directory: /home/bigdata/.cache/pip/wheels/0f/f0/3d/517368b8ce80486e84f89f214e0a022554e4ee64969f46
279b
Successfully built pyspark
Installing collected packages: py4j, pyspark
Successfully installed py4j-0.10.9.5 pyspark-3.3.1
Note: you may need to restart the kernel to use updated packages.
```

In [6]:
```
pip install findspark
```
```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: findspark in ./.local/lib/python3.10/site-packages (2.0.1)
Note: you may need to restart the kernel to use updated packages.
```

In [14]:
```
pip install pyspark_dist_explore
```
```
Defaulting to user installation because normal site-packages is not writeable
Collecting pyspark_dist_explore
  Downloading pyspark_dist_explore-0.1.8-py3-none-any.whl (7.2 kB)
Requirement already satisfied: matplotlib in ./.local/lib/python3.10/site-packages (from pyspark_dist_explore) (3.5.
1)
Requirement already satisfied: pandas in ./.local/lib/python3.10/site-packages (from pyspark_dist_explore) (1.
5.1)
Requirement already satisfied: scipy in /usr/lib/python3/dist-packages (from pyspark_dist_explore) (1.8.0)
Requirement already satisfied: numpy in /usr/lib/python3/dist-packages (from pyspark_dist_explore) (1.21.5)
Requirement already satisfied: pytz>=2020.1 in /usr/lib/python3/dist-packages (from pandas->pyspark_dist_explore) (2022.1)
Requirement already satisfied: python-dateutil>=2.8.1 in ./.local/lib/python3.10/site-packages (from pandas->pyspark_
dist_explore) (2.8.1)
Installing collected packages: pyspark_dist_explore
Successfully installed pyspark_dist_explore-0.1.8
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:

In [36]:
```
import findspark
import warnings
warnings.filterwarnings('ignore')
import matplotlib.pyplot as plt
%matplotlib inline
import pandas as pd
#pd.options.display.mpl_style = 'default'
import numpy as np
from pyspark.sql.types import *
from pyspark.sql import Row
import seaborn as sns
from pyspark import SparkContext
from pyspark import SQLContext
findspark.init()


from pyspark.sql import SparkSession
sc = SparkSession.builder \
     .appName("Churn data Analysis") \
     .master("local[*]") \
     .config("spark.jars","/spark-tree-plotting/*") \
     .config("spark.jars.packages", '--jars /path/to/the/spark-tree-plotting_0.2.jar') \
     .config("spark.driver.memory", '--driver-class-path /path/to/the/spark-tree-plotting_0.2.jar') \
     .getOrCreate()

#spark_con = SparkContext(sc=sc)
spark = SQLContext(sc)


print("Explore the data and analysis the assignment")
```
```
22/12/05 12:47:11 WARN SparkSession: Using an existing Spark session; only runtime SQL configurations will tak
e effect.
Explore the data and analysis the assignment
```

In [2]:
```
df = spark.read.csv("/home/bigdata/TelecomCustomerAnalysis/Churn.csv", header=True, inferSchema=True)
df.printSchema()
```
```
[Stage 1:>                                                          (0 + 1) / 1]
root
 |-- AccountLength: integer (nullable = true)
 |-- VMailMessage: integer (nullable = true)
 |-- DayMins: double (nullable = true)
 |-- EveMins: double (nullable = true)
 |-- NightMins: double (nullable = true)
 |-- IntlMins: double (nullable = true)
 |-- CustServCalls: integer (nullable = true)
 |-- Churn: integer (nullable = true)
 |-- IntlPlan: integer (nullable = true)
 |-- VMailPlan: integer (nullable = true)
 |-- DayCalls: integer (nullable = true)
 |-- DayCharge: double (nullable = true)
 |-- EveCalls: integer (nullable = true)
 |-- EveCharge: double (nullable = true)
 |-- NightCalls: integer (nullable = true)
 |-- NightCharge: double (nullable = true)
 |-- IntlCalls: integer (nullable = true)
 |-- IntlCharge: double (nullable = true)
 |-- State: string (nullable = true)
 |-- AreaCode: integer (nullable = true)
 |-- Phone: string (nullable = true)
```

In [3]:
```
df.show(5)
```
```
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
|AccountLength|VMailMessage|DayMins|EveMins|NightMins|IntlMins|CustServCalls|Churn|IntlPlan|VMailPlan|DayCalls
|DayCharge|EveCalls|EveCharge|NightCalls|NightCharge|IntlCalls|IntlCharge|State|AreaCode|   Phone|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
|          128|          25|  265.1|  197.4|    244.7|    10.0|            1|    0|       0|        1|     110
|    45.07|      99|    16.78|        91|      11.01|        3|       2.7|   KS|     415|382-4657|
|          107|          26|  161.6|  195.5|    254.4|    13.7|            1|    0|       0|        1|     123
|    27.47|     103|    16.62|       103|      11.45|        3|       3.7|   OH|     415|371-7191|
|          137|           0|  243.4|  121.2|    162.6|    12.2|            0|    0|       0|        0|     114
|    41.38|     110|     10.3|       104|       7.32|        5|      3.29|   NJ|     415|358-1921|
|           84|           0|  299.4|   61.9|    196.9|     6.6|            2|    0|       1|        0|      71
|     50.9|      88|     5.26|        89|       8.86|        7|      1.78|   OH|     408|375-9999|
|           75|           0|  166.7|  148.3|    186.9|    10.1|            3|    0|       1|        0|     113
|    28.34|     122|    12.61|       121|       8.41|        3|      2.73|   OK|     415|330-6626|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
only showing top 5 rows
```

In [4]:
```
df.columns
```
Out[4]:
```
['AccountLength',
 'VMailMessage',
 'DayMins',
 'EveMins',
 'NightMins',
 'IntlMins',
 'CustServCalls',
 'Churn',
 'IntlPlan',
 'VMailPlan',
 'DayCalls',
 'DayCharge',
 'EveCalls',
 'EveCharge',
 'NightCalls',
 'NightCharge',
 'IntlCalls',
 'IntlCharge',
 'State',
 'AreaCode',
 'Phone']
```

Account.Length: how long account has been active.

In [5]:
```
df.select('AccountLength').show()


#df['Churn']= df['Churn'].astype('category')
#df['Intl Plan']= df['Intl Plan'].astype('category')
#df['VMail Plan']= df['VMail Plan'].astype('category')
```
```
+-------------+
|AccountLength|
+-------------+
|          128|
|          107|
|          137|
|           84|
|           75|
|          118|
|          121|
|          147|
|          117|
|          141|
|           65|
|           74|
|          168|
|           95|
|           62|
|          161|
|           85|
|           93|
|           76|
|           73|
+-------------+
only showing top 20 rows
```

The sum of all the accountlenght registered

In [58]:
```
df.agg({'AccountLength' : 'max'}).show()
df.agg({'AccountLength' : 'sum'}).show(truncate=False)
#df.select([max('AccountLength')]).show()
```
```
+------------------+
|max(AccountLength)|
+------------------+
|                99|
+------------------+

+------------------+
|sum(AccountLength)|
+------------------+
|336849.0          |
+------------------+
```

In [59]:
```
df.select(['Churn','IntlPlan', 'VMailPlan' ])
```
Out[59]:
```
DataFrame[Churn: string, IntlPlan: string, VMailPlan: string]
```

In [6]:
```
from pyspark.sql.functions import col

df_schema = df.withColumn('Churn', col('Churn').cast(IntegerType())) \
         .withColumn('IntlPlan', col('IntlPlan').cast(IntegerType())) \
         .withColumn('VMailPlan', col('VMailPlan').cast(IntegerType())) \
         .withColumn('VMailMessage', col('VMailMessage').cast(IntegerType()))

df_schema.printSchema()
```
```
root
 |-- AccountLength: integer (nullable = true)
 |-- VMailMessage: integer (nullable = true)
 |-- DayMins: double (nullable = true)
 |-- EveMins: double (nullable = true)
 |-- NightMins: double (nullable = true)
 |-- IntlMins: double (nullable = true)
 |-- CustServCalls: integer (nullable = true)
 |-- Churn: integer (nullable = true)
 |-- IntlPlan: integer (nullable = true)
 |-- VMailPlan: integer (nullable = true)
 |-- DayCalls: integer (nullable = true)
 |-- DayCharge: double (nullable = true)
 |-- EveCalls: integer (nullable = true)
 |-- EveCharge: double (nullable = true)
 |-- NightCalls: integer (nullable = true)
 |-- NightCharge: double (nullable = true)
 |-- IntlCalls: integer (nullable = true)
 |-- IntlCharge: double (nullable = true)
 |-- State: string (nullable = true)
 |-- AreaCode: integer (nullable = true)
 |-- Phone: string (nullable = true)
```

In [7]:
```
df.count()
```
Out[7]:
```
3333
```

In [8]:
```
df_schema.describe()
```
Out[8]:
```
DataFrame[summary: string, AccountLength: string, VMailMessage: string, DayMins: string, EveMins: string, Nigh
tMins: string, IntlMins: string, CustServCalls: string, Churn: string, IntlPlan: string, VMailPlan: string, Da
yCalls: string, DayCharge: string, EveCalls: string, EveCharge: string, NightCalls: string, NightCharge: strin
g, IntlCalls: string, IntlCharge: string, State: string, AreaCode: string, Phone: string]
```

In [9]:
```
#VMail.Message: Number of voicemail messages sent by the customer.
df.select('VMailMessage').show(10)
```
```
+------------+
|VMailMessage|
+------------+
|          25|
|          26|
|           0|
|           0|
|           0|
|           0|
|          24|
|           0|
|           0|
|          37|
+------------+
only showing top 10 rows
```

In [10]:
```
#convert the column to int and calculte the totaal VMailMessage call in a row
df.agg({'VMailMessage' : 'sum'}).show()
df.agg({'VMailMessage': 'max'}).show()
```
```
+-----------------+
|sum(VMailMessage)|
+-----------------+
|            26994|
+-----------------+

+-----------------+
|max(VMailMessage)|
+-----------------+
|               51|
+-----------------+
```

In [65]:
```
#Day.Mins: Time spent on day calls.
df.select(['DayMins', 'DayCalls']).show()
```
```
+-------+--------+
|DayMins|DayCalls|
+-------+--------+
|  265.1|     110|
|  161.6|     123|
|  243.4|     114|
|  299.4|      71|
|  166.7|     113|
|  223.4|      98|
|  218.2|      88|
|    157|      79|
|  184.5|      97|
|  258.6|      84|
|  129.1|     137|
|  187.7|     127|
|  128.8|      96|
|  156.6|      88|
|  120.7|      70|
|  332.9|      67|
|  196.4|     139|
|  190.7|     114|
|  189.7|      66|
|  224.4|      90|
+-------+--------+
only showing top 20 rows
```

In [66]:
```
df.groupby('DayMins').agg({'DayCalls' : 'min'}).show()
```
```
+-------+-------------+
|DayMins|min(DayCalls)|
+-------+-------------+
|      0|            0|
|    100|           98|
|  100.1|           54|
|  100.8|          112|
|    101|           93|
|  101.1|          119|
|  101.2|          122|
|  101.4|          145|
|  101.7|          105|
|  101.9|           79|
|    102|          118|
|  102.1|           75|
|  102.3|          106|
|  102.6|           89|
|  102.7|           89|
|  102.8|          119|
|    103|          129|
|  103.1|           70|
|  103.2|          117|
|  103.3|          103|
+-------+-------------+
only showing top 20 rows
```

In [67]:
```
#Eve.Mins: Time spent on evening calls.
df.select('EveMins', 'EveCalls').show()
```
```
+-------+--------+
|EveMins|EveCalls|
+-------+--------+
|  197.4|      99|
|  195.5|     103|
|  121.2|     110|
|   61.9|      88|
|  148.3|     122|
|  220.6|     101|
|  348.5|     108|
|  103.1|      94|
|  351.6|      80|
|    222|     111|
|  228.5|      83|
|  163.4|     148|
|  104.9|      71|
|  247.6|      75|
|  307.2|      76|
|  317.8|      97|
|  280.9|      90|
|  218.2|     111|
|  212.8|      65|
|  159.5|      88|
+-------+--------+
only showing top 20 rows
```

Eve.Mins: Time spent on evening calls.min, avg, max and sum

In [9]:
```
from pyspark.sql.functions import sum,avg,max, min, rank, col
from pyspark.sql.window import Window

df.groupby('EveMins') \
    .agg(sum('EveCalls'),
         min('EveCalls'),
         avg('EveCalls'),
         max('EveCalls') \
    )\
    .show(truncate=False)
```
```
[Stage 9:>                                                          (0 + 1) / 1]
+-------+-------------+-------------+-------------+-------------+
|EveMins|sum(EveCalls)|min(EveCalls)|avg(EveCalls)|max(EveCalls)|
+-------+-------------+-------------+-------------+-------------+
|0      |0.0          |0            |0.0          |0            |
|101.3  |247.0        |111          |123.5        |136          |
|101.5  |101.0        |101          |101.0        |101          |
|102.2  |191.0        |111          |95.5         |80           |
|102.4  |110.0        |110          |110.0        |110          |
|102.6  |103.0        |103          |103.0        |103          |
|102.8  |170.0        |114          |85.0         |56           |
|103    |80.0         |80           |80.0         |80           |
|103.1  |94.0         |94           |94.0         |94           |
|103.2  |138.0        |138          |138.0        |138          |
|103.3  |99.0         |99           |99.0         |99           |
|103.4  |115.0        |115          |115.0        |115          |
|103.6  |116.0        |116          |116.0        |116          |
|103.8  |95.0         |95           |95.0         |95           |
|104.9  |71.0         |71           |71.0         |71           |
|105.5  |118.0        |118          |118.0        |118          |
|105.6  |119.0        |119          |119.0        |119          |
|105.7  |67.0         |67           |67.0         |67           |
|105.8  |98.0         |98           |98.0         |98           |
|106.1  |80.0         |80           |80.0         |80           |
+-------+-------------+-------------+-------------+-------------+
only showing top 20 rows
```

In [69]:
```
#Night.Mins: Time spent on night calls.
df.select('NightMins', 'NightCalls').show()
df.groupby('NightMins') \
  .agg(sum('NightCalls'),
     min('NightCalls'),
     avg('NightCalls'),
     )\
.show(5)
```
```
+---------+----------+
|NightMins|NightCalls|
+---------+----------+
|    244.7|        91|
|    254.4|       103|
|    162.6|       104|
|    196.9|        89|
|    186.9|       121|
|    203.9|       118|
|    212.6|       118|
|    211.8|        96|
|    215.8|        90|
|    326.4|        97|
|    208.8|       111|
|      196|        94|
|    141.1|       128|
|    192.3|       115|
|      203|        99|
|    160.6|       128|
|     89.3|        75|
|    129.6|       121|
|    165.7|       108|
|    192.8|        74|
+---------+----------+
only showing top 20 rows

[Stage 68:>                                                         (0 + 1) / 1]
+---------+---------------+---------------+---------------+
|NightMins|sum(NightCalls)|min(NightCalls)|avg(NightCalls)|
+---------+---------------+---------------+---------------+
|    100.3|           61.0|             61|           61.0|
|    100.9|          131.0|            131|          131.0|
|    101.2|          103.0|            103|          103.0|
|    101.7|          189.0|            107|           94.5|
|    101.8|           94.0|             94|           94.0|
+---------+---------------+---------------+---------------+
only showing top 5 rows
```

In [70]:
```
df.agg({'NightCalls' : 'sum'}).show(), df.agg({'NightMins' : 'max'}).show()
```
```
+---------------+
|sum(NightCalls)|
+---------------+
|       333659.0|
+---------------+

+--------------+
|max(NightMins)|
+--------------+
|          99.3|
+--------------+
```
Out[70]:
```
(None, None)
```

In [71]:
```
#Intl. Mins: Time spent on international calls.
df.select('IntlMins', 'IntlCalls').show(), df.agg({'IntlMins': 'sum'}).collect()
```
```
+--------+---------+
|IntlMins|IntlCalls|
+--------+---------+
|      10|        3|
|    13.7|        3|
|    12.2|        5|
|     6.6|        7|
|    10.1|        3|
|     6.3|        6|
|     7.5|        7|
|     7.1|        6|
|     8.7|        4|
|    11.2|        5|
|    12.7|        6|
|     9.1|        5|
|    11.2|        2|
|    12.3|        5|
|    13.1|        6|
|     5.4|        9|
|    13.8|        4|
|     8.1|        3|
|      10|        5|
|      13|        2|
+--------+---------+
only showing top 20 rows
```
Out[71]:
```
(None, [Row(sum(IntlMins)=34120.89999999999)])
```

In [72]:
```
#Day.Calls: Number of day calls by customers.
df.select('DayCalls', 'CustServCalls').show()
df.groupby('CustServCalls') \
    .agg(sum('DayCalls'),
        avg('DayCalls'),
        min('DayCalls'),
        max('DayCalls'),

    ) \
    .show(truncate=False)
```
```
+--------+-------------+
|DayCalls|CustServCalls|
+--------+-------------+
|     110|            1|
|     123|            1|
|     114|            0|
|      71|            2|
|     113|            3|
|      98|            0|
|      88|            3|
|      79|            0|
|      97|            1|
|      84|            0|
|     137|            4|
|     127|            0|
|      96|            1|
|      88|            3|
|      70|            4|
|      67|            4|
|     139|            1|
|     114|            3|
|      66|            0|
|      90|            1|
+--------+-------------+
only showing top 20 rows

+-------------+-------------+------------------+-------------+-------------+
|CustServCalls|sum(DayCalls)|avg(DayCalls)     |min(DayCalls)|max(DayCalls)|
+-------------+-------------+------------------+-------------+-------------+
|0            |70327.0      |100.89956958393114|100          |99           |
|1            |119341.0     |101.05249788314987|0            |99           |
|2            |75342.0      |99.26482213438736 |100          |99           |
|3            |42864.0      |99.91608391608392 |100          |99           |
|4            |16895.0      |101.77108433734940|0            |99           |
|5            |6568.0       |99.51515151515152 |100          |99           |
|6            |2142.0       |97.36363636363636 |105          |94           |
|7            |793.0        |88.11111111111111 |107          |90           |
|8            |241.0        |120.5             |116          |125          |
|9            |237.0        |118.5             |117          |120          |
+-------------+-------------+------------------+-------------+-------------+
```

In [73]:
```
#Eve.Calls: Number of evening calls by customers.
df.select('EveCalls', 'CustServCalls').show()
df.groupby('EveCalls').agg(sum('EveCalls'),
                    avg('EveCalls'))\
                    .show(truncate=False)
```
```
+--------+-------------+
|EveCalls|CustServCalls|
+--------+-------------+
|      99|            1|
|     103|            1|
|     110|            0|
|      88|            2|
|     122|            3|
|     101|            0|
|     108|            3|
|      94|            0|
|      80|            1|
|     111|            0|
|      83|            4|
|     148|            0|
|      71|            1|
|      75|            3|
|      76|            4|
|      97|            4|
|      90|            1|
|     111|            3|
|      65|            1|
|      88|            1|
+--------+-------------+
only showing top 20 rows

+--------+-------------+-------------+
|EveCalls|sum(EveCalls)|avg(EveCalls)|
+--------+-------------+-------------+
|125     |4375.0       |125.0        |
|51      |255.0        |51.0         |
|124     |2108.0       |124.0        |
|54      |270.0        |54.0         |
|155     |465.0        |155.0        |
|132     |1452.0       |132.0        |
|154     |308.0        |154.0        |
|101     |6868.0       |101.0        |
|138     |1794.0       |138.0        |
|69      |1242.0       |69.0         |
|112     |5376.0       |112.0        |
|42      |42.0         |42.0         |
|87      |5307.0       |87.0         |
|73      |1679.0       |73.0         |
|64      |960.0        |64.0         |
|113     |6554.0       |113.0        |
|133     |2261.0       |133.0        |
|59      |472.0        |59.0         |
|139     |695.0        |139.0        |
|146     |730.0        |146.0        |
+--------+-------------+-------------+
only showing top 20 rows
```

In [74]:
```
#Intl.Calls: Number of international calls.

df.select('IntlCalls').show()
df.agg({'IntlCalls': 'sum'}).show()
```
```
+---------+
|IntlCalls|
+---------+
|        3|
|        3|
|        5|
|        7|
|        3|
|        6|
|        7|
|        6|
|        4|
|        5|
|        6|
|        5|
|        2|
|        5|
|        6|
|        9|
|        4|
|        3|
|        5|
|        2|
+---------+
only showing top 20 rows

+--------------+
|sum(IntlCalls)|
+--------------+
|       14930.0|
+--------------+
```

In [75]:
```
#Night.Calls: Number of night calls by the customer.
df.select('NightCalls', 'CustServCalls').show(10)
df.agg({'NightCalls' : 'sum'}).show(truncate=False)
```
```
+----------+-------------+
|NightCalls|CustServCalls|
+----------+-------------+
|        91|            1|
|       103|            1|
|       104|            0|
|        89|            2|
|       121|            3|
|       118|            0|
|       118|            3|
|        96|            0|
|        90|            1|
|        97|            0|
+----------+-------------+
only showing top 10 rows

+---------------+
|sum(NightCalls)|
+---------------+
|333659.0       |
+---------------+
```

In [76]:
```
#Day.Charge: Charges of Day Calls.
df.select('DayCalls', 'DayCharge').show()
df.groupby('DayCharge') \
    .agg(min('DayCalls'),
         avg('DayCalls'),
         sum('DayCalls')
        )\
    .show(5)
```
```
+--------+---------+
|DayCalls|DayCharge|
+--------+---------+
|     110|    45.07|
|     123|    27.47|
|     114|    41.38|
|      71|     50.9|
|     113|    28.34|
|      98|    37.98|
|      88|    37.09|
|      79|    26.69|
|      97|    31.37|
|      84|    43.96|
|     137|    21.95|
|     127|    31.91|
|      96|     21.9|
|      88|    26.62|
|      70|    20.52|
|      67|    56.59|
|     139|    33.39|
|     114|    32.42|
|      66|    32.25|
|      90|    38.15|
+--------+---------+
only showing top 20 rows

+---------+-------------+-------------+-------------+
|DayCharge|min(DayCalls)|avg(DayCalls)|sum(DayCalls)|
+---------+-------------+-------------+-------------+
|        0|            0|          0.0|          0.0|
|     0.44|          113|        113.0|        113.0|
|     1.33|           86|         86.0|         86.0|
|     1.34|          100|        100.0|        100.0|
|       10|          104|        104.0|        104.0|
+---------+-------------+-------------+-------------+
only showing top 5 rows
```

Checking if there is a null value

In [11]:
```
from pyspark.sql.functions import *
col_null_cnt_df =  df.select([count(when(col(c).isNull(),c)).alias(c) for c in df.columns])

col_null_cnt_df.show()
```
```
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+-----+
|AccountLength|VMailMessage|DayMins|EveMins|NightMins|IntlMins|CustServCalls|Churn|IntlPlan|VMailPlan|DayCalls
|DayCharge|EveCalls|EveCharge|NightCalls|NightCharge|IntlCalls|IntlCharge|State|AreaCode|Phone|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+-----+
|            0|           0|      0|      0|        0|       0|            0|    0|       0|        0|       0
|        0|       0|        0|         0|          0|        0|         0|    0|       0|    0|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+-----+
```

In [78]:
```
#Night.Charge: Charges of Night Calls.
df.select('NightCalls', 'NightCharge').show()
df.groupby('NightCalls').agg({'NightCharge': 'sum'}).show(5)
```

```
+----------+----------+
|NightCalls|NightCharge|
+----------+----------+
|        91|      11.01|
|       103|      11.45|
|       104|       7.32|
|        89|       8.86|
|       121|       8.41|
|       118|       9.18|
|       118|       9.57|
|        96|       9.53|
|        90|       9.71|
|        97|      14.69|
|       111|        9.4|
|        94|       8.82|
|       128|       6.35|
|       115|       8.65|
|        99|       9.14|
|       128|       7.23|
|        75|       4.02|
|       121|       5.83|
|       108|       7.46|
|        74|       8.68|
+----------+----------+
only showing top 20 rows

+----------+------------------+
|NightCalls|  sum(NightCharge)|
+----------+------------------+
|       125|            271.15|
|       124|            310.73|
|        51|19.560000000000002|
|        54|             14.65|
|       155|             16.85|
+----------+------------------+
only showing top 5 rows
```

SQL Command with Datasets

In [3]:
```
df.createOrReplaceTempView('Telcom')
```

In [4]:
```
spark_df = """select * from Telcom"""
```

In [5]:
```
spark.sql(spark_df).show()
```

```
+-------------+-----------+-------+-------+---------+--------+------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
|AccountLength|VMailMessage|DayMins|EveMins|NightMins|IntlMins|CustServCalls|Churn|IntlPlan|VMailPlan|DayCalls
|DayCharge|EveCalls|EveCharge|NightCalls|NightCharge|IntlCalls|IntlCharge|State|AreaCode|   Phone|
+-------------+-----------+-------+-------+---------+--------+------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
|          128|         25|  265.1|  197.4|    244.7|    10.0|            1|    0|       0|        1|     110
|    45.07|      99|    16.78|        91|      11.01|        3|       2.7|   KS|     415|382-4657|
|          107|         26|  161.6|  195.5|    254.4|    13.7|            1|    0|       0|        1|     123
|    27.47|     103|    16.62|       103|      11.45|        3|       3.7|   OH|     415|371-7191|
|          137|          0|  243.4|  121.2|    162.6|    12.2|            0|    0|       0|        0|     114
|    41.38|     110|     10.3|       104|       7.32|        5|      3.29|   NJ|     415|358-1921|
|           84|          0|  299.4|   61.9|    196.9|     6.6|            2|    0|       1|        0|      71
|     50.9|      88|     5.26|        89|       8.86|        7|      1.78|   OH|     408|375-9999|
|           75|          0|  166.7|  148.3|    186.9|    10.1|            3|    0|       1|        0|     113
|    28.34|     122|    12.61|       121|       8.41|        3|      2.73|   OK|     415|330-6626|
|          118|          0|  223.4|  220.6|    203.9|     6.3|            0|    0|       1|        0|      98
|    37.98|     101|    18.75|       118|       9.18|        6|       1.7|   AL|     510|391-8027|
|          121|         24|  218.2|  348.5|    212.6|     7.5|            3|    0|       0|        1|      88
|    37.09|     108|    29.62|       118|       9.57|        7|      2.03|   MA|     510|355-9993|
|          147|          0|  157.0|  103.1|    211.8|     7.1|            0|    0|       1|        0|      79
|    26.69|      94|     8.76|        96|       9.53|        6|      1.92|   MO|     415|329-9001|
|          117|          0|  184.5|  351.6|    215.8|     8.7|            1|    0|       0|        0|      97
|    31.37|      80|    29.89|        90|       9.71|        4|      2.35|   LA|     408|335-4719|
|          141|         37|  258.6|  222.0|    326.4|    11.2|            0|    0|       1|        1|      84
|    43.96|     111|    18.87|        97|      14.69|        5|      3.02|   WV|     415|330-8173|
|           65|          0|  129.1|  228.5|    208.8|    12.7|            4|    1|       0|        0|     137
|    21.95|      83|    19.42|       111|        9.4|        6|      3.43|   IN|     415|329-6603|
|           74|          0|  187.7|  163.4|    196.0|     9.1|            0|    0|       0|        0|     127
|    31.91|     148|    13.89|        94|       8.82|        5|      2.46|   RI|     415|344-9403|
|          168|          0|  128.8|  104.9|    141.1|    11.2|            1|    0|       0|        0|      96
|     21.9|      71|     8.92|       128|       6.35|        2|      3.02|   IA|     408|363-1107|
|           95|          0|  156.6|  247.6|    192.3|    12.3|            3|    0|       0|        0|      88
|    26.62|      75|    21.05|       115|       8.65|        5|      3.32|   MT|     510|394-8006|
|           62|          0|  120.7|  307.2|    203.0|    13.1|            4|    0|       0|        0|      70
|    20.52|      76|    26.11|        99|       9.14|        6|      3.54|   IA|     415|366-9238|
|          161|          0|  332.9|  317.8|    160.6|     5.4|            4|    1|       0|        0|      67
|    56.59|      97|    27.01|       128|       7.23|        9|      1.46|   NY|     415|351-7269|
|           85|         27|  196.4|  280.9|     89.3|    13.8|            1|    0|       0|        1|     139
|    33.39|      90|    23.88|        75|       4.02|        4|      3.73|   ID|     408|350-8884|
|           93|          0|  190.7|  218.2|    129.6|     8.1|            3|    0|       0|        0|     114
|    32.42|     111|    18.55|       121|       5.83|        3|      2.19|   VT|     510|386-2923|
|           76|         33|  189.7|  212.8|    165.7|    10.0|            1|    0|       0|        1|      66
|    32.25|      65|    18.09|       108|       7.46|        5|       2.7|   VA|     510|356-2992|
|           73|          0|  224.4|  159.5|    192.8|    13.0|            1|    0|       0|        0|      90
|    38.15|      88|    13.56|        74|       8.68|        2|      3.51|   TX|     415|373-2782|
+-------------+-----------+-------+-------+---------+--------+------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+
only showing top 20 rows
```

In [82]:
```
sql_query = """select NightCharge,
                NightCalls from Telcom"""
spark.sql(sql_query).show()
```

```
+-----------+----------+
|NightCharge|NightCalls|
+-----------+----------+
|      11.01|        91|
|      11.45|       103|
|       7.32|       104|
|       8.86|        89|
|       8.41|       121|
|       9.18|       118|
|       9.57|       118|
|       9.53|        96|
|       9.71|        90|
|      14.69|        97|
|        9.4|       111|
|       8.82|        94|
|       6.35|       128|
|       8.65|       115|
|       9.14|        99|
|       7.23|       128|
|       4.02|        75|
|       5.83|       121|
|       7.46|       108|
|       8.68|        74|
+-----------+----------+
only showing top 20 rows
```

Night.Charge: Charges of Night Calls.

In [83]:
```
sql_query = """select NightCharge,
               CASE NightCalls
                   when NightCalls then NightCharge
                   else 'calls'
               End as NightCharge,
               count(*) as NightCalls,
               round(AVG(NightCharge),2) as mean_nightcharge,
               round(AVG(NightCalls),2) as mean_nightcalls,
               SUM(NightCharge) AS sum_nightcharge,
               SUM(NightCalls) AS sum_nightcall
               from Telcom
               group by NightCharge, NightCalls
               order by 3 desc

"""
spark.sql(sql_query).show()
```

```
[Stage 110:>                                                        (0 + 1) / 1]
+-----------+-----------+----------+----------------+---------------+------------------+-------------+
|NightCharge|NightCharge|NightCalls|mean_nightcharge|mean_nightcalls|   sum_nightcharge|sum_nightcall|
+-----------+-----------+----------+----------------+---------------+------------------+-------------+
|       7.88|       7.88|         4|            7.88|           86.0|             31.52|        344.0|
|       9.45|       9.45|         3|            9.45|           93.0|28.349999999999998|        279.0|
|      10.49|      10.49|         3|           10.49|           96.0|             31.47|        288.0|
|       4.86|       4.86|         2|            4.86|           82.0|              9.72|        164.0|
|       9.71|       9.71|         2|            9.71|           82.0|             19.42|        164.0|
|       9.71|       9.71|         2|            9.71|           90.0|             19.42|        180.0|
|       8.15|       8.15|         2|            8.15|          101.0|              16.3|        202.0|
|       8.73|       8.73|         2|            8.73|          100.0|             17.46|        200.0|
|       10.8|       10.8|         2|            10.8|          112.0|              21.6|        224.0|
|       9.66|       9.66|         2|            9.66|          107.0|             19.32|        214.0|
|      12.84|      12.84|         2|           12.84|           83.0|             25.68|        166.0|
|      10.35|      10.35|         2|           10.35|          117.0|              20.7|        234.0|
|       6.39|       6.39|         2|            6.39|          103.0|             12.78|        206.0|
|       9.18|       9.18|         2|            9.18|          118.0|             18.36|        236.0|
|       6.59|       6.59|         2|            6.59|           85.0|             13.18|        170.0|
|       9.29|       9.29|         2|            9.29|           80.0|             18.58|        160.0|
|       8.47|       8.47|         2|            8.47|          109.0|             16.94|        218.0|
|      11.17|      11.17|         2|           11.17|          110.0|             22.34|        220.0|
|      10.37|      10.37|         2|           10.37|          109.0|             20.74|        218.0|
|       9.14|       9.14|         2|            9.14|           99.0|             18.28|        198.0|
+-----------+-----------+----------+----------------+---------------+------------------+-------------+
only showing top 20 rows
```

In [84]:
```
#Day.Charge: Charges of Day Calls.
sql_query = """select DayCharge,
               Case Daycalls
                   when DayCalls then DayCharge
                   else 'charge'
               end as Daycalls,
               count(*)DayCharge,
               min(DayCharge) as min_daycharge,
               max(DayCharge) as max_daycharge,
               sum(DayCharge) as sum_daycharge
               from Telcom
               group by Daycalls, DayCharge
               order by DayCharge

           """

spark.sql(sql_query).show()
```

```
[Stage 113:>                                                        (0 + 1) / 1]
+---------+--------+---------+-------------+-------------+-------------+
|DayCharge|Daycalls|DayCharge|min_daycharge|max_daycharge|sum_daycharge|
+---------+--------+---------+-------------+-------------+-------------+
|        0|       0|        2|            0|            0|          0.0|
|     0.44|    0.44|        1|         0.44|         0.44|         0.44|
|     1.33|    1.33|        1|         1.33|         1.33|         1.33|
|     1.34|    1.34|        1|         1.34|         1.34|         1.34|
|       10|      10|        1|           10|           10|         10.0|
|    10.01|   10.01|        2|        10.01|        10.01|        20.02|
|    10.12|   10.12|        1|        10.12|        10.12|        10.12|
|     10.2|    10.2|        1|         10.2|         10.2|         10.2|
|    10.27|   10.27|        1|        10.27|        10.27|        10.27|
|     10.3|    10.3|        1|         10.3|         10.3|         10.3|
|     10.4|    10.4|        1|         10.4|         10.4|         10.4|
|    10.42|   10.42|        1|        10.42|        10.42|        10.42|
|    10.47|   10.47|        1|        10.47|        10.47|        10.47|
|    10.47|   10.47|        1|        10.47|        10.47|        10.47|
|    10.52|   10.52|        1|        10.52|        10.52|        10.52|
|    10.59|   10.59|        1|        10.59|        10.59|        10.59|
|    10.61|   10.61|        1|        10.61|        10.61|        10.61|
|    10.64|   10.64|        1|        10.64|        10.64|        10.64|
|    10.68|   10.68|        1|        10.68|        10.68|        10.68|
|    10.69|   10.69|        1|        10.69|        10.69|        10.69|
+---------+--------+---------+-------------+-------------+-------------+
only showing top 20 rows
```

In [85]:
```
#IntlCharge: Charges of international calls..

sql_query = """select min(IntlCharge),
               Intlcalls
               from Telcom
               group by IntlCharge, IntlCalls
               order by IntlCharge
            """

spark.sql(sql_query).show(10)
```

```
[Stage 116:>                                                        (0 + 1) / 1]
+---------------+---------+
|min(IntlCharge)|Intlcalls|
+---------------+---------+
|              0|        0|
|            0.3|        2|
|           0.35|        6|
|           0.54|        2|
|           0.54|        7|
|           0.57|        5|
|           0.57|        4|
|           0.59|        4|
|           0.65|        3|
|           0.68|        5|
+---------------+---------+
only showing top 10 rows
```

In [86]:
```
sql_query = """select VMailPlan, VMailMessage from Telcom
            """
spark.sql(sql_query).show(5)
```

```
+---------+------------+
|VMailPlan|VMailMessage|
+---------+------------+
|        1|          25|
|        1|          26|
|        0|           0|
|        0|           0|
|        0|           0|
+---------+------------+
only showing top 5 rows
```

VMail.Plan: Voicemail plan taken by the customer or not.#UDF USER DEFINE FUNCTION

In [87]:
```
def vplantaken(item):

    return(x if x == 1 else 0 for x in item)

spark.udf.register('VoicemailPlan', vplantaken, StringType())

#UDF USER DEFINE FUNCTION
sql_query = """select
               VoicemailPlan(VMailPlan) as voice_mail,
               count(*) as Voicemail
               from Telcom
               where VMailPlan = 1 and VMailPlan = 0
               group by voice_mail
               order by voice_mail

            """

spark.sql(sql_query).show(5)
```

```
[Stage 120:>                                                        (0 + 1) / 1]
+----------+---------+
|voice_mail|Voicemail|
+----------+---------+
+----------+---------+
```

In [88]:
```
#State: State in Area of study which have the heighest subscribers.
sql_query = """select distinct(State), AreaCode
               from Telcom
               order by AreaCode desc limit 5

               """

spark.sql(sql_query).show()
```

```
+-----+--------+
|State|AreaCode|
+-----+--------+
|   IL|     510|
|   TX|     510|
|   WI|     510|
|   IA|     510|
|   WY|     510|
+-----+--------+
```

In [89]:
```
#Phone: Phone number of the customer.
sql_query = """select Phone
               from Telcom


               """
spark.sql(sql_query).show(10)
```

```
+--------+
|   Phone|
+--------+
|382-4657|
|371-7191|
|358-1921|
|375-9999|
|330-6626|
|391-8027|
|355-9993|
|329-9001|
|335-4719|
|330-8173|
+--------+
only showing top 10 rows
```

In [90]:
```
#Area.Code: Area Code of the customer.

sql_query = """select AreaCode
               from Telcom


               """
spark.sql(sql_query).show(10)
```

```
+--------+
|AreaCode|
+--------+
|     415|
|     415|
|     415|
|     408|
|     415|
|     510|
|     510|
|     415|
|     408|
|     415|
+--------+
only showing top 10 rows
```

In [91]:
```
#Int.l.Plan: Does the customer have an international plan or not.
sql_query = """select IntlPlan
               from Telcom
               WHERE IntlPlan = 1


               """
spark.sql(sql_query).show(10)
```

```
+--------+
|IntlPlan|
+--------+
|       1|
|       1|
|       1|
|       1|
|       1|
|       1|
|       1|
|       1|
|       1|
|       1|
+--------+
only showing top 10 rows
```

In [92]:
```
#CustServ.Calls: Number of customer service calls by the customer.
sql_query = """select CustServCalls,
               count(1) as CustService
               from Telcom
               group by CustServCalls
               order by CustService
               """

spark.sql(sql_query).show(10)
```

```
+-------------+-----------+
|CustServCalls|CustService|
+-------------+-----------+
|            8|          2|
|            9|          2|
|            7|          9|
|            6|         22|
|            5|         66|
|            4|        166|
|            3|        429|
|            0|        697|
|            2|        759|
|            1|       1181|
+-------------+-----------+
```

In [17]:
```
#Churn: Customers who churned the telecom service or who doesn't(0="Churner", 1=" Non-Churner") 2850 churn the

sql_query = """select Churn, count(*) as Churners
               from Telcom
               where Churn IN (1, 0)
               GROUP BY Churn
               order by Churners


               """

spark.sql(sql_query).show()
```

```
[Stage 21:>                                                         (0 + 1) / 1]
+-----+--------+
|Churn|Churners|
+-----+--------+
|    1|     483|
|    0|    2850|
+-----+--------+
```

In [94]:
```
df_sel = df.withColumn('DayMins', col('DayMins').cast(IntegerType())) \
           .withColumn('Churn', col('Churn').cast(IntegerType()))
df_sel.printSchema()
```

```
root
 |-- AccountLength: string (nullable = true)
 |-- VMailMessage: string (nullable = true)
 |-- DayMins: integer (nullable = true)
 |-- EveMins: string (nullable = true)
 |-- NightMins: string (nullable = true)
 |-- IntlMins: string (nullable = true)
 |-- CustServCalls: string (nullable = true)
 |-- Churn: integer (nullable = true)
 |-- IntlPlan: string (nullable = true)
 |-- VMailPlan: string (nullable = true)
 |-- DayCalls: string (nullable = true)
 |-- DayCharge: string (nullable = true)
 |-- EveCalls: string (nullable = true)
 |-- EveCharge: string (nullable = true)
 |-- NightCalls: string (nullable = true)
 |-- NightCharge: string (nullable = true)
 |-- IntlCalls: string (nullable = true)
 |-- IntlCharge: string (nullable = true)
 |-- State: string (nullable = true)
 |-- AreaCode: string (nullable = true)
 |-- Phone: string (nullable = true)
```

In [95]:
```
df.select(['DayMins', 'Churn']).show(10)
```

```
+-------+-----+
|DayMins|Churn|
+-------+-----+
|  265.1|    0|
|  161.6|    0|
|  243.4|    0|
|  299.4|    0|
|  166.7|    0|
|  223.4|    0|
|  218.2|    0|
|    157|    0|
|  184.5|    0|
|  258.6|    0|
+-------+-----+
only showing top 10 rows
```

In [ ]:
```
df = df.drop('State', 'Phone')
df.printSchema()
```

LET USE RDD TO FIND EACH CORRELATION OF EACH COLUMN`

In [35]:
```
features = df.rdd.map(lambda row: row[0:])
from pyspark.mllib.stat import Statistics
corr_stat=Statistics.corr(features, method="pearson")
```

In [36]:
```
corr_stat
```

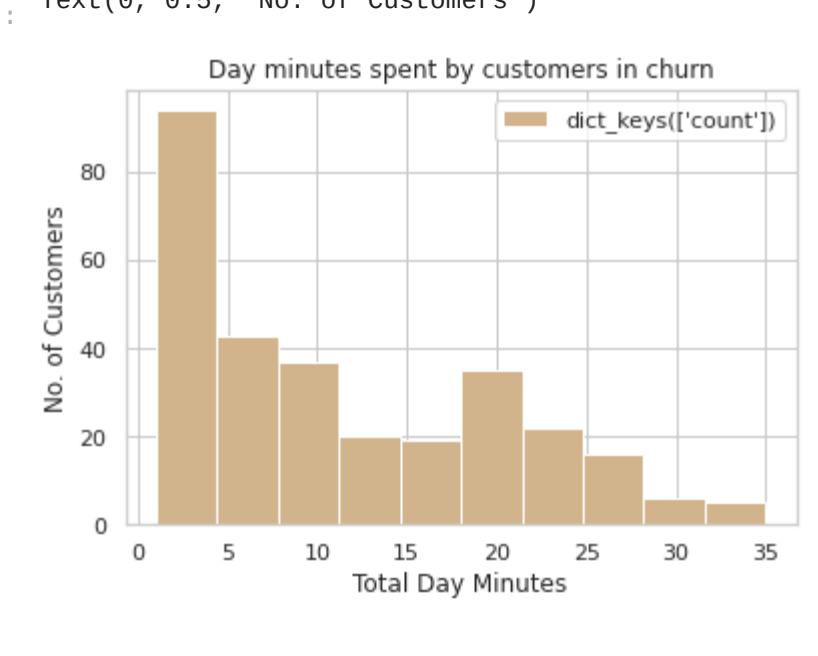
Out[36]:
```
array([[ 1.00000000e+00, -4.62782433e-03,  6.21602053e-03,
        -6.75714199e-03, -8.95519186e-03,  9.51390234e-03,
        -3.79593893e-03,  1.65407422e-02,  2.47346546e-02,
         2.91840907e-03,  3.84698823e-02,  6.21413469e-03,
         1.92599670e-02, -6.74530173e-03, -1.31762751e-02,
        -8.95953455e-03,  2.06614284e-02,  9.54567480e-03,
        -1.24634967e-02],
       [-4.62782433e-03,  1.00000000e+00,  7.78274099e-04,
         1.75620343e-02,  7.68113594e-03,  2.85619588e-03,
        -1.32625831e-02, -8.97279698e-02,  8.74548591e-03,
         9.56926642e-01, -9.54806766e-03,  7.75523459e-04,
        -5.86435129e-03,  1.75777801e-02,  7.12306291e-03,
         7.66329043e-03,  1.39573387e-02,  2.88365791e-03,
        -1.99437008e-03],
       [ 6.21602053e-03,  7.78274099e-04,  1.00000000e+00,
         7.04251099e-03,  4.32336658e-03, -1.01545856e-02,
        -1.34231864e-02,  2.05150829e-01,  4.93958241e-02,
        -1.68406871e-03,  6.75041388e-03,  9.99999952e-01,
         1.57689932e-02,  7.02903525e-03,  2.29724555e-02,
         4.30035704e-03,  8.03335695e-03, -1.00919742e-02,
        -8.26436617e-03],
       [-6.75714199e-03,  1.75620343e-02,  7.04251099e-03,
         1.00000000e+00, -1.25836779e-02, -1.10347144e-02,
        -1.29845529e-02,  9.27957903e-02,  1.91000125e-02,
         2.15450456e-02, -2.14514078e-02,  7.04960719e-03,
        -1.14301082e-02,  9.99999776e-01,  7.58564307e-03,
        -1.25928057e-02,  2.54129174e-03, -1.10666213e-02,
         3.58039485e-03],
       [-8.95519186e-03,  7.68113594e-03,  4.32336658e-03,
        -1.25836779e-02,  1.00000000e+00, -1.52072973e-02,
        -9.28761270e-03,  3.54928534e-02, -2.89047539e-02,
         6.07865672e-03,  2.29378453e-02,  4.32387938e-03,
        -2.09276800e-03, -1.25920204e-02,  1.12038563e-02,
         9.99999215e-01, -1.23534324e-02, -1.51798491e-02,
        -5.82465984e-03],
       [ 9.51390234e-03,  2.85619588e-03, -1.01545856e-02,
        -1.10347144e-02, -1.52072973e-02,  1.00000000e+00,
        -9.63967959e-03,  6.82387756e-02,  4.58707429e-02,
        -1.31787099e-03,  2.15647943e-02, -1.01568616e-02,
         8.70288065e-03, -1.10425820e-02, -1.36049964e-02,
        -1.52135258e-02,  3.23038841e-02,  9.99992742e-01,
        -1.82881682e-02],
       [-3.79593893e-03, -1.32625831e-02, -1.34231864e-02,
        -1.29845529e-02, -9.28761270e-03, -9.63967959e-03,
         1.00000000e+00,  2.08749999e-01, -2.45219562e-02,
        -1.78239441e-02, -1.89419303e-02, -1.34269694e-02,
         2.42257470e-03, -1.29874069e-02, -1.28019273e-02,
        -9.27695358e-03, -1.75605992e-02, -9.67473235e-03,
         2.75722257e-02],
       [ 1.65407422e-02, -8.97279698e-02,  2.05150829e-01,
         9.27957903e-02,  3.54928534e-02,  6.82387756e-02,
         2.08749999e-01,  1.00000000e+00,  2.59851847e-01,
        -1.02148141e-01,  1.84593116e-02,  2.05150743e-01,
         9.23313191e-03,  9.27860394e-02,  6.14120301e-03,
         3.54955562e-02, -5.28443358e-02,  6.82586315e-02,
         6.17423316e-03],
       [ 2.47346546e-02,  8.74548591e-03,  4.93958241e-02,
         1.91000125e-02, -2.89047539e-02,  4.58707429e-02,
        -2.45219562e-02,  2.59851847e-01,  1.00000000e+00,
         6.00637065e-03,  3.75462588e-03,  4.93980611e-02,
         6.11357703e-03,  1.91061524e-02,  1.24511861e-02,
        -2.89127654e-02,  1.73663432e-02,  4.57801298e-02,
         4.85505114e-02],
       [ 2.91840907e-03,  9.56926642e-01, -1.68406871e-03,
         2.15450456e-02,  6.07865672e-03, -1.31787099e-03,
        -1.78239441e-02, -1.02148141e-01,  6.00637065e-03,
         1.00000000e+00, -1.10859022e-02, -1.68562901e-03,
        -6.44444368e-03,  2.15585006e-02,  1.55525275e-02,
         6.06370857e-03,  7.61759475e-03, -1.27626692e-03,
        -7.47095076e-04],
       [ 3.84698823e-02, -9.54806766e-03,  6.75041388e-03,
        -2.14514078e-02,  2.29378453e-02,  2.15647943e-02,
        -1.89419303e-02,  1.84593116e-02,  3.75462588e-03,
        -1.10859022e-02,  1.00000000e+00,  6.75296197e-03,
         6.46211365e-03, -2.14492626e-02, -1.95569654e-02,
         2.29266378e-02,  4.57426823e-03,  2.16660952e-02,
        -9.64604398e-03],
       [ 6.21413469e-03,  7.75523459e-04,  9.99999952e-01,
         7.04960719e-03,  4.32387938e-03, -1.01568616e-02,
        -1.34269694e-02,  2.05150743e-01,  4.93980611e-02,
        -1.68562901e-03,  6.75296197e-03,  1.00000000e+00,
         1.57692822e-02,  7.03613150e-03,  2.29724195e-02,
         4.30086079e-03,  8.03157197e-03, -1.00942572e-02,
        -8.26444108e-03],
       [ 1.92599670e-02, -5.86435129e-03,  1.57689932e-02,
        -1.14301082e-02, -2.09276800e-03,  8.70288065e-03,
         2.42257470e-03,  9.23313191e-03,  6.11357703e-03,
        -6.44444368e-03,  6.46211365e-03,  1.57692822e-02,
         1.00000000e+00, -1.14228943e-02,  7.70970554e-03,
        -2.05598431e-03,  1.74336921e-02,  8.67385764e-03,
        -1.18862708e-02],
       [-6.74530173e-03,  1.75777801e-02,  7.02903525e-03,
         9.99999776e-01, -1.25920204e-02, -1.10425820e-02,
        -1.29874069e-02,  9.27860394e-02,  1.91061524e-02,
         2.15585006e-02, -2.14492626e-02,  7.03613150e-03,
        -1.14228943e-02,  1.00000000e+00,  7.59584297e-03,
        -1.26011421e-02,  2.54145802e-03, -1.10744989e-02,
         3.60669022e-03],
       [-1.31762751e-02,  7.12306291e-03,  2.29724555e-02,
         7.58564307e-03,  1.12038563e-02, -1.36049964e-02,
        -1.28019273e-02,  6.14120301e-03,  1.24511861e-02,
         1.55525275e-02, -1.95569654e-02,  2.29724195e-02,
         7.70970554e-03,  7.59584297e-03,  1.00000000e+00,
         1.11878197e-02,  3.04579532e-04, -1.36301696e-02,
         1.65223169e-02],
       [-8.95953455e-03,  7.66329043e-03,  4.30035704e-03,
        -1.25928057e-02,  9.99999215e-01, -1.52135258e-02,
        -9.27695358e-03,  3.54955562e-02, -2.89127654e-02,
         6.06370857e-03,  2.29266378e-02,  4.30086079e-03,
        -2.05598431e-03, -1.26011421e-02,  1.11878197e-02,
         1.00000000e+00, -1.23292150e-02, -1.51861386e-02,
        -5.84537574e-03],
       [ 2.06614284e-02,  1.39573387e-02,  8.03335695e-03,
         2.54129174e-03, -1.23534324e-02,  3.23038841e-02,
        -1.75605992e-02, -5.28443358e-02,  1.73663432e-02,
         7.61759475e-03,  4.57426823e-03,  8.03157197e-03,
         1.74336921e-02,  2.54145802e-03,  3.04579532e-04,
        -1.23292150e-02,  1.00000000e+00,  3.23721453e-02,
        -2.41785887e-02],
       [ 9.54567480e-03,  2.88365791e-03, -1.00919742e-02,
        -1.10666213e-02, -1.51798491e-02,  9.99992742e-01,
        -9.67473235e-03,  6.82586315e-02,  4.57801298e-02,
        -1.27626692e-03,  2.16660952e-02, -1.00942572e-02,
         8.67385764e-03, -1.10744989e-02, -1.36301696e-02,
        -1.51861386e-02,  3.23721453e-02,  1.00000000e+00,
        -1.83946960e-02],
       [-1.24634967e-02, -1.99437008e-03, -8.26436617e-03,
         3.58039485e-03, -5.82465984e-03, -1.82881682e-02,
         2.75722257e-02,  6.17423316e-03,  4.85505114e-02,
        -7.47095076e-04, -9.64604398e-03, -8.26444108e-03,
        -1.18862708e-02,  3.60669022e-03,  1.65223169e-02,
        -5.84537574e-03, -2.41785887e-02, -1.83946960e-02,
         1.00000000e+00]])
```

Create Histogram for Day minutes spent by customers for churn=0 and 1 values.

from pyspark_dist_explore import Histogram, hist, distplot, pandas_histogram fig, axes = plt.subplots() hist(axes, df.groupby("DayMins", 'Churn').count().select('count'), bins=20) axes.set_title('Day minutes spent by customers for churn') axes.legend() axes.set_xlabel('Total Day Minutes') axes.set_ylabel('No. of Customers')

In [98]:
```
fig, axes = plt.subplots()
hist(axes, df.groupby("DayMins").count().select('count'), bins=10, facecolor= 'tan')
axes.set_title('Day minutes spent by customers in churn')
axes.legend()
axes.set_xlabel('Total Day Minutes')
axes.set_ylabel('No. of Customers')
```

Out[98]:
```
Text(0, 0.5, 'No. of Customers')
```



Getting the unique value from the dataframe

In [34]:
```
df['Churn'].unique()    #unique()
```

Out[34]:
```
array([0, 1])
```

In [35]:
```
df['DayMins'].nunique()
```

Out[35]:
```
2
```

In [53]:
```
df.columns
```

Out[53]:
```
Index(['AccountLength', 'VMailMessage', 'DayMins', 'EveMins', 'NightMins',
       'IntlMins', 'CustServCalls', 'Churn', 'IntlPlan', 'VMailPlan',
       'DayCalls', 'DayCharge', 'EveCalls', 'EveCharge', 'NightCalls',
       'NightCharge', 'IntlCalls', 'IntlCharge', 'AreaCode'],
      dtype='object')
```

Convert the Dataframe to Pandas to perform some statistic analysis

In [8]:
```
df = df.toPandas()
df
```

Out[8]:

	AccountLength	VMailMessage	DayMins	EveMins	NightMins	IntlMins	CustServCalls	Churn	IntlPlan	VMailPlan	...	DayCharge	E
0	128	25	265.1	197.4	244.7	10.0	1	0	0	1	...	45.07	
1	107	26	161.6	195.5	254.4	13.7	1	0	0	1	...	27.47	
2	137	0	243.4	121.2	162.6	12.2	0	0	0	0	...	41.38	
3	84	0	299.4	61.9	196.9	6.6	2	0	1	0	...	50.90	
4	75	0	166.7	148.3	186.9	10.1	3	0	1	0	...	28.34	
...	...	...	...	...	...	...	...	...	...	...	...	...	
3328	192	36	156.2	215.5	279.1	9.9	2	0	0	1	...	26.55	
3329	68	0	231.1	153.4	191.3	9.6	3	0	0	0	...	39.29	
3330	28	0	180.8	288.8	191.9	14.1	2	0	0	0	...	30.74	
3331	184	0	213.8	159.6	139.2	5.0	2	0	1	0	...	36.35	
3332	74	25	234.4	265.9	241.4	13.7	0	0	0	1	...	39.85	

3333 rows × 21 columns

Data preprocessing with Pandas datatypes

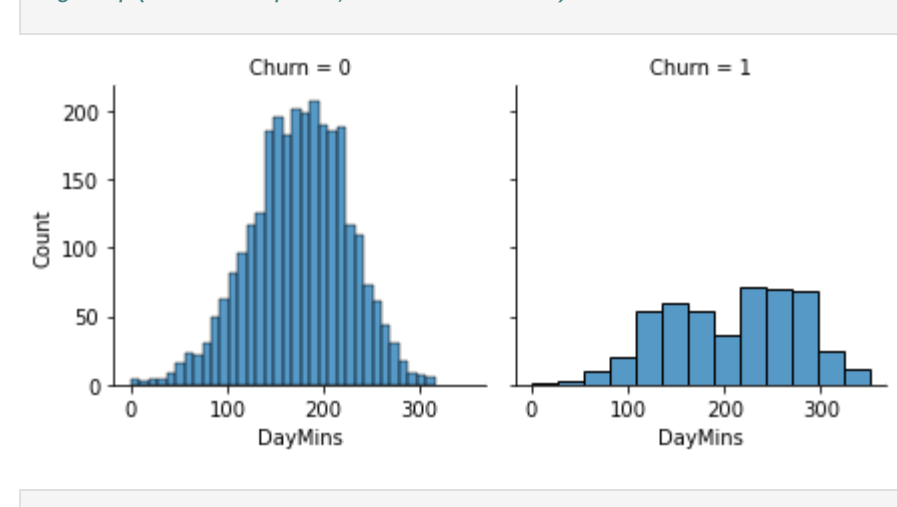
In [9]:
```
df['Churn']= df['Churn'].astype('category')
df['Intl Plan']= df['IntlPlan'].astype('category')
df['VMail Plan']= df['VMailPlan'].astype('category')
```

In [10]:
```
df.dtypes
```

Out[10]:
```
AccountLength       int32
VMailMessage        int32
DayMins           float64
EveMins           float64
NightMins         float64
IntlMins          float64
CustServCalls       int32
Churn            category
IntlPlan            int32
VMailPlan           int32
DayCalls            int32
DayCharge         float64
EveCalls            int32
EveCharge         float64
NightCalls          int32
NightCharge       float64
IntlCalls           int32
IntlCharge        float64
State              object
AreaCode            int32
Phone              object
Intl Plan        category
VMail Plan       category
dtype: object
```

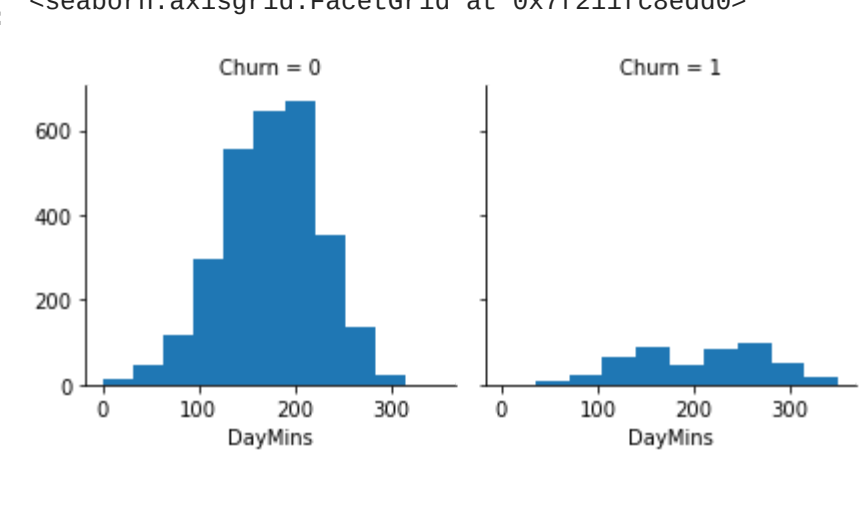
In [68]:
```
g = sns.FacetGrid(data=df, col='Churn', col_wrap=3)
g.map_dataframe(sns.histplot, x="DayMins")
plt.show()

#g = sns.FacetGrid(tips, col="size", height=2.5, col_wrap=3)
#g.map(sns.histplot, "total_bill")
```



In [67]:
```
g = sns.FacetGrid(df, col="Churn")
g.map(plt.hist, "DayMins")
```

Out[67]:
```
<seaborn.axisgrid.FacetGrid at 0x7f211fc8edd0>
```



Create count plots for Number of customers opt voicemail plan with Churn values.

In [105…
```
#How to get the count of each distinct value in a column in
sql_query = """select VMailPlan,
               count(1) as TotalChurn
               from Telcom
               group by VMailPlan
               order by TotalChurn
               """

spark.sql(sql_query).show()
```

```
+---------+----------+
|VMailPlan|TotalChurn|
+---------+----------+
|        1|       922|
|        0|      2411|
+---------+----------+
```

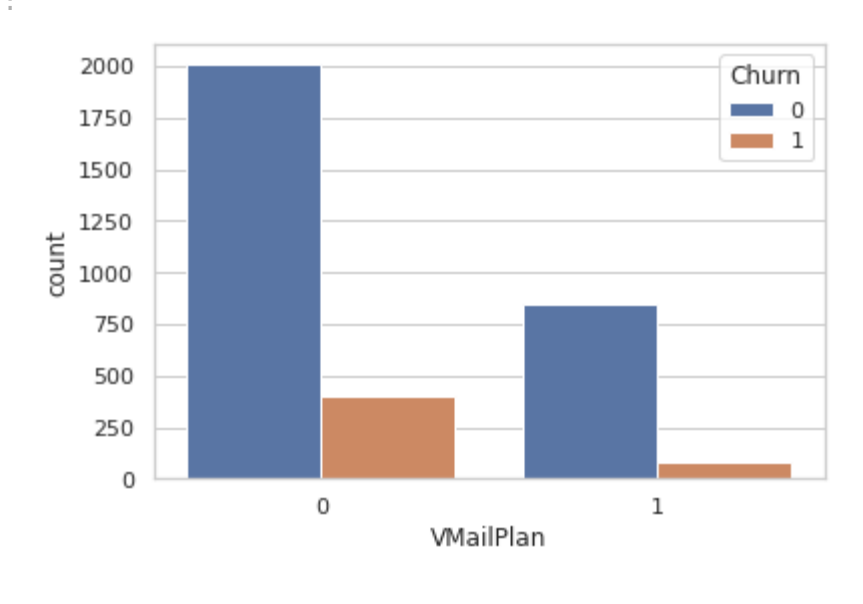
Seaborn count plot on voicemail plan

In [70]:
```
import seaborn as sns

sns.set(style="whitegrid", color_codes=True)

sns.countplot(x="VMailPlan", hue="Churn", data=df)
```

Out[70]: <AxesSubplot:xlabel='VMailPlan', ylabel='count'>



Create count plots for International Plan opt by the customer with Churn values.

In [55]:
```
df.describe()
```

Out[55]:

	Churn	DayMins
count	10.000000	10.000000
mean	0.500000	0.300000
std	0.527046	0.483046
min	0.000000	0.000000
25%	0.000000	0.000000
50%	0.500000	0.000000
75%	1.000000	0.750000
max	1.000000	1.000000

Create count plots for International Plan opt by the customer with Churn values.

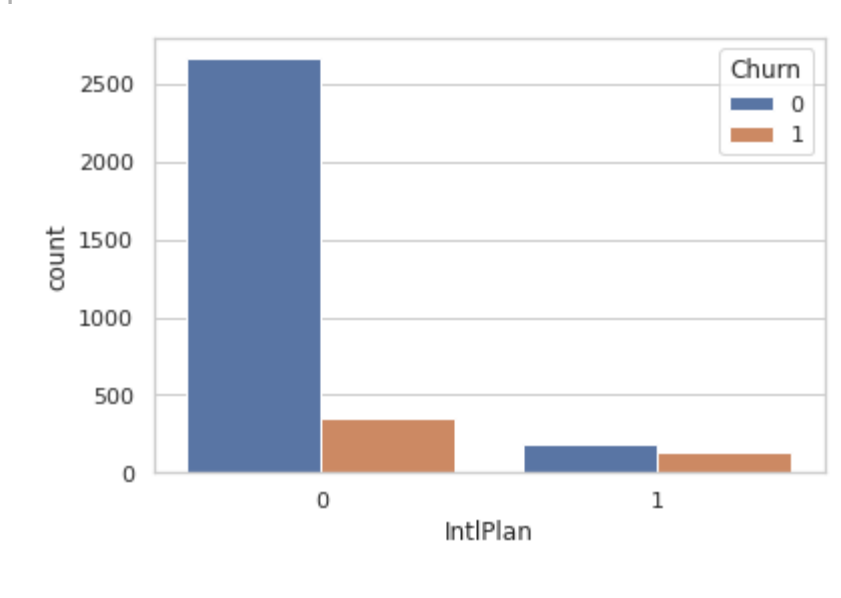
In [61]:
```
sql_query = """select IntlPlan,
               count(1) as nternational_Plan
               from Telcom
               group by IntlPlan
               order by nternational_Plan
               """

spark.sql(sql_query).show()
```

```
+--------+-----------------+
|IntlPlan|nternational_Plan|
+--------+-----------------+
|       1|              323|
|       0|             3010|
+--------+-----------------+
```

In [71]:
```
sns.countplot(x="IntlPlan", hue= "Churn", data=df)
```

Out[71]: <AxesSubplot:xlabel='IntlPlan', ylabel='count'>



Plot Area Wise churner and non-churner.

In [18]:
```
df.select(['AreaCode']).show(10)
```

```
+--------+
|AreaCode|
+--------+
|     415|
|     415|
|     415|
|     408|
|     415|
|     510|
|     510|
|     415|
|     408|
|     415|
+--------+
only showing top 10 rows
```

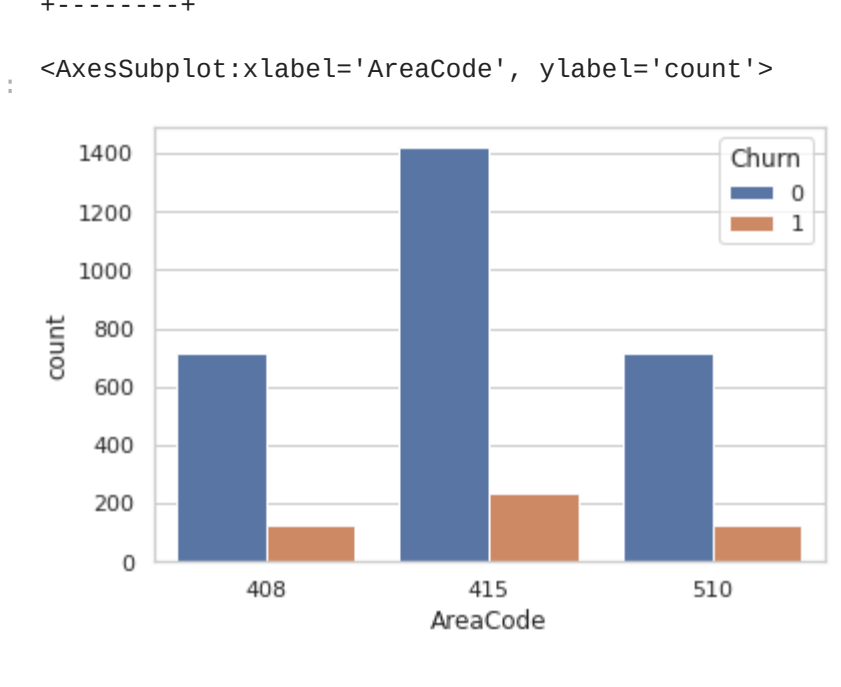
In [72]:
```
sql_query = """select distinct
               AreaCode
               from Telcom

               """

spark.sql(sql_query).show()
sns.countplot(x="AreaCode", hue= "Churn", data=df)
```

```
+--------+
|AreaCode|
+--------+
|     415|
|     510|
|     408|
+--------+
```

Out[72]: <AxesSubplot:xlabel='AreaCode', ylabel='count'>



Get correlation matrix using corr() function.

In [84]:
```
df.corr("IntlPlan", "Churn", method="pearson")
```

Out[84]: 0.2598518473454819

In [112…
```
sql_query = """select CORR(IntlPlan, AreaCode)
               from Telcom

               """

spark.sql(sql_query).show()
```

```
+-----------------------+
|corr(IntlPlan, AreaCode)|
+-----------------------+
|     0.04855051136707131|
+-----------------------+
```

Lets check the Correlation Matrix

In [65]:
```
df.corr('pearson')
```

Out[65]:

	AccountLength	VMailMessage	DayMins	EveMins	NightMins	IntlMins	CustServCalls	Churn	IntlPlan	VMailPlan
AccountLength	1.000000	-0.004628	0.006216	-0.006757	-0.008955	0.009514	-0.003796	0.016541	0.024735	0.002918
VMailMessage	-0.004628	1.000000	0.000778	0.017562	0.007681	0.002856	-0.013263	-0.089728	0.008745	0.956927
DayMins	0.006216	0.000778	1.000000	0.007043	0.004323	-0.010155	-0.013423	0.205151	0.049396	-0.001684
EveMins	-0.006757	0.017562	0.007043	1.000000	-0.012584	-0.011035	-0.012985	0.092796	0.019100	0.021545
NightMins	-0.008955	0.007681	0.004323	-0.012584	1.000000	-0.015207	-0.009288	0.035493	-0.028905	0.006079
IntlMins	0.009514	0.002856	-0.010155	-0.011035	-0.015207	1.000000	-0.009640	0.068239	0.045871	-0.001318
CustServCalls	-0.003796	-0.013263	-0.013423	-0.012985	-0.009288	-0.009640	1.000000	0.208750	-0.024522	-0.017824
Churn	0.016541	-0.089728	0.205151	0.092796	0.035493	0.068239	0.208750	1.000000	0.259852	-0.102148
IntlPlan	0.024735	0.008745	0.049396	0.019100	-0.028905	0.045871	-0.024522	0.259852	1.000000	0.006006
VMailPlan	0.002918	0.956927	-0.001684	0.021545	0.006079	-0.001318	-0.017824	-0.102148	0.006006	1.000000
DayCalls	0.038470	-0.009548	0.006750	-0.021451	0.022938	0.021565	-0.018942	0.018459	0.003755	-0.011086
DayCharge	0.006214	0.000776	1.000000	0.007050	0.004324	-0.010157	-0.013427	0.205151	0.049398	-0.001686
EveCalls	0.019260	-0.005864	0.015769	-0.011430	-0.002093	0.008703	0.002423	0.009233	0.006114	-0.006444
EveCharge	-0.006745	0.017578	0.007029	1.000000	-0.012592	-0.011043	-0.012987	0.092786	0.019106	0.021559
NightCalls	-0.013176	0.007123	0.022972	0.007586	0.011204	-0.013605	-0.012802	0.006141	0.012451	0.015553
NightCharge	-0.008960	0.007663	0.004300	-0.012593	0.999999	-0.015214	-0.009277	0.035496	-0.028913	0.006064
IntlCalls	0.020661	0.013957	0.008033	0.002541	-0.012353	0.032304	-0.017561	-0.052844	0.017366	0.007618
IntlCharge	0.009546	0.002884	-0.010092	-0.011067	-0.015180	0.999993	-0.009675	0.068259	0.045780	-0.001276
AreaCode	-0.012463	-0.001994	-0.008264	0.003580	-0.005825	-0.018288	0.027572	0.006174	0.048551	-0.000747

Correlation between Predicting Variable and independent variable for future analysis for customer Posibility to Churn the Network.

In [66]:
```
df.corr()['Churn']
```

Out[66]:
```
AccountLength    0.016541
VMailMessage    -0.089728
DayMins          0.205151
EveMins          0.092796
NightMins        0.035493
IntlMins         0.068239
CustServCalls    0.208750
Churn            1.000000
IntlPlan         0.259852
VMailPlan       -0.102148
DayCalls         0.018459
DayCharge        0.205151
EveCalls         0.009233
EveCharge        0.092786
NightCalls       0.006141
NightCharge      0.035496
IntlCalls       -0.052844
IntlCharge       0.068259
AreaCode         0.006174
Name: Churn, dtype: float64
```

From the above analysis we fwe discover DayMins, CustServCalls, IntlPlan has high positive correlation that are predictive to Churn the network, while VMail Message, VMail Plan and Intl Calls has weak negative correlation. While remaining variables has either weak positive or negative correlation.

Strong Correlation lies in the range of ±0.5 to ±1 Weak Correlation lies in the range of ±0.1 to ±0.1 and other correlation lies within range of 0.01 to 0.006

Applying Machine Learning Model

Create vectors of all independent variables using VectorAssembler

Fisrts convert pandas to spark once again to apply ML models

In [30]:
```
# Creating the DataFrame
sprak_df = spark.createDataFrame(df)

# Show the DataFrame
sprak_df.show(5)
```

```
[Stage 17:>                                                         (0 + 1) / 1]
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+
|AccountLength|VMailMessage|DayMins|EveMins|NightMins|IntlMins|CustServCalls|Churn|IntlPlan|VMailPlan|DayCalls
|DayCharge|EveCalls|EveCharge|NightCalls|NightCharge|IntlCalls|IntlCharge|State|AreaCode|   Phone|Intl Plan|VM
ail Plan|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+
|          128|          25|  265.1|  197.4|    244.7|    10.0|            1|    0|       0|        1|     110
|    45.07|      99|    16.78|        91|      11.01|        3|       2.7|   KS|     415|382-4657|        0|
      1|
|          107|          26|  161.6|  195.5|    254.4|    13.7|            1|    0|       0|        1|     123
|    27.47|     103|    16.62|       103|      11.45|        3|       3.7|   OH|     415|371-7191|        0|
      1|
|          137|           0|  243.4|  121.2|    162.6|    12.2|            0|    0|       0|        0|     114
|    41.38|     110|     10.3|       104|       7.32|        5|      3.29|   NJ|     415|358-1921|        0|
      0|
|           84|           0|  299.4|   61.9|    196.9|     6.6|            2|    0|       1|        0|      71
|     50.9|      88|     5.26|        89|       8.86|        7|      1.78|   OH|     408|375-9999|        1|
      0|
|           75|           0|  166.7|  148.3|    186.9|    10.1|            3|    0|       1|        0|     113
|    28.34|     122|    12.61|       121|       8.41|        3|      2.73|   OK|     415|330-6626|        1|
      0|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+
only showing top 5 rows
```

Create vectors of all independent variables using VectorAssembler

In [13]:
```
from pyspark.ml.stat import Correlation
from pyspark.ml.linalg import DenseMatrix, Vectors
from pyspark.ml.feature import VectorAssembler
from pyspark.sql.functions import *

from pyspark.ml.classification import DecisionTreeClassifier
from pyspark.ml.evaluation import MulticlassClassificationEvaluator
from sklearn.metrics import confusion_matrix
from sklearn.datasets import load_iris
import sklearn.metrics as metrics


assembler = VectorAssembler(
    inputCols=['AccountLength', 'VMailMessage', 'DayMins', 'EveMins', 'NightMins',
       'IntlMins', 'CustServCalls', 'Churn', 'IntlPlan', 'VMailPlan',
       'DayCalls', 'DayCharge', 'EveCalls', 'EveCharge', 'NightCalls',
       'NightCharge', 'IntlCalls', 'IntlCharge','AreaCode'],
    outputCol="features")
```

In [14]:
```
output = assembler.transform(sprak_df)

output.show(5)
```

```
22/12/05 11:30:37 WARN package: Truncated the string representation of a plan since it was too large. This beh
avior can be adjusted by setting 'spark.sql.debug.maxToStringFields'.
[Stage 6:>                                                          (0 + 1) / 1]
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+--------------------+
|AccountLength|VMailMessage|DayMins|EveMins|NightMins|IntlMins|CustServCalls|Churn|IntlPlan|VMailPlan|DayCalls
|DayCharge|EveCalls|EveCharge|NightCalls|NightCharge|IntlCalls|IntlCharge|State|AreaCode|   Phone|Intl Plan|VM
ail Plan|            features|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+--------------------+
|          128|          25|  265.1|  197.4|    244.7|    10.0|            1|    0|       0|        1|     110
|    45.07|      99|    16.78|        91|      11.01|        3|       2.7|   KS|     415|382-4657|        0|
      1|[128.0,25.0,265.1...|
|          107|          26|  161.6|  195.5|    254.4|    13.7|            1|    0|       0|        1|     123
|    27.47|     103|    16.62|       103|      11.45|        3|       3.7|   OH|     415|371-7191|        0|
      1|[107.0,26.0,161.6...|
|          137|           0|  243.4|  121.2|    162.6|    12.2|            0|    0|       0|        0|     114
|    41.38|     110|     10.3|       104|       7.32|        5|      3.29|   NJ|     415|358-1921|        0|
      0|[137.0,0.0,243.4,...|
|           84|           0|  299.4|   61.9|    196.9|     6.6|            2|    0|       1|        0|      71
|     50.9|      88|     5.26|        89|       8.86|        7|      1.78|   OH|     408|375-9999|        1|
      0|[84.0,0.0,299.4,6...|
|           75|           0|  166.7|  148.3|    186.9|    10.1|            3|    0|       1|        0|     113
|    28.34|     122|    12.61|       121|       8.41|        3|      2.73|   OK|     415|330-6626|        1|
      0|[75.0,0.0,166.7,1...|
+-------------+------------+-------+-------+---------+--------+-------------+-----+--------+---------+--------
+---------+--------+---------+----------+-----------+---------+----------+-----+--------+--------+---------+--
--------+--------------------+
only showing top 5 rows
```

Each independent Variables from the Dataframe printed first 5 features

In [50]:
```
output.select('features').show(5)
```

```
+--------------------+
|            features|
+--------------------+
|[128.0,25.0,265.1...|
|[107.0,26.0,161.6...|
|[137.0,0.0,243.4,...|
|[84.0,0.0,299.4,6...|
|[75.0,0.0,166.7,1...|
+--------------------+
only showing top 5 rows
```

Apply Decision Tree Classifier using dependent and independent variables.

lets split the dataset into trin an test

In [15]:
```
from sklearn.model_selection import train_test_split

train, test = output.randomSplit([0.8, 0.2])
```

Predict the accuracy check with decision tree to understand what customer think

I convert the table to pandas so the prediction can be clearly seen on the dataframe. The prediction isat the endside of the table

Creating a pipeline to build the classifier.

In [16]:
```
treePred = DecisionTreeClassifier(featuresCol="features", labelCol='Churn')
treePred = treePred.fit(train)

pred = treePred.transform(test)
pred.toPandas()
```

Out[16]:

	AccountLength	VMailMessage	DayMins	EveMins	NightMins	IntlMins	CustServCalls	Churn	IntlPlan	VMailPlan	...	IntlCharge	Sta
0	6	0	226.5	152.1	164.4	9.4	3	0	0	0	...	2.54	C
1	11	0	143.4	289.4	194.0	9.7	2	0	0	0	...	2.62	N
2	11	28	190.6	220.1	180.3	6.0	3	0	0	1	...	1.62	D
3	11	38	209.8	196.6	233.0	7.0	1	0	0	1	...	1.89	W
4	12	0	216.7	116.5	220.0	9.8	2	0	1	0	...	2.65	N
...	...	...	...	...	...	...	...	...	...	...	...	...	
644	184	0	213.8	159.6	139.2	5.0	2	0	1	0	...	1.35	C
645	189	0	227.8	169.5	201.1	5.6	3	0	0	0	...	1.51	M
646	201	0	225.9	299.1	251.3	11.2	1	1	0	0	...	3.02	T
647	209	0	153.7	188.6	200.8	10.7	0	0	0	0	...	2.89	N
648	209	0	255.1	230.6	218.0	8.5	3	1	0	0	...	2.30	S

649 rows × 27 columns

In [17]:
```
pred.printSchema()
```

```
root
 |-- AccountLength: long (nullable = true)
 |-- VMailMessage: long (nullable = true)
 |-- DayMins: double (nullable = true)
 |-- EveMins: double (nullable = true)
 |-- NightMins: double (nullable = true)
 |-- IntlMins: double (nullable = true)
 |-- CustServCalls: long (nullable = true)
 |-- Churn: long (nullable = true)
 |-- IntlPlan: long (nullable = true)
 |-- VMailPlan: long (nullable = true)
 |-- DayCalls: long (nullable = true)
 |-- DayCharge: double (nullable = true)
 |-- EveCalls: long (nullable = true)
 |-- EveCharge: double (nullable = true)
 |-- NightCalls: long (nullable = true)
 |-- NightCharge: double (nullable = true)
 |-- IntlCalls: long (nullable = true)
 |-- IntlCharge: double (nullable = true)
 |-- State: string (nullable = true)
 |-- AreaCode: long (nullable = true)
 |-- Phone: string (nullable = true)
 |-- Intl Plan: long (nullable = true)
 |-- VMail Plan: long (nullable = true)
 |-- features: vector (nullable = true)
 |-- rawPrediction: vector (nullable = true)
 |-- probability: vector (nullable = true)
 |-- prediction: double (nullable = false)
```

Evaluating the Model with muticlassification metrix

After going through the models, we can see the predicted test data and accuracy metrics. we used the function MulticlassClassificationEvaluator from pyspark to check the accuracy metrix and the confusion matrix can also be created using confusion_matrix function from sklearn.metrics module.

In [35]:
```
modelEvaluator=MulticlassClassificationEvaluator(predictionCol="prediction")

print("Prediction Accuracy: ")

x_pred=pred.select("prediction").collect()
y_orig=pred.select("Churn").collect()

commonMtrix= confusion_matrix(y_orig, x_pred)
print("Accuracy:",metrics.accuracy_score(y_orig, x_pred))
print('Precision:', metrics.precision_score(y_orig, x_pred))
print('recall:', metrics.recall_score(y_orig, x_pred))


print("Confusion Matrix:")
print(commonMtrix)
```

```
Prediction Accuracy:

Accuracy: 1.0
Precision: 1.0
recall: 1.0
Confusion Matrix:
[[595   0]
 [  0  99]]
```

Using metric classification method to alculate recall, precision, score and individual support which gives us the total sample size.

In [36]:
```
print(metrics.classification_report(y_orig, x_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00       595
           1       1.00      1.00      1.00        99

    accuracy                           1.00       694
   macro avg       1.00      1.00      1.00       694
weighted avg       1.00      1.00      1.00       694
```

Visualizing the Decision tree

In [33]:
```
from spark_tree_plotting import plot_tree
from spark_tree_plotting import export_graphviz
from PIL import Image
import io
import pydotplus

png_model = plot_tree(treePred,
                      featureNames=['AccountLength', 'VMailMessage', 'DayMins', 'EveMins', 'NightMins',
                                    'IntlMins', 'CustServCalls', 'Churn', 'IntlPlan', 'VMailPlan',
                                    'DayCalls', 'DayCharge', 'EveCalls', 'EveCharge', 'NightCalls',
                                    'NightCharge', 'IntlCalls', 'IntlCharge','AreaCode'],
                      categoryNames={},
                      classNames=treePred.Churn,
                      filled=True,
                      roundedCorners=True,
                      roundLeaves=True)

image = Image.open(io.BytesIO(png_model))
```

In [ ]: