BT- PREDICTIVE MODEL

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import sklearn as sk
import tensorflow as tf
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.ensemble import RandomForestClassifier
from sklearn.feature_selection import SelectKBest, f_classif
from sklearn.model_selection import train_test_split
from sklearn.impute import KNNImputer
from sklearn.preprocessing import LabelEncoder
from sklearn.feature_selection import SelectKBest, chi2
from imblearn.over_sampling import RandomOverSampler
from imblearn.under_sampling import RandomUnderSampler
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler
from sklearn import metrics
from sklearn.model_selection import GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import GradientBoostingClassifier


import os
os.environ['OMP_NUM_THREADS']='1'


from google.colab import drive
drive.mount('/content/drive/')
```

```
     Mounted at /content/drive/
```

```
fileName = '/content/drive/MyDrive/Step Up Data Set.csv'


data = pd.read_csv(fileName)


data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7043 non-null   object 
 1   gender            7043 non-null   object 
 2   SeniorCitizen     7043 non-null   int64  
 3   Partner           7043 non-null   object 
 4   Dependents        7043 non-null   object 
 5   tenure            7043 non-null   int64  
 6   PhoneService      7043 non-null   object 
 7   MultipleLines     7043 non-null   object 
 8   InternetService   7043 non-null   object 
 9   OnlineSecurity    7043 non-null   object 
 10  OnlineBackup      7043 non-null   object 
 11  DeviceProtection  7043 non-null   object 
 12  TechSupport       7043 non-null   object 
 13  StreamingTV       7043 non-null   object 
 14  StreamingMovies   7043 non-null   object 
 15  Contract          7043 non-null   object 
 16  PaperlessBilling  7043 non-null   object 
 17  PaymentMethod     7043 non-null   object 
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7043 non-null   object 
 20  Churn             7043 non-null   object 
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB
```

```
data2 = data


# Convert total charges to float
# The null values are converting to nan
data.isna().sum()
```

```
customerID           0
gender               0
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
```

```
# convert total charges to float
data['TotalCharges'] = pd.to_numeric(data['TotalCharges'], errors='coerce')

# identify the values that could not be converted
invalid_values = data[data['TotalCharges'].isna()]['TotalCharges']

#print(data2)
print("Invalid values:", invalid_values)
```

```
Invalid values: 488    NaN
753    NaN
936    NaN
1082   NaN
1340   NaN
3331   NaN
3826   NaN
4380   NaN
5218   NaN
6670   NaN
6754   NaN
Name: TotalCharges, dtype: float64
```

```
data.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineS
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	
1	5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	
2	3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	DSL	
4	9237-HQITU	Female	0	No	No	2	Yes	No	Fiber optic	

5 rows × 21 columns

```
data.describe()
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
count	7043.000000	7043.000000	7043.000000	7032.000000
mean	0.162147	32.371149	64.761692	2283.300441
std	0.368612	24.559481	30.090047	2266.771362
min	0.000000	0.000000	18.250000	18.800000
25%	0.000000	9.000000	35.500000	401.450000
50%	0.000000	29.000000	70.350000	1397.475000
75%	0.000000	55.000000	89.850000	3794.737500
max	1.000000	72.000000	118.750000	8684.800000

```
data.isna()
#to see the number of  missing values
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	Onl
0	False	False	False	False	False	False	False	False	False	
1	False	False	False	False	False	False	False	False	False	
2	False	False	False	False	False	False	False	False	False	
3	False	False	False	False	False	False	False	False	False	
4	False	False	False	False	False	False	False	False	False	
...	...	...	...	...	...	...	...	...	...	
7038	False	False	False	False	False	False	False	False	False	
7039	False	False	False	False	False	False	False	False	False	

```
data.isna().sum()
```

```
customerID           0
gender               0
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
```

```
set(data.duplicated())
```

```
     {False}
```

```
# we can pass the result of the df.duplicated into a set to see if there is any instance of True
# No duplicates in the data
set(data.duplicated())
```

```
     {False}
```

```
data.shape
```

```
     (7043, 21)
```

```
# Checking the class imbalance
data['Churn'].value_counts(normalize=True)
```

```
     No     0.73463
     Yes    0.26537
     Name: Churn, dtype: float64
```

```
df=data
```

```
df.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineS
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	
1	5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	
2	3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	DSL	

```
df.info()
```

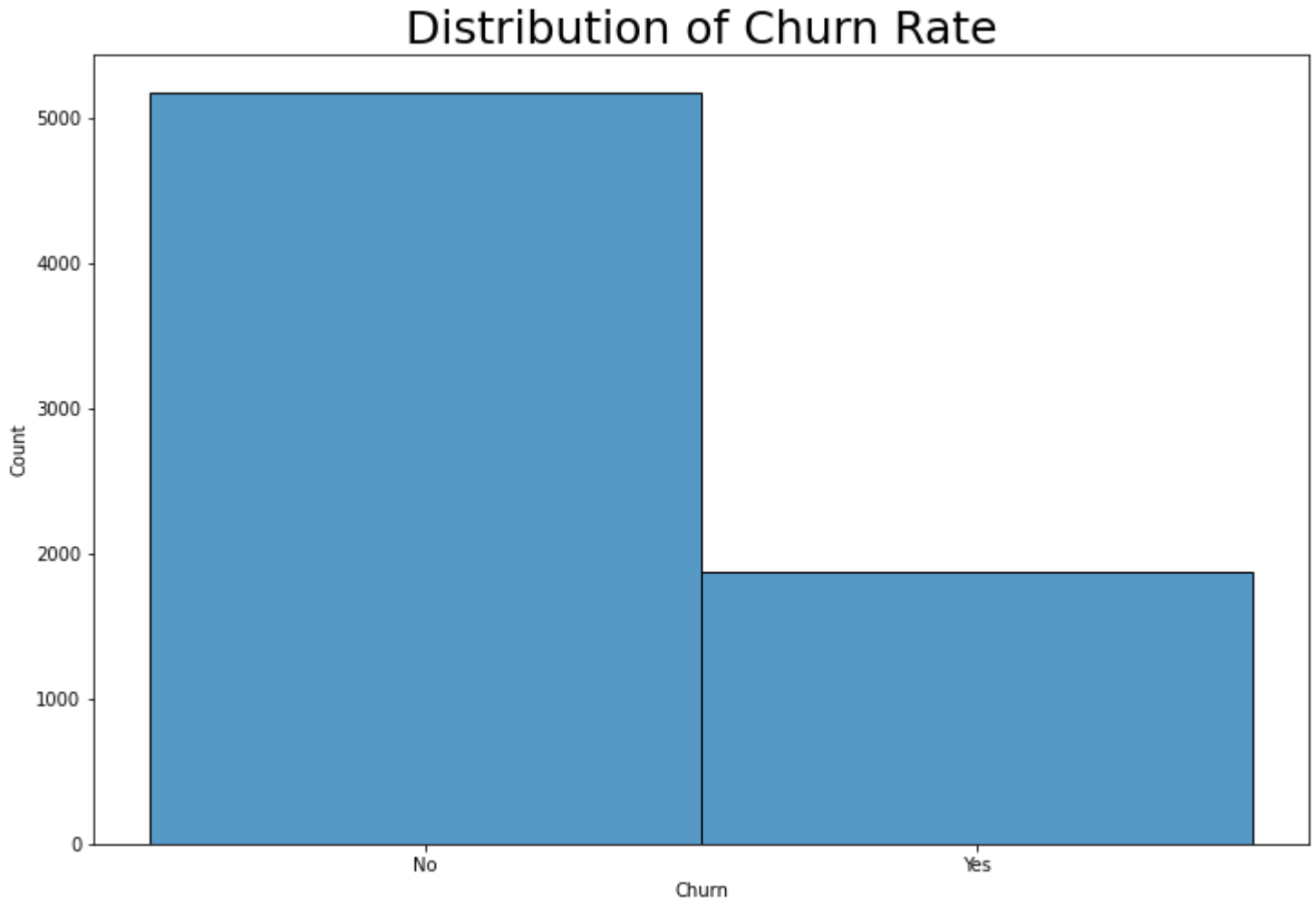
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7043 non-null   object 
 1   gender            7043 non-null   object 
 2   SeniorCitizen     7043 non-null   int64  
 3   Partner           7043 non-null   object 
 4   Dependents        7043 non-null   object 
 5   tenure            7043 non-null   int64  
 6   PhoneService      7043 non-null   object 
 7   MultipleLines     7043 non-null   object 
 8   InternetService   7043 non-null   object 
 9   OnlineSecurity    7043 non-null   object 
 10  OnlineBackup      7043 non-null   object 
 11  DeviceProtection  7043 non-null   object 
 12  TechSupport       7043 non-null   object 
 13  StreamingTV       7043 non-null   object 
 14  StreamingMovies   7043 non-null   object 
 15  Contract          7043 non-null   object 
 16  PaperlessBilling  7043 non-null   object 
 17  PaymentMethod     7043 non-null   object 
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7043 non-null   object 
```

```
dtypes: float64(2), int64(2), object(17)
memory usage: 1.1+ MB
```

```
plt.figure(figsize=(15,10))
sns.histplot(df.tenure)
plt.title('tenure', fontsize = 25)
plt.show()
```

tenure

```
plt.figure(figsize=(12,8))
sns.histplot(df.Churn)
plt.title('Distribution of Churn Rate', fontsize = 25)
plt.show()
```




```
df.nunique()
```

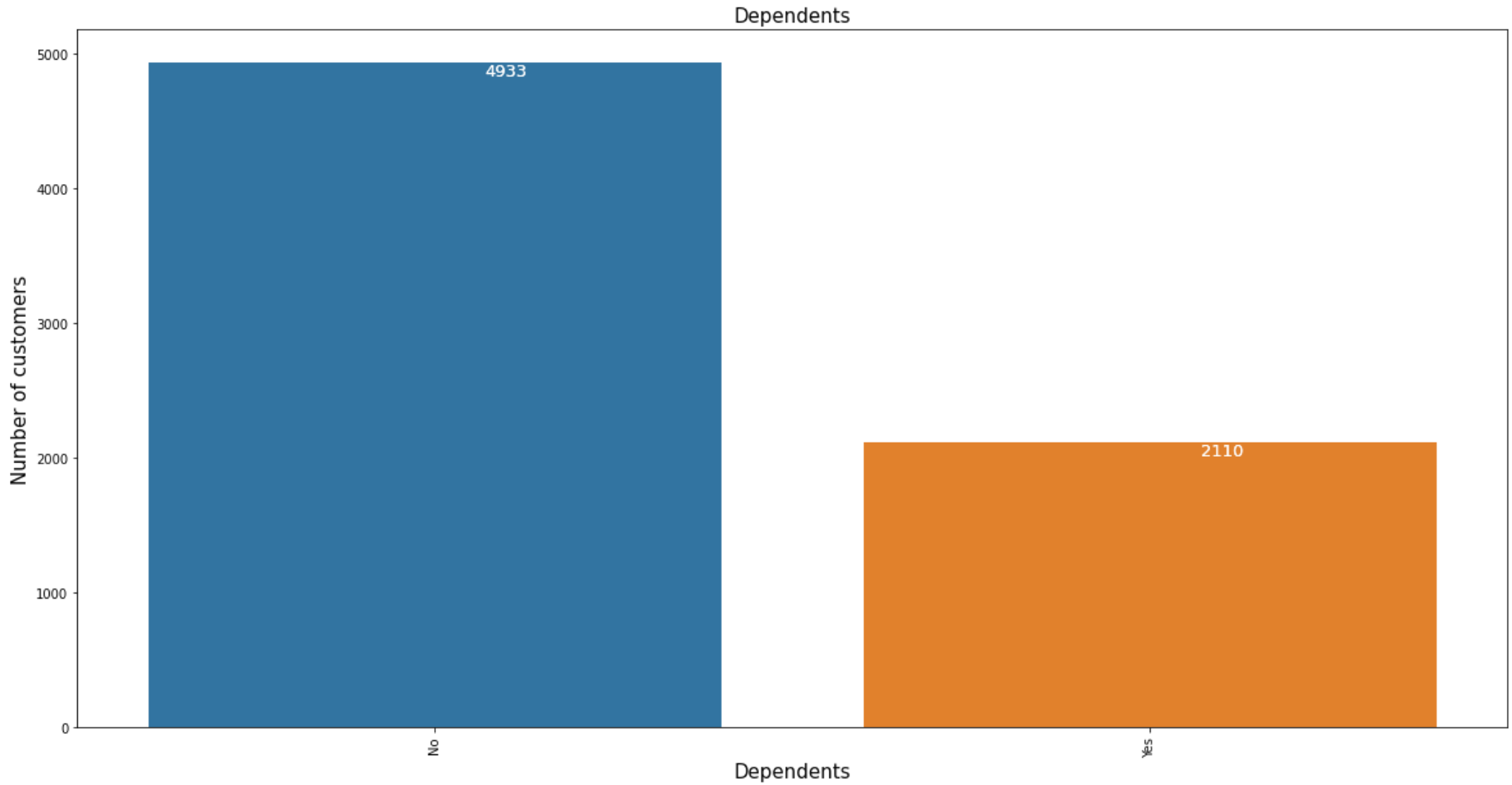
```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6530
Churn                  2
dtype: int64
```

```
df['Dependents'].value_counts()
```

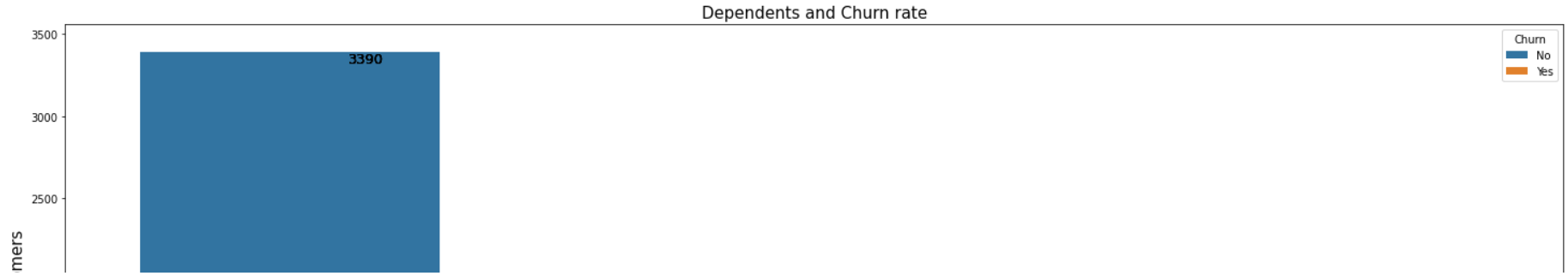
```
No     4933
Yes    2110
Name: Dependents, dtype: int64
```

```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='Dependents', data=df)
ax.set_title('Dependents' , fontsize = 15)
sns.set(font_scale=1.5)
plt.xlabel('Dependents', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='vertical')
```

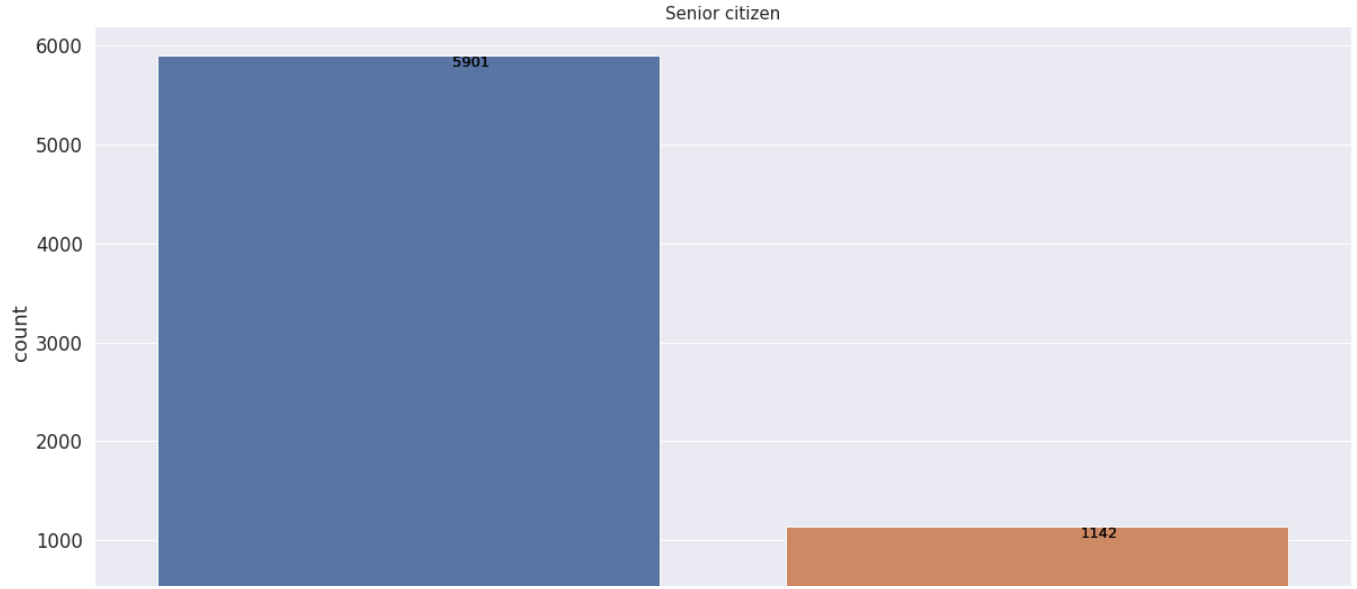
```
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='white', size=13)
```



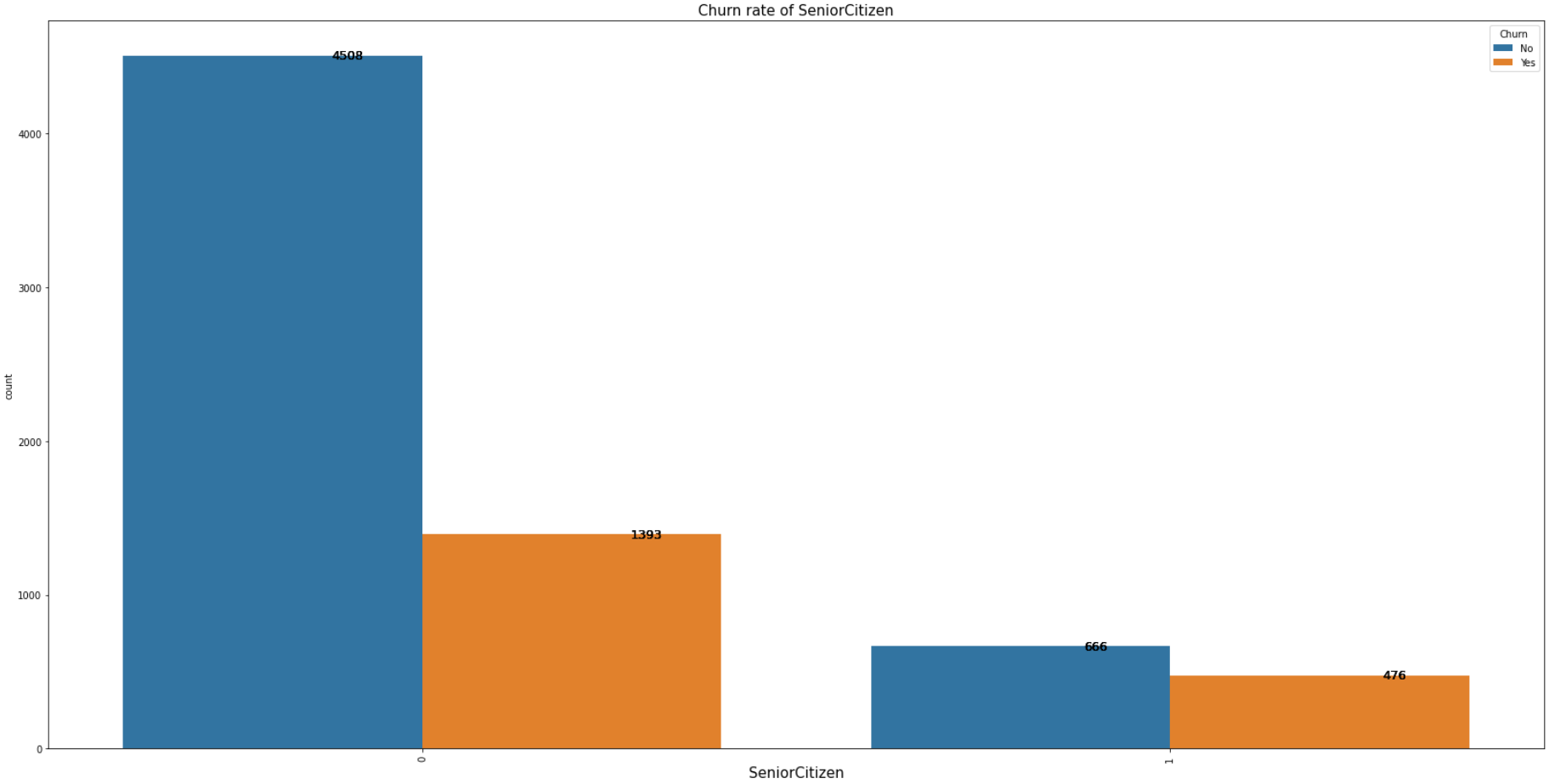
```
plt.figure(figsize=(25,10))
ax=sns.countplot(x='Dependents',hue ='Churn', data=df)
ax.set_title('Dependents and Churn rate' , fontsize = 15)
plt.xlabel('Dependents', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='top', color='black',  size=13)
```




```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='SeniorCitizen', data=df)
ax.set_title('Senior citizen' , fontsize = 15)
plt.xlabel('Senior citizen', fontsize=15)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.5, p.get_height()), ha='center', va='top', color='black', size=13)
```



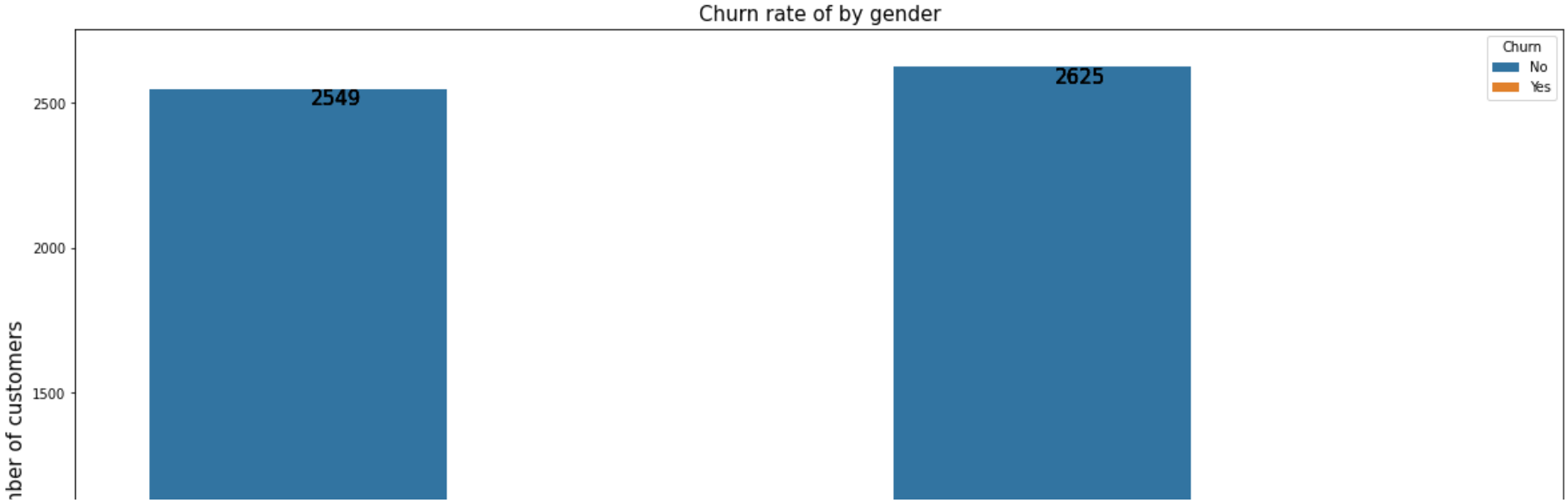

```
plt.figure(figsize=(28,14))
ax=sns.countplot(x='SeniorCitizen', hue='Churn', data=df)
ax.set_title('Churn rate of SeniorCitizen' , fontsize = 15)
plt.xlabel('SeniorCitizen', fontsize=15)
plt.xticks(rotation='vertical')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='center', color='black', size=13)
```




```
plt.figure(figsize=(16,10))
ax=sns.countplot(x='gender', data=df)
ax.set_title('Distribution of gender' , fontsize = 15)
plt.xlabel('Gender', fontsize=15)
```

```
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black', size=15)
```

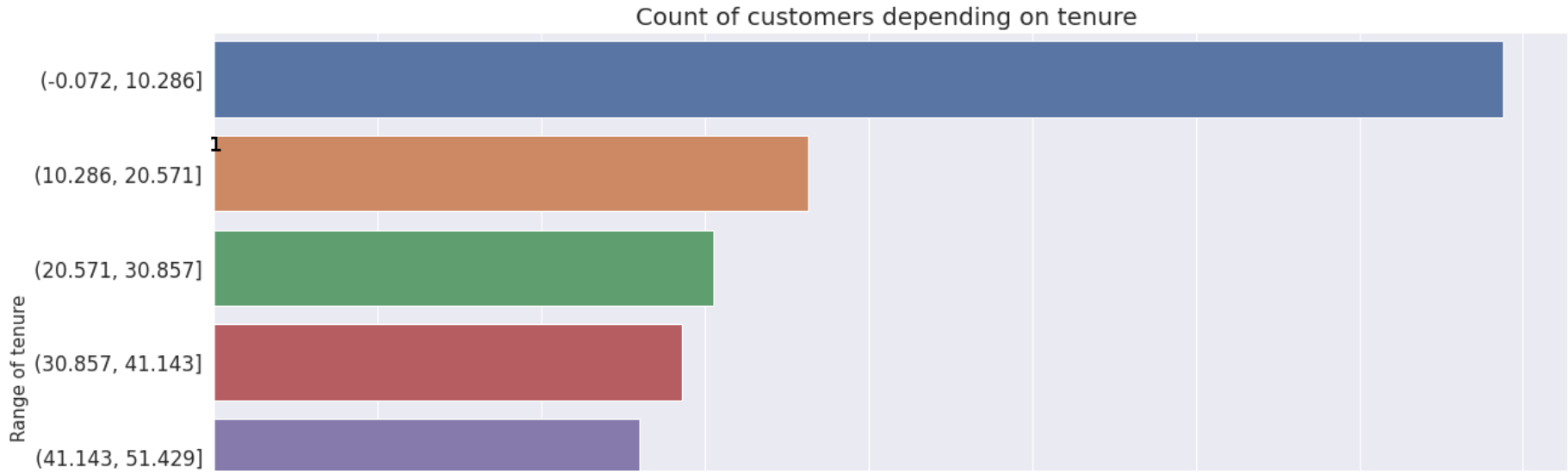

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='gender', hue='Churn', data=df)
ax.set_title('Churn rate of by gender' , fontsize = 15)
plt.xlabel('Gender', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



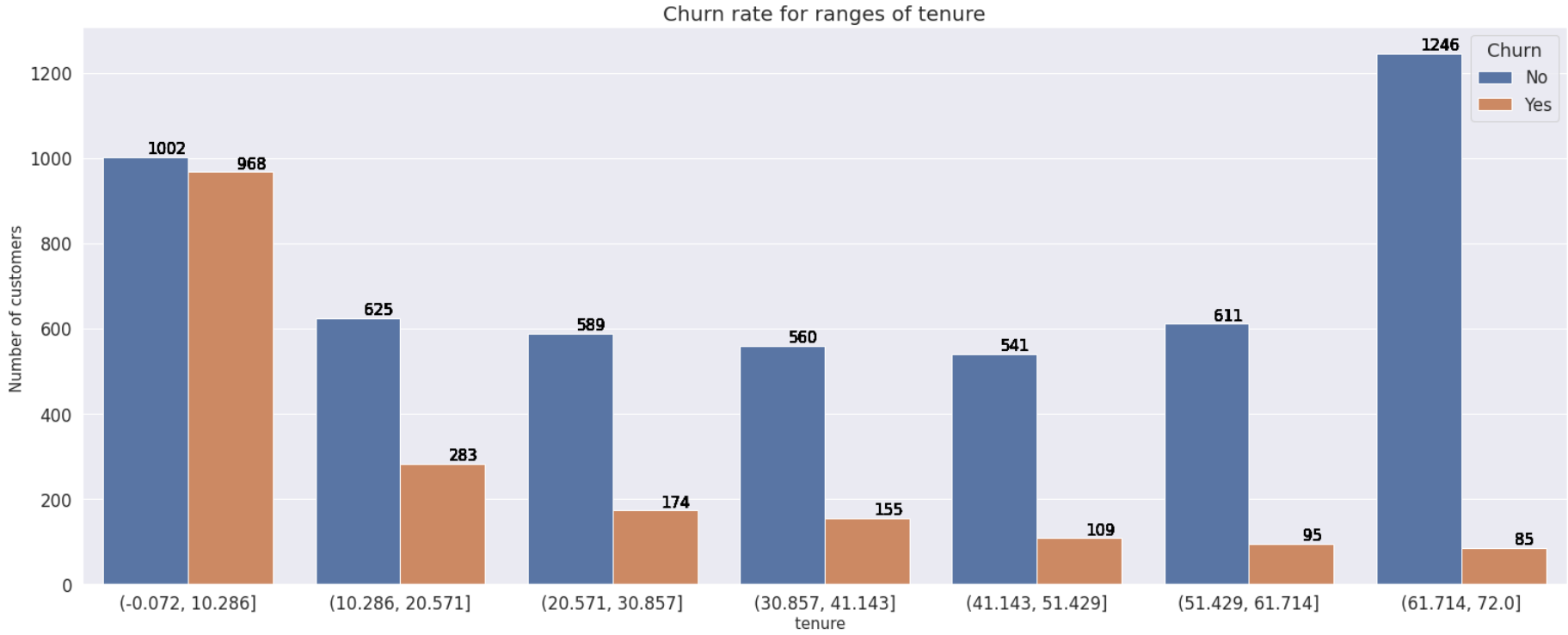

```
df.nunique()
```

```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6531
Churn                  2
dtype: int64
```

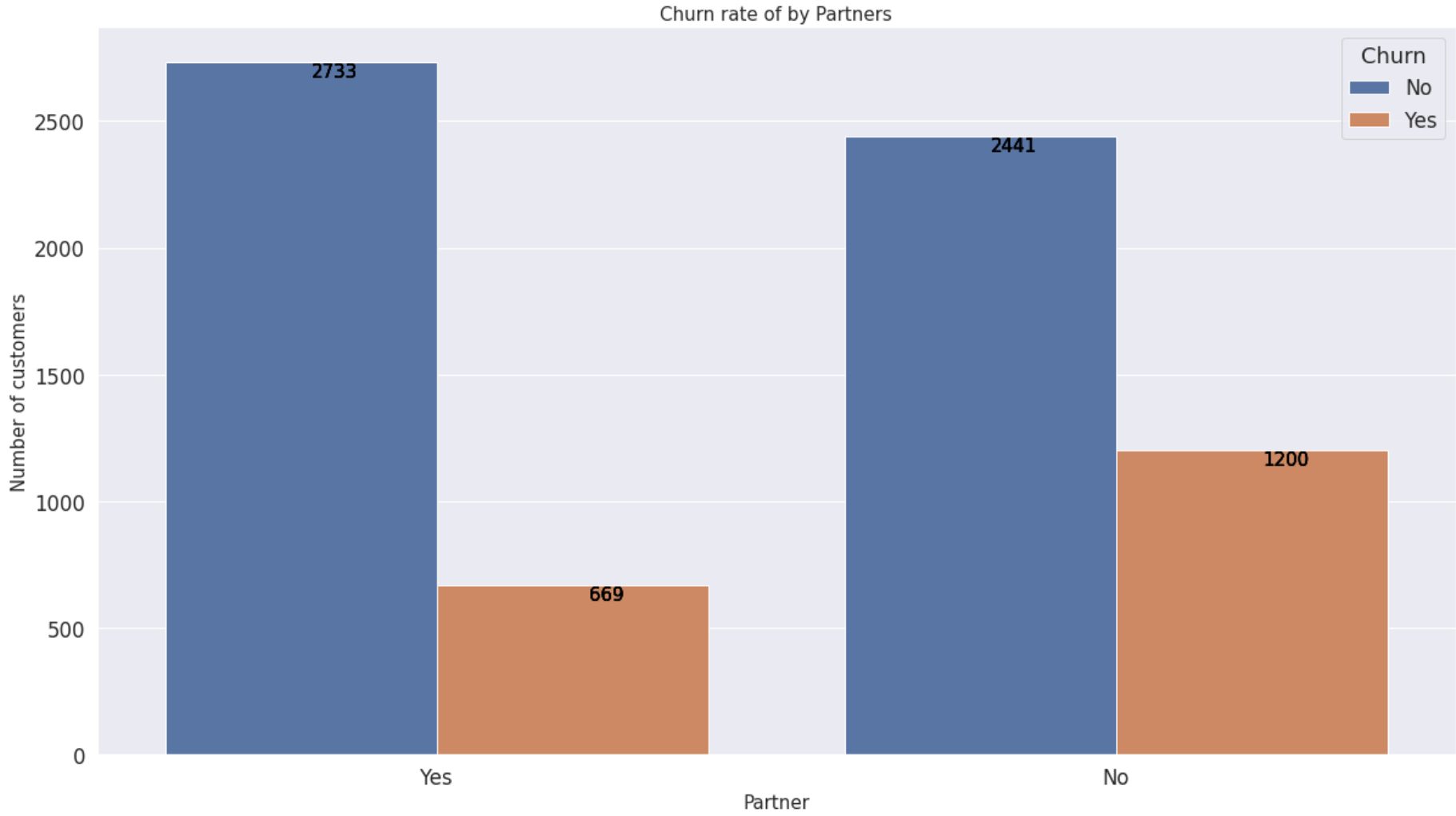
```
bins = pd.cut(df['tenure'], 7)



 #

plt.figure(figsize=(20,10))
ax=sns.countplot(y=bins)
sns.set(font_scale=1.5)
ax.set_title('Count of customers depending on tenure ' , fontsize = 20)
plt.xlabel('Number of customers  ', fontsize=15)
plt.ylabel('Range of tenure  ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black', size=15)
```




```
plt.figure(figsize=(26,10))
sns.set(font_scale=1.5)
ax=sns.countplot(x=bins,  hue='Churn', data=df)
ax.set_title('Churn rate for ranges of tenure' , fontsize = 20)
plt.xlabel('tenure  ', fontsize=15)
plt.ylabel('Number of customers ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black', size=15)
```

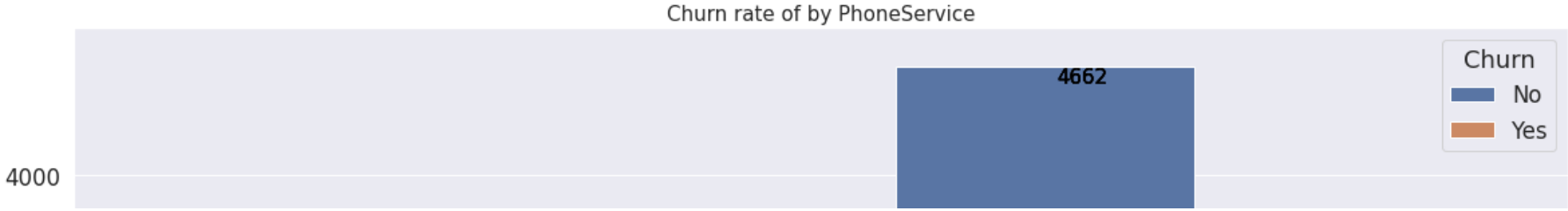



```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='Partner', hue='Churn', data=df)
ax.set_title('Churn rate of by Partners' , fontsize = 15)
plt.xlabel('Partner', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```

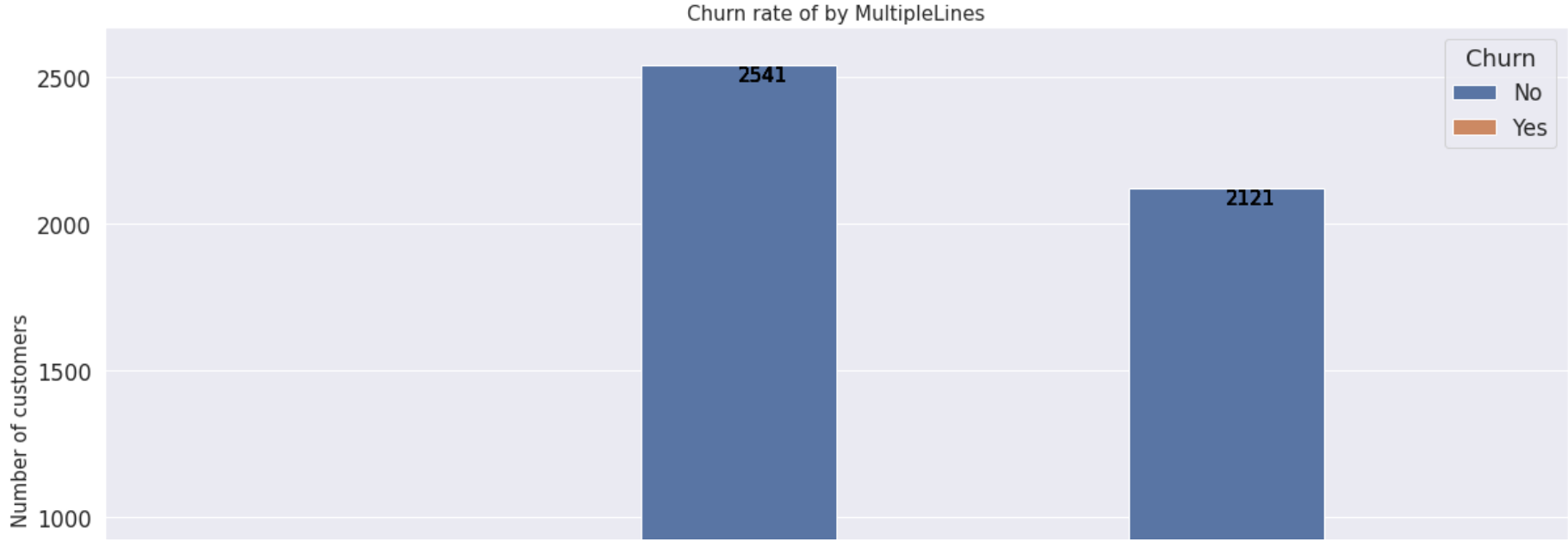



```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='PhoneService', hue='Churn', data=df)
```

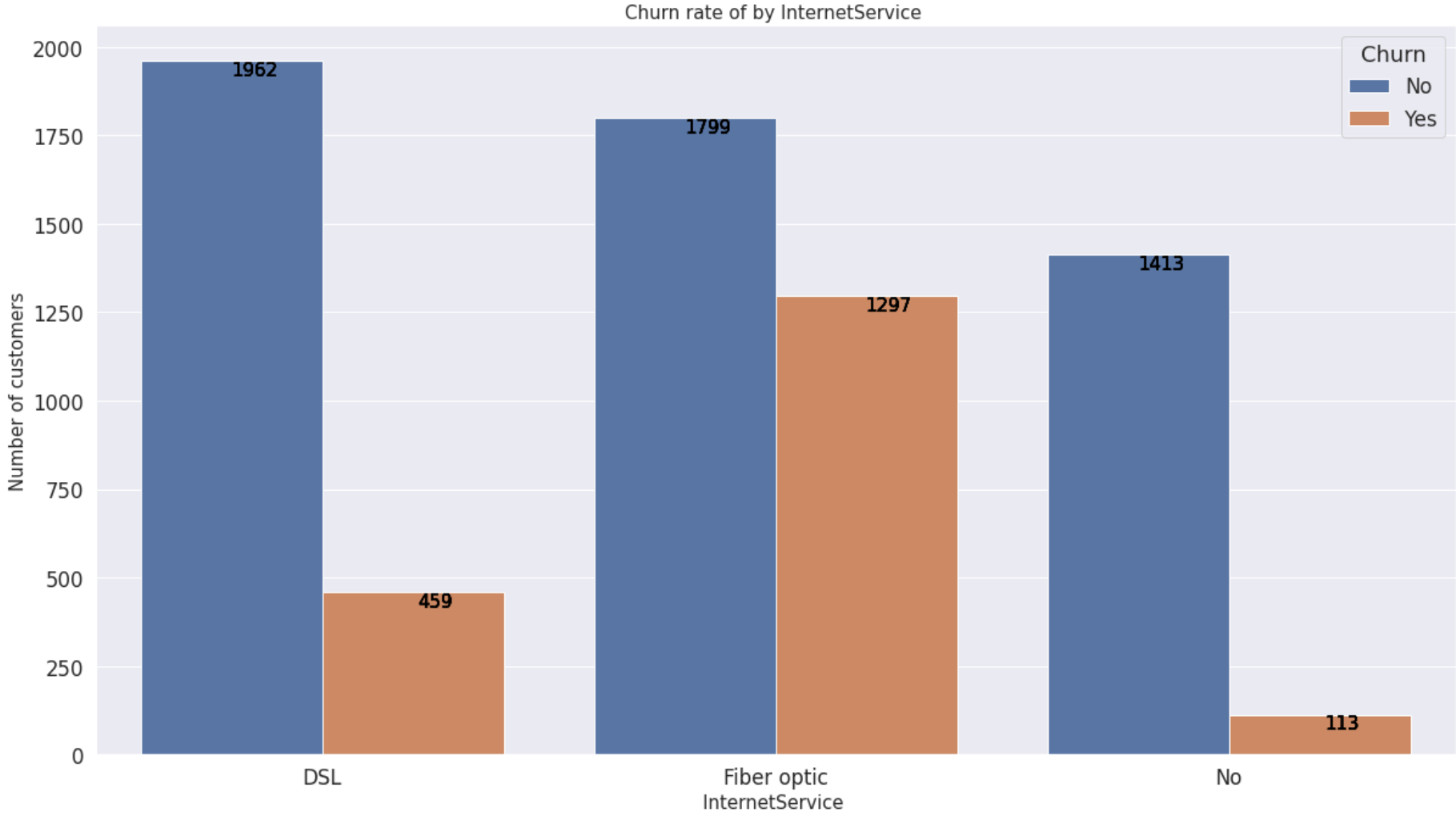
```
ax.set_title('Churn rate of by PhoneService' , fontsize = 15)
plt.xlabel('PhoneService', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



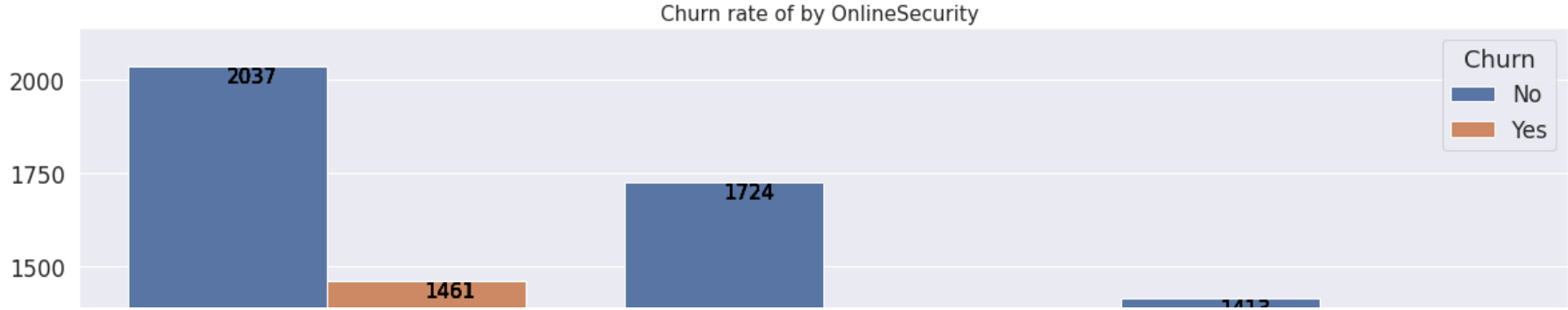

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='MultipleLines', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate of by MultipleLines' , fontsize = 15)
plt.xlabel('MultipleLines', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



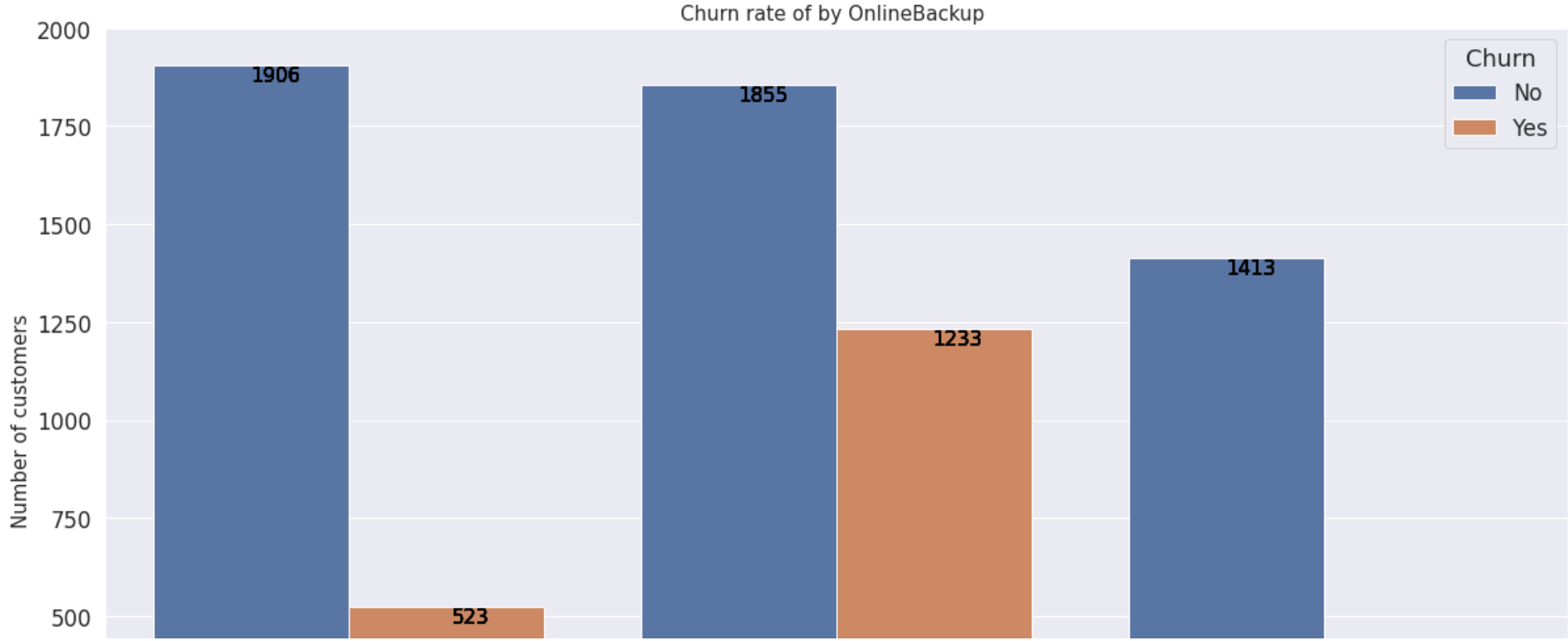

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='InternetService', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate of by InternetService ' , fontsize = 15)
plt.xlabel('InternetService ', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```


Churn rate of by InternetService
Churn
No
Yes
Number of customers
2000
1750
1500
1250
1000
750
500
250
0
1962
459
1799
1297
1413
113
DSL
Fiber optic
No
InternetService

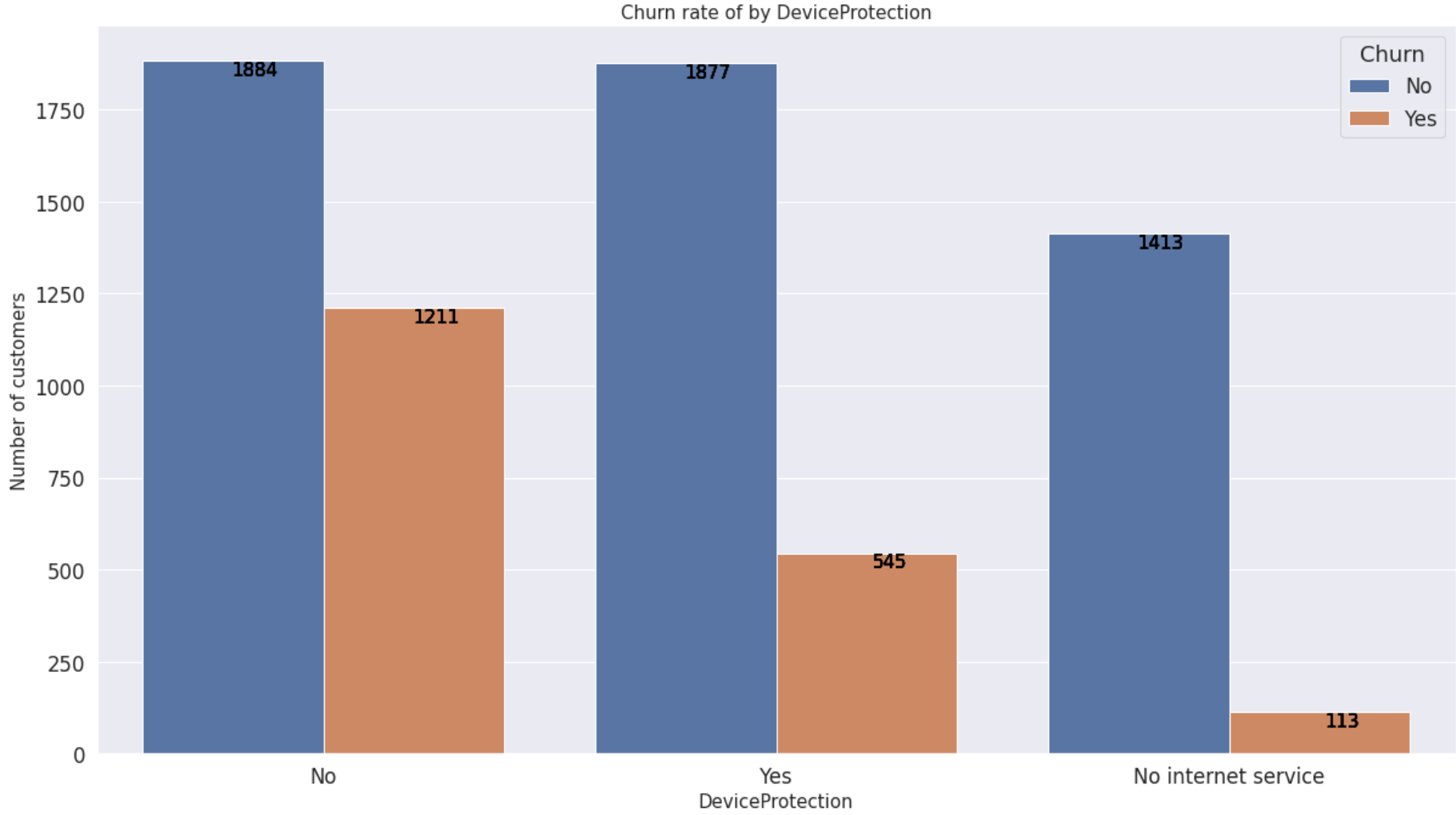
```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='OnlineSecurity', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate of by OnlineSecurity ' , fontsize = 15)
plt.xlabel('OnlineSecurity ', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```




```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='OnlineBackup', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate of by OnlineBackup ' , fontsize = 15)
plt.xlabel('OnlineBackup ', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```

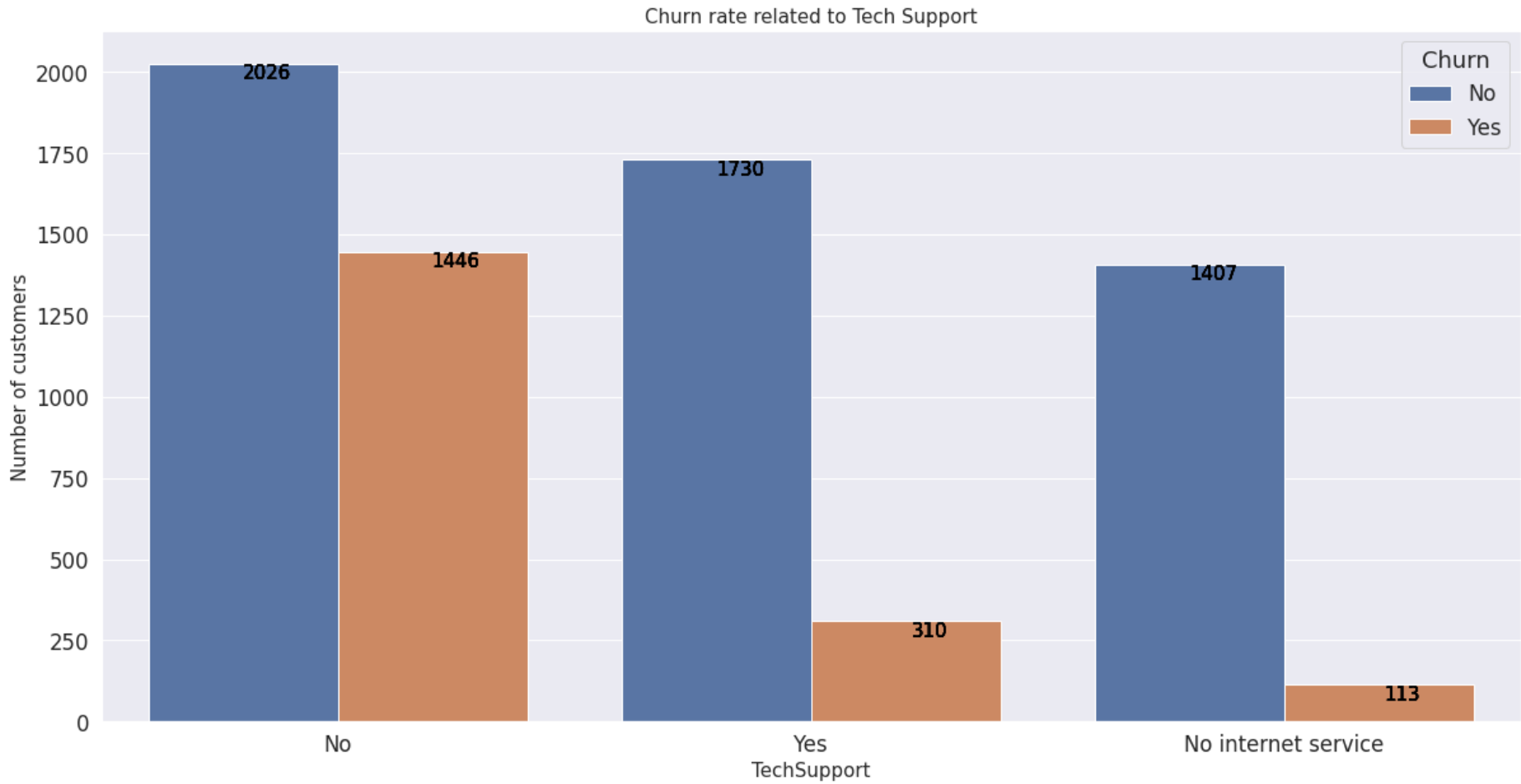



```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='DeviceProtection', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate of by DeviceProtection' , fontsize = 15)
plt.xlabel('DeviceProtection', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```

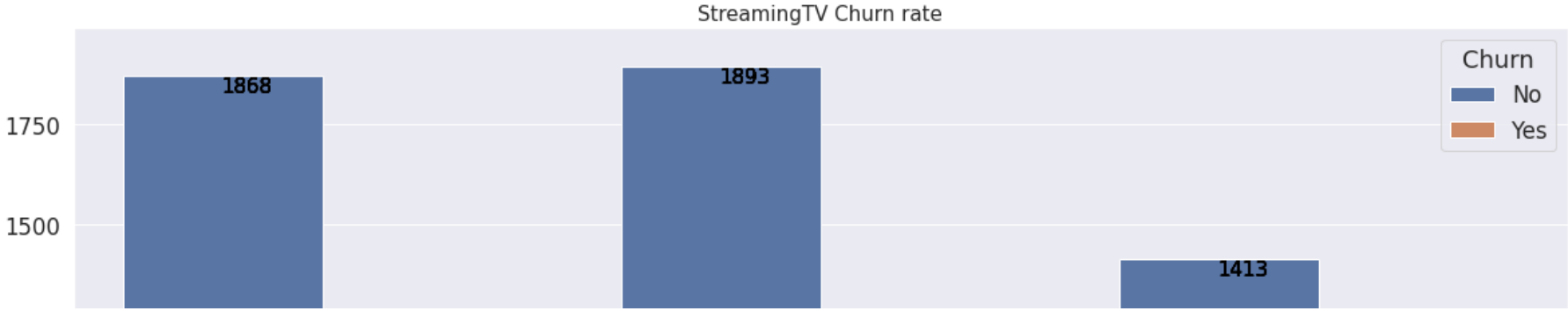



```
plt.figure(figsize=(20,10))
ax=sns.countplot(x='TechSupport', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Churn rate related to Tech Support' , fontsize = 15)
plt.xlabel('TechSupport', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
```

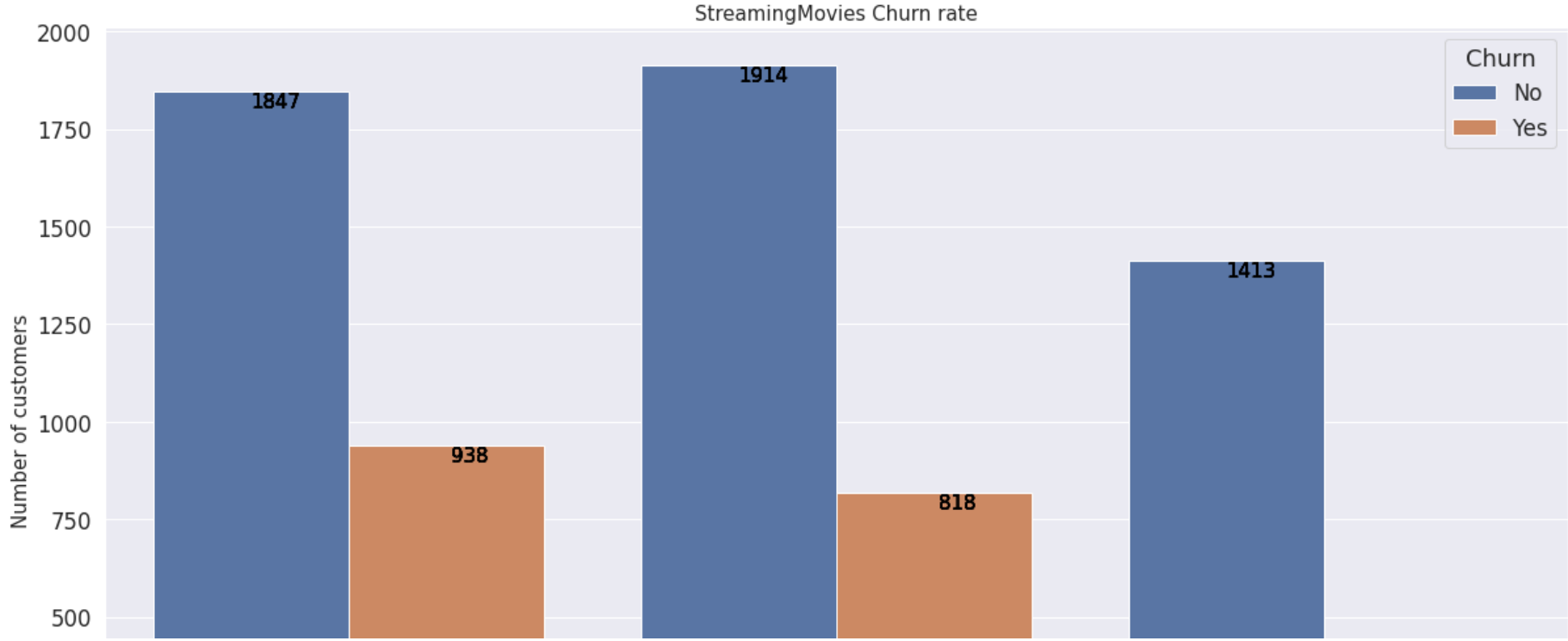
```
for p in ax.patches:
    ax.annotate(format(p.get_height(), '.0f'),
                (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



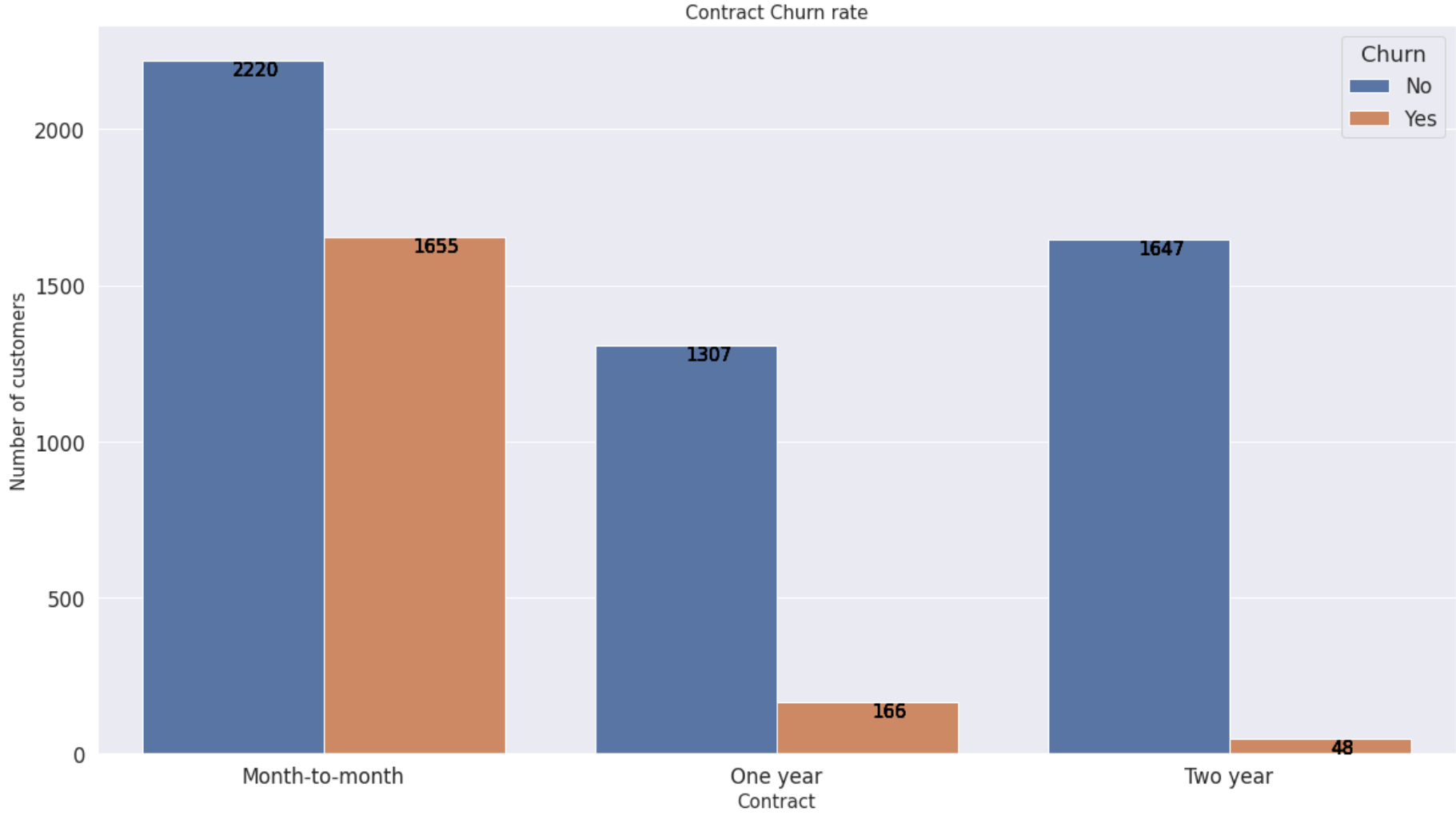
```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingTV', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('StreamingTV Churn rate' , fontsize = 15)
plt.xlabel('StreamingTV', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```




```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='StreamingMovies', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('StreamingMovies Churn rate' , fontsize = 15)
plt.xlabel('StreamingMovies', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



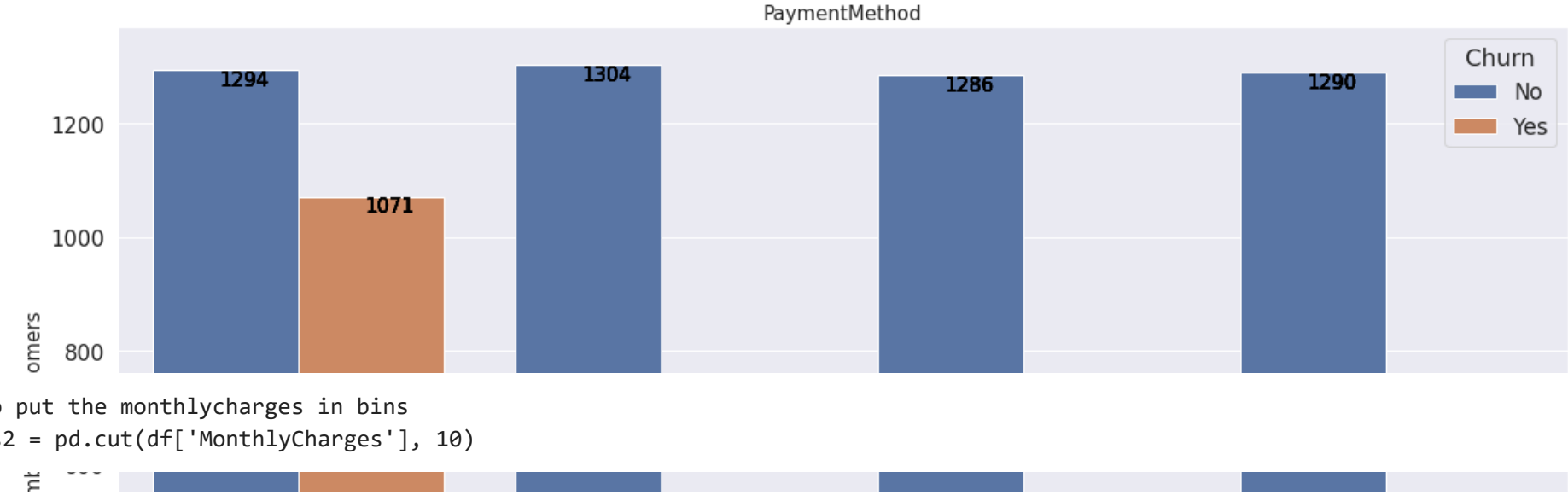

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='Contract', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('Contract Churn rate' , fontsize = 15)
plt.xlabel('Contract', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```




```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='PaperlessBilling', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('PaperlessBilling' , fontsize = 15)
plt.xlabel('PaperlessBilling', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
```

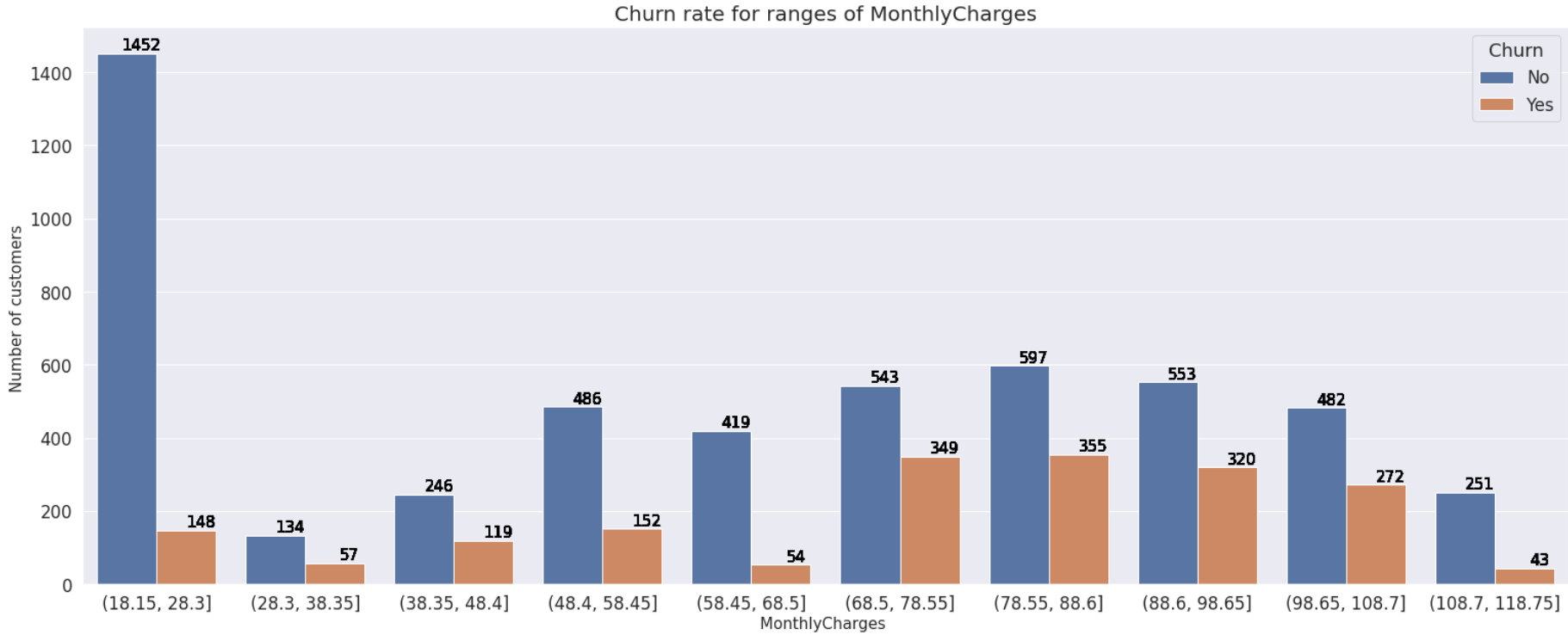
```
for p in ax.patches:
    ax.annotate(format(p.get_height(), '.0f'),
                (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```

```
plt.figure(figsize=(20,11))
ax=sns.countplot(x='PaymentMethod', hue='Churn', data=df)
sns.set(font_scale=1.5)
ax.set_title('PaymentMethod' , fontsize = 15)
plt.xlabel('PaymentMethod', fontsize=15)
plt.ylabel('Number of customers', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.25, p.get_height()), ha='center', va='top', color='black', size=15)
```



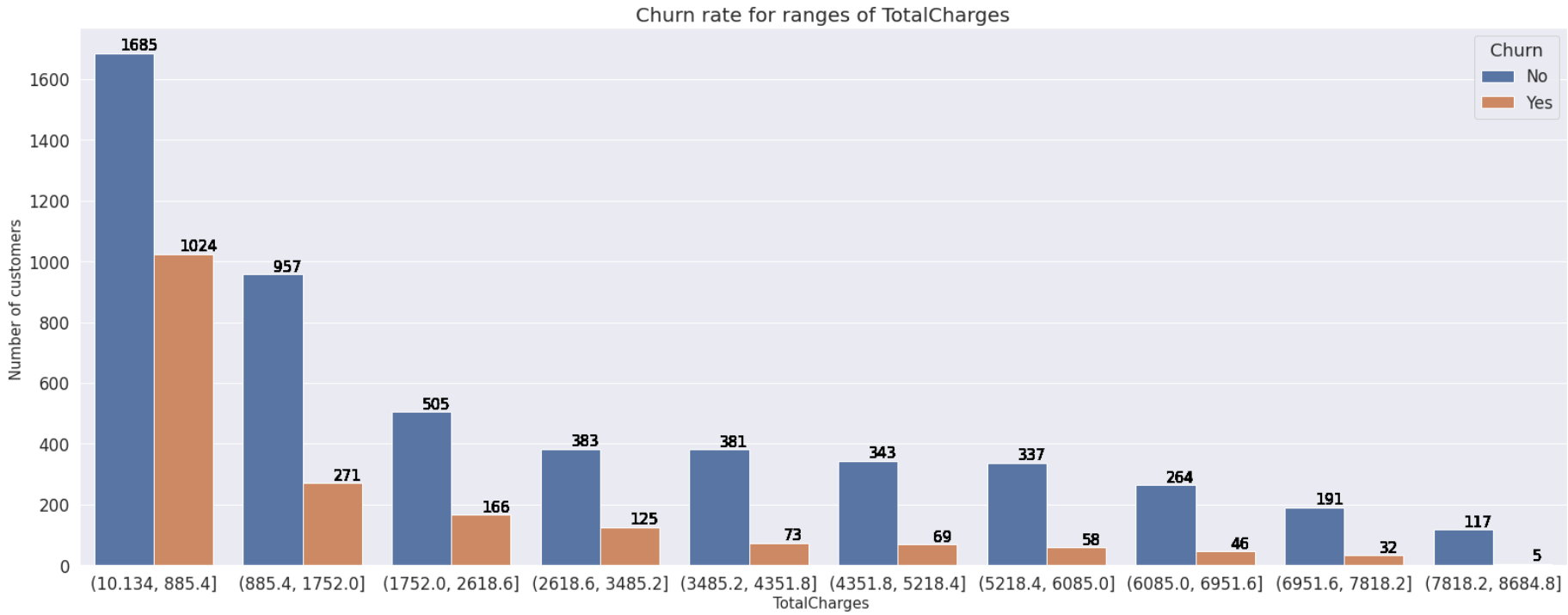

```
# To put the monthlycharges in bins
bins2 = pd.cut(df['MonthlyCharges'], 10)
```

```
plt.figure(figsize=(26,10))
sns.set(font_scale=1.5)
ax=sns.countplot(x=bins2,  hue='Churn', data=df)
ax.set_title('Churn rate for ranges of MonthlyCharges' , fontsize = 20)
plt.xlabel('MonthlyCharges ', fontsize=15)
plt.ylabel('Number of customers ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
        ax.annotate(format(p.get_height(), '.0f'),
                    (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black', size=15)
```




```
# Total charges in bins
bins3 = pd.cut(df['TotalCharges'], 10)


plt.figure(figsize=(27,10))
sns.set(font_scale=1.5)
ax=sns.countplot(x=bins3,  hue='Churn', data=df)
ax.set_title('Churn rate for ranges of TotalCharges' , fontsize = 20)
plt.xlabel('TotalCharges ', fontsize=15)
plt.ylabel('Number of customers ', fontsize=15)
plt.xticks(rotation='horizontal')
for p in ax.patches:
    for p in ax.patches:
```

```
ax.annotate(format(p.get_height(), '.0f'),
            (p.get_x()+0.3, p.get_height()), ha='center', va='bottom', color='black', size=15)
```



```
df.nunique()
```

```
customerID          7043
gender                 2
SeniorCitizen          2
Partner                2
Dependents             2
tenure                73
PhoneService           2
MultipleLines          3
InternetService        3
OnlineSecurity         3
OnlineBackup           3
DeviceProtection       3
TechSupport            3
StreamingTV            3
StreamingMovies        3
Contract               3
PaperlessBilling       2
PaymentMethod          4
MonthlyCharges      1585
TotalCharges        6531
Churn                  2
dtype: int64
```

```
df.describe()
```

	SeniorCitizen	tenure	MonthlyCharges
count	7043.000000	7043.000000	7043.000000
mean	0.162147	32.371149	64.761692

```
df.isna().sum()
```

```
customerID           0
gender               0
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
```

```
# To drop missing values
df= df.dropna()
```

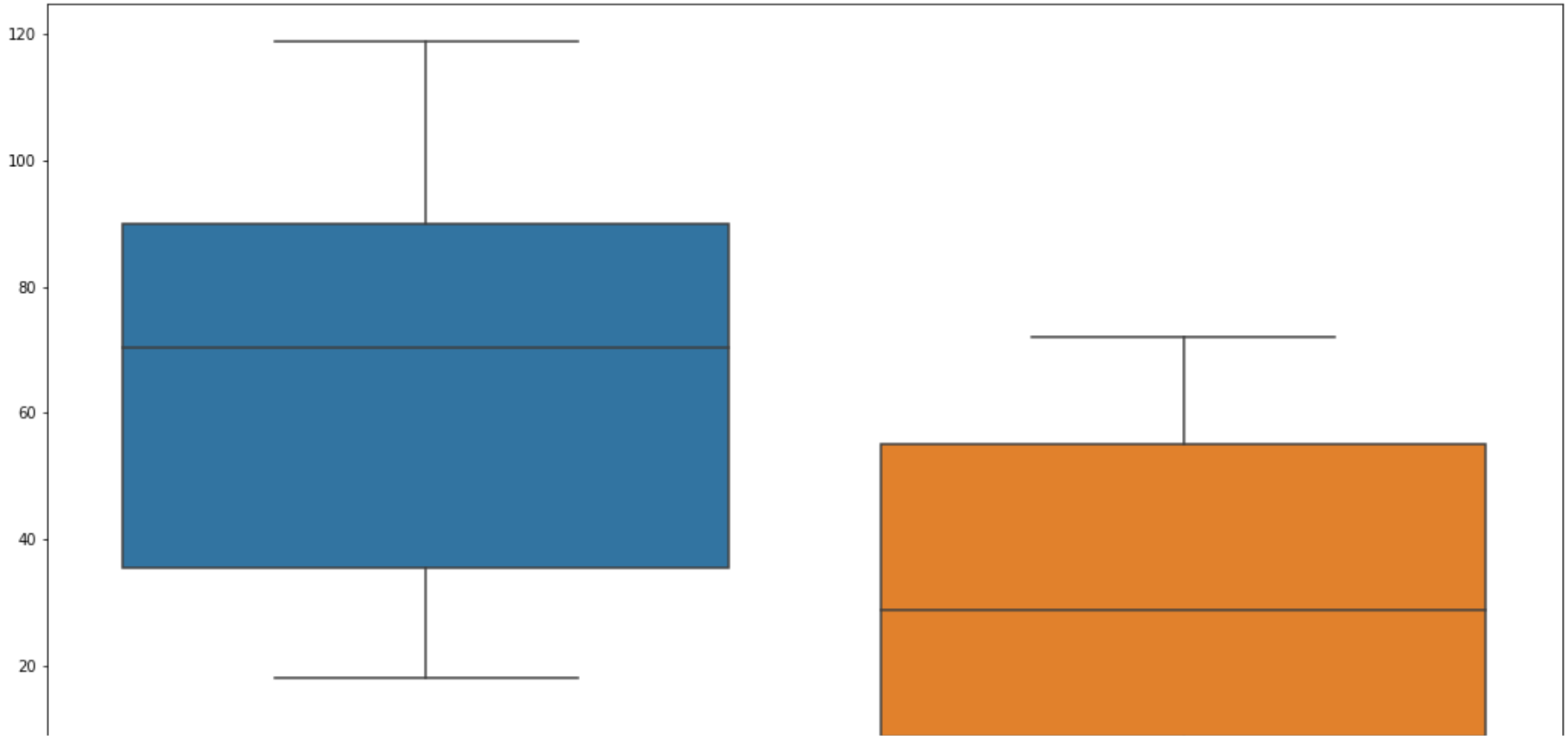
```
t=7
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7032 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   customerID        7032 non-null   object 
 1   gender            7032 non-null   object 
 2   SeniorCitizen     7032 non-null   int64  
 3   Partner           7032 non-null   object 
 4   Dependents        7032 non-null   object 
 5   tenure            7032 non-null   int64  
 6   PhoneService      7032 non-null   object 
 7   MultipleLines     7032 non-null   object 
 8   InternetService   7032 non-null   object 
 9   OnlineSecurity    7032 non-null   object 
 10  OnlineBackup      7032 non-null   object 
 11  DeviceProtection  7032 non-null   object 
 12  TechSupport       7032 non-null   object 
 13  StreamingTV       7032 non-null   object 
 14  StreamingMovies   7032 non-null   object 
 15  Contract          7032 non-null   object 
 16  PaperlessBilling  7032 non-null   object 
 17  PaymentMethod     7032 non-null   object 
 18  MonthlyCharges    7032 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7032 non-null   object 
dtypes: float64(2), int64(2), object(17)
memory usage: 1.2+ MB
```

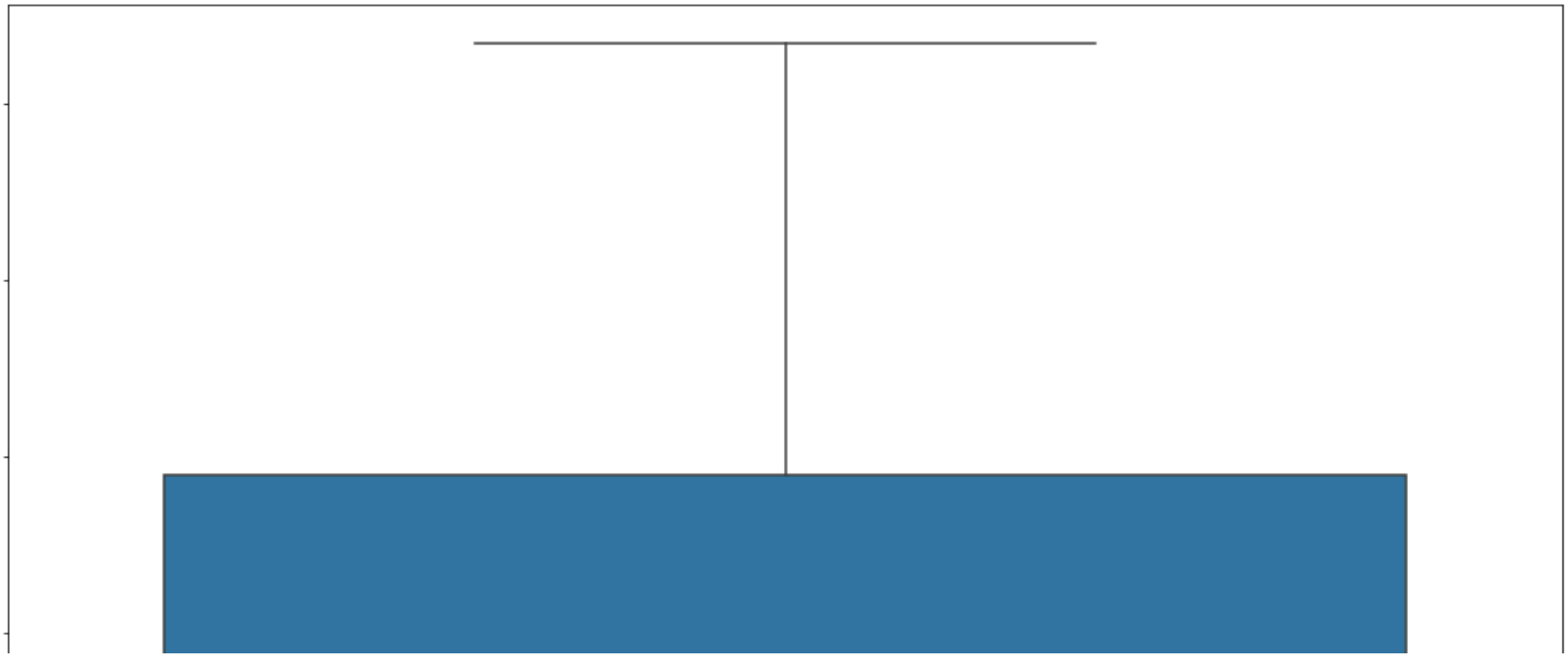
```
plt.figure(figsize=(18,10))
sns.boxplot(data=df[['MonthlyCharges','tenure']])
```

<Axes: >




```
plt.figure(figsize=(18,10))
sns.boxplot(data=df[['TotalCharges']])
```

<Axes: >



df.head()

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	Online
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	

```
 #
df = df.drop('customerID', axis=1)
```

```
df.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	On
0	Female	0	Yes	No	1	No	No phone service	DSL	No	
1	Male	0	No	No	34	Yes	No	DSL	Yes	
2	Male	0	No	No	2	Yes	No	DSL	Yes	
3	Male	0	No	No	45	No	No phone service	DSL	Yes	
4	Female	0	No	No	2	Yes	No	Fiber optic	No	

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7032 entries, 0 to 7042
Data columns (total 20 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   gender            7032 non-null   object
```

```
 1   SeniorCitizen     7032 non-null   int64
 2   Partner           7032 non-null   object
 3   Dependents        7032 non-null   object
 4   tenure            7032 non-null   int64
 5   PhoneService      7032 non-null   object
 6   MultipleLines     7032 non-null   object
 7   InternetService   7032 non-null   object
 8   OnlineSecurity    7032 non-null   object
 9   OnlineBackup      7032 non-null   object
 10  DeviceProtection  7032 non-null   object
 11  TechSupport       7032 non-null   object
 12  StreamingTV       7032 non-null   object
 13  StreamingMovies   7032 non-null   object
 14  Contract          7032 non-null   object
 15  PaperlessBilling  7032 non-null   object
 16  PaymentMethod     7032 non-null   object
 17  MonthlyCharges    7032 non-null   float64
 18  TotalCharges      7032 non-null   float64
 19  Churn             7032 non-null   object
dtypes: float64(2), int64(2), object(16)
memory usage: 1.1+ MB
```

```
df2=data
```

```
# To split data into X and y variables before handling class imbalance using oversampling
X = df.drop('Churn', axis=1)
y = df['Churn']
sampler = RandomOverSampler()
X_resampled, y_resampled = sampler.fit_resample(X, y)
```

```
X_resampled.shape
```

```
(10326, 19)
```

```
y_resampled.shape
```

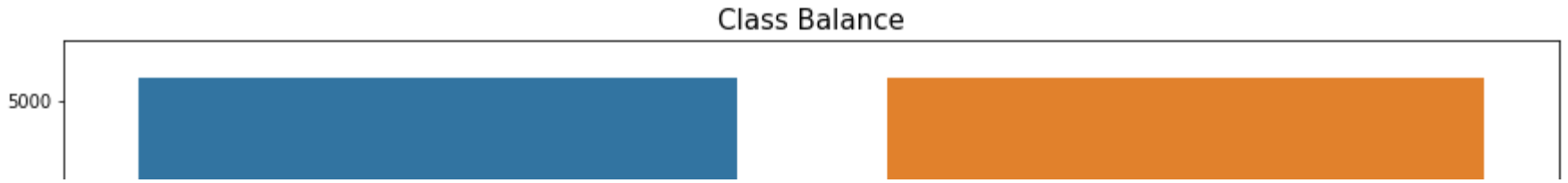
```
(10326,)
```

```
y_resampled.value_counts(normalize=True)
```

```
No     0.5
Yes    0.5
Name: Churn, dtype: float64
```

```
plt.figure(figsize=(15,8))
plt.title('Class Balance', fontsize=15)
sns.countplot(x= y_resampled)
```

```
<Axes: title={'center': 'Class Balance'}, xlabel='Churn', ylabel='count'>
```




```
#Encoding
# encode categorical variables
le = LabelEncoder()
for col in X_resampled.select_dtypes(include='object'):
    X_resampled[col] = le.fit_transform(X_resampled[col])
```

```
X_resampled.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	On
0	0	0	1	0	1	0	1	0	0	
1	1	0	0	0	34	1	0	0	2	
2	1	0	0	0	2	1	0	0	2	
3	1	0	0	0	45	0	1	0	2	
4	0	0	0	0	2	1	0	1	0	

```
y_resampled.tail()
```

```
10321    Yes
10322    Yes
10323    Yes
10324    Yes
```

```
10325    Yes
Name: Churn, dtype: object
```

```
# Replace categorical values in the outcome column
y_resampled = y_resampled.replace({'Yes': 1, 'No': 0})

# Check the new values in the outcome column
print(y_resampled.unique())
```

```
[0 1]
```

```
y_resampled.tail()
```

```
10321    1
10322    1
10323    1
10324    1
10325    1
Name: Churn, dtype: int64
```

```
X = X_resampled
```

```
y = y_resampled
```

```
corr = df.corr()
corr
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges
SeniorCitizen	1.000000	0.015683	0.219874	0.102411
tenure	0.015683	1.000000	0.246862	0.825880

```
# Instantiate SelectKBest with f_classif as the scoring function
selector = SelectKBest(score_func=f_classif, k=10)

# Fit the selector to the data
selector.fit(X_resampled, y_resampled)

# Get the indices of the selected features
selected_features_indices = selector.get_support(indices=True)

# Get the names of the selected features
selected_features_names = X_resampled.columns[selected_features_indices]

# Print the names of the selected features
print(selected_features_names)
```

```
Index(['Dependents', 'tenure', 'OnlineSecurity', 'OnlineBackup',
       'DeviceProtection', 'TechSupport', 'Contract', 'PaperlessBilling',
       'MonthlyCharges', 'TotalCharges'],
      dtype='object')
```

```
# Display the scores of the top 10 features
scores = selector.scores_
top_k_scores = sorted(scores, reverse=True)[:10]
top_k_indices = np.argsort(scores)[::-1][:10]

print("Top 5 feature scores:")
for i in range(len(top_k_scores)):
```

```
    print("Feature {}: Score = {:.2f}".format(top_k_indices[i], top_k_scores[i]))
```

```
 Top 5 feature scores:
 Feature 14: Score = 3184.29
 Feature 4: Score = 2115.86
 Feature 8: Score = 1258.81
 Feature 11: Score = 1167.91
 Feature 18: Score = 610.67
 Feature 17: Score = 573.25
 Feature 9: Score = 553.77
 Feature 15: Score = 507.65
 Feature 10: Score = 411.91
 Feature 3: Score = 368.79
```

```
# Get the names and scores of the top 10 features
feature_names = df.drop('Churn', axis=1).columns
top_scores = selector.scores_.argsort()[-10:][::-1]
top_features = feature_names[top_scores]

# Print the names and scores of the top 10 features
for i, feature in enumerate(top_features):
    print("{}. {} ({:.2f})".format(i+1, feature, selector.scores_[top_scores][i]))

# Create a bar plot of the top 10 features and their scores
plt.figure(figsize=(20,8))
sns.set(font_scale=1.5)
plt.bar(range(len(top_scores)), selector.scores_[top_scores])
plt.xticks(range(len(top_scores)), top_features, rotation='vertical')
plt.xlabel("Feature")
plt.ylabel("Score")
plt.title("Top 10 Features selected by SelectKBest")
```

```
plt.show()
```

```
1. Contract (3184.29)
2. tenure (2115.86)
3. OnlineSecurity (1258.81)
4. TechSupport (1167.91)
5. TotalCharges (610.67)
6. MonthlyCharges (573.25)
7. OnlineBackup (553.77)
8. PaperlessBilling (507.65)
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7032 entries, 0 to 7042
Data columns (total 20 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   gender            7032 non-null   object 
 1   SeniorCitizen     7032 non-null   int64  
 2   Partner           7032 non-null   object 
 3   Dependents        7032 non-null   object 
 4   tenure            7032 non-null   int64  
 5   PhoneService      7032 non-null   object 
 6   MultipleLines     7032 non-null   object 
 7   InternetService   7032 non-null   object 
 8   OnlineSecurity    7032 non-null   object 
 9   OnlineBackup      7032 non-null   object 
 10  DeviceProtection  7032 non-null   object 
 11  TechSupport       7032 non-null   object 
 12  StreamingTV       7032 non-null   object 
 13  StreamingMovies   7032 non-null   object 
 14  Contract          7032 non-null   object 
 15  PaperlessBilling  7032 non-null   object 
 16  PaymentMethod     7032 non-null   object 
 17  MonthlyCharges    7032 non-null   float64
 18  TotalCharges      7032 non-null   float64
 19  Churn             7032 non-null   object 
dtypes: float64(2), int64(2), object(16)
memory usage: 1.1+ MB
```

```
# select the top K features using f_classic
kbest = SelectKBest(score_func=f_classif, k=10)
X_resampled = kbest.fit_transform(X_resampled, y_resampled)

# split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X_resampled, y_resampled, test_size=0.3,random_state = 30)
```

```
scaler = StandardScaler()
X_train_sc = scaler.fit_transform(X_train)
X_test_sc = scaler.transform (X_test)
```

```
# train a decision tree classifier on the data
clf = DecisionTreeClassifier()

#clf = RandomForestClassifier()

clf.fit(X_train_sc, y_train)

# test the classifier on the test set and print the classification report
y_pred = clf.predict(X_test_sc)
print(classification_report(y_test, y_pred))
```

```
                  precision    recall  f1-score   support

               0       0.90      0.77      0.83      1543
               1       0.80      0.92      0.86      1555

        accuracy                           0.85      3098
       macro avg       0.85      0.84      0.84      3098
```

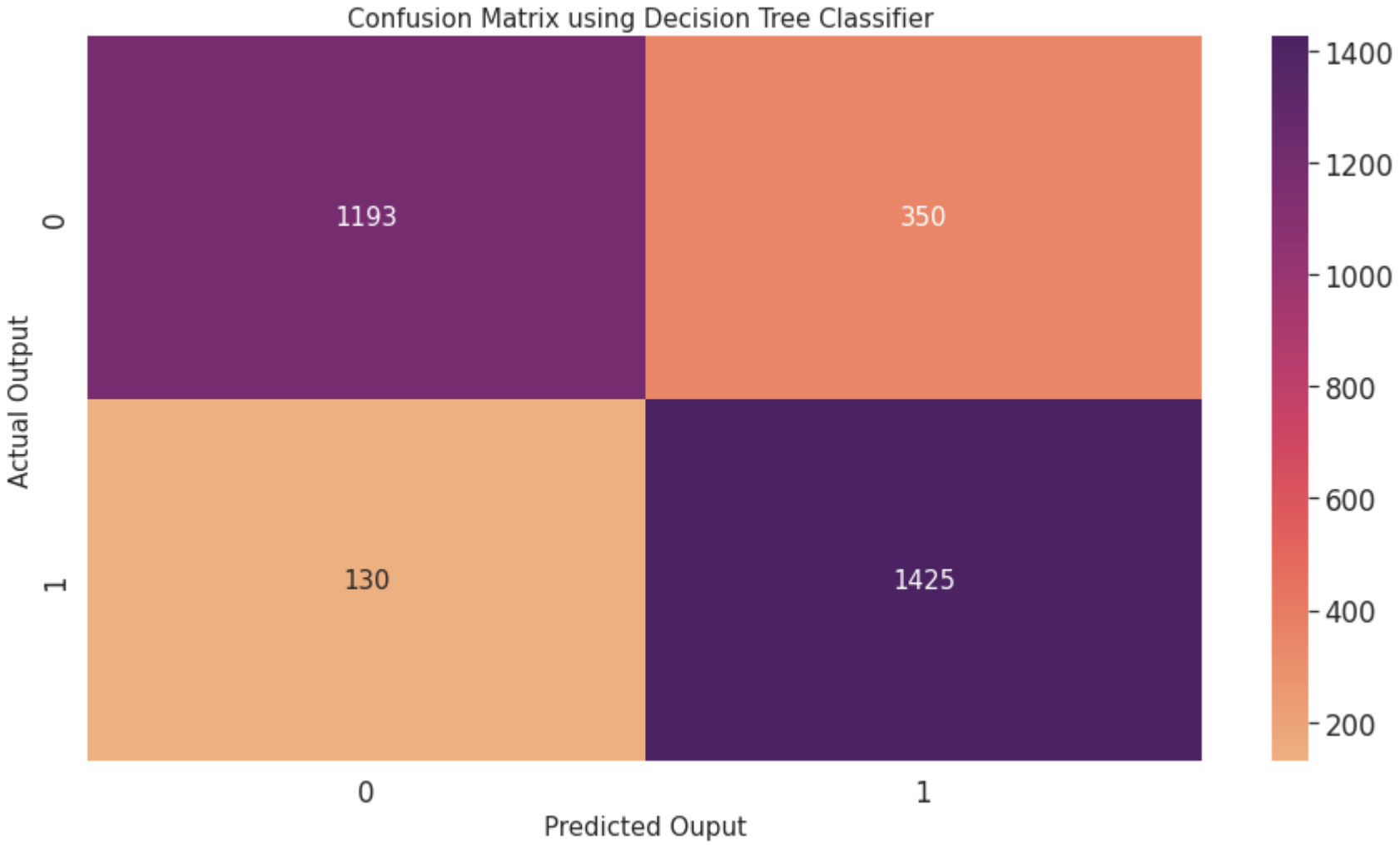
```
     weighted avg       0.85      0.85      0.84      3098
```

```
Accuracy = metrics.accuracy_score(y_test, y_pred)
print('Accuracy score:%.2f\n\n'%(Accuracy))
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

```
     Accuracy score:0.85


     The confusion matrix is:
     [[1193  350]
      [ 130 1425]]


     ---------------------
     Classification Report:

                   precision    recall  f1-score   support

                0       0.90      0.77      0.83      1543
                1       0.80      0.92      0.86      1555

            accuracy                           0.85      3098
           macro avg       0.85      0.84      0.84      3098
        weighted avg       0.85      0.85      0.84      3098
```

```
plt.figure(figsize=(15,8))
zx = sns. heatmap(conf_matrix, cmap ='flare', annot_kws={"size": 15}, annot= True, fmt = 'd')
plt.title('Confusion Matrix using Decision Tree Classifier ', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
```

```
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```




```
# Define the Decision Tree classifier
dt = DecisionTreeClassifier()

# Define the hyperparameters to tune
param_grid = {'max_depth': [12, 15, 20],
              'min_samples_split': [2,3, 4, 6, 8,],
```

```
              'min_samples_leaf': [1, 2, 3, 4, 5]}

# Perform hyperparameter tuning using GridSearchCV
grid_search = GridSearchCV(estimator=dt, param_grid=param_grid, cv=5, verbose=0)
grid_search.fit(X, y)

# Print the results
print("Best accuracy score: {:.2f}".format(grid_search.best_score_))
print("Best parameters: {}".format(grid_search.best_params_))
```

```
Best accuracy score: 0.87
Best parameters: {'max_depth': 20, 'min_samples_leaf': 1, 'min_samples_split': 2}
```

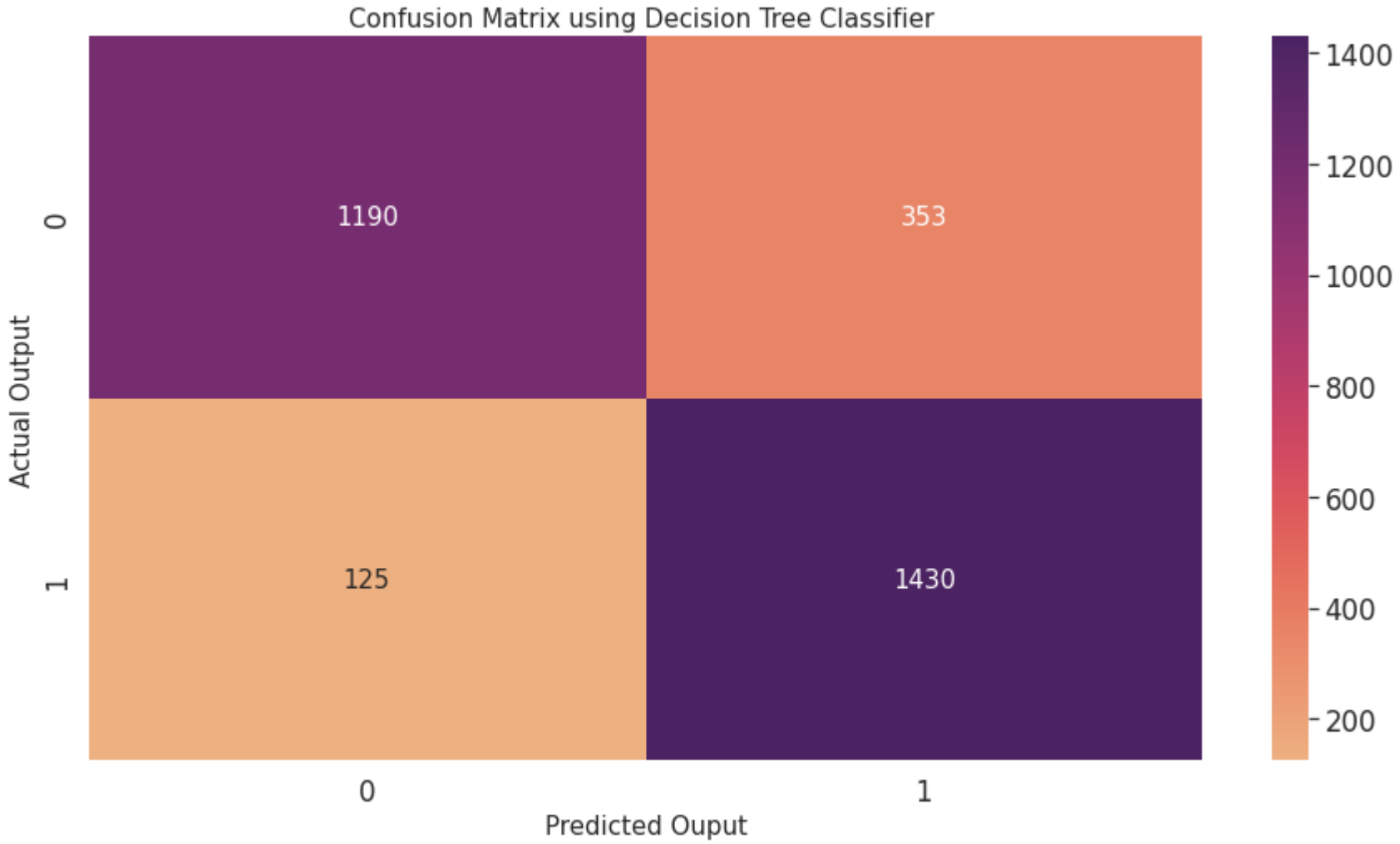
```
# Using best hypeparameter


# train a decision tree classifier on the data
clf = DecisionTreeClassifier(max_depth= 20, min_samples_leaf = 1, min_samples_split= 2)

#clf = RandomForestClassifier()

clf.fit(X_train_sc, y_train)

# test the classifier on the test set and print the classification report
y_pred = clf.predict(X_test_sc)
print(classification_report(y_test, y_pred))
```

```
                  precision    recall  f1-score   support

               0       0.90      0.77      0.83      1543
               1       0.80      0.92      0.86      1555

        accuracy                           0.85      3098
       macro avg       0.85      0.85      0.84      3098
    weighted avg       0.85      0.85      0.84      3098
```

```
Accuracy = metrics.accuracy_score(y_test, y_pred)
print('Accuracy score:%.2f\n\n'%(Accuracy))
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

```
Accuracy score:0.85


The confusion matrix is:
[[1190  353]
 [ 125 1430]]


---------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.90      0.77      0.83      1543
           1       0.80      0.92      0.86      1555

    accuracy                           0.85      3098
   macro avg       0.85      0.85      0.84      3098
weighted avg       0.85      0.85      0.84      3098
```

```
plt.figure(figsize=(15,8))
zx = sns. heatmap(conf_matrix, cmap ='flare', annot_kws={"size": 15}, annot= True, fmt = 'd')
plt.title('Confusion Matrix using Decision Tree Classifier ', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```




```
#Using RandomForest

# train a decision tree classifier on the data
#clf = DecisionTreeClassifier()
```

```
clf = RandomForestClassifier()

clf.fit(X_train_sc, y_train)

# test the classifier on the test set and print the classification report
y_pred = clf.predict(X_test_sc)
print(classification_report(y_test, y_pred))
```

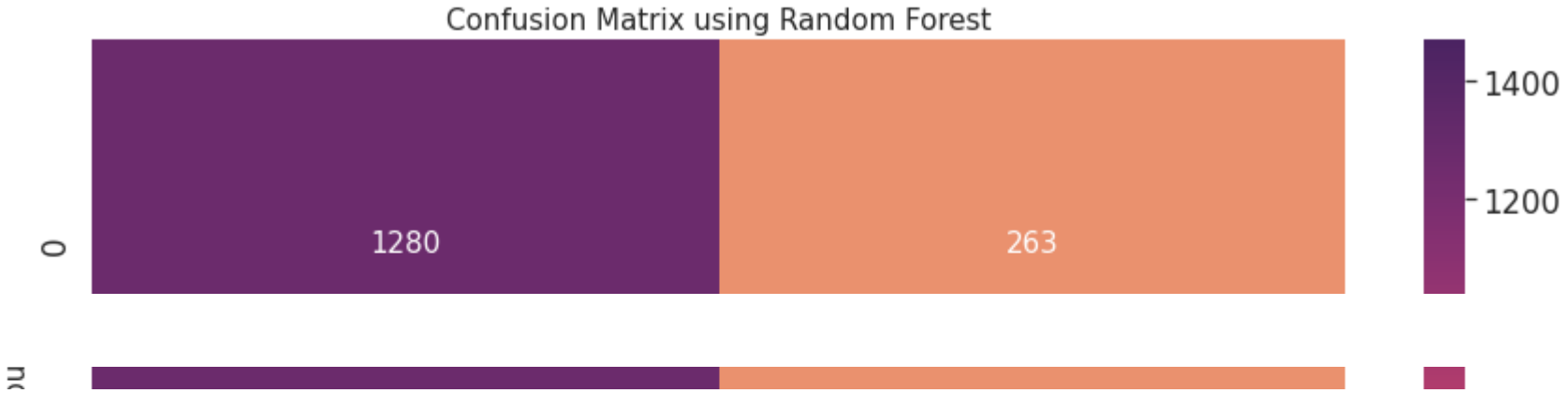
```
                   precision    recall  f1-score   support

                0       0.94      0.83      0.88      1543
                1       0.85      0.95      0.89      1555

         accuracy                           0.89      3098
        macro avg       0.89      0.89      0.89      3098
     weighted avg       0.89      0.89      0.89      3098
```

```
Accuracy = metrics.accuracy_score(y_test, y_pred)
print('Accuracy score:%.2f\n\n'%(Accuracy))
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

```
     Accuracy score:0.89


     The confusion matrix is:
     [[1280  263]
      [  85 1470]]
```

```
---------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.94      0.83      0.88      1543
           1       0.85      0.95      0.89      1555

    accuracy                           0.89      3098
   macro avg       0.89      0.89      0.89      3098
weighted avg       0.89      0.89      0.89      3098
```

```
plt.figure(figsize=(15,8))
zx = sns. heatmap(conf_matrix, cmap ='flare',annot_kws={"size": 15}, annot= True, fmt = 'd')
plt.title('Confusion Matrix using Random Forest', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```




```
# GRADIENT BOOSTED DECISION TREE

#Using Gradient Boosted Decision Tree
# train a decision tree classifier on the data
#clf = DecisionTreeClassifier()
#clf = RandomForestClassifier()

clf = GradientBoostingClassifier(n_estimators=100, learning_rate=0.5, max_depth=14, random_state=42)
clf.fit(X_train_sc, y_train)

# test the classifier on the test set and print the classification report
y_pred = clf.predict(X_test_sc)
print(classification_report(y_test, y_pred))
```

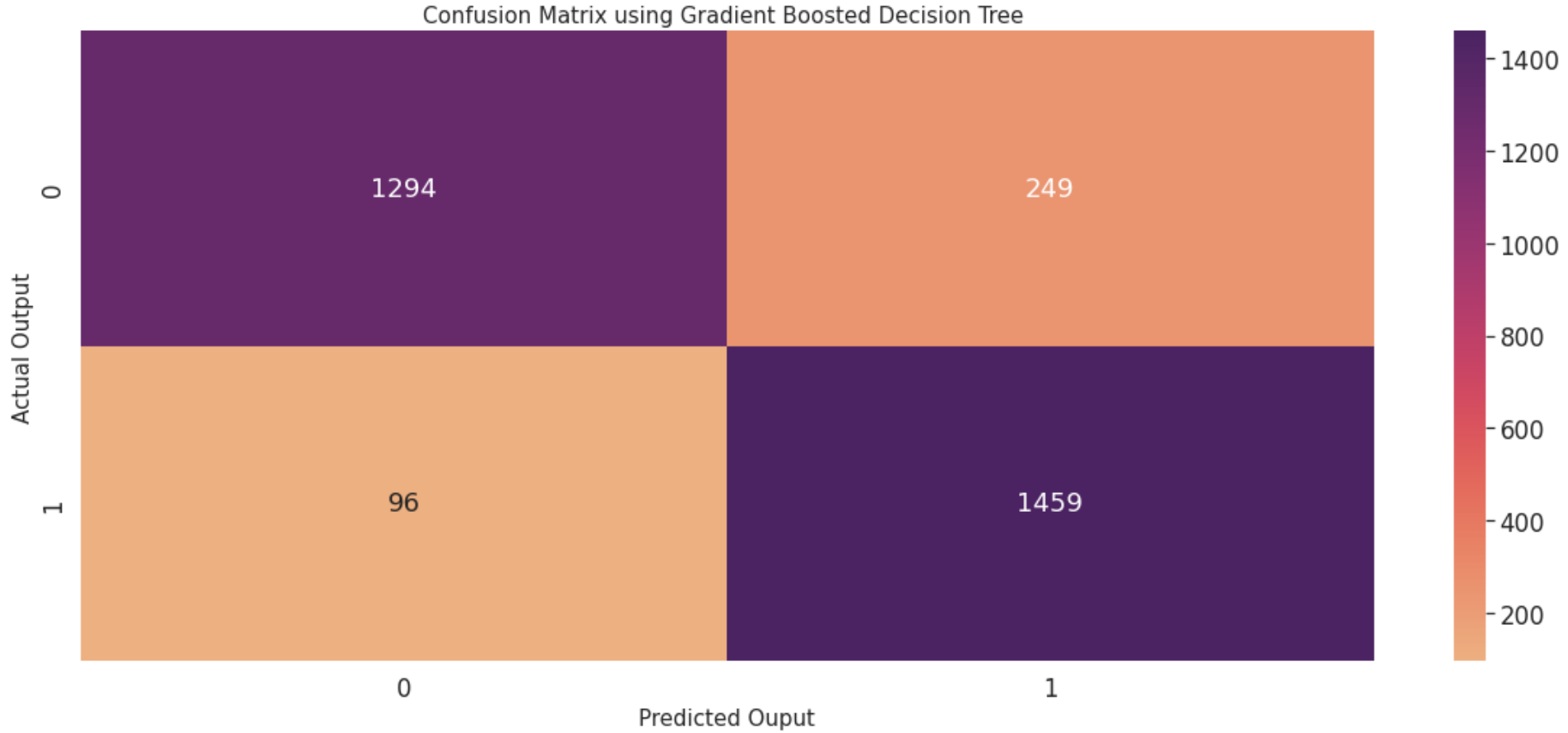
```
                  precision    recall  f1-score   support

               0       0.93      0.84      0.88      1543
               1       0.85      0.94      0.89      1555

        accuracy                           0.89      3098
       macro avg       0.89      0.89      0.89      3098
    weighted avg       0.89      0.89      0.89      3098
```

```
from sklearn import metrics
Accuracy = metrics.accuracy_score(y_test, y_pred)
print('Accuracy score:%.2f\n\n'%(Accuracy))
```

```
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

```
     Accuracy score:0.89


     The confusion matrix is:
     [[1294  249]
      [  96 1459]]


     ---------------------
     Classification Report:

                   precision    recall  f1-score   support

                0       0.93      0.84      0.88      1543
                1       0.85      0.94      0.89      1555

            accuracy                           0.89      3098
           macro avg       0.89      0.89      0.89      3098
        weighted avg       0.89      0.89      0.89      3098
```

```
plt.figure(figsize=(20,8))
zx = sns. heatmap(conf_matrix, cmap ='flare', annot_kws={"size": 18},annot= True, fmt = 'd')
plt.title('Confusion Matrix using Gradient Boosted Decision Tree ', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```




```
# Identifying top 10 features driving the Gradient Boosted Decision model by allowing the model to select importance features


# split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,random_state = 40)



scaler = StandardScaler()
X_train_scale = scaler.fit_transform(X_train)
X_test_scale = scaler.transform (X_test)
```

```
# Step 4: Model Evaluation
from sklearn.metrics import f1_score


clf = GradientBoostingClassifier(n_estimators=100, learning_rate=0.5, max_depth=18, random_state=42)
clf.fit(X_train_scale, y_train)
y_pred = clf.predict(X_test_scale)
score = f1_score(y_test, y_pred)
print(f"F1-score: {score:.4f}")
```

```
F1-score: 0.8707
```

```
from sklearn import metrics
Accuracy = metrics.accuracy_score(y_test, y_pred)
print('Accuracy score:%.2f\n\n'%(Accuracy))
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

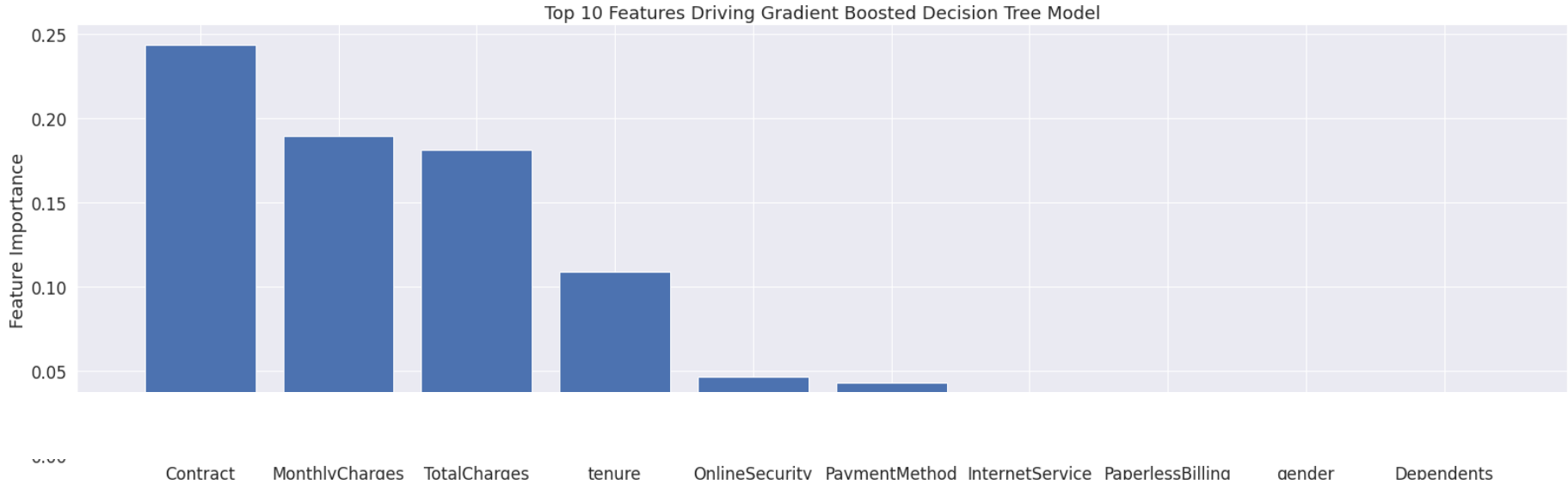
```
Accuracy score:0.86


The confusion matrix is:
[[1238  304]
 [ 122 1434]]


---------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.91      0.80      0.85      1542
           1       0.83      0.92      0.87      1556
```

```
              accuracy                           0.86      3098
             macro avg       0.87      0.86      0.86      3098
          weighted avg       0.87      0.86      0.86      3098
```

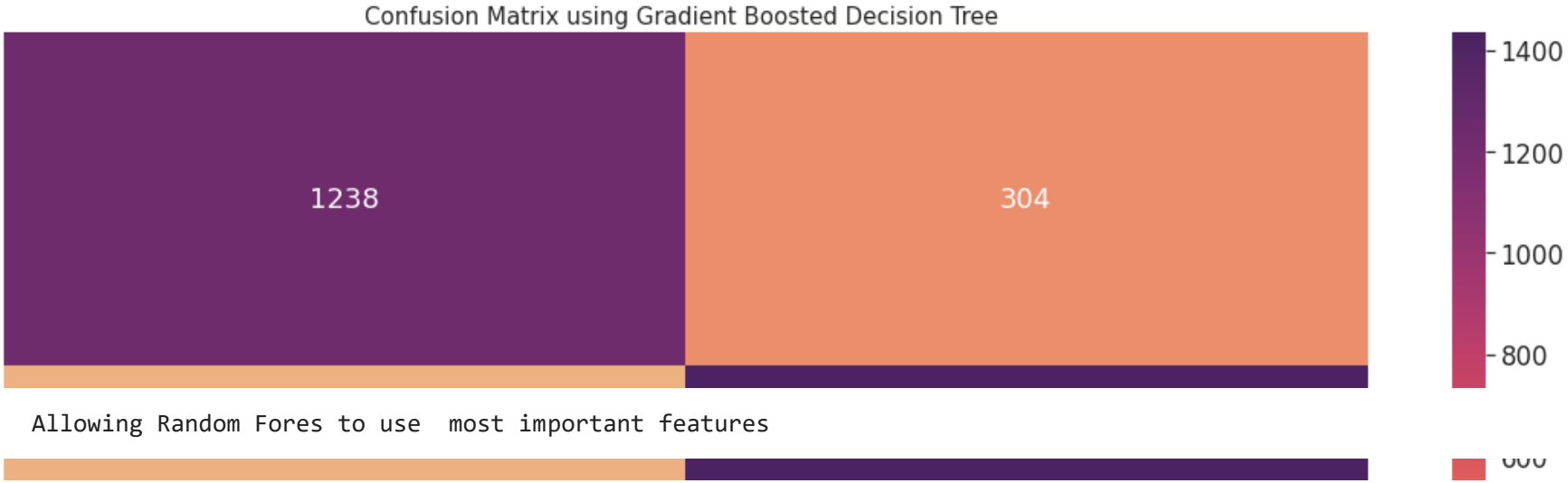
```
#Step 5: Feature Importance Analysis
feature_importances = clf.feature_importances_
feature_names = df.drop('Churn', axis=1).columns
```

```
# Step 6: Plot Feature Importance Graph
```

```
top_features = pd.Series(feature_importances, index=feature_names).sort_values(ascending=False)[:10]
plt.figure(figsize=(27,8))
plt.bar(top_features.index, top_features)
plt.title('Top 10 Features Driving Gradient Boosted Decision Tree Model')
plt.xlabel('Feature Name')
plt.ylabel('Feature Importance')
plt.show()
```




```
plt.figure(figsize=(20,8))
zx = sns. heatmap(conf_matrix, cmap ='flare', annot_kws={"size": 18},annot= True, fmt = 'd')
plt.title('Confusion Matrix using Gradient Boosted Decision Tree ', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```




```
# Model 3    Allowing Random Fores to use  most important features
```

```
# split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,random_state =40)
```

```
scaler = StandardScaler()
X_train_scale2 = scaler.fit_transform(X_train)
X_test_scale2 = scaler.transform (X_test)


#clf = GradientBoostingClassifier(n_estimators=100, learning_rate=0.5, max_depth=18, random_state=42)
clf = RandomForestClassifier()

clf.fit(X_train_scale2, y_train)
y_pred = clf.predict(X_test_scale2)
score = f1_score(y_test, y_pred)
print(f"F1-score: {score:.4f}")
```

```
     F1-score: 0.8835
```

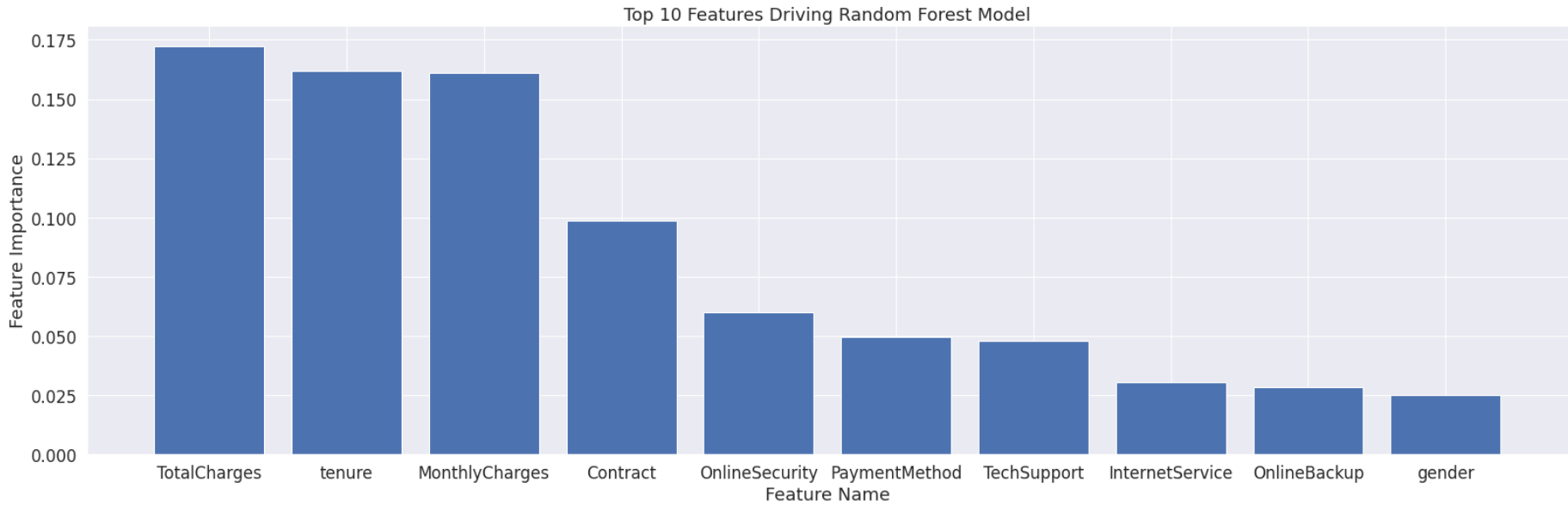
```
from sklearn import metrics
Accuracy = metrics.accuracy_score(y_test, y_pred)
```

```
print('Accuracy score:%.2f\n\n'%(Accuracy))
conf_matrix = metrics.confusion_matrix(y_test, y_pred)
print('The confusion matrix is:')
print(conf_matrix,'\n\n')
print('---------------------')
result = metrics.classification_report(y_test, y_pred)
print('Classification Report:\n')
print(result)
```

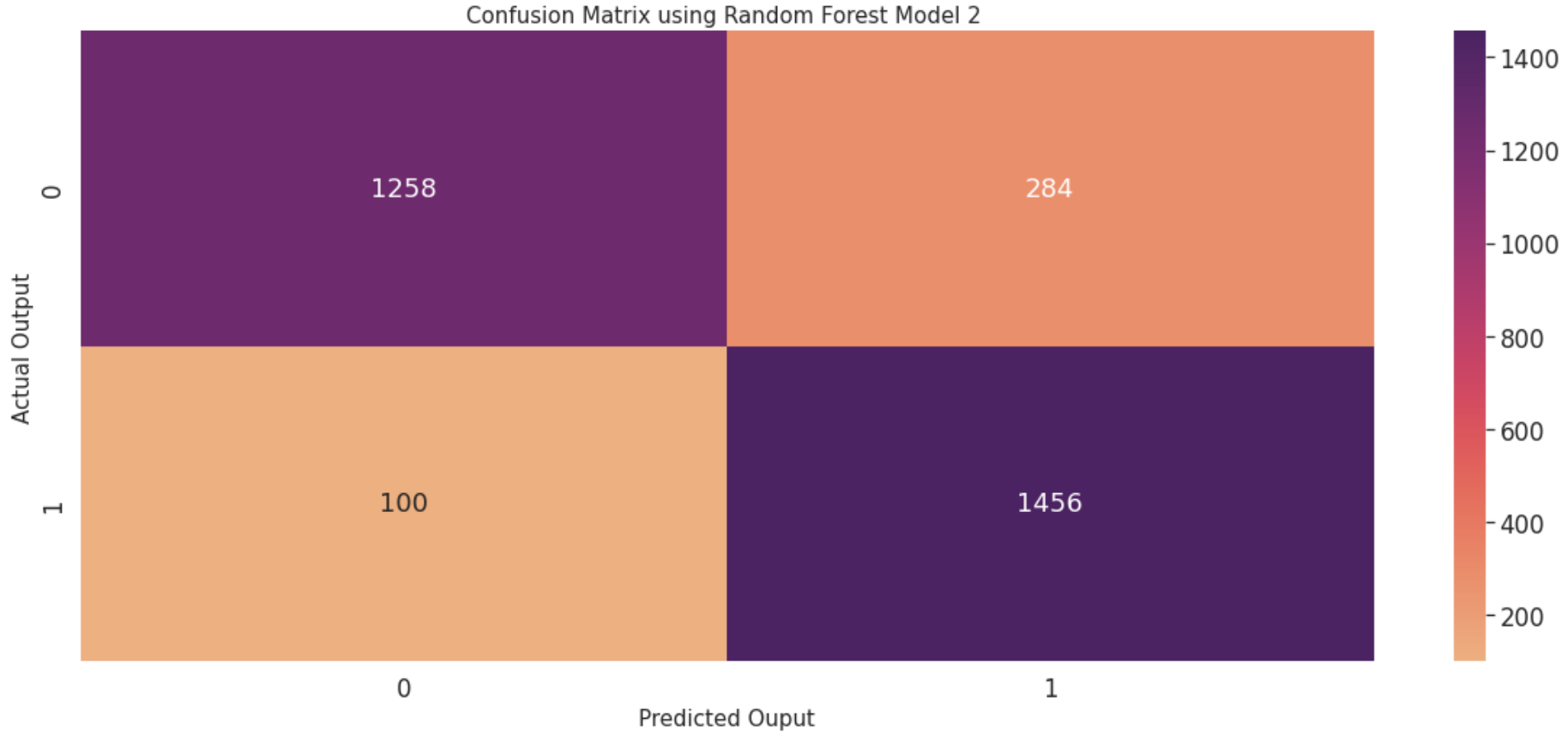
```
Accuracy score:0.88


The confusion matrix is:
[[1258  284]
 [ 100 1456]]


---------------------
Classification Report:

              precision    recall  f1-score   support

           0       0.93      0.82      0.87      1542
           1       0.84      0.94      0.88      1556

    accuracy                           0.88      3098
   macro avg       0.88      0.88      0.88      3098
weighted avg       0.88      0.88      0.88      3098
```

```
#Step 5: Feature Importance Analysis
feature_importances = clf.feature_importances_
feature_names = df.drop('Churn', axis=1).columns


top_features = pd.Series(feature_importances, index=feature_names).sort_values(ascending=False)[:10]
plt.figure(figsize=(27,8))
plt.bar(top_features.index, top_features)
plt.title('Top 10 Features Driving Random Forest Model')
plt.xlabel('Feature Name')
```

```
plt.ylabel('Feature Importance')
plt.show()
```




```
plt.figure(figsize=(20,8))
zx = sns. heatmap(conf_matrix, cmap ='flare', annot_kws={"size": 18},annot= True, fmt = 'd')
plt.title('Confusion Matrix using Random Forest Model 2 ', fontsize= 15)
plt.xlabel('Predicted Ouput', fontsize =15)
plt.ylabel('Actual Output', fontsize =15)
plt.show()
```



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