



## Telecom Project

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### Problem Statement :

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- In the telecom industry, customers are able to choose from a pool of companies to cater their needs regarding communication and internet.
- Customers are very critical about the kind of services they receive and judge the entire company based on a single experience! These communication services have become so recurrent and inseparable from the daily routine that a 30 minute maintenance break kicks in anxiety in the users highlighting our taken-for-granted attitude towards these services! Coupled with high customer acquisition costs, churn analysis becomes very pivotal!
- Churn rate is a metric that describes the number of customers that cancelled or did not renew their subscription with the company.

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Telecom\_Domain\_Project\_1

- Thus, higher the churn rate, more customers stop buying from your business, directly affecting the revenue! Hence, based on the insights gained from the churn analysis, companies can build strategies, target segments, improve the quality of the services being provided to improve the customer experience, thus cultivating trust with the customers.
- That is why building predictive models and creating reports of churn analysis becomes key that paves the way for growth!

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#### Aim :

- To classify the potential churn customers based on numerical and categorical features.
- It is a binary classification problem for an imbalanced dataset.

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#### In short:

To predict whether a customer will churn (stop using or not recharge again) based on their service usage, contract details, and billing information.

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### Dataset Attributes :

- customerID : Customer ID
- gender : Whether the customer is a male or a female
- SeniorCitizen : Whether the customer is a senior citizen or not (1, 0)
- Partner : Whether the customer has a partner or not (Yes, No)
- Dependents : Whether the customer has dependents or not (Yes, No)
- tenure : Number of months the customer has stayed with the company
- PhoneService : Whether the customer has a phone service or not (Yes, No)
- MultipleLines : Whether the customer has multiple lines or not (Yes, No, No phone service)
- InternetService : Customer's internet service provider (DSL, Fiber optic, No)
- OnlineSecurity : Whether the customer has online security or not (Yes, No, No internet service)
- OnlineBackup : Whether the customer has online backup or not (Yes, No, No internet service)
- DeviceProtection : Whether the customer has device protection or not (Yes, No, No internet service)

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- TechSupport : Whether the customer has tech support or not (Yes, No, No internet service)
- StreamingTV : Whether the customer has streaming TV or not (Yes, No, No internet service)
- StreamingMovies : Whether the customer has streaming movies or not (Yes, No, No internet service)
- Contract : The contract term of the customer (Month-to-month, One year, Two year)
- PaperlessBilling : Whether the customer has paperless billing or not (Yes, No)
- PaymentMethod : The customer's payment method (Electronic check, Mailed check, Bank transfer (automatic), Credit card (automatic))
- MonthlyCharges : The amount charged to the customer monthly
- TotalCharges : The total amount charged to the customer
- Churn : Whether the customer churned or not (Yes or No)

```
In [1]: import os, sys
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
import warnings
warnings.filterwarnings ("ignore")
sns.set()

In [2]: customer_churn=pd.read_csv('/Users/abhisheksenapati/Desktop/Machine Learning & Stats/ML_final_project/Telecom/Data
customer_churn.head()
```

Out [2]:

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

5 rows × 11 columns

```
In [3]: customer_churn.columns

Out[3]: Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
              'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
              'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
              'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
              'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
              dtype='object')

In [4]: customer_churn.shape

Out[4]: (7043, 21)

In [5]: customer_churn.isnull().sum().sum()

Out[5]: 0

In [6]: #duplicates data
customer_churn.duplicated().sum()
```

Out[6]: 0

```
In [7]: # check balance or not dependent var

((customer_churn['Churn'].value_counts(normalize=True))*100).round(2)
```

Out[7]: Churn  
No 73.46  
Yes 26.54  
Name: proportion, dtype: float64

```
In [8]: # 26.5% yes churn very bad
```

```
In [9]: customer_churn['Churn'].value_counts()
```

Out[9]: Churn  
No 5174  
Yes 1869  
Name: count, dtype: int64

```
In [10]: # 1869 out of 7043 which is very bad as mentioned.
```

```
In [11]: # lebel encoding

customer_churn['Churn']=np.where(customer_churn['Churn']=='Yes',1,0)
```

```
In [12]: customer_churn['Churn'].value_counts()
```

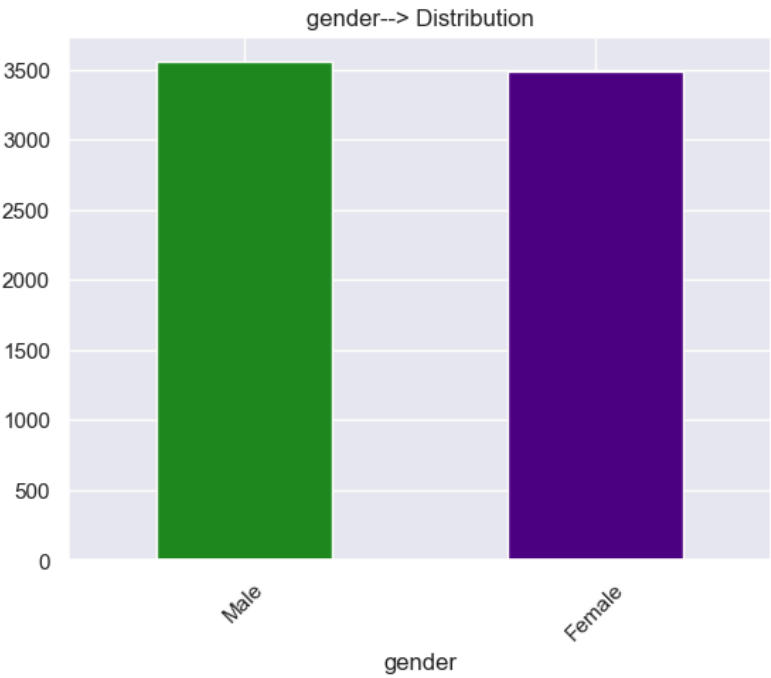
Out[12]: Churn  
0 5174  
1 1869  
Name: count, dtype: int64

```
In [13]: customer_churn.columns
```

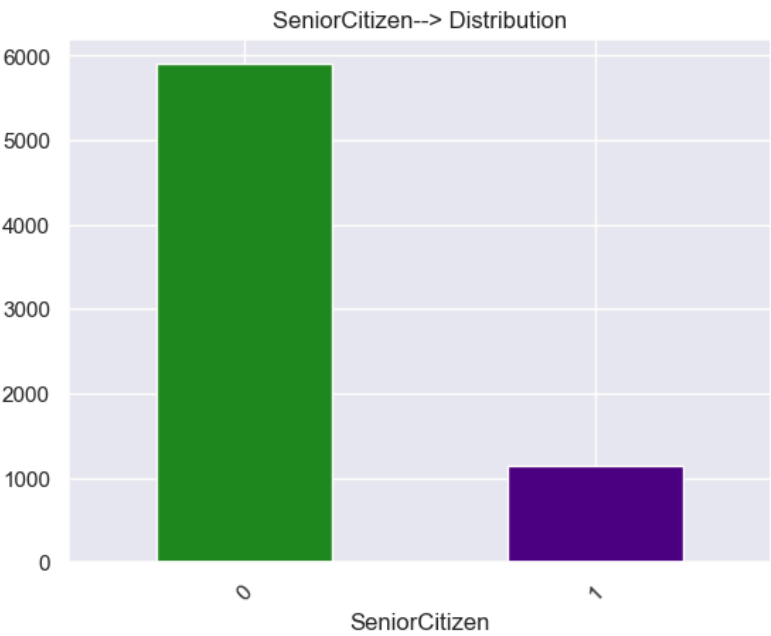
Out[13]: Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',  
'tenure', 'PhoneService', 'MultipleLines', 'InternetService',  
'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',  
'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',  
'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],  
dtype='object')

```
In [14]: # using bar plot understand the distribution
cols = ['gender', 'SeniorCitizen', 'Partner', 'Dependents', 'PhoneService', 'MultipleLines',
        'InternetService', 'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
        'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod', 'Churn']

for col in cols:
    customer_churn[col].value_counts().plot(kind='bar', color=['forestgreen', 'indigo'])
    plt.title(f'{col}--> Distribution')
    plt.xticks(rotation=45)
    plt.figure(figsize=(4,5))
    plt.show()
```



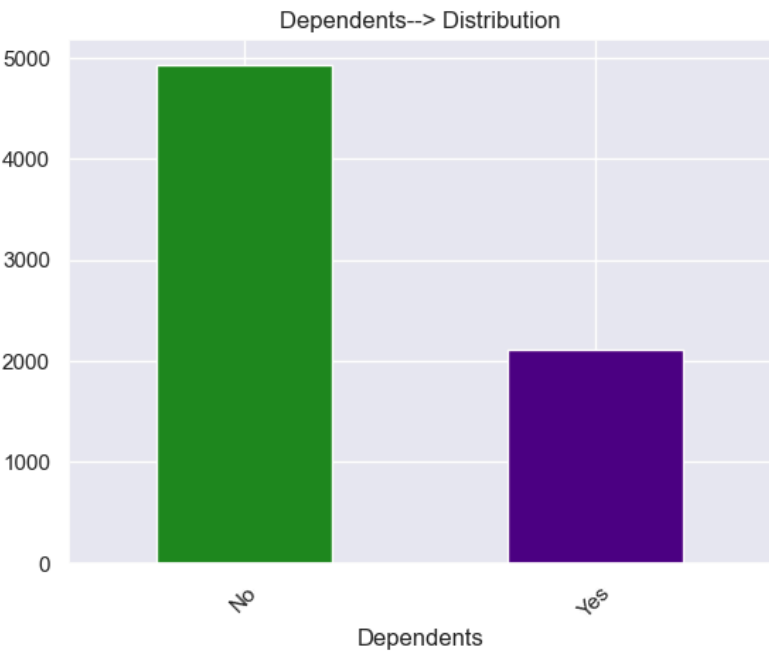
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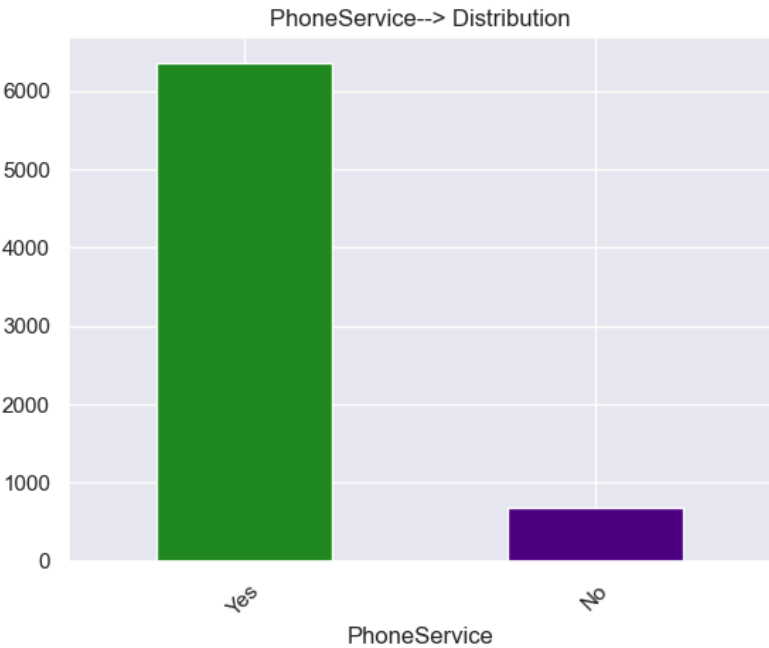
<Figure size 400x500 with 0 Axes>



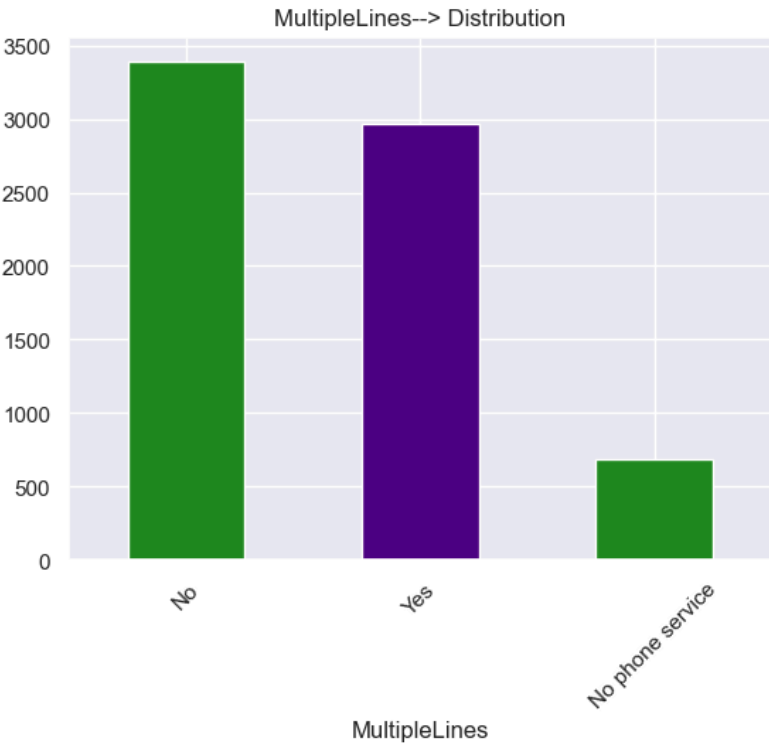
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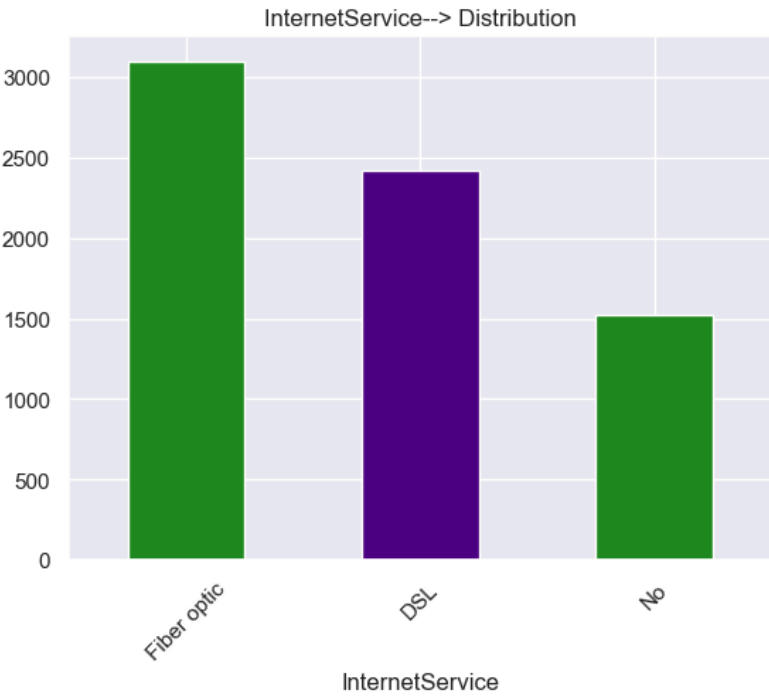
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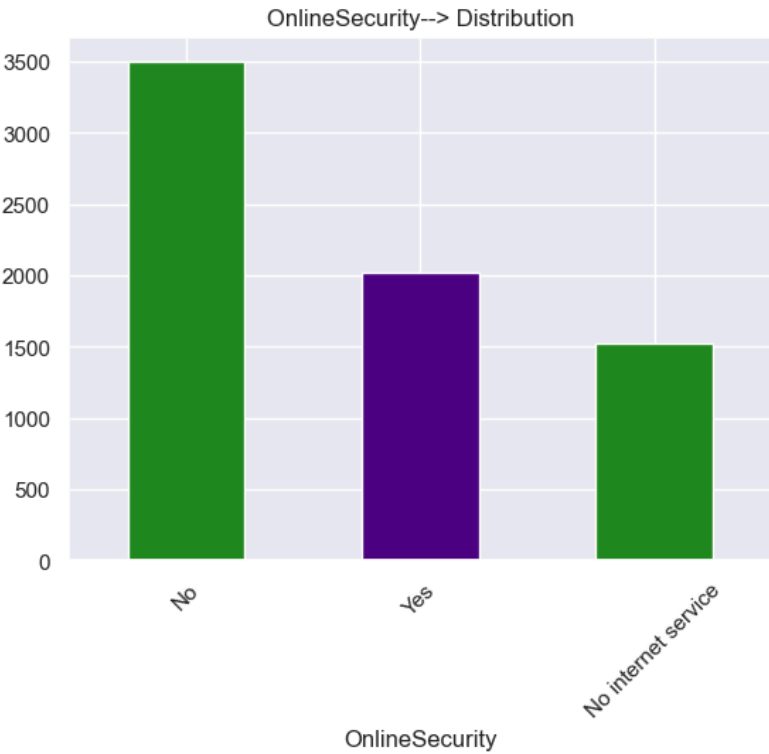
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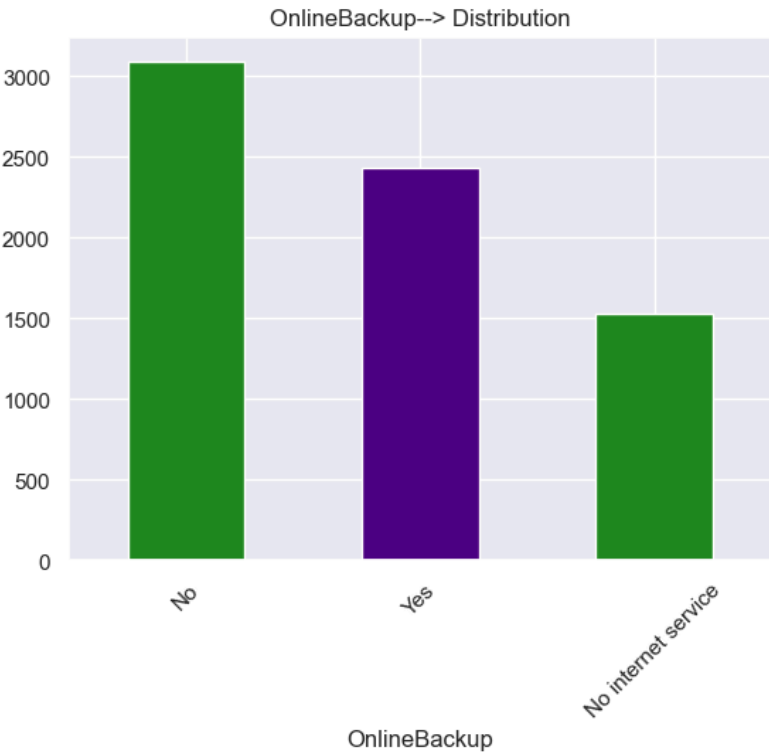
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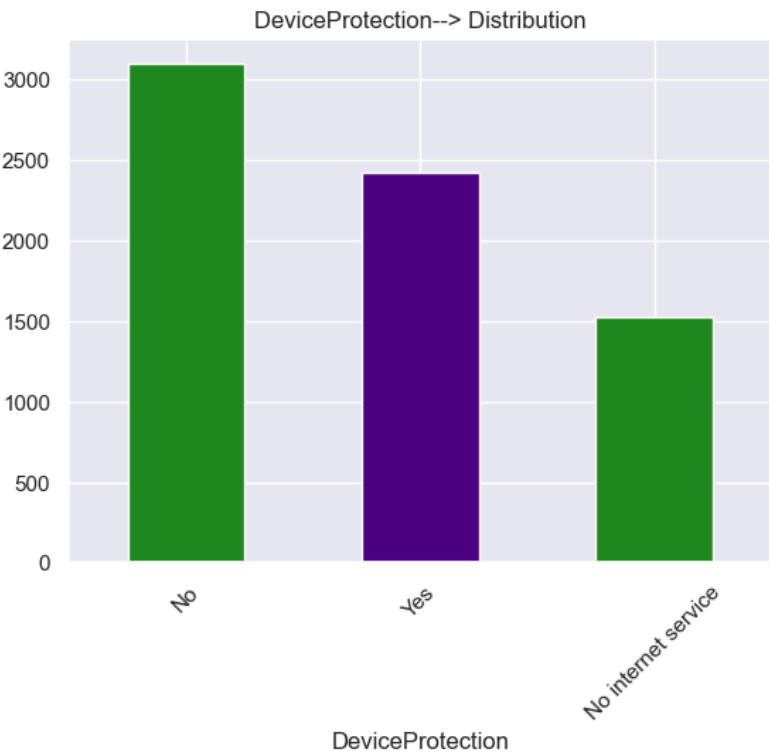
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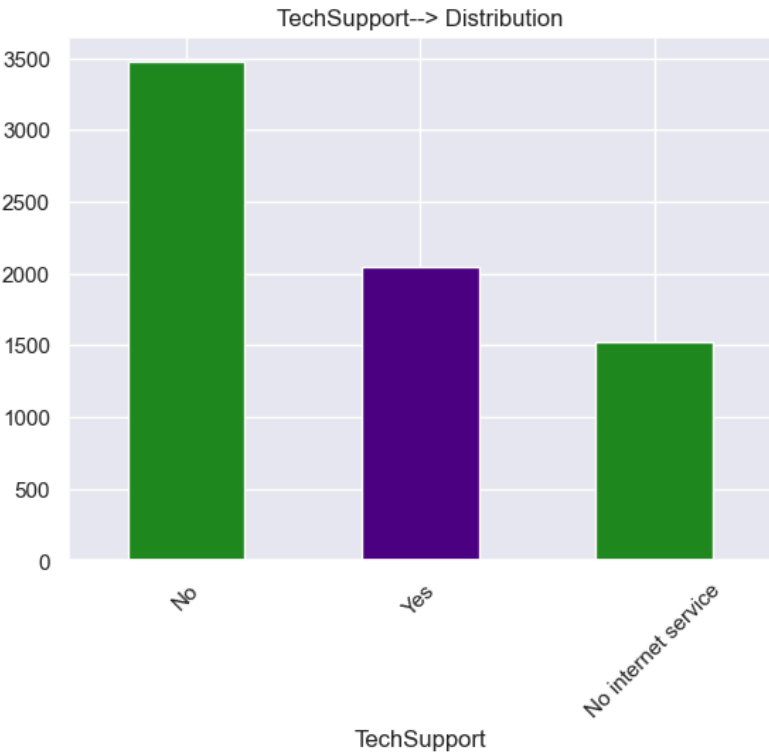


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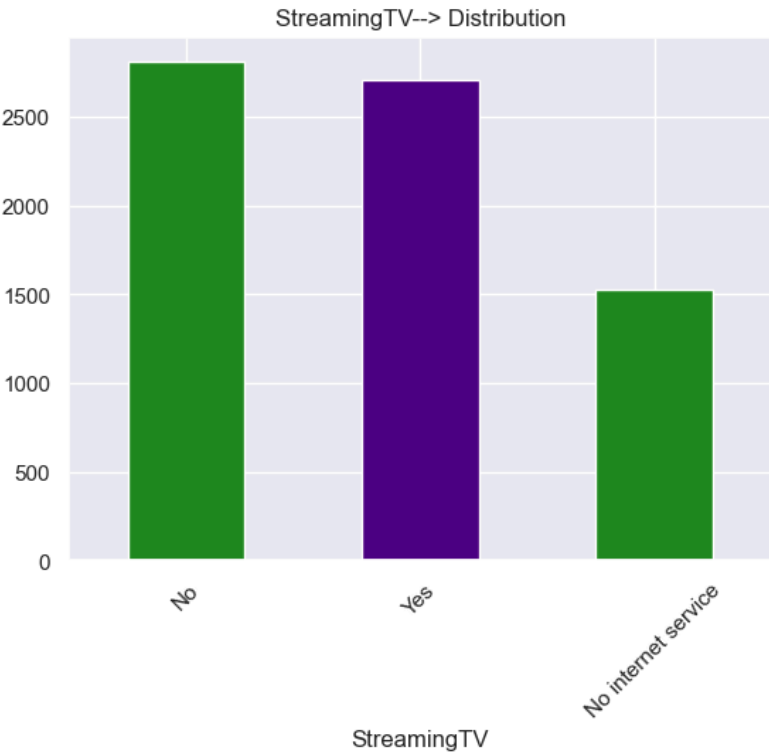


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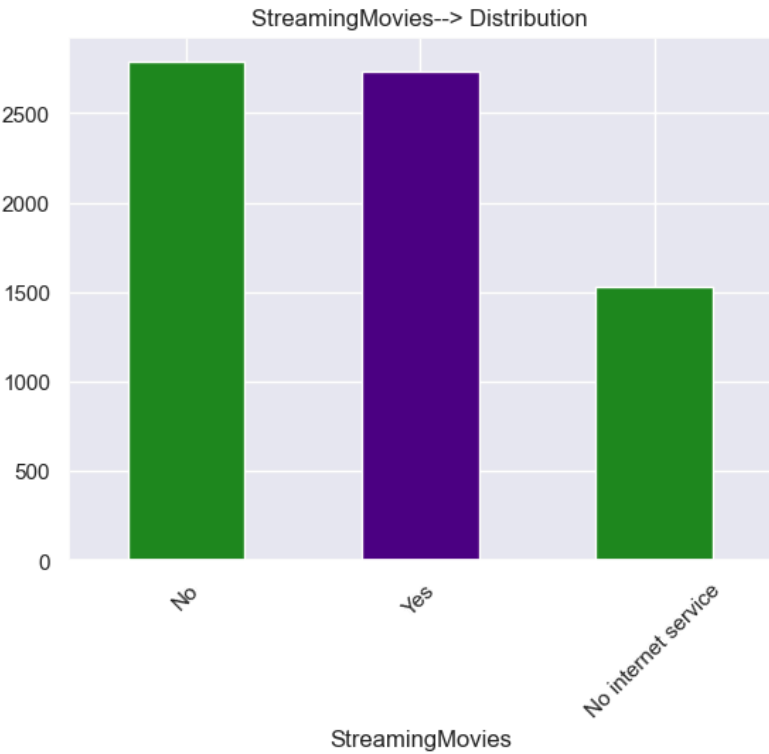




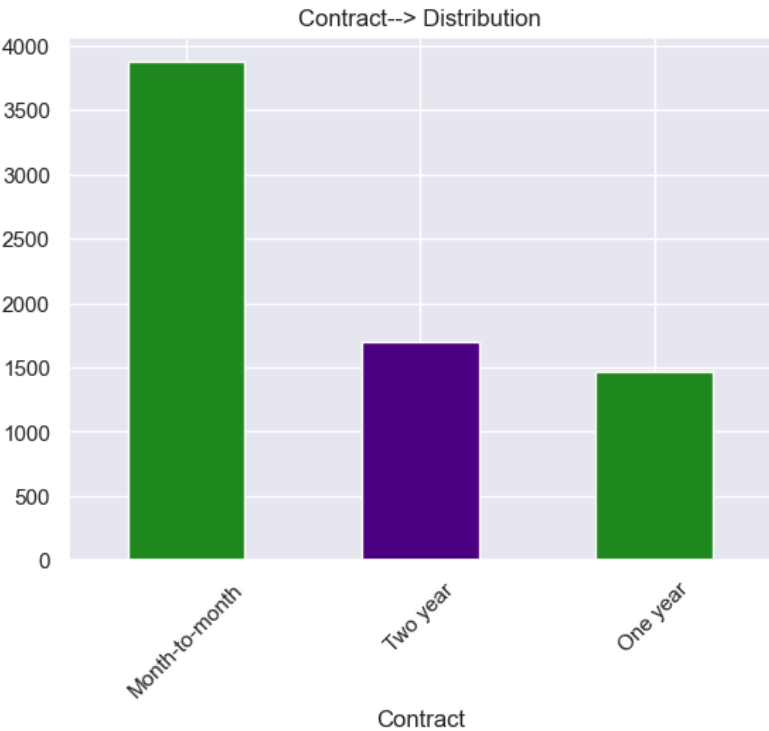
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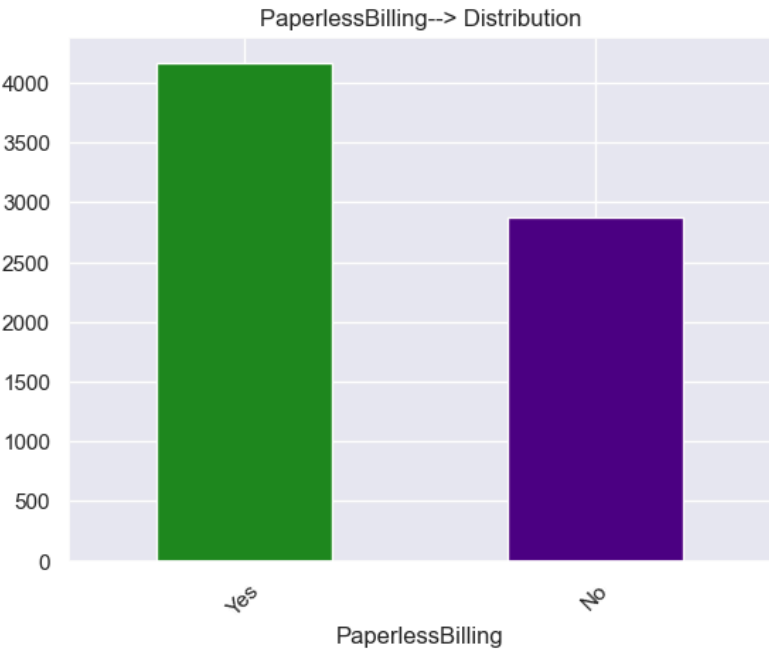
<Figure size 400x500 with 0 Axes>



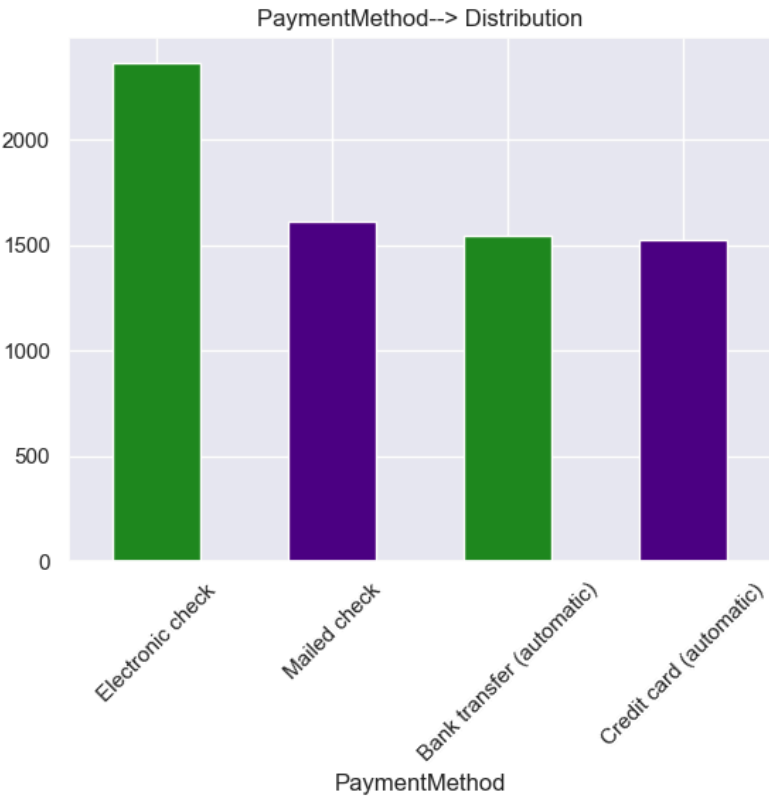
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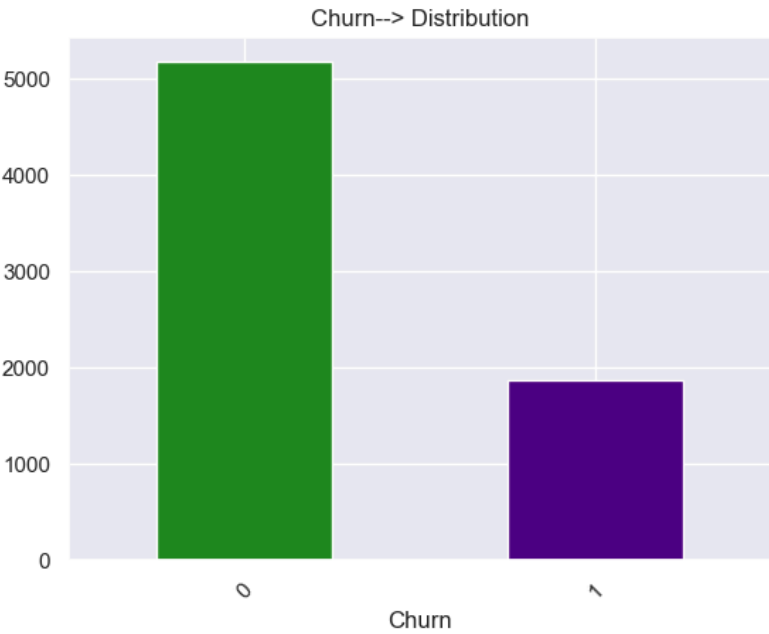
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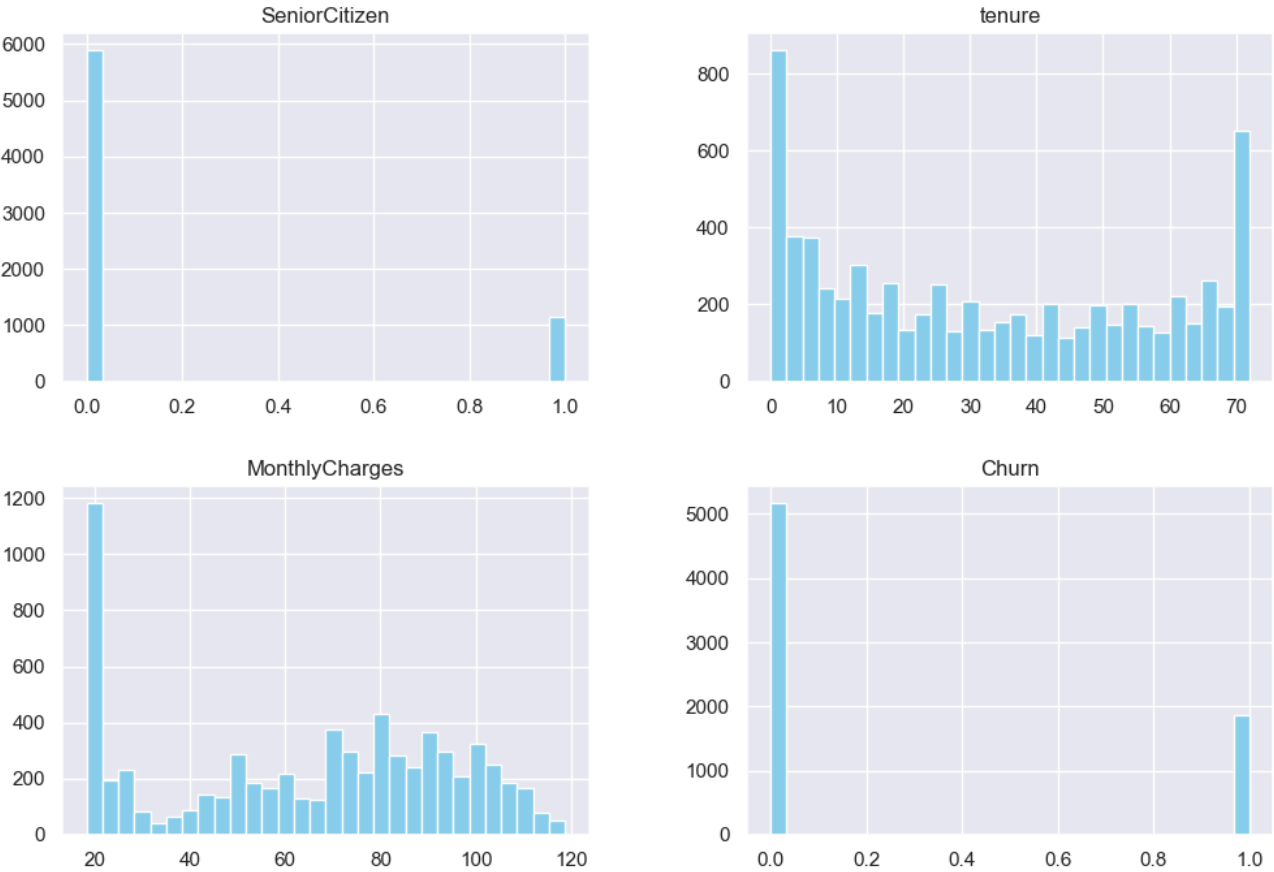


<Figure size 400x500 with 0 Axes>

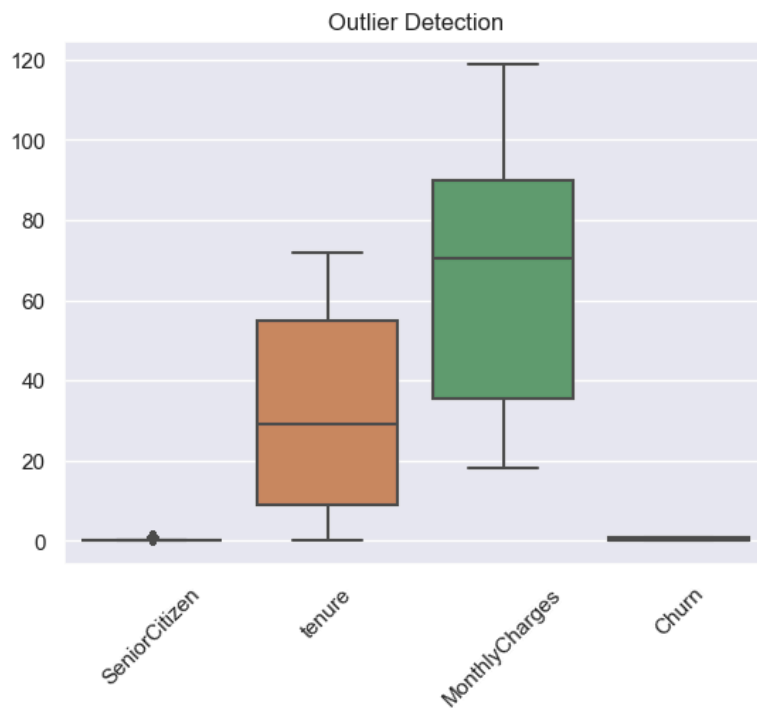
```
In [15]: # num col distribution
num_cols = customer_churn.select_dtypes(include=['int64','float64']).columns

In [16]: customer_churn[num_cols].hist(figsize=(12,8), bins=30, color='skyblue')
plt.suptitle('Numerical Features Distribution')
plt.show()
```

Numerical Features Distribution



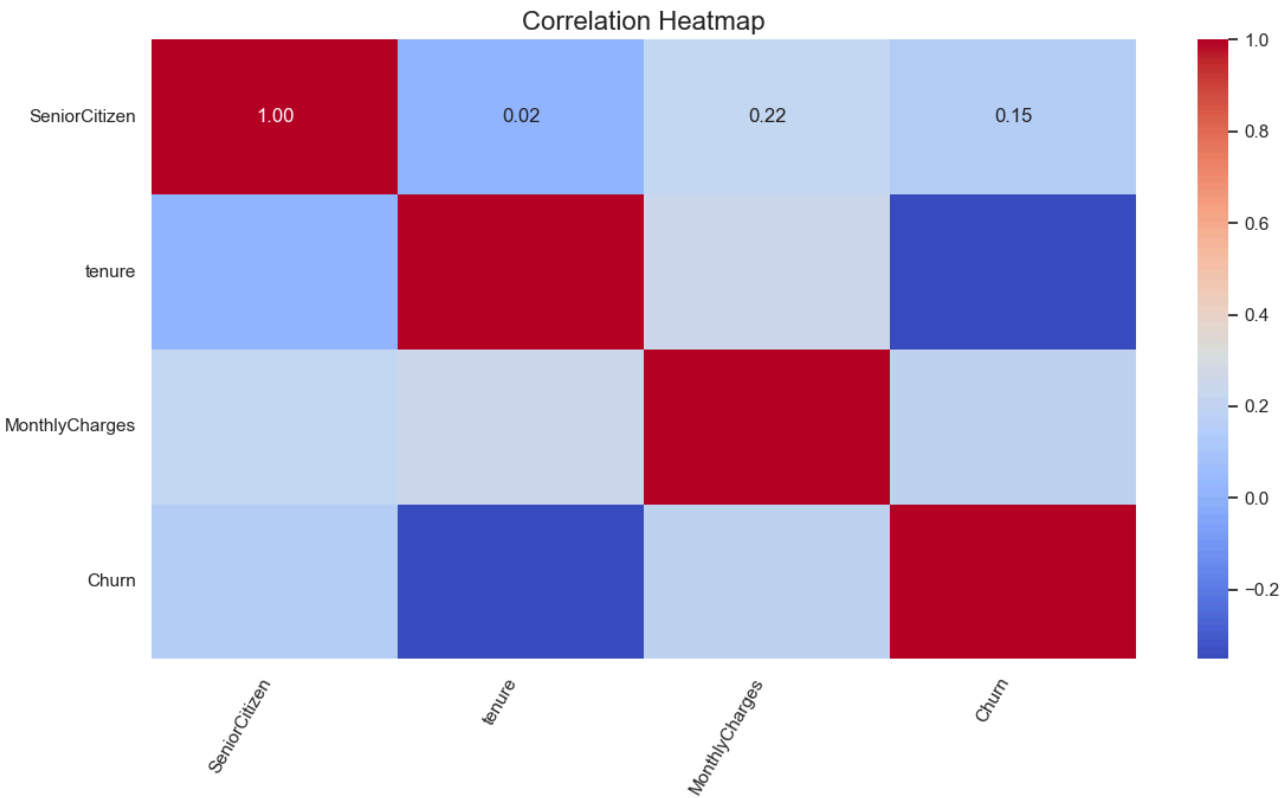
```
In [17]: # checking any outlier
sns.boxplot(data=customer_churn[num_cols])
plt.title('Outlier Detection')
plt.xticks(rotation=45)
plt.show()
```



```
In [18]: customer_churn.columns
```

```
Out[18]: Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
               'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
               'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
               'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
               'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
              dtype='object')
```

```
In [19]: # heatmap - corr()
plt.figure(figsize=(12,7))
sns.heatmap(customer_churn.corr(numeric_only=True), annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation Heatmap', fontsize=16)
plt.xticks(rotation=60, ha='right')
plt.yticks(rotation=0)
plt.tight_layout()
plt.show()
```



```
In [20]: customer_churn.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   int64
dtypes: float64(1), int64(3), object(17)
memory usage: 1.1+ MB
```

```
In [21]: for i in customer_churn.columns:
          print("*****", i, "*****")
          print()
          print(set(customer_churn[i].to_list()))
          print()
```

\*\*\*\*\* customerID \*\*\*\*\*

{'9863-JZAIC', '4195-PNGZS', '7064-JHXCE', '3096-GKWEB', '1768-HNVGJ', '8570-KLJYJ', '5961-VUSRV', '3170-NMYVV', '0104-PPXDV', '6633-MPWBS', '4177-JPDFU', '7551-DACSP', '3866-MDTUB', '6518-KZXC'B', '3190-FZATL', '9269-CQOOL', '1098-TDVUQ', '9732-OUYRN', '3217-FZDMN', '3589-PPVKW', '2592-YKDIF', '6158-HDPXZ', '0697-ZMSWS', '0404-SWRVG', '2761-XECQW', '8766-PAFNE', '0031-PVLZI', '0725-CXOTM', '6173-ITPWD', '8065-YKXKD', '7526-BEZQB', '7901-TBKJX', '1257-SXUXQ', '4274-OWWYO', '1619-YWUBB', '3077-RSNTJ', '0303-WMMRN', '5186-EJEGJ', '7690-KPNCU', '6215-NQCYP', '7950-XWOVN', '9710-ZUSHQ', '0277-BKSPQ', '9477-LGWQI', '6837-BJYDQ', '0820-FNRNX', '5294-DMSFH', '0916-QQFDP', '7017-VFHAY', '0100-DUVFC', '4915-BFSXL', '6281-FKEWS', '1092-GANHU', '1156-ZFYDO', '9967-ATRFs', '8062-YBDOE', '5288-AHOUP', '7938-OUHI0', '6196-HB0BZ', '3078-ZKNTS', '3097-FQTVJ', '8818-XYFCO', '0222-CNVPT', '7666-WKRON', '7730-IUTDZ', '6696-YDAYZ', '6784-XYJAE', '8399-YNDCH', '8984-HPEMB', '3795-GWTRD', '4433-JCGCG', '2729-VNVAP', '2519-ERQOJ', '5160-UXJED', '3604-WLABM', '3550-SAHFP', '8947-YRTDV', '7508-SMHXL', '4635-EJYPD', '2137-DQMEV', '4806-DXQCE', '4176-FXYB0', '9720-JJJOR', '9189-JWSHV', '7633-MVPUY', '3214-IYUQU', '1342-JPNKI', '4277-PVRAN', '3627-FHKBK', '0617-AQNWT', '6568-POCUI', '8434-VGEQQ', '1260-TTRXI', '2294-SALNE', '9917-KWRBE', '5906-DVAPM', '1444-VVSGW', '9079-YEQJQ', '1104-TNLZA', '5787-KXGIY', '0899-LIIBW', '5057-LCOUI', '9063-ZGTUY', '1139-WUOAH', '3372-CDXFJ', '2576-HXMPA', '0193-ESXPZ', '2676-SSLT0', '4912-PIGUY', '5027-YOCXN', '8095-WANWK', '0947-IDHRQ', '7273-TEFQD', '1456-TWCGB', '5346-BZCHP', '6139-ZZRBQ', '8763-KIAFH', '5276-KQWHG', '3524-WQDSG', '7563-BIUPC', '5183-KLYEM', '6218-KNUBD', '5067-DGXLL', '6250-CGGUN', '6773-LQTVT', '0596-BQCEQ', '8748-HFWBO', '0601-WZJHF', '2546-KZAAT', '8849-AYPTR', '2382-BCKQJ', '9462-MJUAW', '8945-MUQUF', '8917-FAEMR', '2506-CLAKW', '8932-CZHRQ', '4644-PIZRT', '8080-POTJR', '4897-QSUYC', '8016-NCFV0', '0089-IIQK0', '5028-GZLDO', '3199-NPKCN', '6685-XSHHU', '7606-BPHHN', '7296-PIXQY', '7599-NTMDP', '1493-NHPBI', '5213-TWJWU', '7733-UDMTP', '6572-ADKRS', '4402-FTBXC', '3753-TSEMP', '8884-MRNSU', '6941-KXRRV', '6457-USBER', '4695-WJZUE', '9817-APLHW', '7691-KGKGP', '2599-CIPQE', '4566-GOLUK', '6366-ZGQGL', '1702-CCFNJ', '4139-DETXS', '0661-KBKP'A', '0410-IPFTY', '2266-FUBDZ', '4658-HCOHW', '4580-TMHJU', '2868-MZAGQ', '3061-BCKYI', '2725-KXXWT', '3722-WPXTK', '3005-TYFRD', '5227-JSCFE', '6855-VLGOS', '5999-LCXA0', '5947-SGKCL', '8229-MYEJZ', '3191-CSNMG', '2155-AMQRX', '7029-IJEJK', '8961-QDZZJ', '1452-KIOVK', '8975-SKGRX', '4623-ZKHLV', '2876-VBBBL', '8327-WKMIE', '1891-UAWWU', '8812-ZRHP', '2535-PBCGC', '2483-XSSMZ', '3528-HFRIQ', '7562-UXTPG', '1448-CYWKC', '9700-ZCLOT', '0230-WEQUW', '6519-CFDBX', '1689-YQBYI', '6743-HHQP', '1796-JANOW', '1051-EQPZR', '6265-SXWBU', '9609-BENEA', '2775-SFEEF', '7233-IQONP', '5568-DMXZS', '9385-NXKDA', '7893-IXHRQ', '3349-ANQNH', '5274-XHAKY', '4039-PIMHX', '4023-RTIQM', '8205-OTCHB', '0661-WCQNG', '6974-DAFLI', '2075-RMJIK', '9508-ILZDG', '3082-YVEKW', '2541-YGPKE', '0260-ZDLGK', '4598-ZADCK', '9093-FPDLG', '6437-UKHMV', '5356-KZCKT', '1329-VHWNP', '1355-KUSBG', '7845-URHJN', '0963-ZBDNR', '6870-ZWMNX', '9588-OZDMQ', '5917-RYRMG', '4760-THGOT', '0415-MOSGF', '7005-CYUIL', '5832-XKAES', '9444-JTXHZ', '1730-VFMW0', '6937-GCDGQ', '7638-QVMVY', '6465-GSRCL', '5982-PSMKW', '3580-HYCSP', '5003-XZWW0', '4800-CZMPC', '6366-XIVKZ', '2958-NHPPS', '4109-CYRBD', '3410-MHHUM', '5351-QESIO', '1041-RXHRA', '1791-PQHBB', '1090-ESELR', '1767-CJKBA', '9369-XFEHK', '9800-OUIGR', '2274-XUATA', '2040-VZIKE', '0742-NXBGR', '3547-LQRIK', '8718-PTMEZ', '8896-RAZCR', '5915-DGNVC', '1285-OKIPP', '0536-BGFMZ', '8681-ICONS', '5339-PXDVH', '7126-RBHSO', '1154-HYWWO', '6142-VSJQO', '8802-UOJNF', '8644-XLFBW', '3870-SPZSI', '5240-CAOYT', '9513-DXHDA', '4248-QPAVC', '5014-WUQM0', '4163-KIUHY', '7133-VBDCQ', '6979-ZNSFF', '0570-BFOHT', '4795-UXVCJ', '8058-JMEQO', '4299-SIMNS', '5832-EXGTT', '6869-FGJJC', '6754-WKSHP', '2672-DZUOY', '7297-DVYGA', '6353-BRMMA', '6194-HBGON', '1324-NLTJE', '5626-MGTUK', '9154-QDGTI', '7298-IZWLY', '3340-QBBFM', '3319-DWOEP', '7760-OYPDY', '3776-EKTKM', '2984-MIIZL', '8777-BMBTS', '4456-RHSNB', '8178-EYZUO', '0347-UBKUZ', '0485-ZBSLN', '4822-RVYBB', '0247-SLUJI', '3055-VTCGS', '6230-BSUXY', '6710-HSJDJ', '6502-MJQAE', '9746-UGFAC', '1577-HKTFG', '0422-OHQHQ', '9512-UIBFX', '4576-CSAJH', '4716-HHKQH', '4291-SHSBH', '1567-DSCIC', '3704-IEAXF', '6893-ODYYE', '7691-XVTZ

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\*\*\*\*\* gender \*\*\*\*\*

{'Male', 'Female'}

\*\*\*\*\* SeniorCitizen \*\*\*\*\*

{0, 1}

\*\*\*\*\* Partner \*\*\*\*\*

{'Yes', 'No'}

\*\*\*\*\* Dependents \*\*\*\*\*

{'Yes', 'No'}

\*\*\*\*\* tenure \*\*\*\*\*

{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 3 1, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 6 0, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72}

\*\*\*\*\* PhoneService \*\*\*\*\*

{'Yes', 'No'}

\*\*\*\*\* MultipleLines \*\*\*\*\*

{'Yes', 'No', 'No phone service'}

\*\*\*\*\* InternetService \*\*\*\*\*

{'No', 'Fiber optic', 'DSL'}

\*\*\*\*\* OnlineSecurity \*\*\*\*\*

{'Yes', 'No', 'No internet service'}

\*\*\*\*\* OnlineBackup \*\*\*\*\*

{'Yes', 'No', 'No internet service'}

\*\*\*\*\* DeviceProtection \*\*\*\*\*

{'Yes', 'No', 'No internet service'}

\*\*\*\*\* TechSupport \*\*\*\*\*

['Yes', 'No', 'No internet service']

\*\*\*\*\* StreamingTV \*\*\*\*\*

['Yes', 'No', 'No internet service']

\*\*\*\*\* StreamingMovies \*\*\*\*\*

['Yes', 'No', 'No internet service']

\*\*\*\*\* Contract \*\*\*\*\*

['Month-to-month', 'One year', 'Two year']

\*\*\*\*\* PaperlessBilling \*\*\*\*\*

['Yes', 'No']

\*\*\*\*\* PaymentMethod \*\*\*\*\*

['Mailed check', 'Bank transfer (automatic)', 'Credit card (automatic)', 'Electronic check']

\*\*\*\*\* MonthlyCharges \*\*\*\*\*

[18.95, 19.8, 20.65, 20.15, 20.2, 20.75, 24.95, 20.4, 24.25, 25.9, 19.95, 29.75, 29.85, 30.2, 24.3, 33.75, 30.15, 31.05, 35.45, 29.95, 30.4, 39.65, 35.9, 40.2, 42.3, 42.1, 44.35, 45.25, 45.55, 45.65, 45.3, 49.95, 49.55, 49.25, 49.05, 53.85, 54.4, 55.2, 56.95, 56.15, 55.3, 59.9, 59.6, 55.65, 54.65, 62.15, 64.7, 64.15, 66.15, 64.5, 66.85, 69.7, 70.7, 69.2, 69.5, 70.45, 74.8, 74.85, 76.2, 75.3, 78.9, 79.85, 80.65, 79.75, 79.2, 74.75, 84.5, 79.35, 82.05, 84.0, 85.2, 89.1, 90.05, 90.25, 89.9, 91.65, 94.4, 95.5, 96.35, 97.85, 95.45, 99.65, 100.35, 99.35, 102.45, 102.7, 103.8, 103.4, 104.15, 104.4, 104.6, 105.35, 108.0, 109.2, 103.7, 104.8, 105.5, 106.7, 108.45, 111.6, 110.5, 113.25, 111.05, 112.25, 24.75, 115.1, 115.05, 116.05, 25.25, 24.5, 25.75, 25.0, 25.5, 26.25, 26.0, 26.5, 28.5, 29.5, 29.25, 30.75, 30.5, 30.25, 31.0, 33.5, 34.25, 34.5, 34.0, 35.75, 35.5, 35.0, 35.25, 36.0, 36.25, 36.5, 38.5, 38.25, 39.0, 39.5, 40.25, 40.0, 40.75, 43.75, 43.25, 44.0, 44.75, 44.25, 44.5, 45.0, 45.75, 45.5, 46.0, 46.25, 48.75, 48.25, 49.5, 49.0, 49.75, 50.25, 50.0, 50.5, 50.75, 51.25, 51.0, 51.75, 51.5, 52.5, 52.0, 53.75, 53.5, 53.0, 54.75, 54.25, 54.0, 54.5, 55.0, 55.5, 55.25, 55.75, 56.0, 56.75, 56.25, 56.5, 57.75, 57.5, 58.75, 58.25, 58.5, 58.0, 59.75, 59.0, 59.5, 59.25, 60.0, 60.25, 60.5, 60.75, 61.5, 61.25, 61.75, 61.0, 62.25, 62.5, 63.25, 63.75, 64.25, 64.75, 64.0, 65.0, 65.5, 65.75, 65.25, 66.5, 66.25, 66.0, 66.75, 67.25, 67.5, 67.75, 68.75, 68.5, 68.25, 69.75, 69.0, 69.25, 70.0, 70.5, 70.75, 70.25, 71.5, 71.0, 71.25, 71.75, 72.75, 72.25, 72.0, 73.25, 73.5, 73.0, 73.75, 74.5, 74.25, 74.0, 75.0, 75.25, 75.5,

75.75, 76.5, 76.0, 76.75, 76.25, 77.75, 77.0, 77.5, 78.75, 78.0, 78.5, 78.25, 79.25, 79.5, 79.0, 80.0, 80.25, 80.5, 80.75, 81.0, 81.25, 81.5, 81.75, 82.5, 82.75, 82.0, 83.25, 83.75, 83.5, 83.0, 84.25, 84.75, 85.75, 85.5, 85.0, 85.25, 86.75, 86.0, 86.5, 86.25, 87.0, 87.25, 87.75, 88.0, 88.5, 88.75, 88.25, 89.25, 89.0, 89.75, 89.5, 90.0, 90.5, 90.75, 18.25, 18.75, 91.0, 91.5, 91.25, 91.75, 92.0, 92.5, 93.0, 93.5, 93.25, 93.75, 94.5, 94.25, 94.75, 94.0, 95.25, 95.0, 95.75, 19.5, 19.75, 19.25, 96.75, 96.5, 19.0, 96.0, 96.25, 97.0, 97.75, 97.25, 98.75, 98.25, 98.5, 98.0, 99.25, 99.0, 99.75, 99.5, 100.0, 100.75, 100.25, 20.25, 20.5, 101.75, 100.5, 20.0, 101.0, 101.5, 102.5, 102.0, 101.25, 102.25, 103.75, 103.25, 103.0, 103.5, 104.0, 104.5, 104.75, 104.25, 105.0, 105.25, 21.0, 21.25, 105.75, 106.0, 106.75, 106.5, 106.25, 107.5, 107.25, 107.0, 107.75, 108.5, 108.25, 108.75, 109.25, 109.5, 109.75, 109.0, 110.0, 110.75, 110.25, 111.25, 111.5, 111.75, 112.75, 113.0, 113.75, 114.5, 114.0, 114.75, 115.75, 115.0, 23.75, 115.5, 115.25, 116.25, 116.75, 116.0, 116.5, 23.5, 117.5, 118.75, 24.0, 18.4, 18.9, 19.4, 19.9, 19.65, 19.15, 20.9, 21.15, 23.65, 23.4, 23.9, 23.15, 24.9, 24.4, 24.15, 24.65, 25.15, 25.4, 25.65, 26.4, 26.9, 29.65, 29.9, 29.15, 29.4, 30.9, 31.65, 33.15, 33.65, 33.9, 34.65, 34.4, 35.4, 35.65, 35.15, 36.65, 36.15, 38.9, 39.9, 39.4, 39.15, 40.4, 40.65, 40.15, 40.9, 41.15, 41.9, 42.9, 42.4, 43.65, 43.9, 44.4, 44.65, 44.9, 44.15, 45.4, 45.15, 45.9, 46.4, 47.15, 47.4, 48.15, 48.9, 48.65, 48.4, 49.15, 49.9, 49.4, 49.65, 50.65, 50.15, 50.9, 50.4, 51.65, 51.4, 51.15, 52.15, 53.65, 53.9, 53.4, 53.15, 54.9, 54.15, 55.15, 55.9, 55.4, 56.4, 56.9, 56.65, 57.15, 57.65, 58.65, 58.9, 58.4, 59.4, 59.65, 59.15, 60.9, 60.15, 60.65, 60.4, 61.65, 61.9, 61.4, 61.15, 62.65, 63.15, 63.4, 63.9, 18.55, 64.9, 64.4, 64.65, 65.15, 65.65, 19.05, 65.4, 65.9, 66.4, 66.9, 66.65, 67.65, 67.4, 68.65, 68.4, 68.9, 68.15, 69.65, 69.9, 69.15, 69.4, 70.9, 70.15, 70.4, 70.65, 71.15, 71.9, 71.4, 71.65, 72.65, 72.9, 72.15, 73.9, 73.15, 73.65, 74.9, 74.4, 74.65, 74.15, 75.9, 75.15, 75.65, 75.4, 21.3, 76.9, 76.65, 76.4, 76.15, 77.4, 77.15, 77.9, 77.65, 78.4, 78.65, 78.15, 79.9, 79.15, 79.4, 79.65, 80.9, 80.4, 80.15, 81.15, 81.4, 81.65, 81.9, 82.4, 82.9, 82.65, 83.15, 83.4, 83.9, 83.65, 84.15, 84.9, 84.4, 84.65, 85.4, 85.65, 85.15, 85.9, 23.05, 86.65, 86.15, 86.4, 86.9, 87.65, 87.9, 87.4, 87.15, 88.15, 88.9, 88.65, 88.4, 89.15, 89.65, 89.4, 75.05, 90.4, 90.15, 90.65, 90.9, 91.4, 91.15, 92.9, 92.65, 92.15, 92.4, 93.15, 93.4, 93.9, 93.65, 94.9, 94.65, 94.15, 76.55, 95.15, 95.4, 95.65, 95.9, 96.65, 96.15, 96.9, 96.4, 97.65, 97.9, 98.65, 98.9, 98.15, 98.4, 99.9, 99.4, 99.15, 77.8, 77.55, 100.9, 100.15, 100.65, 100.4, 101.9, 101.15, 101.4, 102.15, 102.65, 102.9, 102.4, 103.9, 103.15, 103.65, 104.65, 104.9, 105.65, 105.15, 105.9, 105.4, 106.9, 106.4, 106.65, 106.15, 107.15, 107.65, 107.9, 107.4, 108.15, 108.65, 108.4, 108.9, 109.9, 109.4, 109.15, 109.65, 110.65, 110.15, 110.9, 111.9, 111.65, 111.15, 111.4, 112.4, 112.9, 113.65, 113.4, 113.15, 114.65, 114.9, 115.65, 115.15, 29.3, 116.15, 116.4, 117.15, 118.65, 33.55, 34.55, 34.8, 34.05, 34.3, 35.8, 35.55, 35.05, 35.3, 36.05, 38.55, 38.8, 39.3, 39.55, 39.05, 40.05, 40.3, 40.55, 41.05, 43.8, 43.55, 43.3, 43.05, 44.8, 44.3, 44.05, 44.55, 45.05, 45.8, 46.3, 46.05, 47.8, 47.05, 48.55, 48.8, 49.3, 49.8, 50.55, 50.05, 50.3, 50.8, 51.8, 51.05, 51.55, 51.3, 52.55, 52.3, 53.8, 53.3, 53.55, 54.8, 54.3, 54.55, 54.05, 55.05, 55.8, 55.55, 56.8, 56.05, 56.3, 56.55, 57.8, 57.55, 58.55, 59.8, 59.3, 59.55, 59.05, 60.3, 60.05, 60.8, 60.55, 61.05, 61.8, 61.55, 61.3, 62.8, 62.05, 62.55, 62.3, 63.3, 63.55, 63.8, 63.05, 64.8, 64.05, 64.3, 64.55, 65.55, 65.8, 65.05, 65.3, 66.8, 66.05, 66.3, 67.8, 67.05, 68.55, 68.8, 68.05, 68.3, 18.8, 69.3, 69.55, 69.05, 69.8, 19.3, 70.8, 70.05, 19.55, 70.3, 20.3, 71.55, 20.55, 20.05, 20.8, 70.55, 72.8, 21.05, 71.05, 71.3, 71.8, 73.8, 73.55, 73.05, 73.3, 23.8, 74.3, 74.05, 23.3, 23.55, 24.55, 24.05, 74.55, 24.8, 75.55, 25.3, 75.8, 25.05, 76.05, 25.55, 26.8, 26.05, 26.3, 76.8, 25.8, 76.3, 78.05, 78.3, 78.55, 78.8, 77.3, 79.3, 79.05, 79.55, 79.8, 29.05, 80.55, 29.8, 80.05, 80.3, 30.3, 81.8, 81.3, 80.8, 81.05, 81.55, 82.3, 30.55, 30.05, 82.55, 83.3, 83.55, 83.8, 83.05, 84.55, 84.8, 84.3, 84.05, 85.8, 85.3, 85.05, 85.55, 86.8, 86.05, 86.3, 86.55, 87.05, 87.55, 87.8, 87.3, 88.55, 88.05, 88.8, 88.3, 89.05, 89.55, 89.8, 89.3, 90.3, 90.55, 90.8, 91.3, 91.55, 91.05, 91.8, 92.05, 92.55, 92.3, 93.05, 93.8, 93.55, 93.3, 94.05, 94.8, 94.3, 94.55, 95.05, 95.8, 95.3, 95.55, 96.05, 96.8, 96.55, 96.3, 97.55, 97.8, 97.05, 98.3, 98.8, 98.05, 98.55, 99.3, 99.8, 99.05, 99.55, 100.8, 100.55, 100.05, 100.3, 101.05, 101.55, 101.3, 101.8, 102.05, 102.55, 102.8, 103.05, 103.3,

104.3, 104.55, 104.05, 105.3, 105.55, 105.05, 105.8, 106.05, 106.8, 106.55, 106.3, 107.05, 107.55, 108.55, 108.05, 108.3, 108.8, 109.55, 109.8, 109.05, 109.3, 110.05, 110.3, 110.8, 110.55, 111.55, 111.8, 111.3, 112.55, 113.3, 113.05, 113.8, 114.05, 114.55, 114.3, 115.8, 115.55, 116.8, 116.3, 116.55, 117.8, 18.7, 19.2, 19.45, 19.7, 20.7, 20.45, 20.95, 21.2, 21.45, 22.95, 23.95, 23.45, 24.7, 24.45, 24.2, 25.7, 25.2, 25.45, 25.95, 26.2, 26.45, 28.45, 29.45, 29.2, 29.7, 30.45, 31.2, 33.45, 33.7, 34.7, 34.2, 34.95, 35.7, 35.2, 36.45, 37.7, 39.7, 39.2, 39.95, 39.45, 40.7, 40.45, 41.95, 43.95, 43.7, 43.45, 44.95, 44.45, 44.7, 44.2, 45.7, 45.95, 45.2, 45.45, 46.2, 47.95, 48.95, 48.7, 48.2, 48.45, 49.2, 49.45, 49.7, 50.2, 50.45, 50.95, 50.7, 51.2, 51.7, 51.45, 52.2, 52.7, 53.95, 53.45, 53.7, 54.7, 54.2, 54.45, 54.95, 55.45, 55.95, 55.7, 56.45, 56.7, 56.2, 57.95, 57.45, 57.2, 58.45, 58.95, 58.7, 58.2, 59.95, 59.45, 59.2, 59.7, 60.45, 60.2, 60.7, 60.95, 61.2, 61.95, 61.45, 62.7, 62.45, 63.95, 63.7, 64.95, 64.2, 64.45, 65.2, 65.7, 65.45, 66.7, 66.2, 67.45, 67.95, 67.2, 67.7, 68.95, 68.7, 68.45, 69.45, 69.95, 70.2, 70.95, 71.7, 71.45, 71.95, 72.95, 72.45, 72.2, 73.2, 73.45, 73.95, 73.7, 74.2, 74.7, 74.45, 74.95, 75.95, 75.45, 75.7, 75.2, 76.45, 76.95, 77.95, 77.2, 78.45, 78.95, 78.2, 78.7, 79.95, 79.45, 79.7, 80.95, 80.7, 80.45, 80.2, 81.95, 81.45, 81.7, 81.2, 82.95, 82.45, 82.7, 83.7, 83.2, 83.45, 83.95, 84.2, 84.95, 84.7, 84.45, 85.95, 85.45, 85.7, 86.2, 86.45, 86.95, 86.7, 87.95, 87.2, 87.45, 87.7, 88.95, 88.2, 88.45, 88.7, 89.7, 89.2, 89.45, 89.95, 90.95, 90.45, 90.7, 90.2, 91.7, 91.2, 91.45, 91.95, 92.2, 92.95, 92.45, 92.7, 93.95, 93.45, 93.2, 93.7, 94.45, 94.2, 94.7, 94.95, 95.2, 95.95, 95.7, 96.7, 96.2, 96.95, 97.45, 97.95, 97.2, 97.7, 98.7, 98.2, 98.45, 99.45, 99.7, 99.95, 99.2, 100.45, 100.7, 100.95, 100.2, 101.45, 101.95, 101.7, 102.95, 103.2, 103.45, 103.95, 104.95, 104.7, 104.45, 104.2, 105.45, 105.2, 105.95, 105.7, 106.45, 106.95, 106.2, 107.95, 107.45, 107.2, 107.7, 108.95, 108.2, 109.7, 109.95, 109.45, 110.45, 110.2, 110.7, 111.95, 111.2, 111.45, 112.95, 112.2, 113.2, 113.45, 113.95, 114.95, 114.7, 114.45, 114.2, 116.45, 116.95, 116.2, 117.2, 117.45, 118.2, 64.35, 64.85, 64.6, 64.1, 65.35, 65.85, 65.1, 65.6, 66.35, 66.1, 66.6, 67.85, 67.6, 68.85, 68.6, 68.35, 68.1, 69.35, 69.85, 69.1, 69.6, 70.35, 70.6, 70.85, 70.1, 71.1, 71.35, 71.6, 71.85, 72.1, 72.85, 72.35, 72.6, 73.6, 73.85, 73.35, 73.1, 74.35, 74.6, 74.1, 75.35, 75.6, 75.1, 75.85, 76.1, 76.85, 76.35, 76.6, 77.35, 77.85, 78.85, 78.1, 78.6, 78.35, 79.1, 79.6, 80.6, 80.35, 80.1, 80.85, 81.85, 81.35, 81.1, 81.6, 82.85, 82.1, 82.35, 83.35, 83.85, 83.6, 84.6, 84.85, 84.35, 84.1, 85.1, 85.35, 85.6, 85.85, 86.1, 86.6, 86.85, 86.35, 87.35, 87.1, 87.6, 88.1, 88.6, 88.85, 88.35, 89.85, 89.35, 89.6, 90.85, 90.35, 90.1, 90.6, 91.35, 91.1, 91.85, 91.6, 92.1, 92.35, 92.85, 92.6, 93.35, 93.85, 93.6, 94.35, 94.85, 94.1, 94.6, 95.6, 95.1, 95.35, 95.85, 96.1, 96.85, 96.6, 97.1, 97.35, 98.85, 98.6, 98.35, 98.1, 99.1, 99.85, 99.6, 100.6, 100.85, 100.1, 101.35, 101.1, 101.6, 101.85, 102.1, 102.85, 102.6, 102.35, 103.1, 103.85, 103.35, 103.6, 104.1, 104.85, 104.35, 105.1, 105.6, 105.85, 106.35, 106.6, 106.1, 106.85, 107.35, 107.6, 108.1, 108.85, 108.6, 108.35, 109.85, 109.6, 109.1, 110.85, 110.35, 110.1, 110.6, 111.35, 111.1, 112.6, 112.1, 112.35, 113.1, 113.6, 113.35, 114.35, 114.85, 114.1, 114.6, 115.6, 115.85, 116.1, 116.85, 116.6, 117.6, 117.35, 118.6, 118.35, 18.85, 19.6, 19.35, 19.85, 19.1, 20.85, 20.6, 20.1, 20.35, 21.1, 23.6, 23.85, 24.1, 24.85, 24.6, 24.35, 25.35, 25.6, 25.1, 25.85, 26.1, 26.35, 28.6, 29.6, 29.35, 29.1, 30.1, 30.85, 30.35, 30.6, 31.35, 31.1, 33.6, 34.6, 34.85, 35.6, 35.1, 35.35, 36.1, 36.85, 38.6, 38.1, 38.85, 39.6, 39.1, 39.85, 39.35, 40.6, 40.35, 40.1, 41.35, 41.1, 41.6, 42.6, 42.35, 43.85, 43.35, 43.6, 44.6, 44.85, 44.1, 45.6, 45.35, 45.85, 45.1, 46.35, 46.1, 46.6, 47.85, 47.6, 48.6, 48.85, 48.35, 49.85, 49.35, 49.1, 49.6, 50.6, 50.35, 50.1, 50.85, 51.6, 51.35, 51.1, 52.1, 52.85, 53.6, 53.1, 53.35, 54.1, 54.6, 54.85, 54.35, 55.1, 55.35, 55.85, 55.6, 56.6, 56.35, 56.1, 56.85, 57.6, 58.6, 58.35, 58.85, 59.85, 59.1, 60.85, 60.35, 60.6, 60.1, 61.6, 61.35, 61.1, 62.1, 62.85, 63.85, 63.35, 63.6, 63.1}

\*\*\*\*\* TotalCharges \*\*\*\*\*

{'1161.75', '419.4', '95.65', '2909.95', '161.95', '7285.7', '360.1', '3632', '702.05', '482.8', '1660', '1336.8',

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4.1', '318.9', '3753.2', '1311.75', '3128.8', '1699.15', '156.25', '1574.5', '1888.65', '1012.4', '4059.85', '400',
'20.5', '1893.5', '1664.3', '1312.15', '1955.4', '931.9', '3694.45', '3316.1', '438', '6312.9', '3121.45', '2978.3',
'2490.15', '1611', '6310.9', '2657.55', '3562.5', '6474.45', '865', '2568.15', '6519.75', '1789.25', '1111.85', '24
2.05', '260.7', '239.05', '3624.3', '3766.2', '84.2', '730.1', '2696.55', '648.65', '1539.45', '4872.45', '368.85',
'5656.75', '3545.35', '1514.85', '4055.5', '2203.7', '6347.55', '8547.15', '664.4', '2361.8', '4758.8', '6224.8', '1
22.7', '1067.15', '6529.25', '2588.95', '5542.55', '2936.25', '221.1', '1431.65', '211.95', '1119.35', '268.4', '242
7.1', '3043.6', '7806.5', '1902', '1583.5', '3895.35', '1618.2', '289.1', '3827.9', '5526.75', '4693.2', '194.55',
'2716.3', '356.1', '1090.1', '7521.95', '2365.15', '452.8', '3180.5', '287.4', '4242.35', '523.1', '1108', '6083.1',
'1496.45', '5846.65', '2513.5', '2404.15', '6219.6', '20.65', '947.4', '6890', '4233.95', '6825.65', '252', '4676.
7', '94.4', '4388.4', '425.9', '63.75', '790.15', '2049.05', '6770.5', '294.95', '1776', '3590.2', '1993.8', '1732.9
5', '69.55', '196.75', '7737.55', '6096.45', '244.8', '864.85', '6350.5', '4576.3', '270.6', '6300.85', '2181.75',
'3808', '2656.5', '288.35', '6033.1', '1292.2', '5468.45', '1639.3', '3005.8', '1253.9', '129.15', '1381.2', '273.2
5', '3457.45', '181.65', '265.35', '1050.5', '3532.85', '50.5', '196.4', '849.9', '927.65', '5825.5', '2421.75', '10
66.15', '1973.75', '272.95', '844.45', '2093.4', '2395.7', '627.4', '1123.15', '75.55', '369.1', '4370.25', '144.1
5', '69.15', '438.4', '4915.15', '3591.25', '1127.35', '4991.5', '1940.85', '8312.4', '4965', '2459.8', '660.9', '45
42.35', '794.25', '3529.95', '45.6', '212.4', '3131.8', '675.6', '1215.45', '3346.8', '1078.9', '1540.05', '343.45',
'1806.35', '6126.1', '6055.55', '6441.4', '762.45', '442.2', '827.3', '1702.9', '3097', '5981.65', '6643.5', '764.9
5', '46.35', '605.9', '1156.1', '1043.3', '3053', '788.8', '472.65', '2257.75', '6981.35', '406.05', '1672.15', '293
4.3', '1031.1', '7726.35', '2413.05', '3364.55', '6368.2', '1698.55', '1466.1', '180.25', '7534.65', '4014.6', '633.
85', '168.9', '5508.35', '369.3', '505.45', '1496.9', '1516.6', '1559.25', '3161.2', '139.25', '7634.8', '472.25',
'319.6', '150.35', '5471.75', '232.55', '4473.45', '1160.45', '254.5', '2425.4', '1841.2', '1500.5', '7578.05', '656
2.9', '6474.4', '1782.05', '1826.7', '1129.75', '4447.75', '1077.5', '6110.2', '2302.35', '6859.05', '5760.65', '496
8', '1073.3', '58.15', '492', '3608', '6239.05', '2658.4', '1600.25', '4964.7', '1267.95', '605.75', '1470.05', '730
3.05', '7511.3', '1302.65', '793.55', '1916', '1359.5', '4801.1', '2719.2', '2078.55', '268.35', '3557.7', '243.65',
'1269.6', '4475.9', '4807.35', '6118.95', '318.6', '1620.2', '3024.15', '1742.95', '5364.8', '7412.25', '24.6', '153
7.9', '450.8', '42.45', '669', '3094.65', '458.1'}
```

\*\*\*\*\* Churn \*\*\*\*\*

```
{0, 1}
```

In [22]: *# issue with TotalCharges, SeniorCitizen col they are in onject type*

```
In [23]: #customer_churn['TotalCharges']--> first need to handle if missing value
customer_churn['TotalCharges']=customer_churn['TotalCharges'].replace("", np.nan)
customer_churn['TotalCharges'].isnull().sum()
```

Out [23]: 11

```
In [24]: # filling with mode as its in object types
customer_churn['TotalCharges'].mode()
```

Out [24]: 0 20.2  
Name: TotalCharges, dtype: object

```
In [25]: customer_churn['TotalCharges']=customer_churn['TotalCharges'].fillna('20.2')
customer_churn['TotalCharges'].isnull().sum()
```

Out [25]: 0

```
In [26]: customer_churn['TotalCharges']=customer_churn['TotalCharges'].astype('float64')
customer_churn['TotalCharges'].dtypes
```

Out [26]: dtype('float64')

```
In [27]: customer_churn['SeniorCitizen']=customer_churn['SeniorCitizen'].astype('int64')
```

```
In [28]: # saving pre processed data before -> encoding for automation/pycaret approach:

customer_churn.to_csv('telecomproj1_data_forPycaret.csv', index=False)
```

```
In [29]: # drop id col
customer_churn=customer_churn.drop(['customerID'], axis=1)
```

```
In [30]: customer_churn.columns
```

Out [30]: Index(['gender', 'SeniorCitizen', 'Partner', 'Dependents', 'tenure',  
                  'PhoneService', 'MultipleLines', 'InternetService', 'OnlineSecurity',  
                  'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',  
                  'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod',  
                  'MonthlyCharges', 'TotalCharges', 'Churn'],  
              dtype='object')

```
In [31]: # one hot encoding

customer_churn=pd.get_dummies(customer_churn, columns=['gender', 'Partner', 'Dependents',
```

```
'PhoneService', 'MultipleLines', 'InternetService', 'OnlineSecurity',  
'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',  
'StreamingMovies', 'Contract', 'PaperlessBilling', 'PaymentMethod'],drop_first=True)
```

In [32]: `customer_churn.info()`

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 7043 entries, 0 to 7042  
Data columns (total 31 columns):  
#   Column                                     Non-Null Count  Dtype  
---  -  
0   SeniorCitizen                             7043 non-null   int64  
1   tenure                                    7043 non-null   int64  
2   MonthlyCharges                            7043 non-null   float64  
3   TotalCharges                             7043 non-null   float64  
4   Churn                                     7043 non-null   int64  
5   gender_Male                              7043 non-null   bool  
6   Partner_Yes                              7043 non-null   bool  
7   Dependents_Yes                           7043 non-null   bool  
8   PhoneService_Yes                         7043 non-null   bool  
9   MultipleLines_No phone service           7043 non-null   bool  
10  MultipleLines_Yes                        7043 non-null   bool  
11  InternetService_Fiber optic              7043 non-null   bool  
12  InternetService_No                       7043 non-null   bool  
13  OnlineSecurity_No internet service       7043 non-null   bool  
14  OnlineSecurity_Yes                       7043 non-null   bool  
15  OnlineBackup_No internet service         7043 non-null   bool  
16  OnlineBackup_Yes                         7043 non-null   bool  
17  DeviceProtection_No internet service     7043 non-null   bool  
18  DeviceProtection_Yes                     7043 non-null   bool  
19  TechSupport_No internet service          7043 non-null   bool  
20  TechSupport_Yes                          7043 non-null   bool  
21  StreamingTV_No internet service          7043 non-null   bool  
22  StreamingTV_Yes                          7043 non-null   bool  
23  StreamingMovies_No internet service      7043 non-null   bool  
24  StreamingMovies_Yes                      7043 non-null   bool  
25  Contract_One year                        7043 non-null   bool  
26  Contract_Two year                        7043 non-null   bool  
27  PaperlessBilling_Yes                     7043 non-null   bool  
28  PaymentMethod_Credit card (automatic)    7043 non-null   bool  
29  PaymentMethod_Electronic check          7043 non-null   bool  
30  PaymentMethod_Mailed check               7043 non-null   bool  
dtypes: bool(26), float64(2), int64(3)  
memory usage: 454.1 KB
```

In [33]: `customer_churn.head(3)`

Out[33]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Male	Partner_Yes	Dependents_Yes	PhoneService_Yes
0	0	1	29.85	29.85	0	False	True	False	False
1	0	34	56.95	1889.50	0	True	False	False	True
2	0	2	53.85	108.15	1	True	False	False	True

3 rows x 31 columns

In [34]: `# converting true=1 and false =0`

```
df= customer_churn.applymap(lambda x: int(x) if isinstance (x,bool) else x)
```

In [35]: `df.head()`

Out[35]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Churn	gender_Male	Partner_Yes	Dependents_Yes	PhoneService_Yes
0	0	1	29.85	29.85	0	0	1	0	0
1	0	34	56.95	1889.50	0	1	0	0	1
2	0	2	53.85	108.15	1	1	0	0	1
3	0	45	42.30	1840.75	0	1	0	0	0
4	0	2	70.70	151.65	1	0	0	0	1

5 rows x 31 columns

In [36]: `# split the data into x & y :`

```
x= df.drop(['Churn'],axis=1)
x.columns=='Churn'
```

Out[36]: `array([False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False, False])`

In [37]: `y= df['Churn']`

In [38]: `x.shape`

Out[38]: `(7043, 30)`

In [39]: `y.shape`

Out[39]: `(7043,)`

In [40]: `x.columns`

Out[40]: `Index(['SeniorCitizen', 'tenure', 'MonthlyCharges', 'TotalCharges', 'gender_Male', 'Partner_Yes', 'Dependents_Yes', 'PhoneService_Yes', 'MultipleLines_No phone service', 'MultipleLines_Yes', 'InternetService_Fiber optic', 'InternetService_No', 'OnlineSecurity_No internet service', 'OnlineSecurity_Yes', 'OnlineBackup_No internet service', 'OnlineBackup_Yes', 'DeviceProtection_No internet service', 'DeviceProtection_Yes', 'TechSupport_No internet service', 'TechSupport_Yes', 'StreamingTV_No internet service', 'StreamingTV_Yes', 'StreamingMovies_No internet service', 'StreamingMovies_Yes', 'Contract_One year', 'Contract_Two year', 'PaperlessBilling_Yes', 'PaymentMethod_Credit card (automatic)', 'PaymentMethod_Electronic check', 'PaymentMethod_Mailed check'], dtype='object')`

In [41]: `# Feature scaling for x: only for non binary part:-`

```
from sklearn.preprocessing import StandardScaler
scaler=StandardScaler()
scaler_columns=['tenure', 'MonthlyCharges', 'TotalCharges']
x[scaler_columns]=scaler.fit_transform(x[scaler_columns])
x.head()
```

Out [41]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	gender_Male	Partner_Yes	Dependents_Yes	PhoneService_Yes	Multipl phc
0	0	-1.277445	-1.160323	-0.992638	0	1	0	0	
1	0	0.066327	-0.259629	-0.172181	1	0	0	1	
2	0	-1.236724	-0.362660	-0.958093	1	0	0	1	
3	0	0.514251	-0.746535	-0.193689	1	0	0	0	
4	0	-1.236724	0.197365	-0.938901	0	0	0	1	

5 rows × 30 columns

In [42]:

```
# handling imbalance data set using smote technique

import imblearn
from imblearn.over_sampling import SMOTE

smote=SMOTE()
x_smote,y_smote=smote.fit_resample(x,y)
print(y.value_counts())
print()
print(y_smote.value_counts())

Churn
0    5174
1    1869
Name: count, dtype: int64

Churn
0    5174
1    5174
Name: count, dtype: int64
```

In [43]:

```
# splitting the data into training and test
```

```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x_smote,y_smote,test_size=0.3,random_state=42)
```

## Model Building:-

In [44]:

```
#importing all model then will check which one giving best model interms of accuracy:

from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier,VotingClassifier,BaggingClassifier,AdaBoostClassifier,GradientB
from sklearn.neighbors import KNeighborsClassifier
from xgboost import XGBClassifier
from sklearn.svm import SVC
from sklearn.naive_bayes import GaussianNB,BernoulliNB
from sklearn.metrics import confusion_matrix,accuracy_score,classification_report

Building all classifier model:
```

In [45]:

```
list_model=[]
list_accuracy=[]

#for logit

logit=LogisticRegression()
lr=logit.fit(x_train,y_train)
y_pred_lr=logit.predict(x_test)
accuracy_lr=accuracy_score(y_test,y_pred_lr)

# dec tree

dtree=DecisionTreeClassifier()
dt=dtree.fit(x_train,y_train)
y_pred_dt=dtree.predict(x_test)
accuracy_dt=accuracy_score(y_test,y_pred_dt)

#baggingclassifier

bagging=BaggingClassifier()
```

```

bg=bagging.fit(x_train,y_train)
y_pred_bg=bagging.predict(x_test)
accuracy_bg=accuracy_score(y_test,y_pred_bg)

#Randomforestclassifier

rforest=RandomForestClassifier()
rf=rforest.fit(x_train,y_train)
y_pred_rf=rforest.predict(x_test)
accuracy_rf=accuracy_score(y_test,y_pred_rf)

#adaboostclassifier

ada=AdaBoostClassifier()
ab=ada.fit(x_train,y_train)
y_pred_ab=ada.predict(x_test)
accuracy_ab=accuracy_score(y_test,y_pred_ab)

#gradboosting

gdboost=GradientBoostingClassifier()
gdb=gdboost.fit(x_train,y_train)
y_pred_gdb=gdboost.predict(x_test)
accuracy_gdb=accuracy_score(y_test,y_pred_gdb)

#xgboost

xgboost=XGBClassifier()
xgb=xgboost.fit(x_train,y_train)
y_pred_xgb=xgboost.predict(x_test)
accuracy_xgb=accuracy_score(y_test,y_pred_xgb)

#svm
svm=SVC()
sv=svm.fit(x_train,y_train)
y_pred_svm=svm.predict(x_test)
accuracy_svm=accuracy_score(y_test,y_pred_svm)

#KNeighborsClassifier

knn=KNeighborsClassifier()

```

localhost:8888/nbconvert/html/Desktop/Machine Learning %26 Stats/ML\_final\_project/Telecom/Telecom\_Project/Telecom\_project\_1/Jupyter/Telecom\_Domain\_Project\_1.ipynb?download=false

75/88

```

kn=knn.fit(x_train,y_train)
y_pred_knn=knn.predict(x_test)
accuracy_knn=accuracy_score(y_test,y_pred_knn)

#GussianNb

gnn=GaussianNB()
gn=gnn.fit(x_train,y_train)
y_pred_gnn=gnn.predict(x_test)
accuracy_gnn=accuracy_score(y_test,y_pred_gnn)

#BernoulliNB

bnb=BernoulliNB()
bn=bnb.fit(x_train,y_train)
y_pred_bnb=bnb.predict(x_test)
accuracy_bnb=accuracy_score(y_test,y_pred_bnb)

# votingclass- comb pred from multiple model

voting=VotingClassifier(estimators=[('lr',logit),('dt',dtree),('bg',bagging),('rf',rforest),('ada',ada),('gdb',gdbo
model_voting=voting.fit(x_train,y_train)
y_pred_voting=voting.predict(x_test)
accuracy_voting=accuracy_score(y_test,y_pred_voting)

```

Assigning all model into dataframe:

```

In [46]: models_name=['LogisticRegg','DecisionTree','Bagging','Randomforest','Adaboost','GradBoosting','XGBoost','SVM','KNN']

accuracies=[accuracy_lr,accuracy_dt,accuracy_bg,accuracy_rf,accuracy_ab,accuracy_gdb,accuracy_xgb,accuracy_svm,accu

model=[logit,dtree,bagging,rforest,ada,gdboost,xgboost,svm,knn,gnn,bnb,voting]

df_accuracy=pd.DataFrame({'MODEL_USED':models_name,
                           'ACCURACY':accuracies})
df_accuracy=df_accuracy.sort_values(by='ACCURACY',ascending=False)
df_accuracy.reset_index(drop=True)

```

Out [46]:

	MODEL_USED	ACCURACY
0	Randomforest	0.844444
1	XGBoost	0.825443
2	VotingClassifier	0.822866
3	Bagging	0.815459
4	GradBoosting	0.813849
5	LogisticRegg	0.810306
6	SVM	0.806119
7	KNN	0.801932
8	Adaboost	0.788084
9	BernoulliNB	0.770370
10	DecisionTree	0.766184
11	GaussianNB	0.760709

Evaluating most highest model:  
Random Forest:

In [47]:

```
rfEvaluation_train=rforest.predict(x_train)
rfEvaluation_test=rforest.predict(x_test)
accuracy_rf_train=accuracy_score(y_train,rfEvaluation_train)
accuracy_rf_test=accuracy_score(y_test,rfEvaluation_test)
print()
print()
print('*'*50)
print('Training accuracy: ',accuracy_rf_train)
print()
print('*'*50)
print('Test accuracy: ',accuracy_rf_test)
print()
print('*'*50)
```

```
*****
Training accuracy:  0.998895485296148

*****
Test accuracy:  0.8444444444444444

*****
```

Review:-

- This indicates train: (99%+ and test: 83%) the model fits the training data almost perfectly by memorizing, but might be overfitting as its not able to perfect on unseen data.
- So cross validation should be performed to verify whether the high training performance is genuine or just due to random variations (randomstate) in the training data.

In [48]:

```
print('Training accuracy: ',classification_report(y_train,rfEvaluation_train))
print('*'*50)
print('Test accuracy: ',classification_report(y_test,rfEvaluation_test))
```

Training accuracy:		precision	recall	f1-score	support
0	1.00	1.00	1.00	3600	
1	1.00	1.00	1.00	3643	
accuracy			1.00	7243	
macro avg		1.00	1.00	7243	
weighted avg		1.00	1.00	7243	

\*\*\*\*\*

Test accuracy:		precision	recall	f1-score	support
0	0.87	0.82	0.84	1574	
1	0.82	0.87	0.85	1531	
accuracy			0.84	3105	
macro avg		0.85	0.84	3105	
weighted avg		0.85	0.84	3105	

```
In [49]: print('-----Confusion matrix-----')
print()
print('*'*50)
print(f"Training Confusion matrix:\n{confusion_matrix(y_train, rfEvaluation_train)}")
print()
print('*'*50)
print(f"Test Confusion matrix:\n {confusion_matrix(y_test, rfEvaluation_test)}")
print()
print('*'*50)
print()
```

```
-----Confusion matrix-----

*****
Training Confusion matrix:
[[3594   6]
 [   2 3641]]

*****
Test Confusion matrix:
[[1291  283]
 [ 200 1331]]

*****
```

## Cross validation:

```
In [50]: #cross validation for rf:

from sklearn.model_selection import cross_val_score

In [51]: training=cross_val_score(rforest,x_train,y_train,cv=10)
print('Training accuracy',training.mean())
print('*'*25)
print('cv std: ',training.std())
print('*'*25)
print('Test accuracy: ',accuracy_rf_test)
```

```
Training accuracy 0.8333617831967993
*****
cv std: 0.017794711590090086
*****
Test accuracy: 0.8444444444444444
```

### Post CV:-

- Avg training accuracy: 83%
- cv\_stdDev: 0.0135
- The model is more realistic; CV shows consistent performance with low variance



- The gap between CV training and test accuracy is smaller, indicating better generalization.
- Since there is no overfitting problem now, we can consider hyperparam tuning.

Focus on recall -> recall is usually more important bcz missing a churned customer means losing a valuable customer, which is costly. so, it's crucial to focus on capturing as many churned customers as possible.

## Hyper Parameter Tuning (RandomForest) :

```
In [52]: from sklearn.model_selection import GridSearchCV
```

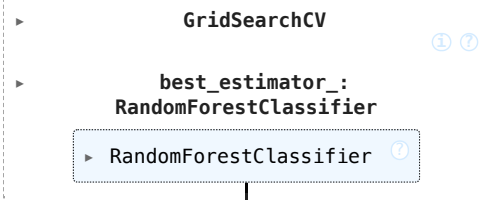
```
In [53]: param_grid = {
    'n_estimators': [100, 200, 300],
    'max_features': ['sqrt', 'log2'],
    'max_depth': [5, 10, 15, None],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
    'criterion': ['gini', 'entropy']
}

rf_tuned = RandomForestClassifier(random_state = 42)

CV_rf = GridSearchCV(estimator=rf_tuned,
                    param_grid=param_grid,
                    cv = 10,
                    scoring='recall',
                    verbose=1,
                    n_jobs=-1 )
CV_rf.fit(x_train, y_train)
```

Fitting 10 folds for each of 432 candidates, totalling 4320 fits

```
Out [53]:
```



```
In [54]: print('Best Tunned Parameters ->')
print('*' * 20)
CV_rf.best_params_
```

```
Best Tunned Parameters ->
*****
```

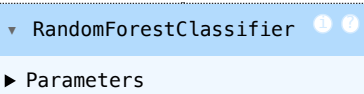
```
Out [54]: {'criterion': 'entropy',
    'max_depth': 15,
    'max_features': 'log2',
    'min_samples_leaf': 1,
    'min_samples_split': 2,
    'n_estimators': 300}
```

## Training RandomForest using Tunned Parameter:

```
In [55]: rforest_2 = RandomForestClassifier(random_state = 42,
    max_features = 'log2',
    max_depth = 15,
    n_estimators = 300,
    min_samples_leaf=1,
    min_samples_split=2,
    criterion = 'entropy')

rf2=rforest_2.fit(x_train, y_train)
rf2
```

```
Out [55]:
```



```
In [56]: # Prediction for tuned model:
y_pred_rf2=rforest_2.predict(x_test)

# accuracy for tuned model:
accuracy_rf2=accuracy_score(y_test,y_pred_rf2)
```

```
In [57]: accuracy_rf2
```

```
Out[57]: 0.8479871175523349
```

```
In [58]: # model evaluation

rf2Evaluation_train=rforest_2.predict(x_train)
rf2Evaluation_test=rforest_2.predict(x_test)
accuracy_rf2_train=accuracy_score(y_train,rf2Evaluation_train)
accuracy_rf2_test=accuracy_score(y_test,rf2Evaluation_test)
print()
print()
print('*'*50)
print('-----Accuracy Repot-----')
print()
print('*'*50)
print('Training accuracy: ',accuracy_rf2_train)
print()
print('*'*50)
print('Test accuracy: ',accuracy_rf2_test)
print()
print('*'*50)
print('-----Confusion matrix-----')
print()
print('*'*50)
print('Training Confusion matrix: \n',confusion_matrix(y_train, rf2Evaluation_train))
print()
print('*'*50)
print('Test Confusion matrix: \n',confusion_matrix(y_test, rf2Evaluation_test))
print()
print('*'*50)
print()
```

```
*****
-----Accuracy Repot-----

*****
Training accuracy: 0.9646555294767362

*****
Test accuracy: 0.8479871175523349

*****
-----Confusion matrix-----

*****
Training Confusion matrix:
[[3350 250]
 [ 6 3637]]

*****
Test Confusion matrix:
[[1269 305]
 [ 167 1364]]

*****
```

```
In [59]: # cross val on hyper parameter tuning

training_cv=cross_val_score(rforest_2,x_train,y_train,cv=10)
print('Training accuracy',training_cv.mean())
print('*'*25)
print('cv std: ',training_cv.std())
print('*'*25)
print('Test accuracy: ',accuracy_rf2_test)
```

```
Training accuracy 0.8323937892931987
*****
cv std: 0.014466867478318367
*****
Test accuracy: 0.8479871175523349
```

	precision	recall	f1-score	support
0	0.87	0.82	0.84	1574
1	0.82	0.87	0.85	1531
accuracy			0.84	3105
macro avg	0.85	0.84	0.84	3105
weighted avg	0.85	0.84	0.84	3105

	precision	recall	f1-score	support
0	0.88	0.81	0.84	1574
1	0.82	0.89	0.85	1531
accuracy			0.85	3105
macro avg	0.85	0.85	0.85	3105
weighted avg	0.85	0.85	0.85	3105

```
In [61]: print("Original Model:\n", confusion_matrix(y_test, rfEvaluation_test))
print()
print('* '*25)
print()
print("Tuned Model:\n", confusion_matrix(y_test, rf2Evaluation_test))
```

```
[[1269  305]
 [ 167 1364]]
```

- the tuned random forest model provides balanced performance
- with improved recall for churners, stable cross-validation accuracy,
- and acceptable variance.
- it captures customer churns more effectively,
- making it a better choice for deployment over the original model.

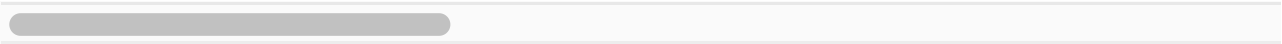
```
In [62]: rf2_res = pd.DataFrame(y_pred_rf2, columns=['prediction']).reset_index(drop=True)
x_test_output = x_test.reset_index(drop=True)

final_results = pd.concat([x_test_output, rf2_res], axis=1)
final_results.head()
```

Out [62]:

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	gender_Male	Partner_Yes	Dependents_Yes	PhoneService_Yes	Multipl phc
0	1	0.582773	0.635481	0.716429	1	0	0	1	
1	0	-0.870241	-1.477726	-0.897143	0	0	0	1	
2	0	0.962175	1.104706	1.319523	0	1	0	1	
3	0	0.486316	-0.937874	-0.320938	0	1	0	0	
4	0	1.043616	1.325725	1.738212	1	0	0	1	

5 rows × 31 columns



## Saving the model:

```
In [63]: import pickle

In [64]: with open('telco_churn_model_jupyter.pkl', 'wb') as file:
          pickle.dump(rf2, file)

          print("The final mode i.e, the tuned model (rf2), \nhas been successfully saved as telco_churn_model_jupyter.pkl.")

The final mode i.e, the tuned model (rf2),
has been successfully saved as telco_churn_model_jupyter.pkl.
```

----- END -----

```
In [ ]:

In [ ]:

In [ ]:
```

```
In [ ]:

In [ ]:

In [ ]:

In [ ]:
```