



Customer Churn Prediction

Data loading

Import pandas and load the dataset, then display the first 5 rows.

```
In [3]: import pandas as pd  
  
import warnings  
warnings.filterwarnings('ignore')  
  
df = pd.read_csv('/content/WA_Fn-UseC_-Telco-Customer-Churn.csv')  
display(df.head())
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService
0	7590-VHVEG	Female	0	Yes	No	1	N
1	5575-GNVDE	Male	0	No	No	34	Ye
2	3668-QPYBK	Male	0	No	No	2	Ye
3	7795-CFOCW	Male	0	No	No	45	N
4	9237-HQITU	Female	0	No	No	2	Ye

5 rows × 21 columns

Display the data types and a summary of the dataset to understand the data types of columns and check for non-null values.

```
In [4]: display(df.info())  
display(df.describe())
```

```

<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
None

```

	SeniorCitizen	tenure	MonthlyCharges
count	7043.000000	7043.000000	7043.000000
mean	0.162147	32.371149	64.761692
std	0.368612	24.559481	30.090047
min	0.000000	0.000000	18.250000
25%	0.000000	9.000000	35.500000
50%	0.000000	29.000000	70.350000
75%	0.000000	55.000000	89.850000
max	1.000000	72.000000	118.750000

Data Cleaning

Check for missing values in the dataset and convert the 'TotalCharges' column to numeric as it was identified as object type during the initial inspection.

```
In [5]: # Convert 'TotalCharges' to numeric, coercing errors to NaN  
df['TotalCharges'] = pd.to_numeric(df['TotalCharges'], errors='coerce')  
  
# Check for missing values again after conversion  
display(df.isnull().sum())
```

	0
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

Fill the missing values in the 'TotalCharges' column with the median.

```
In [6]: # Fill missing values in 'TotalCharges' with the median  
df['TotalCharges'].fillna(df['TotalCharges'].median(), inplace=True)  
  
display(df.isnull().sum())
```

	0
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	0
Churn	0

dtype: int64

Exploratory Data Analysis (EDA)

Visualize the distribution of the 'Churn' column to understand the class balance and examine the distribution of some categorical features to identify relationships with churn.

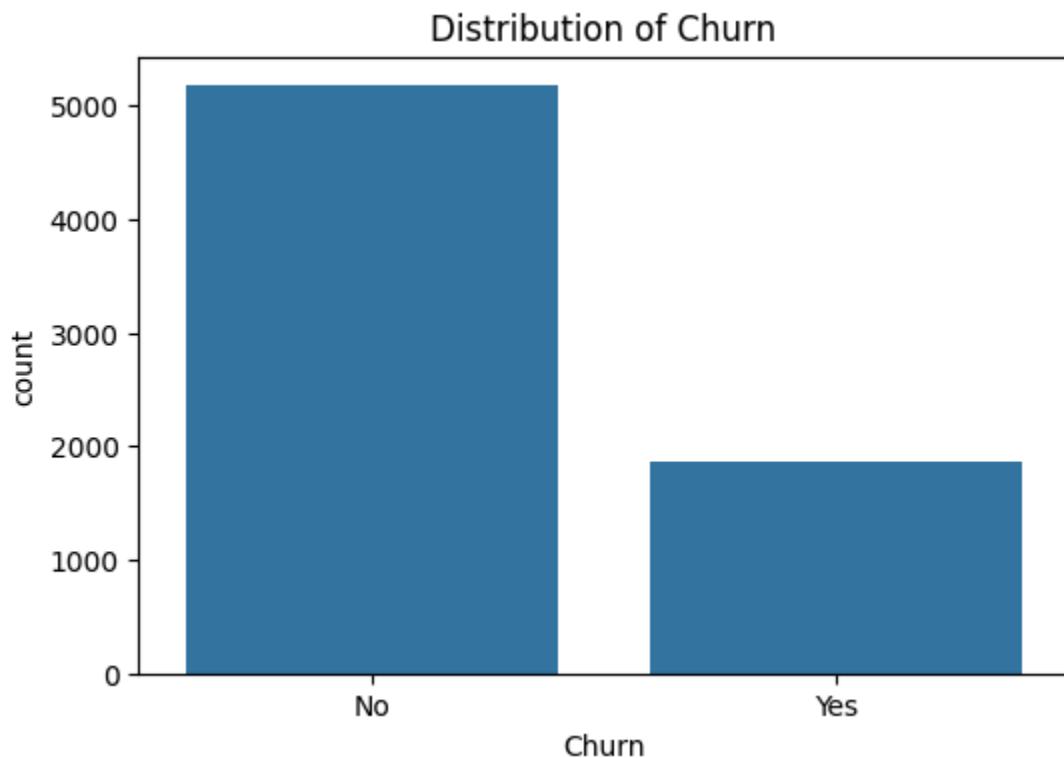
```
In [7]: import matplotlib.pyplot as plt
import seaborn as sns

# Distribution of Churn
```

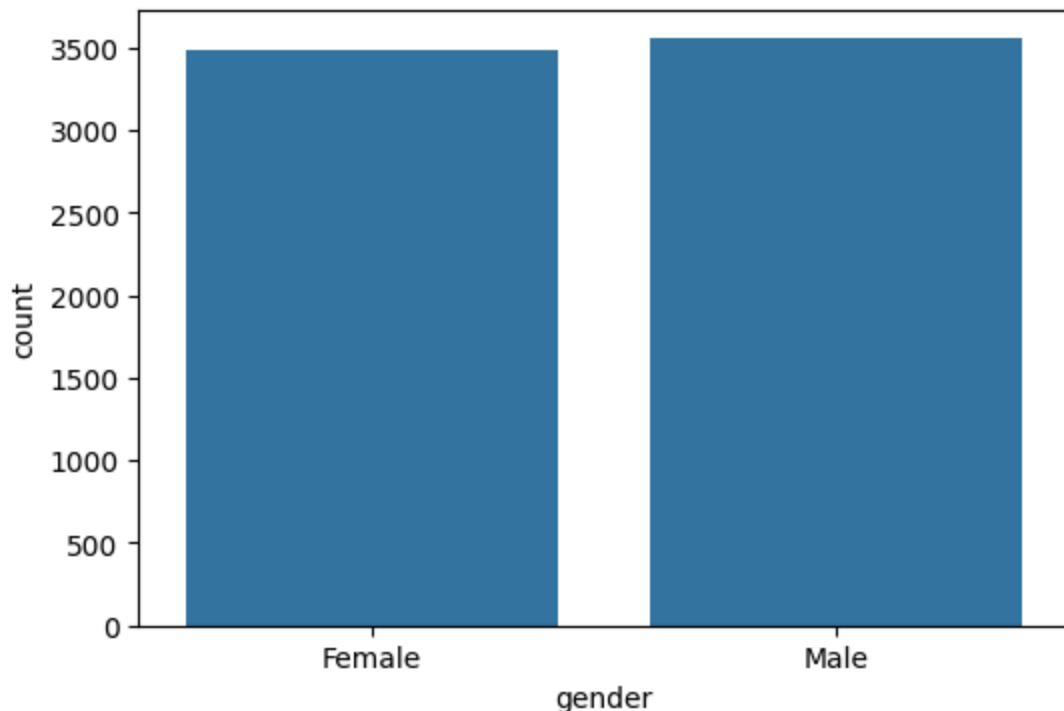
```
plt.figure(figsize=(6, 4))
sns.countplot(x='Churn', data=df)
plt.title('Distribution of Churn')
plt.show()

# Distribution of Gender
plt.figure(figsize=(6, 4))
sns.countplot(x='gender', data=df)
plt.title('Distribution of Gender')
plt.show()

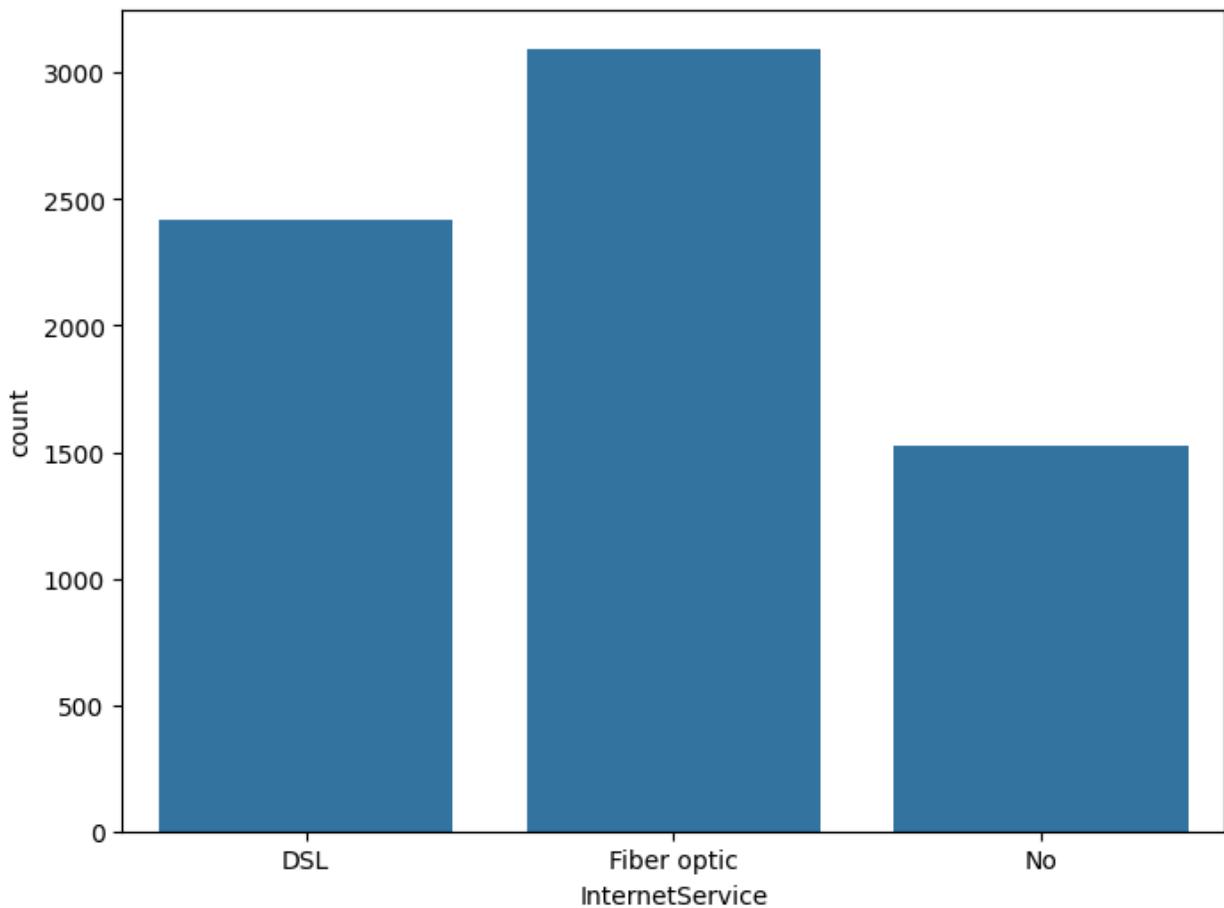
# Distribution of InternetService
plt.figure(figsize=(8, 6))
sns.countplot(x='InternetService', data=df)
plt.title('Distribution of Internet Service')
plt.show()
```



Distribution of Gender



Distribution of Internet Service



Visualize the relationship between various categorical features and the 'Churn' using countplots to understand which categories have a higher churn rate.

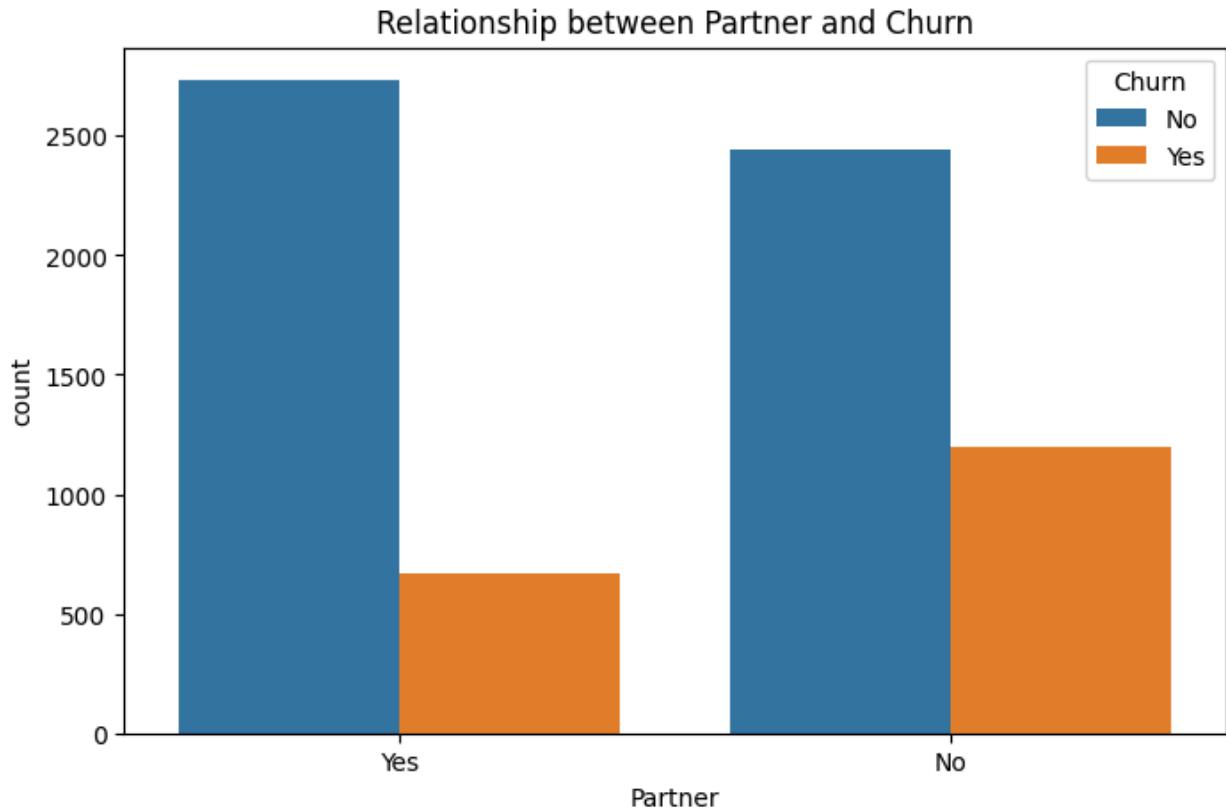
Also, visualize the distribution of numerical features using histograms to identify their patterns and potential outliers.

```
In [8]: # Relationship between categorical features and Churn
categorical_features = ['Partner', 'Dependents', 'PhoneService', 'MultipleLine',
                        'OnlineBackup', 'DeviceProtection', 'TechSupport', 'StreamingTV',
                        'Contract', 'PaperlessBilling', 'PaymentMethod']

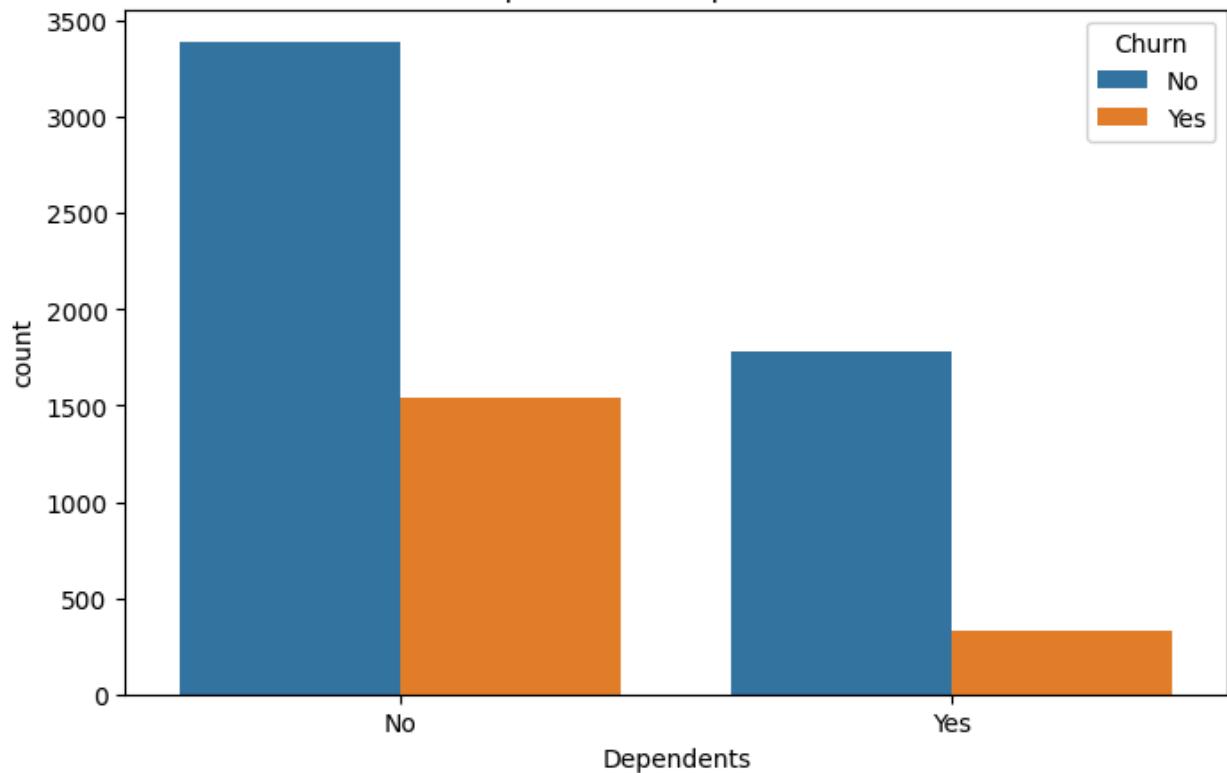
for feature in categorical_features:
    plt.figure(figsize=(8, 5))
    sns.countplot(x=feature, hue='Churn', data=df)
    plt.title(f'Relationship between {feature} and Churn')
    plt.show()

# Distribution of numerical features
numerical_features = ['tenure', 'MonthlyCharges', 'TotalCharges']

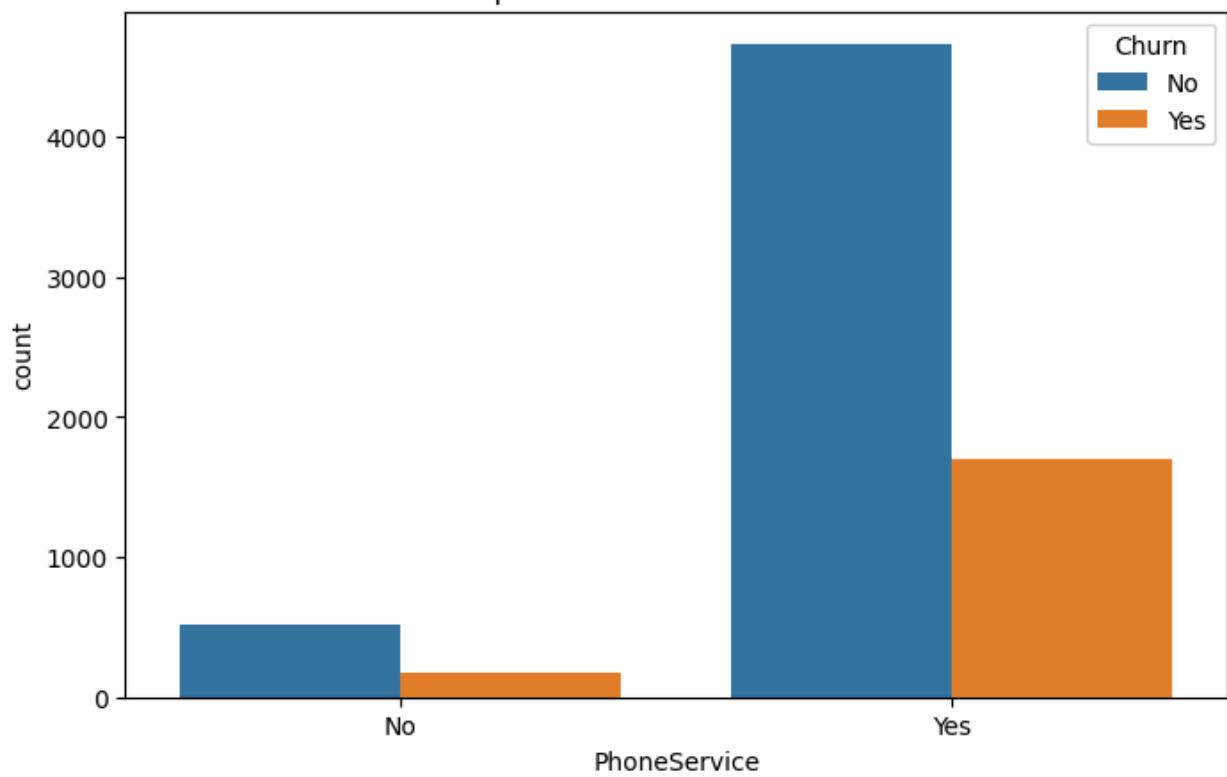
for feature in numerical_features:
    plt.figure(figsize=(8, 5))
    sns.histplot(data=df, x=feature, hue='Churn', kde=True)
    plt.title(f'Distribution of {feature} by Churn')
    plt.show()
```



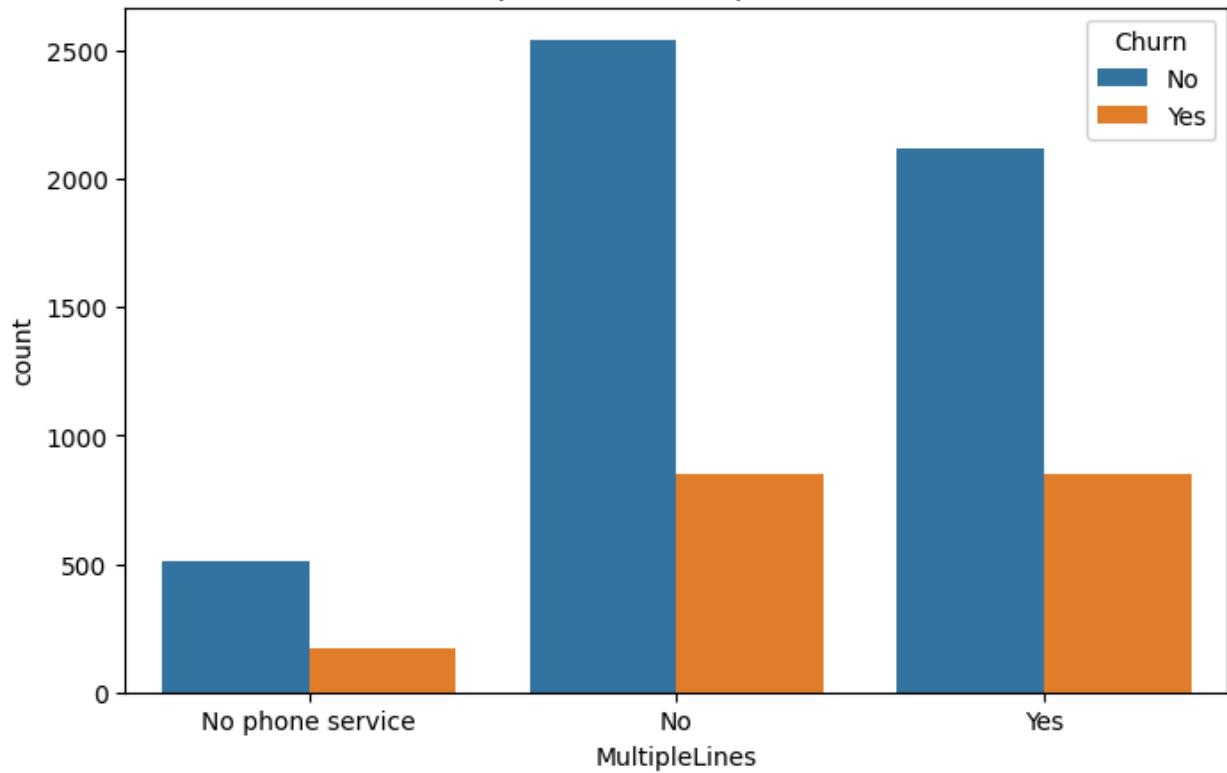
Relationship between Dependents and Churn



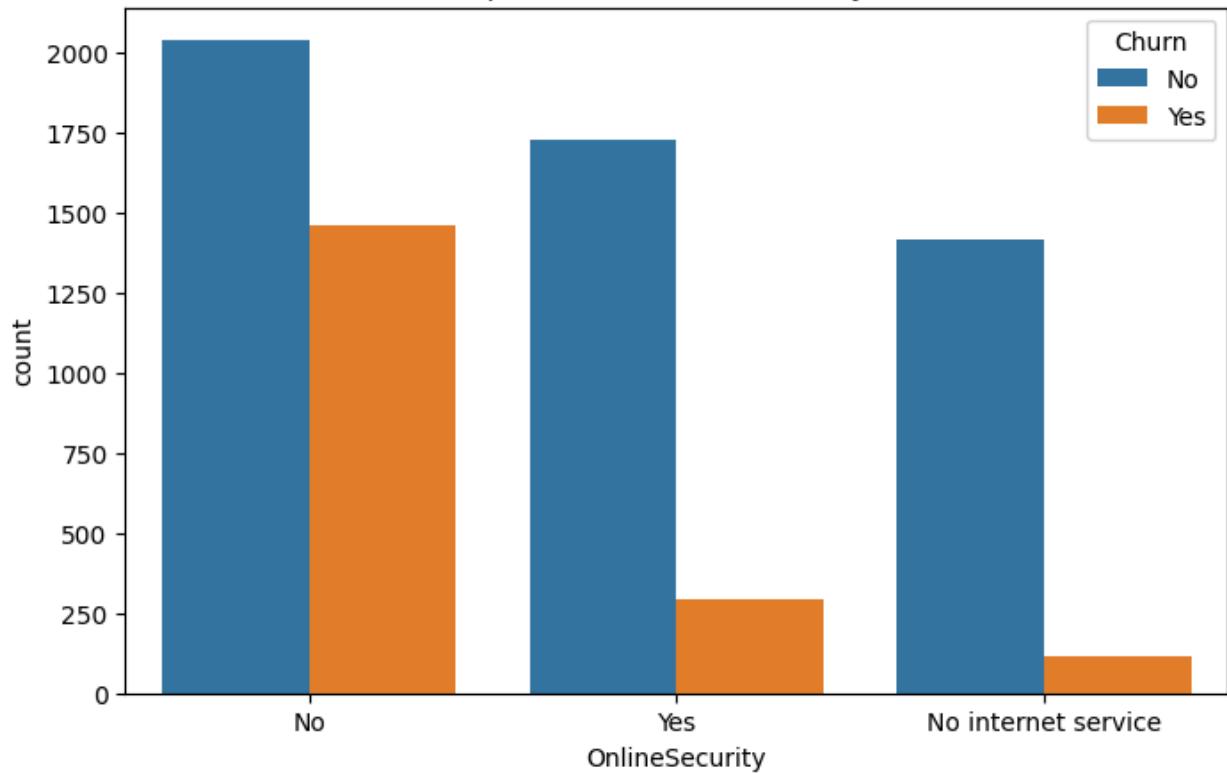
Relationship between PhoneService and Churn

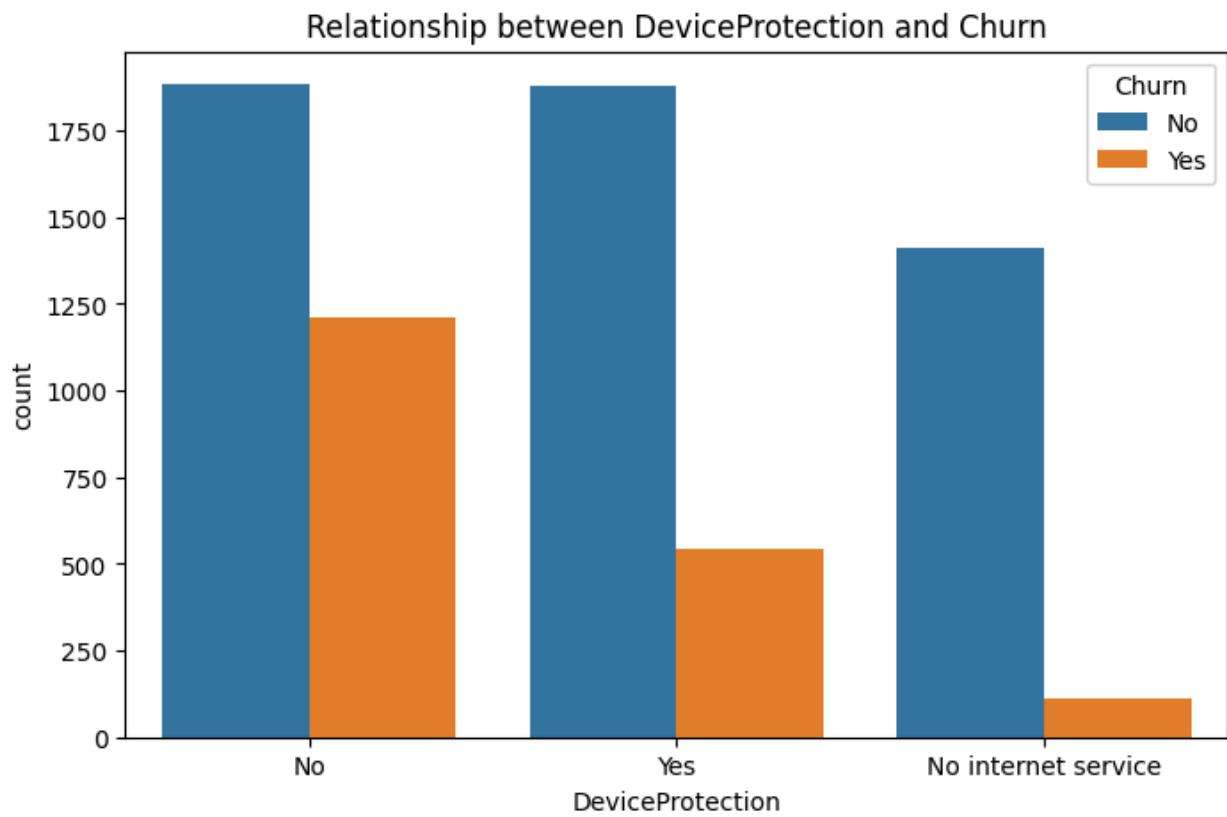
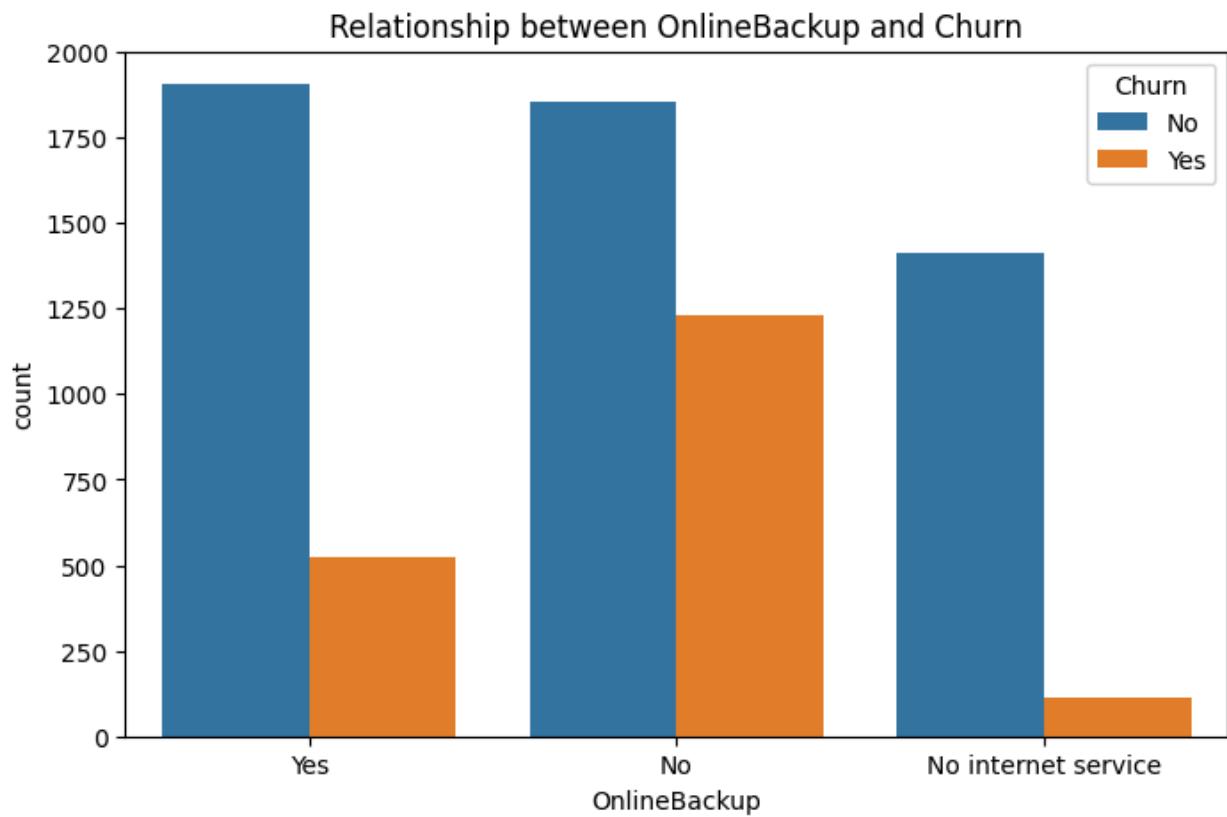


Relationship between MultipleLines and Churn

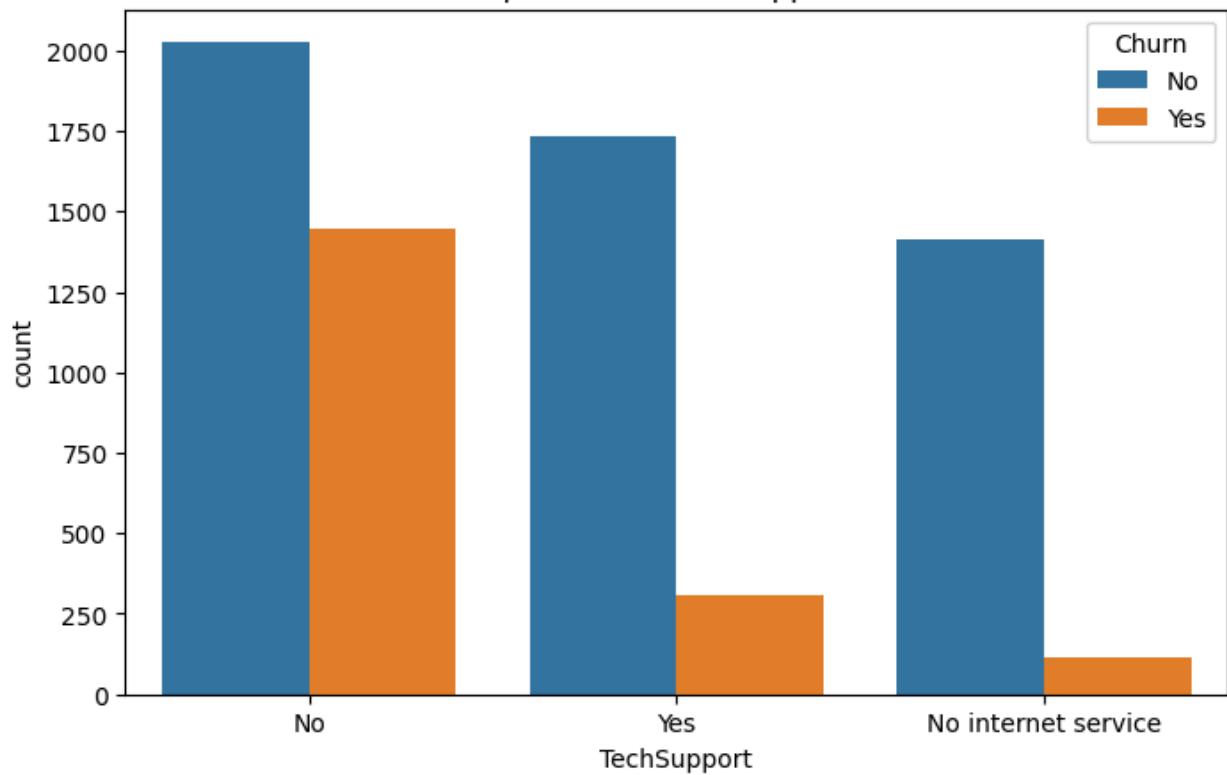


Relationship between OnlineSecurity and Churn

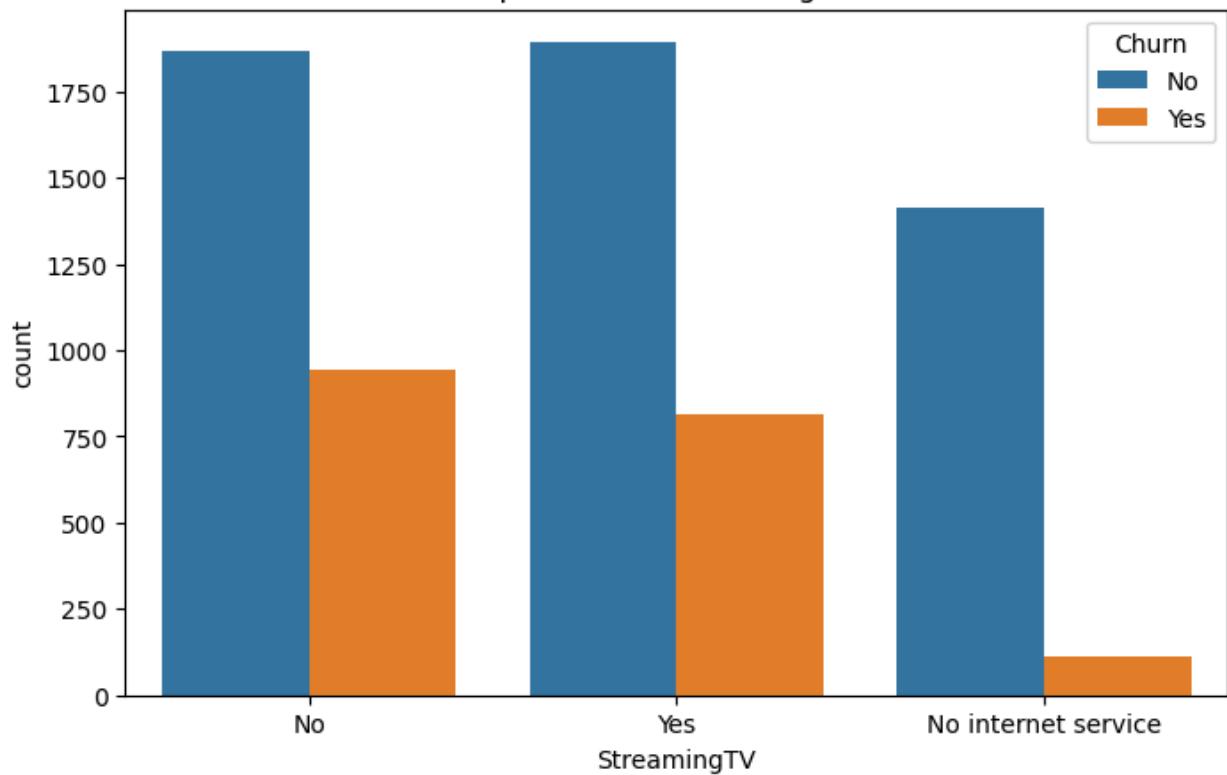




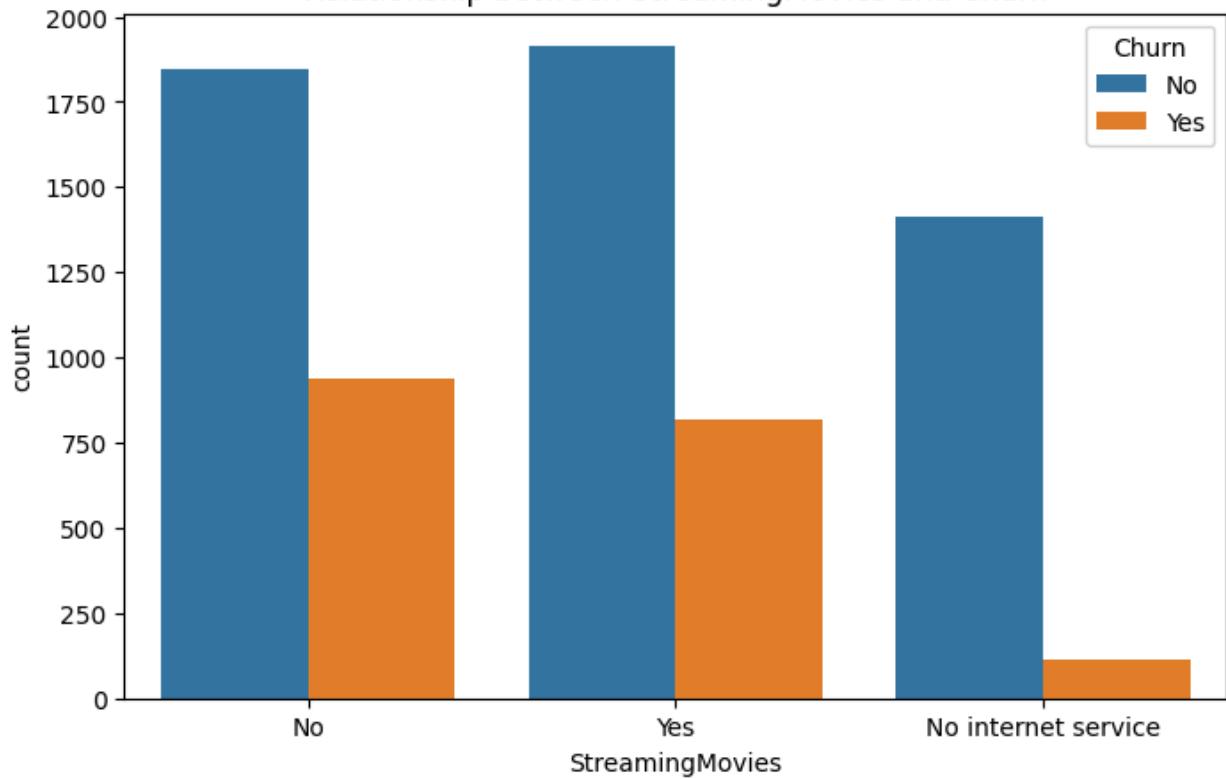
Relationship between TechSupport and Churn



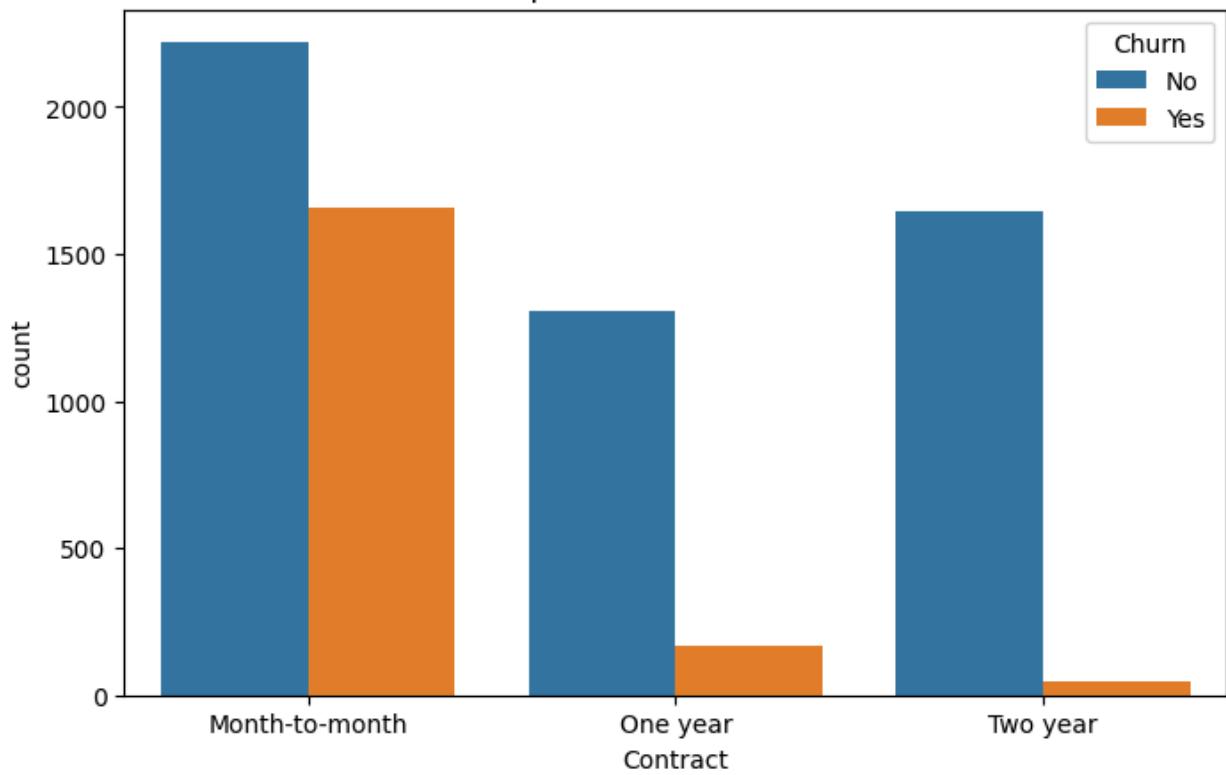
Relationship between StreamingTV and Churn



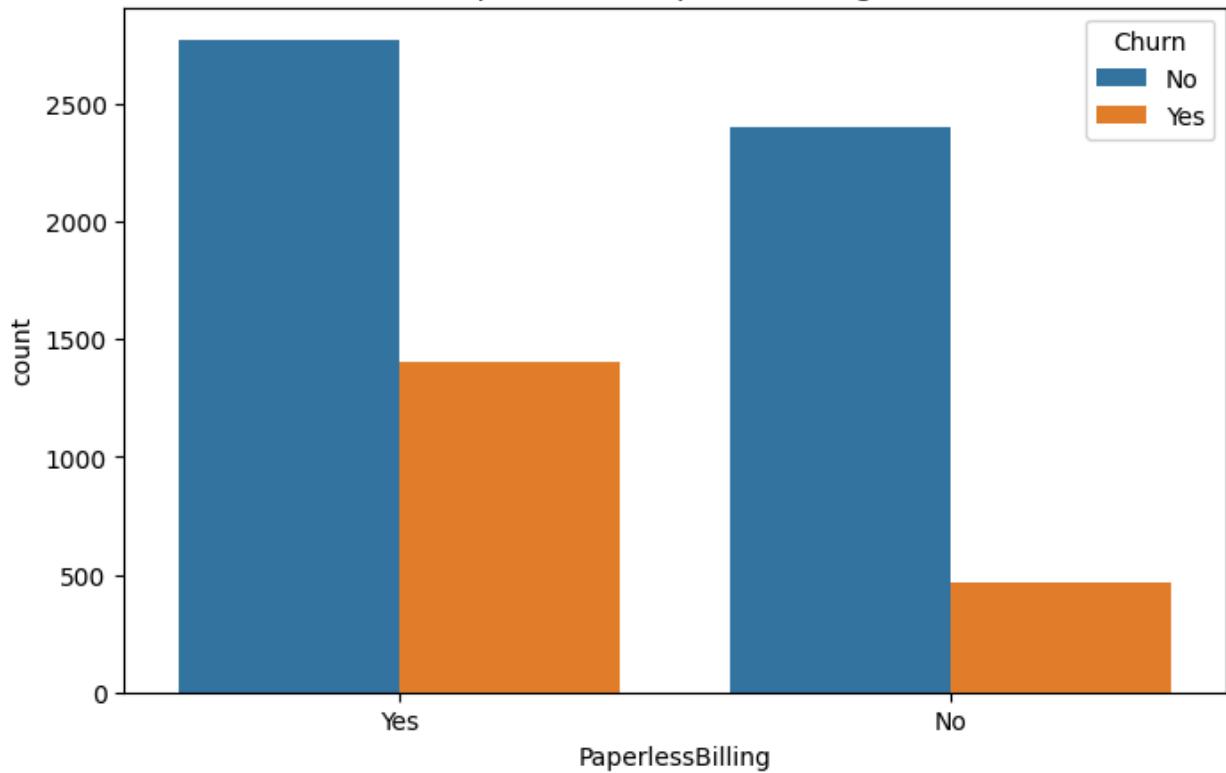
Relationship between StreamingMovies and Churn



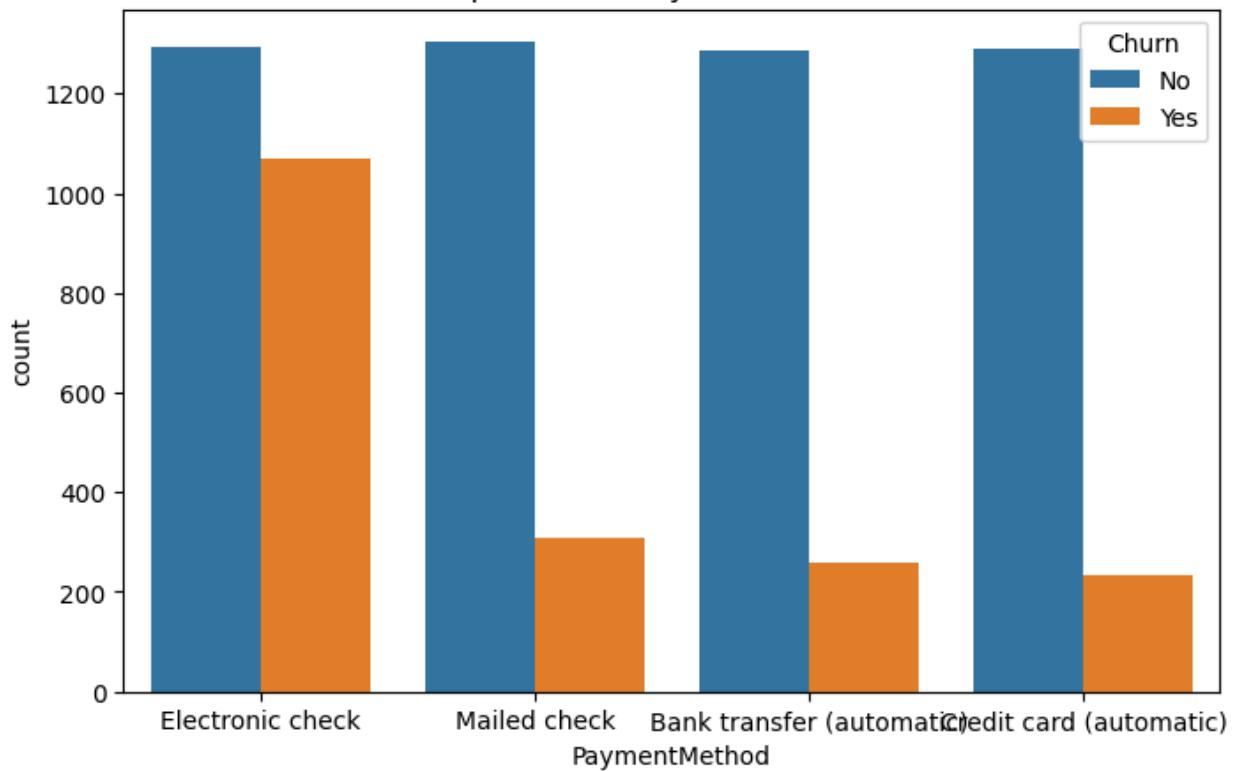
Relationship between Contract and Churn



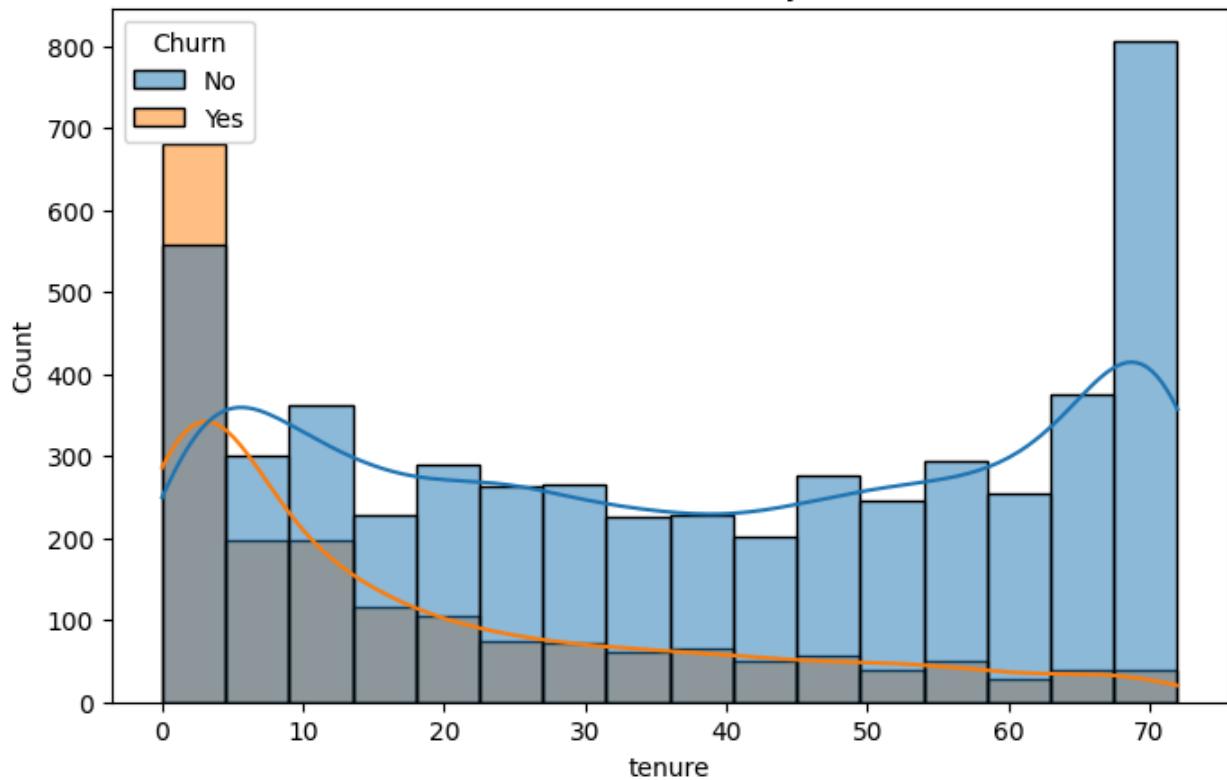
Relationship between PaperlessBilling and Churn



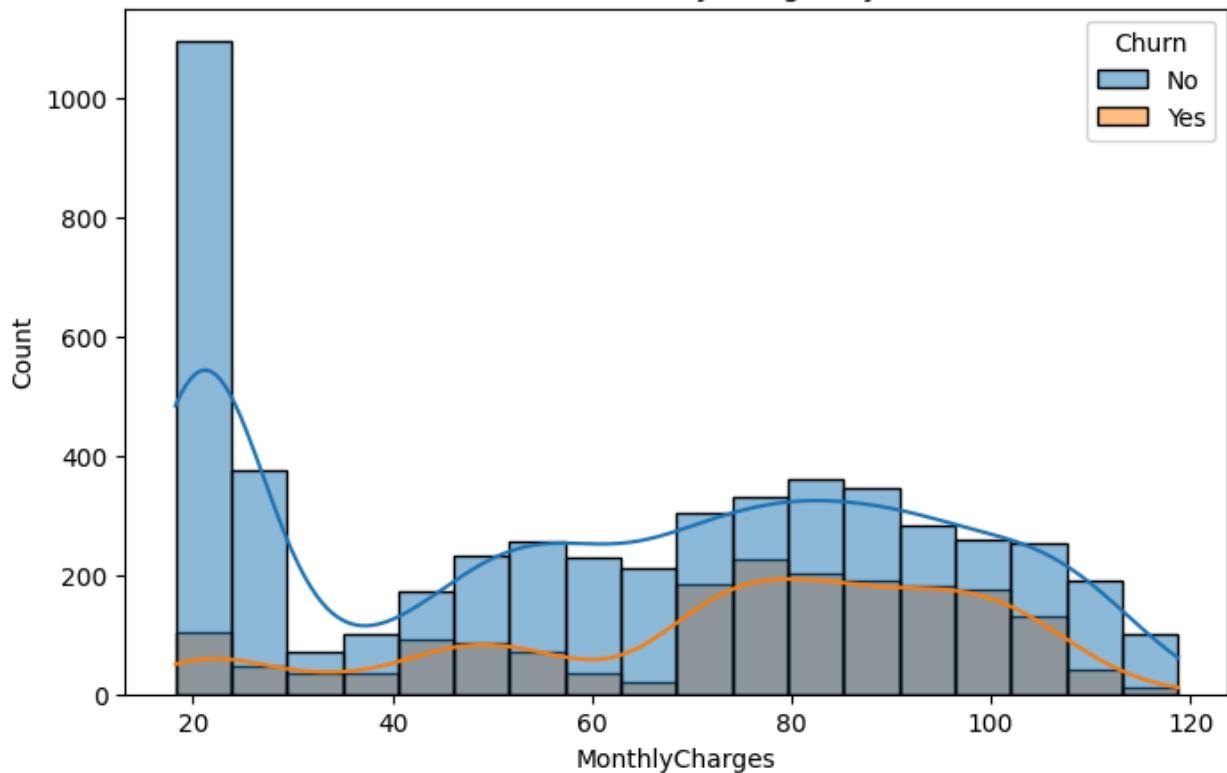
Relationship between PaymentMethod and Churn

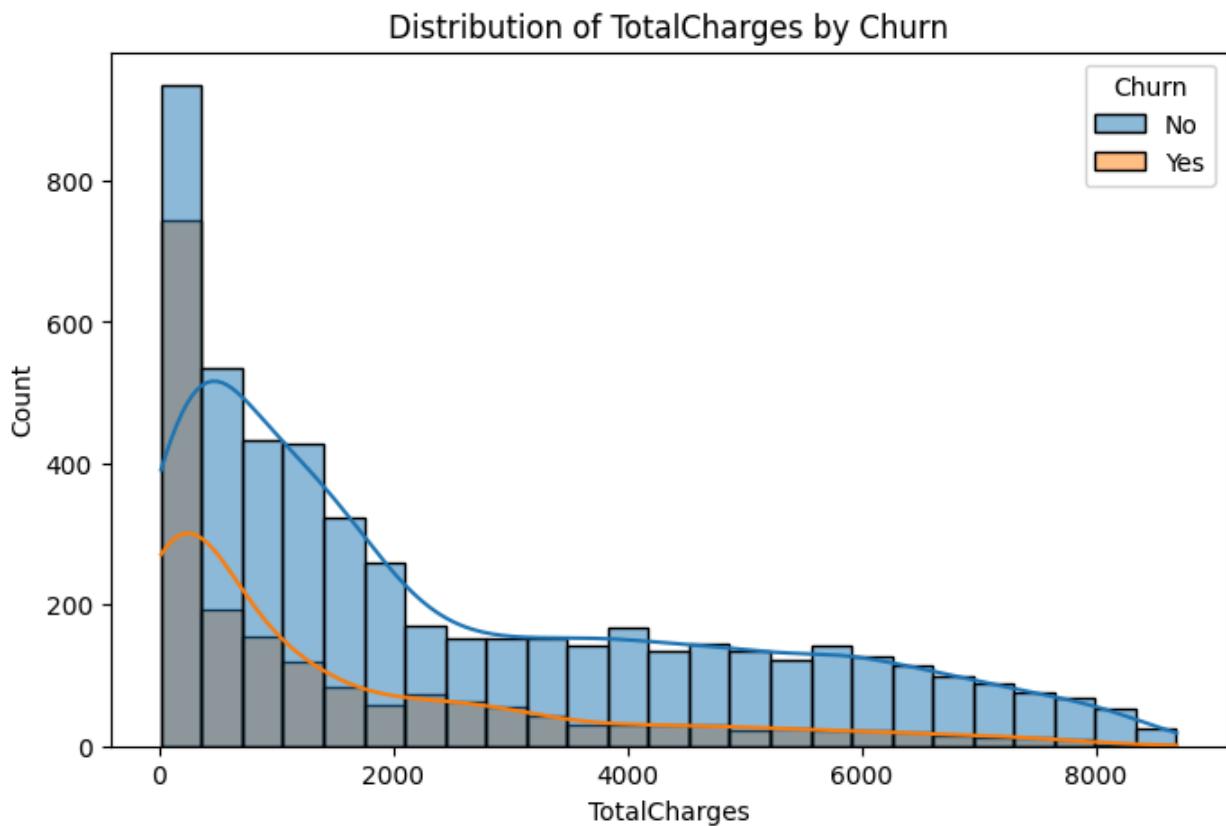


Distribution of tenure by Churn



Distribution of MonthlyCharges by Churn





Feature Engineering

Create new features like 'Monthly to Total Charges Ratio' and 'Has Internet' to potentially capture more information and improve model performance.

```
In [9]: # Create a new feature: Monthly to Total Charges Ratio
df['Monthly_to_Total_Charges_Ratio'] = df['MonthlyCharges'] / df['TotalCharges']

# Create a new feature: Has Internet
df['HasInternet'] = df['InternetService'].apply(lambda x: 0 if x == 'No' else 1)

# Display the first few rows with new features
display(df.head())
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService
0	7590-VHVEG	Female	0	Yes	No	1	N
1	5575-GNVDE	Male	0	No	No	34	Ye
2	3668-QPYBK	Male	0	No	No	2	Ye
3	7795-CFOCW	Male	0	No	No	45	N
4	9237-HQITU	Female	0	No	No	2	Ye

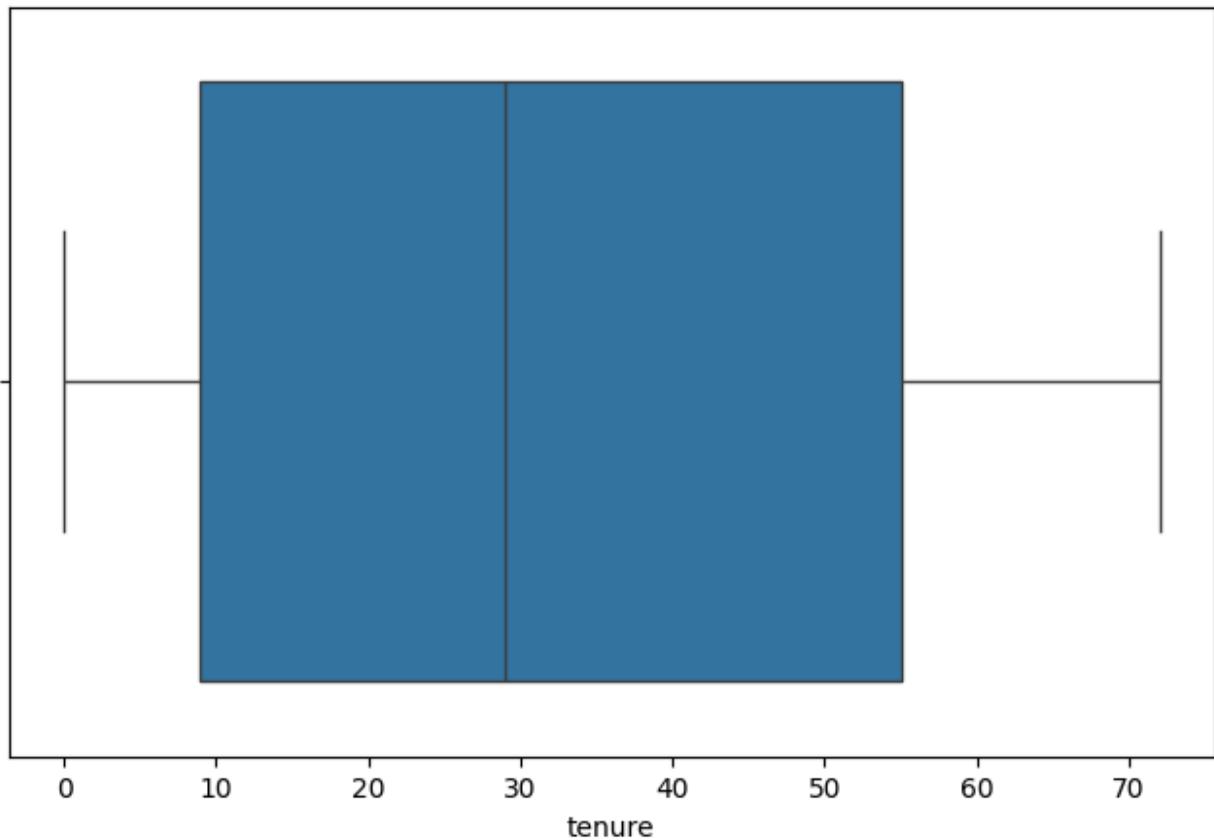
5 rows × 23 columns

Outlier Detection and Handling

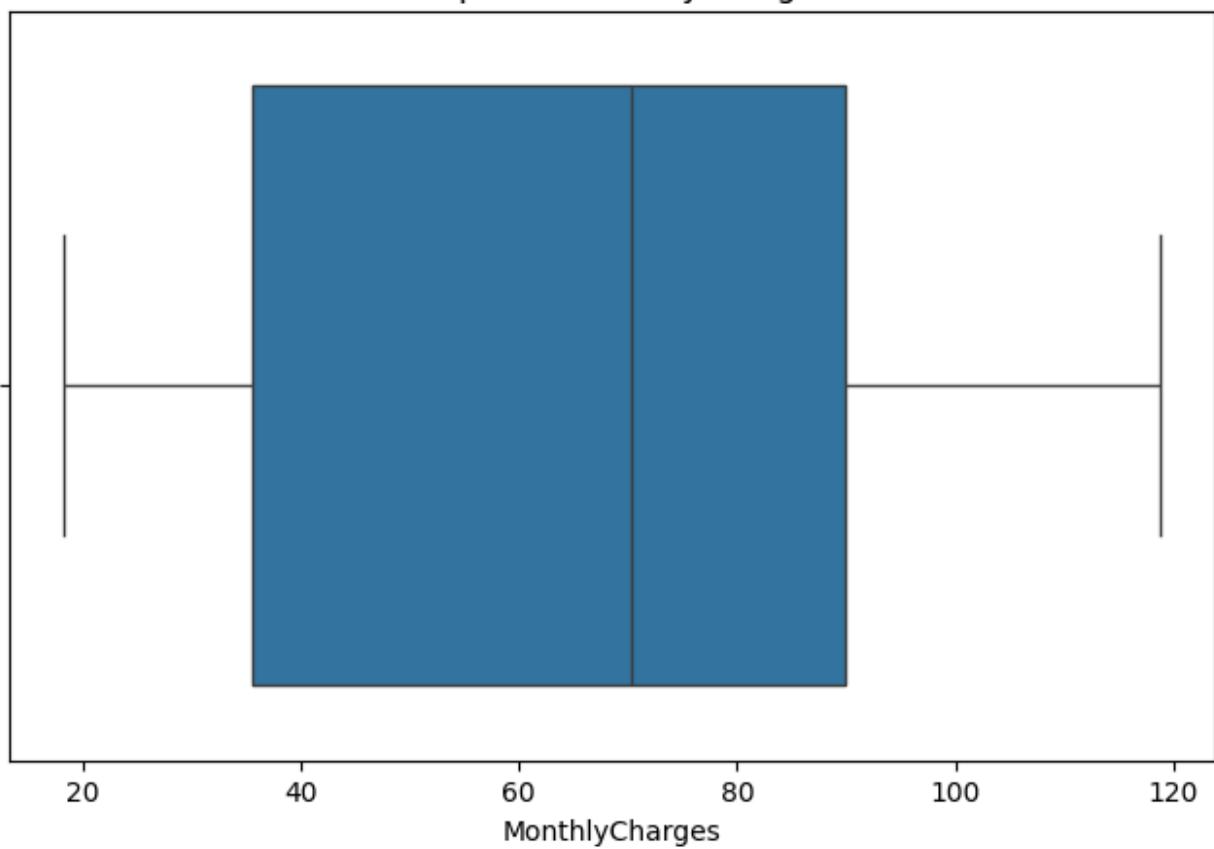
Use box plots to visualize the distribution of numerical features and identify outliers.

```
In [10]: # Visualize outliers using box plots
numerical_features = ['tenure', 'MonthlyCharges', 'TotalCharges', 'Monthly_to_
for feature in numerical_features:
    plt.figure(figsize=(8, 5))
    sns.boxplot(x=df[feature])
    plt.title(f'Box plot of {feature}')
    plt.show()
```

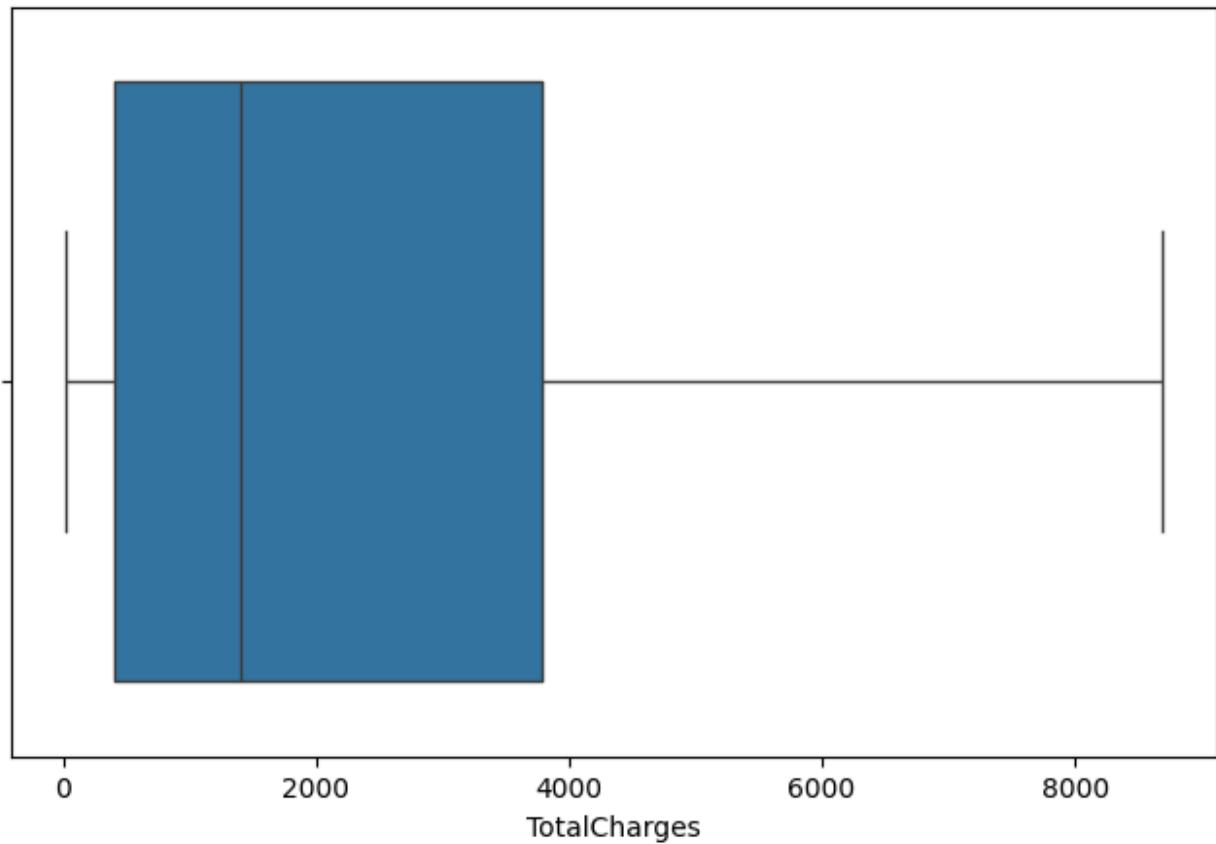
Box plot of tenure



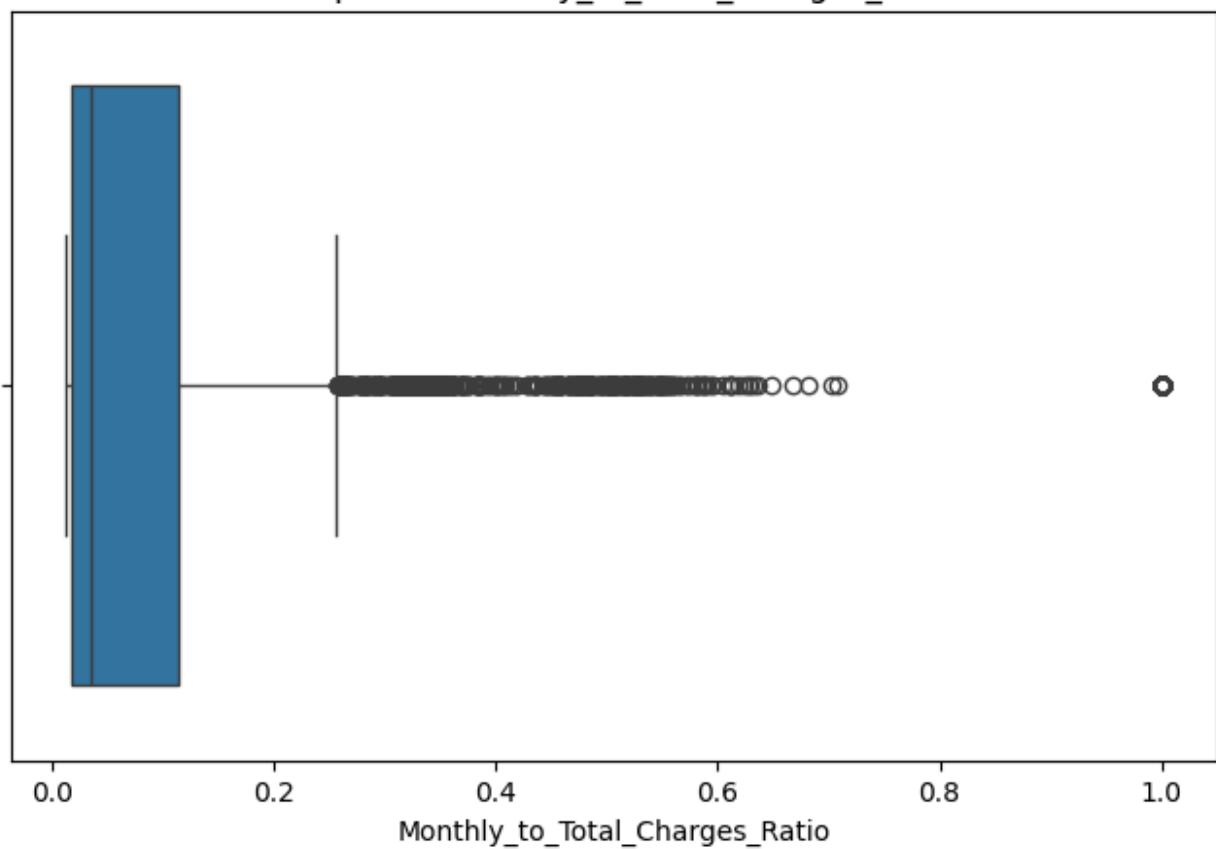
Box plot of MonthlyCharges



Box plot of TotalCharges



Box plot of Monthly_to_Total_Charges_Ratio



Handling Class Imbalance

Handle the class imbalance in the target variable using oversampling with SMOTE to improve model performance on the minority class.

```
In [11]: !pip install imbalanced-learn

from imblearn.over_sampling import SMOTE
from sklearn.model_selection import train_test_split

# Separate features and target
X = df.drop('Churn', axis=1)
y = df['Churn']

# Convert categorical features to dummy variables
X = pd.get_dummies(X)

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Apply SMOTE to the training data
smote = SMOTE(random_state=42)
X_train_sampled, y_train_sampled = smote.fit_resample(X_train, y_train)

# Display the distribution of the target variable after resampling
display(y_train_sampled.value_counts())
```

```
Requirement already satisfied: imbalanced-learn in /usr/local/lib/python3.12/dist-packages (0.14.0)
Requirement already satisfied: numpy<3,>=1.25.2 in /usr/local/lib/python3.12/dist-packages (from imbalanced-learn) (2.0.2)
Requirement already satisfied: scipy<2,>=1.11.4 in /usr/local/lib/python3.12/dist-packages (from imbalanced-learn) (1.16.2)
Requirement already satisfied: scikit-learn<2,>=1.4.2 in /usr/local/lib/python3.12/dist-packages (from imbalanced-learn) (1.6.1)
Requirement already satisfied: joblib<2,>=1.2.0 in /usr/local/lib/python3.12/dist-packages (from imbalanced-learn) (1.5.2)
Requirement already satisfied: threadpoolctl<4,>=2.0.0 in /usr/local/lib/python3.12/dist-packages (from imbalanced-learn) (3.6.0)
```

count

Churn

No	4139
Yes	4139

dtype: int64

Data Preprocessing

Scale numerical features using StandardScaler and encode categorical features using One-Hot Encoding to prepare the data for model training. We will use the resampled training data for fitting the scaler and encoder to avoid data leakage.

```
In [12]: from sklearn.preprocessing import StandardScaler

# Identify numerical and categorical features (excluding the target and custom
numerical_features = ['tenure', 'MonthlyCharges', 'TotalCharges', 'Monthly_to_
categorical_features = X_train_sampled.select_dtypes(include='bool').columns.t

# Scale numerical features
scaler = StandardScaler()
X_train_sampled[numerical_features] = scaler.fit_transform(X_train_sampled[num
X_test[numerical_features] = scaler.transform(X_test[numerical_features])

# Display the first few rows of the preprocessed training data
display(X_train_sampled.head())
```

	SeniorCitizen	tenure	MonthlyCharges	TotalCharges	Monthly_to_Total_Charg
0	0	0.289835	-0.662262	-0.175158	
1	0	-0.542950	0.238505	-0.424976	
2	0	-0.626228	-0.963097	-0.679835	
3	0	-0.084918	0.182859	-0.082492	
4	0	-1.125899	-0.823983	-0.927700	

5 rows × 7090 columns

Model Selection and Building

Build a simple Deep Learning model to predict churn.

```
In [13]: import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Build Deep Learning model
dl_model = Sequential([
    Dense(32, activation='relu', input_shape=(X_train_sampled.shape[1],)),
    Dense(16, activation='relu'),
    Dense(1, activation='sigmoid')
])
```

```
# Compile the Deep Learning model
dl_model.compile(optimizer='adam',
                  loss='binary_crossentropy',
                  metrics=['accuracy'])

print("Models built successfully.")
```

Models built successfully.

Build and train Logistic Regression, Random Forest, Decision Tree, and Gradient Boosting models.

```
In [14]: from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.tree import DecisionTreeClassifier

# Build Logistic Regression model
lg_model = LogisticRegression(random_state=42)

# Build Random Forest model
rf_model = RandomForestClassifier(random_state=42)

# Build Decision Tree model
dt_model = DecisionTreeClassifier(random_state=42)

# Build Gradient Boosting model
gb_model = GradientBoostingClassifier(random_state=42)

# Train Logistic Regression model
lg_model.fit(X_train_sampled, y_train_sampled)

# Train Random Forest model
rf_model.fit(X_train_sampled, y_train_sampled)

# Train Decision Tree model
dt_model.fit(X_train_sampled, y_train_sampled)

# Train Gradient Boosting model
gb_model.fit(X_train_sampled, y_train_sampled)

print("Logistic Regression, Random Forest, Decision Tree, and Gradient Boosting models built and trained successfully.")
```

Logistic Regression, Random Forest, Decision Tree, and Gradient Boosting models built and trained successfully.

Model Training and Evaluation

Train the Deep Learning model on the resampled training data and evaluate their performance on the test set using accuracy and a classification report.

```
In [15]: from sklearn.metrics import classification_report, accuracy_score, precision_s
```

```

# Convert y_train_resampled to numeric for Deep Learning model
y_train_sampled_numeric = y_train_sampled.apply(lambda x: 1 if x == 'Yes' else 0)

# Train Deep Learning model
history = dl_model.fit(X_train_sampled, y_train_sampled_numeric, epochs=50, batch_size=32)

# Predict on the test set
y_pred_dl_prob = dl_model.predict(X_test)
y_pred_dl = (y_pred_dl_prob > 0.5).astype("int64")

# Convert y_test to numeric for classification report
y_test_numeric = y_test.apply(lambda x: 1 if x == 'Yes' else 0)

# Evaluate Deep Learning model
dl_accuracy = accuracy_score(y_test_numeric, y_pred_dl)
dl_report = classification_report(y_test_numeric, y_pred_dl)

print("\nDeep Learning Model Evaluation:")
print(f"Accuracy: {dl_accuracy}")
print("Classification Report:")
print(dl_report)

```

45/45 ————— 0s 3ms/step

Deep Learning Model Evaluation:

Accuracy: 0.7735982966643009

Classification Report:

	precision	recall	f1-score	support
0	0.78	0.97	0.86	1035
1	0.75	0.22	0.34	374
accuracy			0.77	1409
macro avg	0.76	0.60	0.60	1409
weighted avg	0.77	0.77	0.72	1409

Evaluate the performance of the Logistic Regression, Random Forest, Decision Tree, and Gradient Boosting models using accuracy and a classification report to compare them with the other models.

```

In [16]: from sklearn.metrics import classification_report, accuracy_score, precision_score, recall_score, f1_score
# List of models and their corresponding names
models = [
    ('Logistic Regression', lg_model),
    ('Random Forest', rf_model),
    ('Decision Tree', dt_model),
    ('Gradient Boosting', gb_model)
]

```

```
# Convert y_test to numeric for evaluation metrics
y_test_numeric = y_test.apply(lambda x: 1 if x == 'Yes' else 0)

for model_name, model in models:
    # Predict on the test set
    y_pred = model.predict(X_test)

    # Convert predictions to numeric if they are not already (for consistent eval)
    y_pred_numeric = pd.Series(y_pred).apply(lambda x: 1 if x == 'Yes' or x == 'No' else 0)

    # Evaluate model
    accuracy = accuracy_score(y_test_numeric, y_pred_numeric)
    precision = precision_score(y_test_numeric, y_pred_numeric, pos_label=1)
    f1_score_val = f1_score(y_test_numeric, y_pred_numeric, pos_label=1)
    recall = recall_score(y_test_numeric, y_pred_numeric, pos_label=1)
    report = classification_report(y_test_numeric, y_pred_numeric)

    print(f"\n{model_name} Model Evaluation:")
    print(f"Accuracy: {accuracy}")
    print(f"Precision: {precision}")
    print(f"F1-Score: {f1_score_val}")
    print(f"Recall: {recall}")
    print("-" * 30) # Separator for clarity
    print("Classification Report:")
    print(report)
    print("-" * 30) # Separator for clarity
```

Logistic Regression Model Evaluation:

Accuracy: 0.8112136266855926
Precision: 0.6753246753246753
F1-Score: 0.6099706744868035
Recall: 0.5561497326203209

Classification Report:

	precision	recall	f1-score	support
0	0.85	0.90	0.88	1035
1	0.68	0.56	0.61	374
accuracy			0.81	1409
macro avg	0.76	0.73	0.74	1409
weighted avg	0.80	0.81	0.80	1409

Random Forest Model Evaluation:

Accuracy: 0.7849538679914834
Precision: 0.6053412462908012
F1-Score: 0.5738396624472574
Recall: 0.5454545454545454

Classification Report:

	precision	recall	f1-score	support
0	0.84	0.87	0.86	1035
1	0.61	0.55	0.57	374
accuracy			0.78	1409
macro avg	0.72	0.71	0.72	1409
weighted avg	0.78	0.78	0.78	1409

Decision Tree Model Evaluation:

Accuracy: 0.7721788502484032
Precision: 0.5786350148367952
F1-Score: 0.5485232067510548
Recall: 0.5213903743315508

Classification Report:

	precision	recall	f1-score	support
0	0.83	0.86	0.85	1035
1	0.58	0.52	0.55	374
accuracy			0.77	1409
macro avg	0.71	0.69	0.70	1409
weighted avg	0.77	0.77	0.77	1409

Gradient Boosting Model Evaluation:

Accuracy: 0.7856635911994322
Precision: 0.5913705583756346

```
F1-Score: 0.6067708333333334
Recall: 0.6229946524064172
-----
Classification Report:
precision    recall   f1-score   support
0            0.86      0.84      0.85      1035
1            0.59      0.62      0.61       374
accuracy                           0.79      1409
macro avg       0.73      0.73      0.73      1409
weighted avg    0.79      0.79      0.79      1409
-----
```

Model Comparison

Create a table to compare the performance metrics of all built models.

Feature Importance

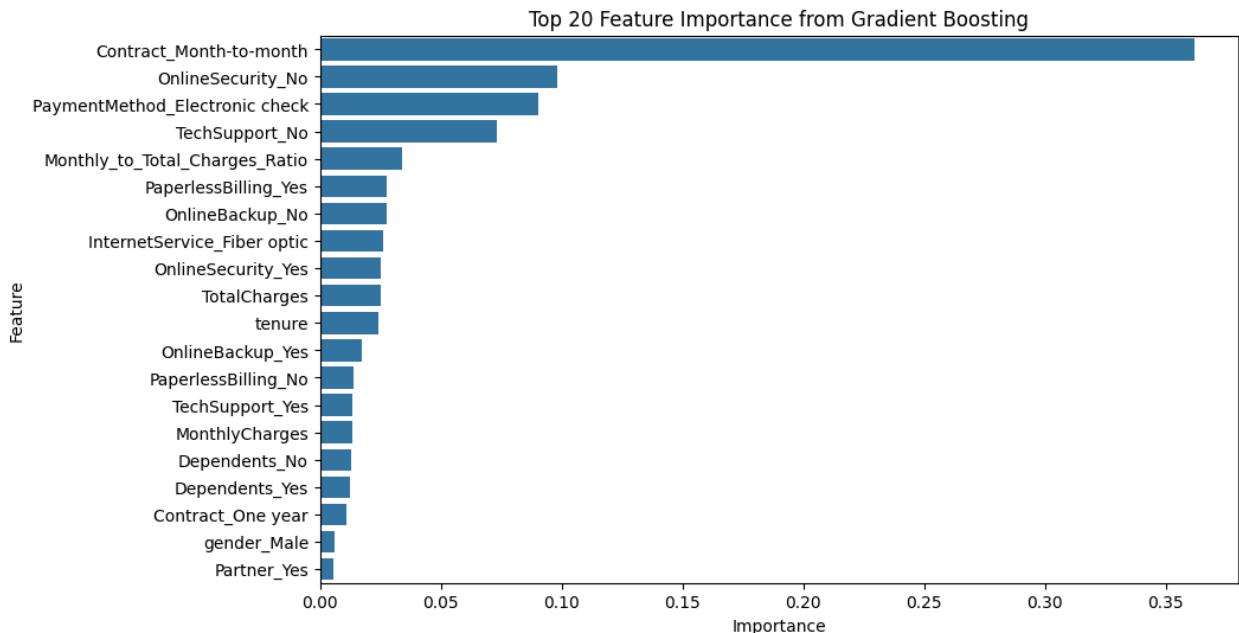
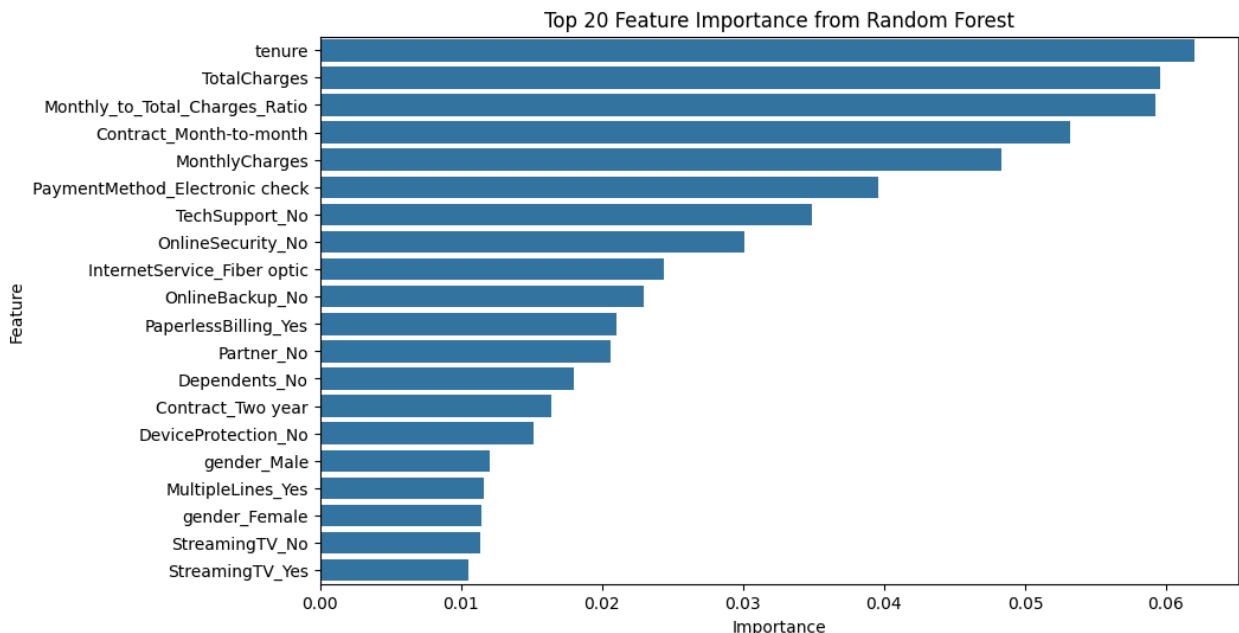
Extract and visualize the feature importance scores from the Random Forest and Gradient Boosting models to understand which features contribute most to the churn prediction.

```
In [20]: # Get feature importance from Random Forest model
rf_feature_importance = pd.Series(rf_model.feature_importances_, index=X_train.columns)

# Visualize feature importance for Random Forest
plt.figure(figsize=(10, 6))
sns.barplot(x=rf_feature_importance[:20], y=rf_feature_importance[:20].index)
plt.title('Top 20 Feature Importance from Random Forest')
plt.xlabel('Importance')
plt.ylabel('Feature')
plt.show()

# Get feature importance from Gradient Boosting model
gb_feature_importance = pd.Series(gb_model.feature_importances_, index=X_train.columns)

# Visualize feature importance for Gradient Boosting
plt.figure(figsize=(10, 6))
sns.barplot(x=gb_feature_importance[:20], y=gb_feature_importance[:20].index)
plt.title('Top 20 Feature Importance from Gradient Boosting')
plt.xlabel('Importance')
plt.ylabel('Feature')
plt.show()
```



ROC AUC Curve

Plot the ROC AUC curves for the trained models to evaluate their ability to distinguish between churn and non-churn classes.

In [22]:

```
from sklearn.metrics import roc_curve, auc

# Get predicted probabilities for the positive class (Churn=Yes)
y_pred_log_reg_prob = lg_model.predict_proba(X_test)[:, 1]
y_pred_rf_prob = rf_model.predict_proba(X_test)[:, 1]
y_pred_dt_prob = dt_model.predict_proba(X_test)[:, 1]
y_pred_gb_prob = gb_model.predict_proba(X_test)[:, 1]
```

```

# For DL model, we already have probabilities y_pred_dl_prob

# Convert y_test to numeric for ROC curve calculation
y_test_numeric = y_test.apply(lambda x: 1 if x == 'Yes' else 0)

# Calculate ROC curve and AUC for Logistic Regression
fpr_log_reg, tpr_log_reg, _ = roc_curve(y_test_numeric, y_pred_log_reg_prob)
roc_auc_log_reg = auc(fpr_log_reg, tpr_log_reg)

# Calculate ROC curve and AUC for Random Forest
fpr_rf, tpr_rf, _ = roc_curve(y_test_numeric, y_pred_rf_prob)
roc_auc_rf = auc(fpr_rf, tpr_rf)

# Calculate ROC curve and AUC for Decision Tree
fpr_dt, tpr_dt, _ = roc_curve(y_test_numeric, y_pred_dt_prob)
roc_auc_dt = auc(fpr_dt, tpr_dt)

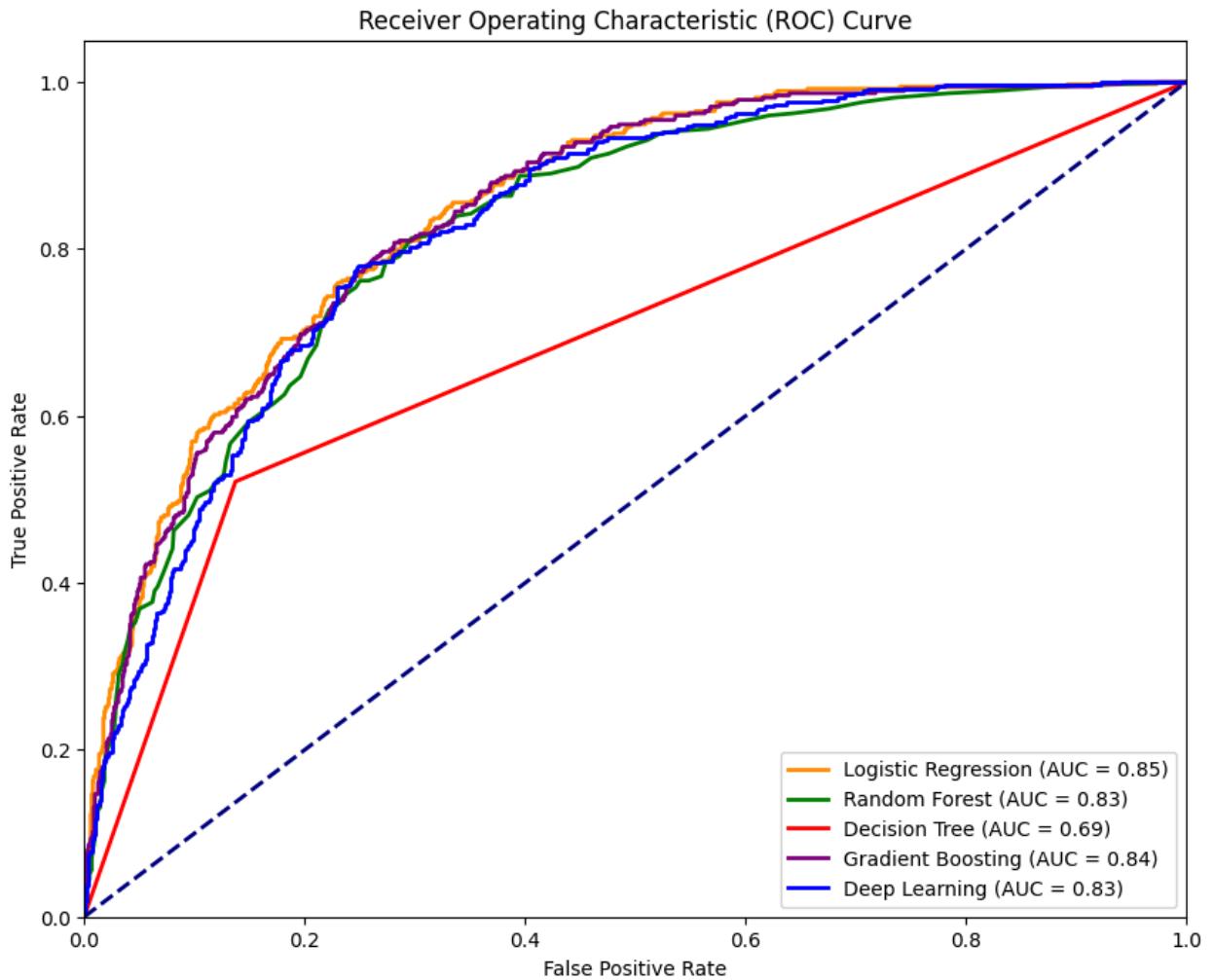
# Calculate ROC curve and AUC for Gradient Boosting
fpr_gb, tpr_gb, _ = roc_curve(y_test_numeric, y_pred_gb_prob)
roc_auc_gb = auc(fpr_gb, tpr_gb)

# Calculate ROC curve and AUC for Deep Learning
fpr_dl, tpr_dl, _ = roc_curve(y_test_numeric, y_pred_dl_prob)
roc_auc_dl = auc(fpr_dl, tpr_dl)

# Plot ROC curves
plt.figure(figsize=(10, 8))
plt.plot(fpr_log_reg, tpr_log_reg, color='darkorange', lw=2, label=f'Logistic Regression (AUC = {roc_auc_log_reg:.4f})')
plt.plot(fpr_rf, tpr_rf, color='green', lw=2, label=f'Random Forest (AUC = {roc_auc_rf:.4f})')
plt.plot(fpr_dt, tpr_dt, color='red', lw=2, label=f'Decision Tree (AUC = {roc_auc_dt:.4f})')
plt.plot(fpr_gb, tpr_gb, color='purple', lw=2, label=f'Gradient Boosting (AUC = {roc_auc_gb:.4f})')
plt.plot(fpr_dl, tpr_dl, color='blue', lw=2, label=f'Deep Learning (AUC = {roc_auc_dl:.4f})')

plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc="lower right")
plt.show()

```

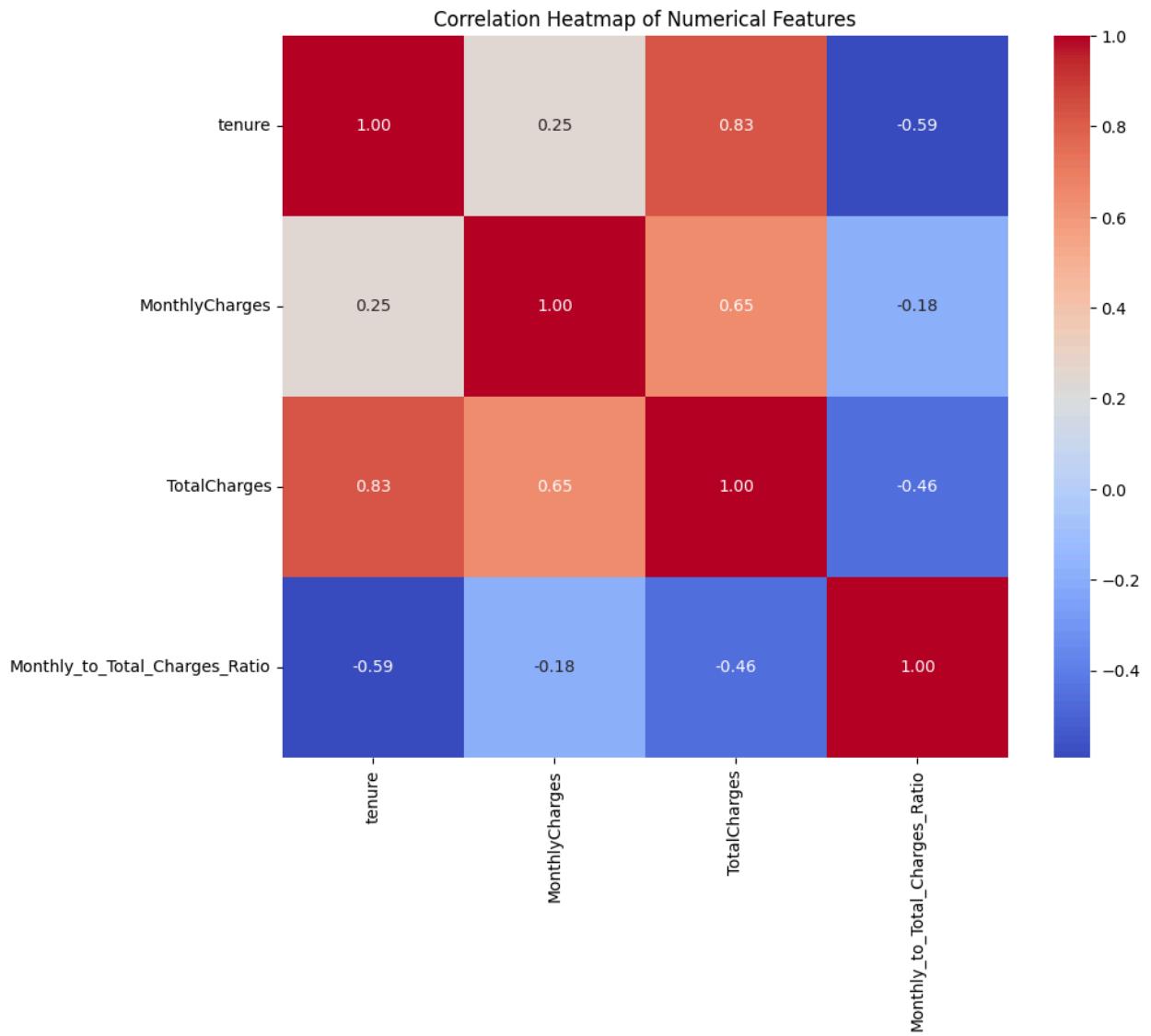


Heatmaps

Generate a heatmap of the correlation matrix to visualize the relationships between numerical features.

```
In [23]: # Calculate the correlation matrix for numerical features
correlation_matrix = df[numerical_features].corr()

# Generate a heatmap
plt.figure(figsize=(10, 8))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation Heatmap of Numerical Features')
plt.show()
```



Conclusion and Summary of Findings

This project aimed to build a customer churn prediction model using the Telco Customer Churn dataset. The process involved several key steps:

- 1. Data Loading and Initial Inspection:** The dataset was loaded and inspected, revealing a mix of numerical and categorical features and the presence of missing values in the 'TotalCharges' column, which was also incorrectly identified as an object type.
- 2. Data Cleaning:** Missing values in 'TotalCharges' were handled by imputing with the median, and the column was converted to a numeric type.
- 3. Exploratory Data Analysis (EDA):**

- The distribution of the target variable 'Churn' showed an imbalance, with significantly more non-churn customers than churn customers.
 - Analysis of categorical features revealed potential relationships with churn, such as customers with month-to-month contracts, electronic check payment methods, and certain internet services having higher churn rates.
 - Histograms of numerical features showed varying distributions, with 'tenure' and 'TotalCharges' being skewed.
4. **Feature Engineering:** A new feature, 'Monthly_to_Total_Charges_Ratio', and a binary feature 'HasInternet' were created to potentially capture more predictive information.
 5. **Outlier Detection and Handling:** Box plots were used to visualize outliers in numerical features. While outliers were present, no specific handling was performed in this iteration, but this could be a future area for improvement.
 6. **Handling Class Imbalance:** The class imbalance in the target variable was addressed using SMOTE (Synthetic Minority Over-sampling Technique) on the training data, resulting in a balanced training set.
 7. **Data Preprocessing:** Numerical features were scaled using StandardScaler, and categorical features were encoded using one-hot encoding to prepare the data for model training.
 8. **Model Selection and Building:** Several models were built, including Logistic Regression, a Deep Learning model, Random Forest, Decision Tree, and Gradient Boosting.
 9. **Model Training and Evaluation:** All models were trained on the resampled training data and evaluated on the test set using accuracy and classification reports (Precision, Recall, F1-Score). The performance table provided a comparison of these metrics across models.
 10. **Feature Importance:** Feature importance was determined for tree-based models (Random Forest and Gradient Boosting), highlighting the features that contribute most to churn prediction (e.g., 'Contract_Month-to-month', 'OnlineSecurity_No', 'PaymentMethod_Electronic check', 'tenure', 'TotalCharges', 'MonthlyCharges').

11. **ROC AUC Curve:** ROC AUC curves were plotted for all models, providing a visual representation of their ability to discriminate between churn and non-churn classes. The AUC scores provided a quantitative measure of this ability.
12. **Heatmaps:** A heatmap of the correlation matrix for numerical features was generated, showing the relationships between 'tenure', 'MonthlyCharges', 'TotalCharges', and the engineered 'Monthly_to_Total_Charges_Ratio'. 'tenure' and 'TotalCharges' showed a strong positive correlation.

Overall Conclusion:

Based on the evaluation metrics and visualizations, the Gradient Boosting model and Logistic Regression model appear to perform relatively well in terms of F1-score and AUC, indicating a good balance between precision and recall in predicting churn. The Deep Learning model, while showing high precision, had a low recall for the churn class in this initial build. The feature importance analysis provided valuable insights into which factors are most influential in customer churn.