In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
sns.set_theme(color_codes=True)
```

In [2]:
```
df = pd.read_excel('E comm.xlsx')
df.head()
```

Out[2]:

	CustomerID	Churn	Tenure	PreferredLoginDevice	CityTier	WarehouseToHome	PreferredPaymentMode	Gender	HourSp
0	50001	1	4.0	Mobile Phone	3	6.0	Debit Card	Female	
1	50002	1	NaN	Phone	1	8.0	UPI	Male	
2	50003	1	NaN	Phone	1	30.0	Debit Card	Male	
3	50004	1	0.0	Phone	3	15.0	Debit Card	Male	
4	50005	1	0.0	Phone	1	12.0	CC	Male	

Data Preprocessing Part 1

In [3]:
```
df.dtypes
```

Out[3]:
```
CustomerID                    int64
Churn                         int64
Tenure                      float64
PreferredLoginDevice         object
CityTier                      int64
WarehouseToHome             float64
PreferredPaymentMode         object
Gender                       object
HourSpendOnApp              float64
NumberOfDeviceRegistered      int64
PreferedOrderCat             object
SatisfactionScore             int64
MaritalStatus                object
NumberOfAddress               int64
Complain                      int64
OrderAmountHikeFromlastYear float64
CouponUsed                  float64
OrderCount                  float64
DaySinceLastOrder           float64
CashbackAmount              float64
dtype: object
```

In [4]:
```
#Check the number of unique value from all of the object datatype
df.select_dtypes(include='object').nunique()
```

Out[4]:
```
PreferredLoginDevice    3
PreferredPaymentMode    7
Gender                  2
PreferedOrderCat        6
MaritalStatus           3
dtype: int64
```

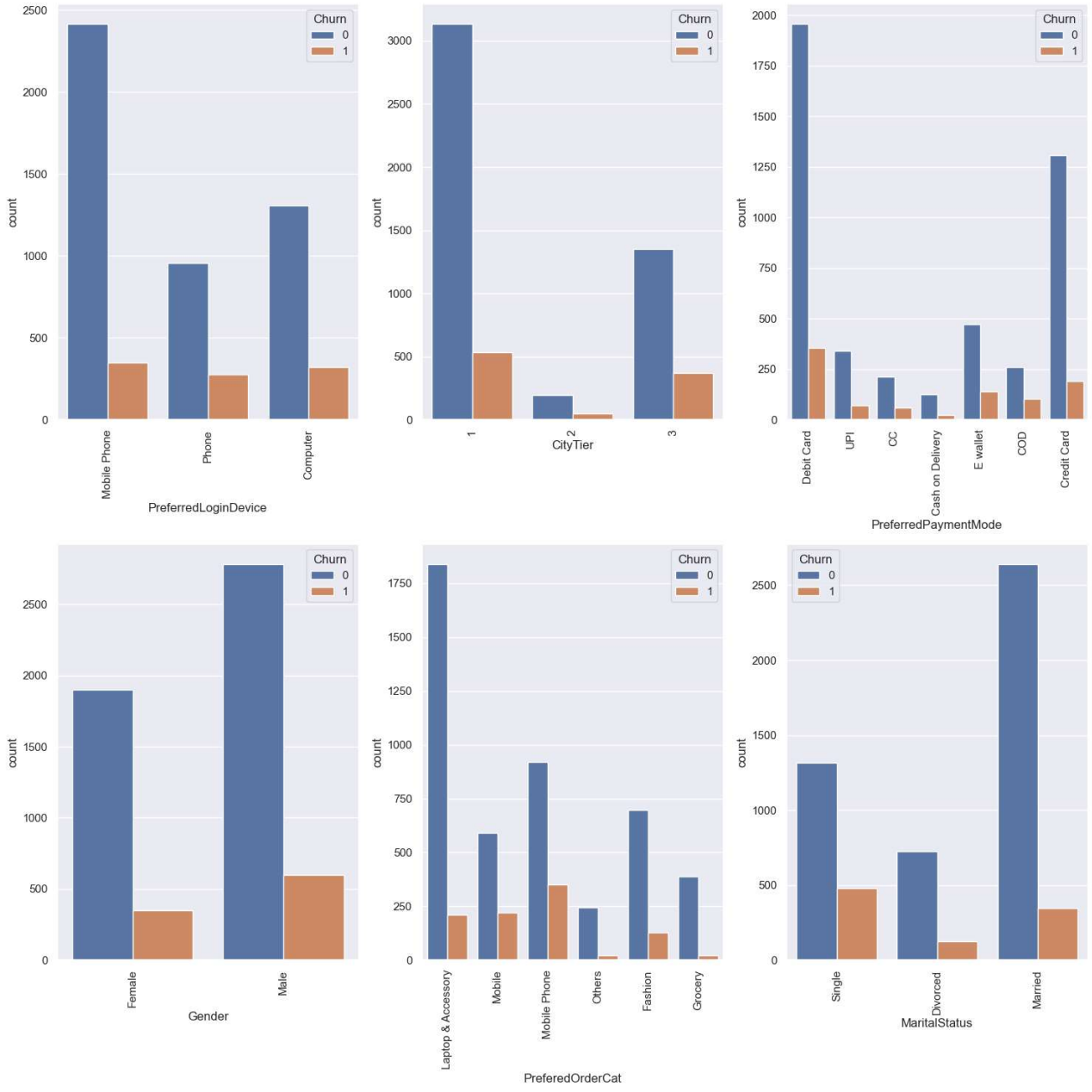
In [5]:
```
# Remove CustomerID column
df.drop(columns='CustomerID', inplace=True)
df.head()
```

Out[5]:

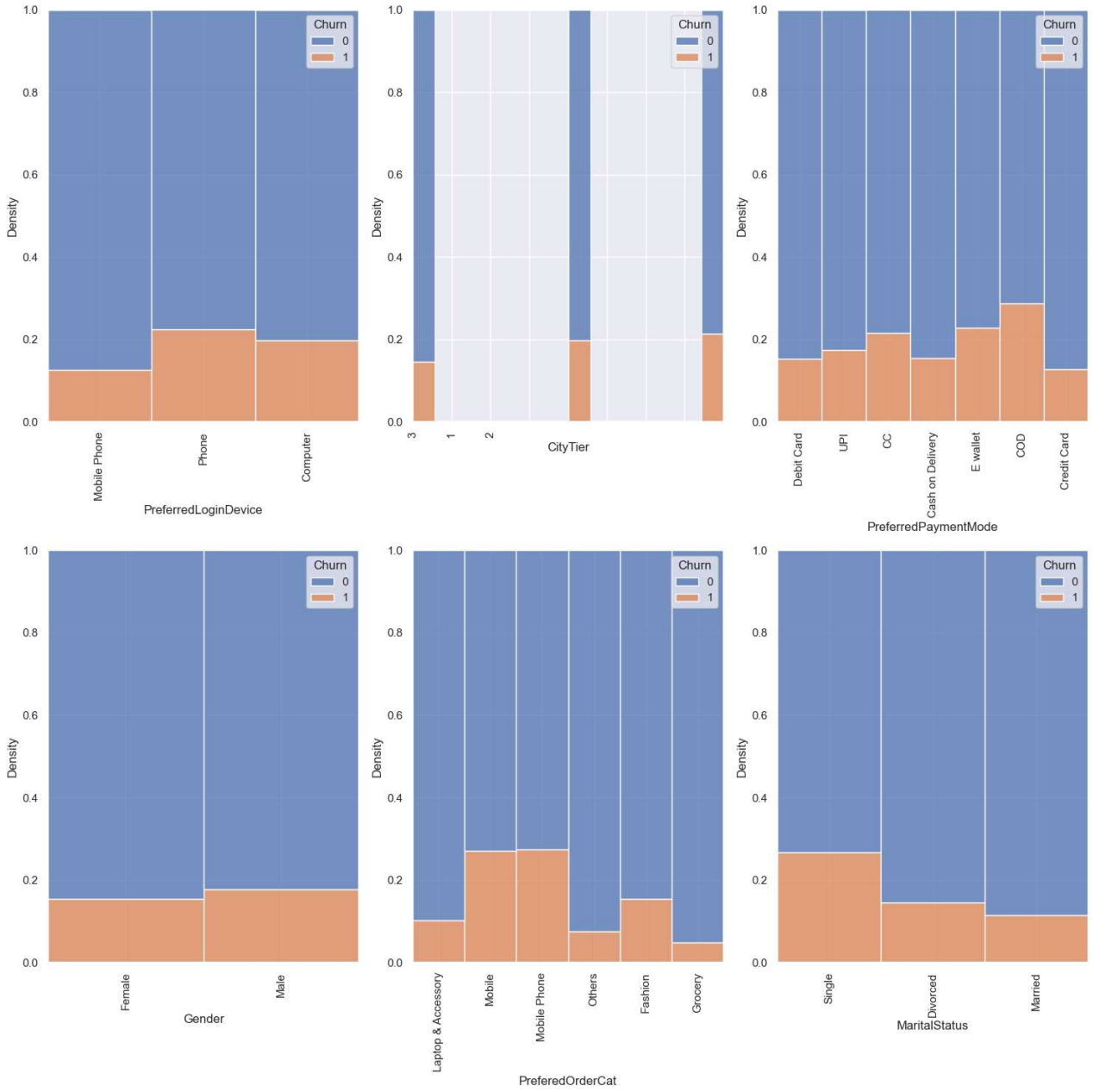
	Churn	Tenure	PreferredLoginDevice	CityTier	WarehouseToHome	PreferredPaymentMode	Gender	HourSpendOnApp	N
0	1	4.0	Mobile Phone	3	6.0	Debit Card	Female	3.0	
1	1	NaN	Phone	1	8.0	UPI	Male	3.0	
2	1	NaN	Phone	1	30.0	Debit Card	Male	2.0	
3	1	0.0	Phone	3	15.0	Debit Card	Male	2.0	
4	1	0.0	Phone	1	12.0	CC	Male	NaN	

Exploratory Data Analysis

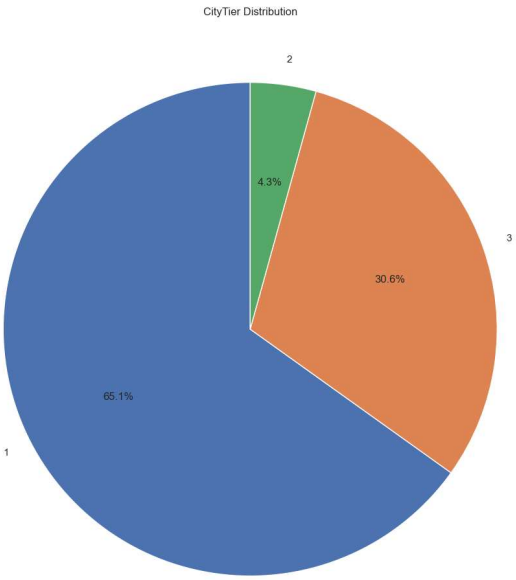
In [6]:
```
# list of categorical variables to plot
cat_vars = ['PreferredLoginDevice', 'CityTier', 'PreferredPaymentMode', 'Gender',
            'PreferedOrderCat','MaritalStatus']

# create figure with subplots
fig, axs = plt.subplots(nrows=2, ncols=3, figsize=(15, 15))
axs = axs.flatten()

# create barplot for each categorical variable
for i, var in enumerate(cat_vars):
    sns.countplot(x=var, hue='Churn', data=df, ax=axs[i])
    axs[i].set_xticklabels(axs[i].get_xticklabels(), rotation=90)

# adjust spacing between subplots
fig.tight_layout()

# show plot
plt.show()
```

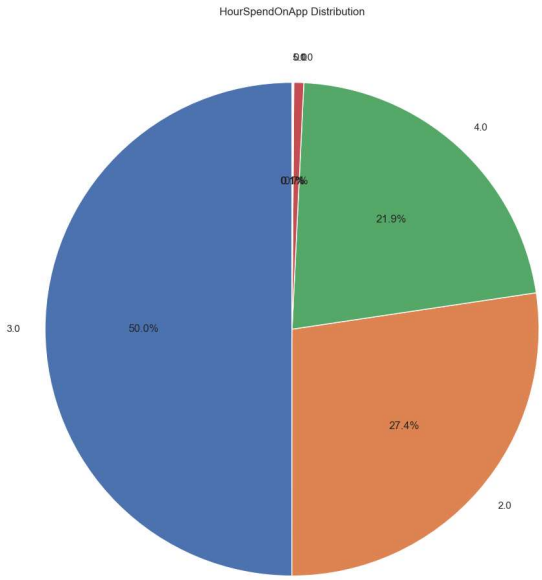


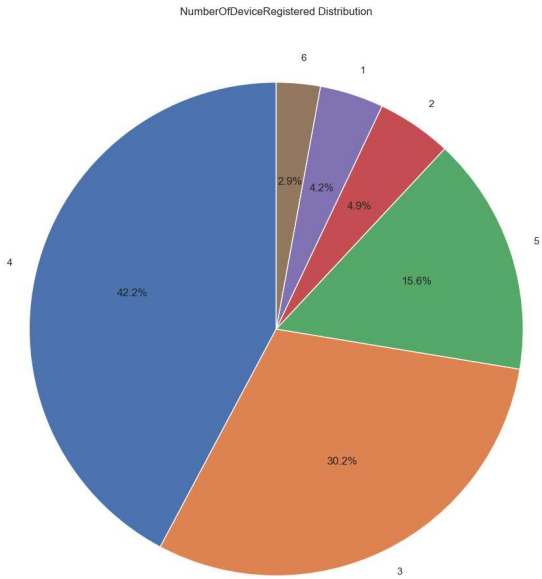
In [7]:
```
import warnings
warnings.filterwarnings("ignore")
# get list of categorical variables
cat_vars = ['PreferredLoginDevice', 'CityTier', 'PreferredPaymentMode', 'Gender',
            'PreferedOrderCat','MaritalStatus']

# create figure with subplots
fig, axs = plt.subplots(nrows=2, ncols=3, figsize=(15, 15))
axs = axs.flatten()

# create histplot for each categorical variable
for i, var in enumerate(cat_vars):
    sns.histplot(x=var, hue='Churn', data=df, ax=axs[i], multiple="fill", kde=False, element="bars"
    axs[i].set_xticklabels(df[var].unique(), rotation=90)
    axs[i].set_xlabel(var)

# adjust spacing between subplots
fig.tight_layout()

# show plot
plt.show()
```

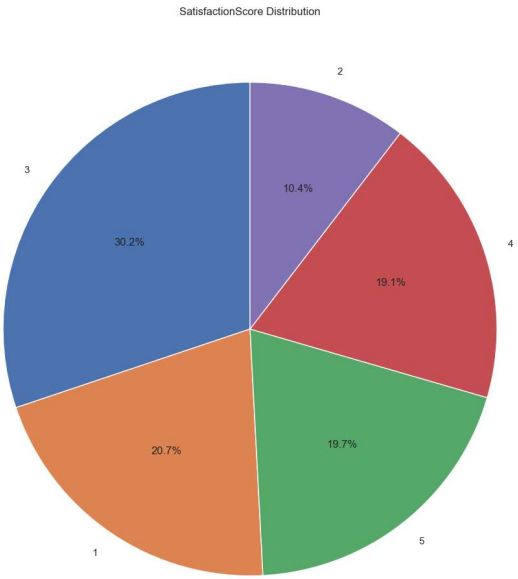


In [8]:
```
cat_vars = ['CityTier', 'HourSpendOnApp', 'NumberOfDeviceRegistered', 'SatisfactionScore']

# create a figure and axes
fig, axs = plt.subplots(nrows=2, ncols=2, figsize=(20, 20))

# create a pie chart for each categorical variable
for i, var in enumerate(cat_vars):
    if i < len(axs.flat):
        # count the number of occurrences for each category
        cat_counts = df[var].value_counts()

        # create a pie chart
        axs.flat[i].pie(cat_counts, labels=cat_counts.index, autopct='%1.1f%%', startangle=90)

        # set a title for each subplot
        axs.flat[i].set_title(f'{var} Distribution')

# adjust spacing between subplots
fig.tight_layout()

# show the plot
plt.show()
```

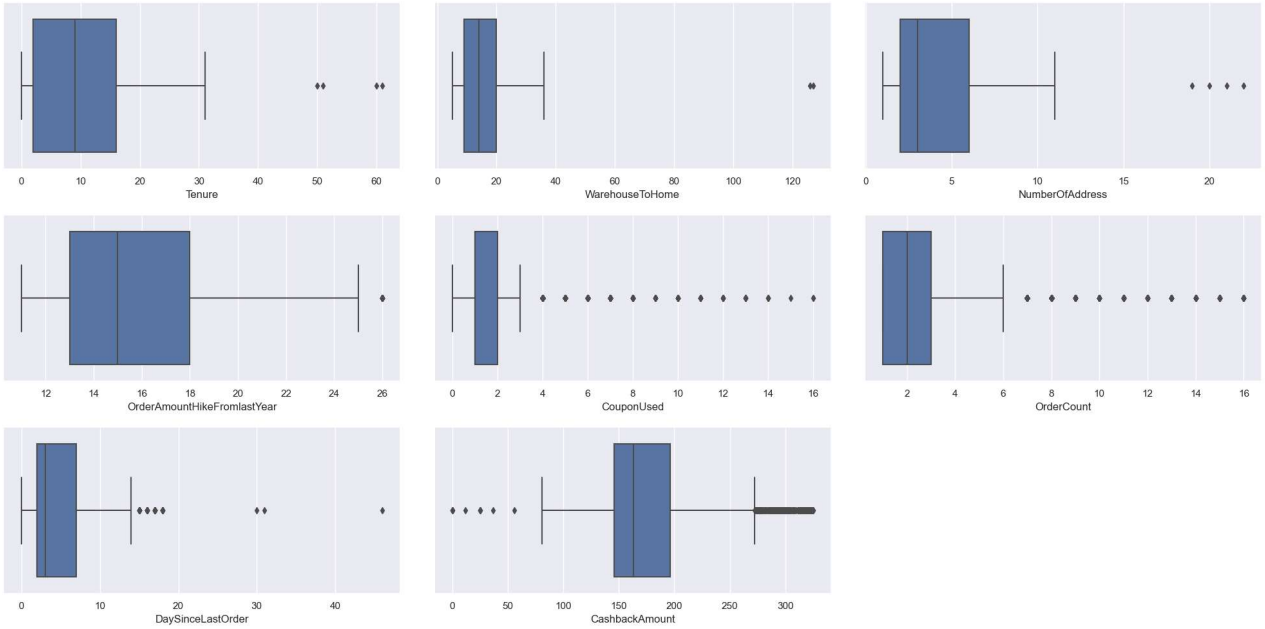

CityTier Distribution
2
3
1
4.3%
30.6%
65.1%


HourSpendOnApp Distribution
4.0
3.0
2.0
21.9%
50.0%
27.4%

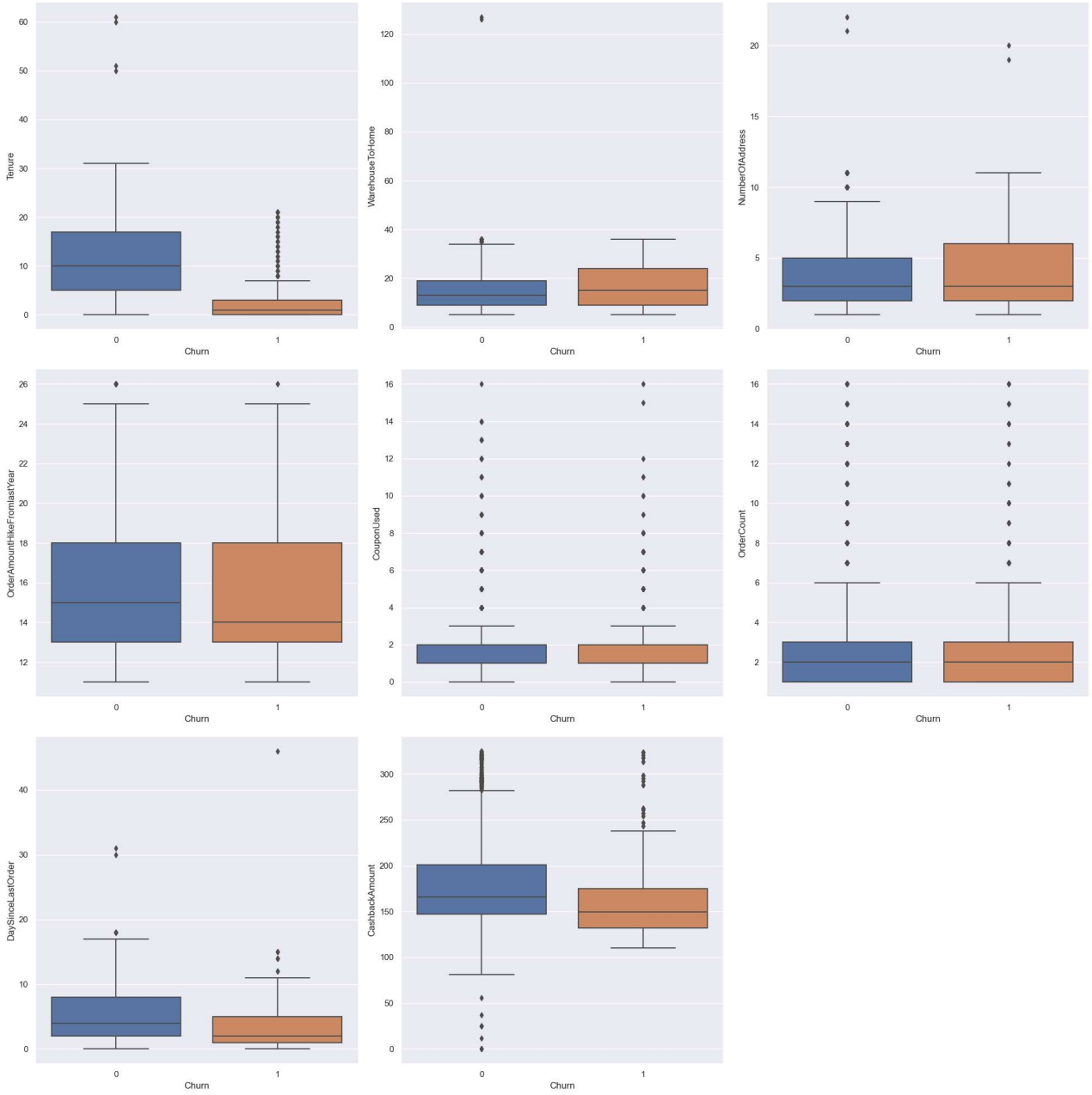

NumberOfDeviceRegistered Distribution
6
1
2
5
4
3
2.9%
4.2%
4.9%
15.6%
42.2%
30.2%


SatisfactionScore Distribution
2
3
4
1
5
10.4%
30.2%
19.1%
20.7%
19.7%

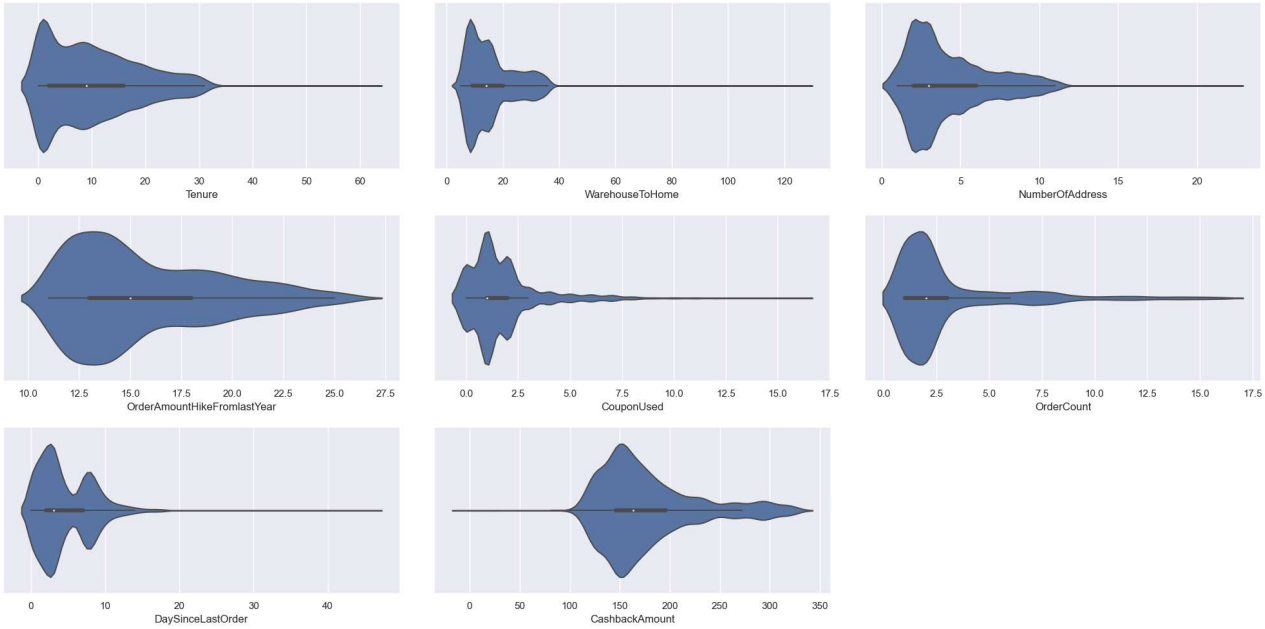
In [9]:
```
num_vars = ['Tenure', 'WarehouseToHome', 'NumberOfAddress', 'OrderAmountHikeFromlastYear',
            'CouponUsed', 'OrderCount', 'DaySinceLastOrder', 'CashbackAmount']

fig, axs = plt.subplots(nrows=3, ncols=3, figsize=(20, 10))
axs = axs.flatten()

for i, var in enumerate(num_vars):
    sns.boxplot(x=var, data=df, ax=axs[i])

fig.tight_layout()

# remove the ninth subplot
fig.delaxes(axs[8])

plt.show()
```



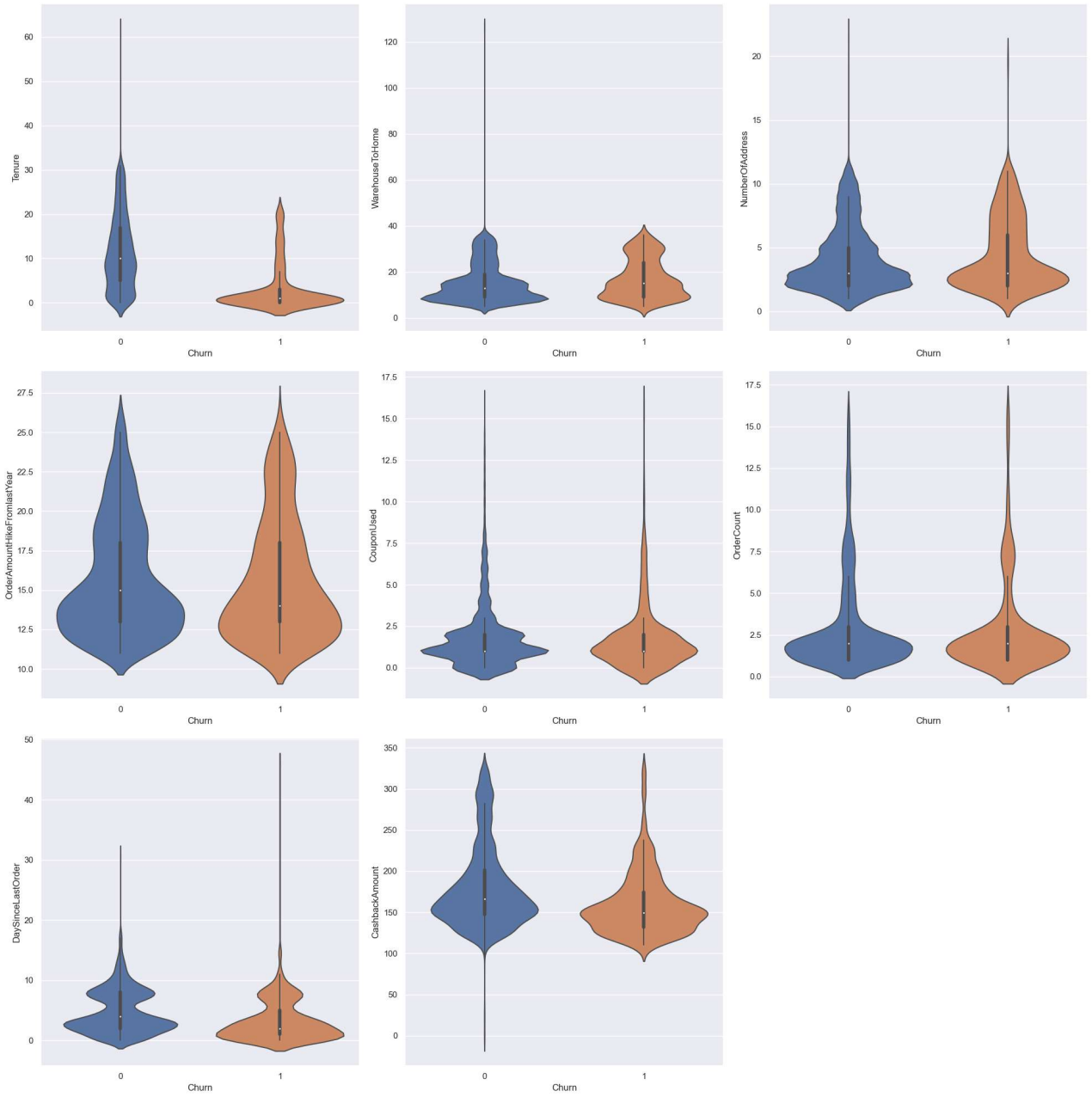
In [10]:
```
num_vars = ['Tenure', 'WarehouseToHome', 'NumberOfAddress', 'OrderAmountHikeFromlastYear',
            'CouponUsed', 'OrderCount', 'DaySinceLastOrder', 'CashbackAmount']

fig, axs = plt.subplots(nrows=3, ncols=3, figsize=(20, 20))
axs = axs.flatten()

for i, var in enumerate(num_vars):
    sns.boxplot(y=var, x='Churn', data=df, ax=axs[i])

fig.tight_layout()

# remove the ninth subplot
fig.delaxes(axs[8])

plt.show()
```



In [11]:
```
num_vars = ['Tenure', 'WarehouseToHome', 'NumberOfAddress', 'OrderAmountHikeFromlastYear',
            'CouponUsed', 'OrderCount', 'DaySinceLastOrder', 'CashbackAmount']

fig, axs = plt.subplots(nrows=3, ncols=3, figsize=(20, 10))
axs = axs.flatten()

for i, var in enumerate(num_vars):
    sns.violinplot(x=var, data=df, ax=axs[i])

fig.tight_layout()

# remove the ninth subplot
fig.delaxes(axs[8])

plt.show()
```

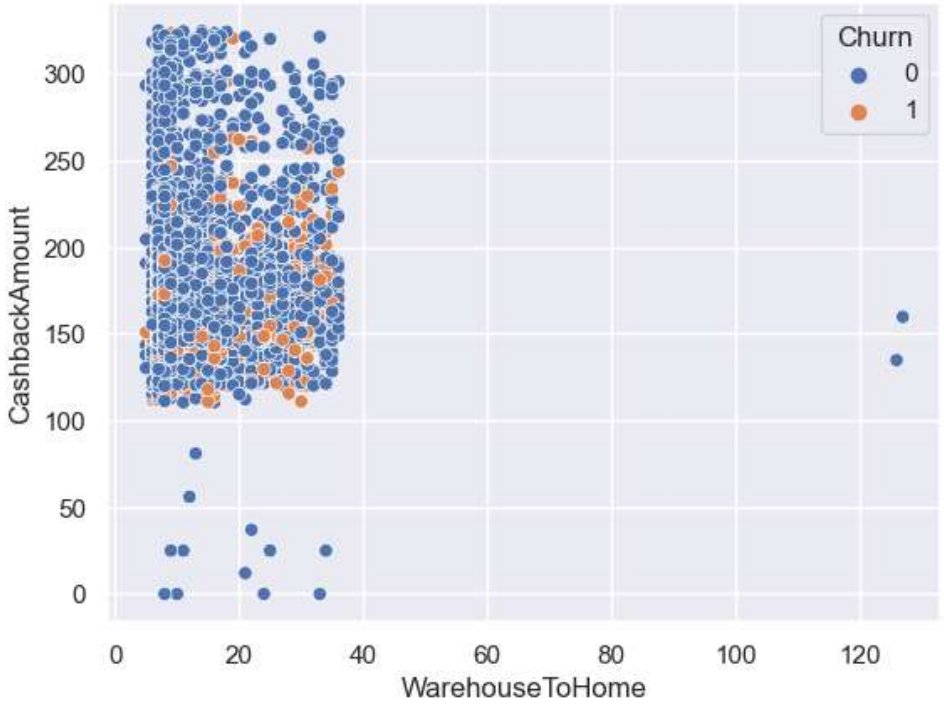


In [12]:
```
num_vars = ['Tenure', 'WarehouseToHome', 'NumberOfAddress', 'OrderAmountHikeFromlastYear',
            'CouponUsed', 'OrderCount', 'DaySinceLastOrder', 'CashbackAmount']

fig, axs = plt.subplots(nrows=3, ncols=3, figsize=(20, 20))
axs = axs.flatten()

for i, var in enumerate(num_vars):
    sns.violinplot(y=var, data=df, x='Churn', ax=axs[i])

fig.tight_layout()

# remove the ninth subplot
fig.delaxes(axs[8])

plt.show()
```



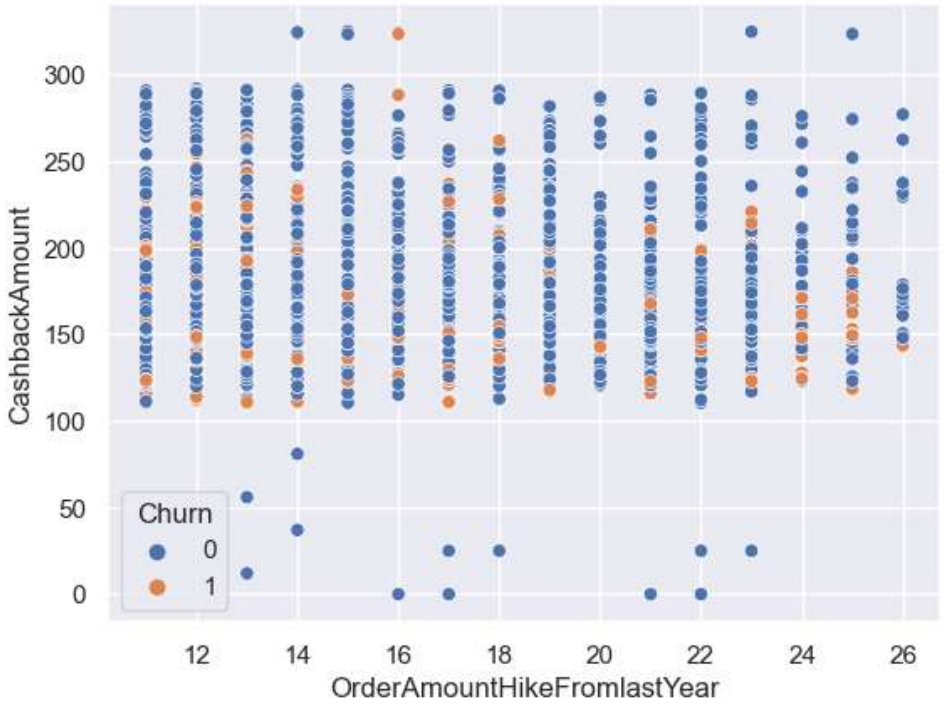
In [13]:
```
sns.scatterplot(x='WarehouseToHome', y='CashbackAmount', hue='Churn', data=df)
```

Out[13]:
```
<AxesSubplot:xlabel='WarehouseToHome', ylabel='CashbackAmount'>
```



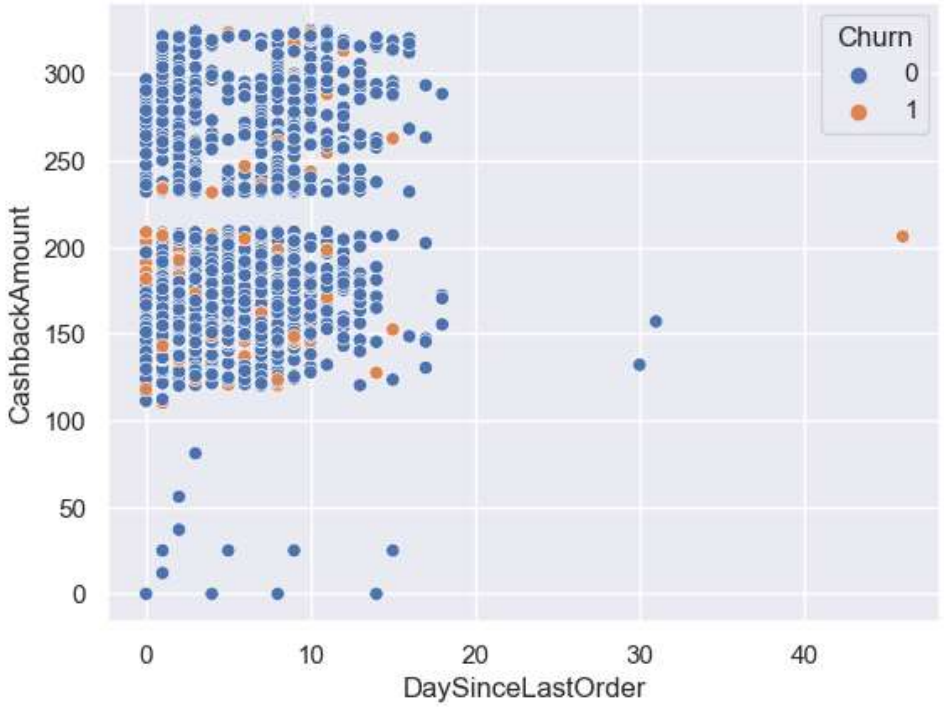
In [14]:
```
sns.scatterplot(x='OrderAmountHikeFromlastYear', y='CashbackAmount', hue='Churn', data=df)
```

Out[14]:
```
<AxesSubplot:xlabel='OrderAmountHikeFromlastYear', ylabel='CashbackAmount'>
```



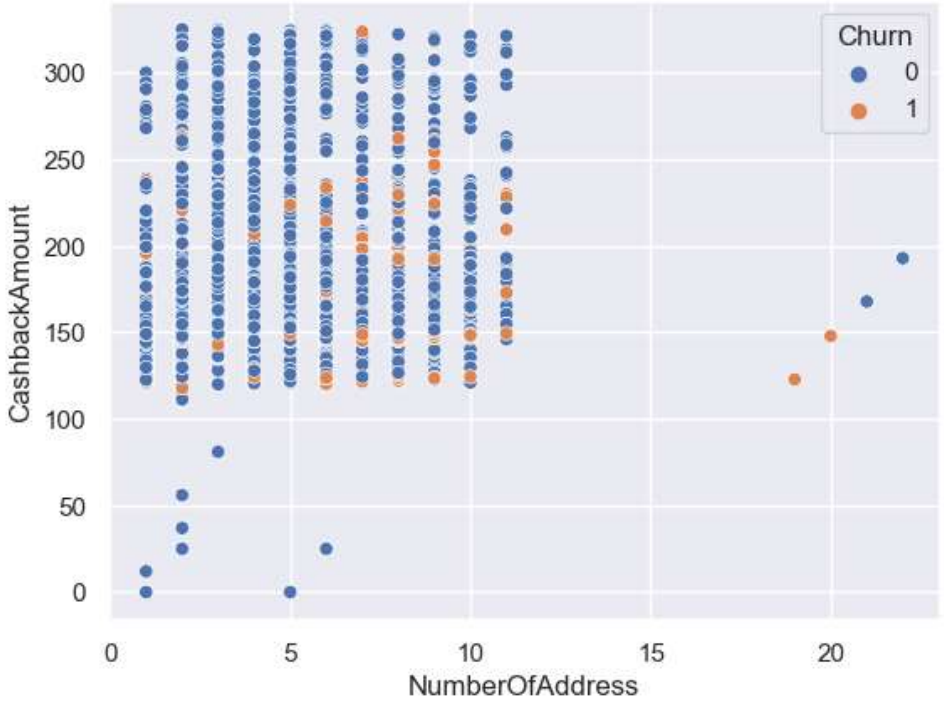
In [15]:
```
sns.scatterplot(x='DaySinceLastOrder', y='CashbackAmount', hue='Churn', data=df)
```

Out[15]:
```
<AxesSubplot:xlabel='DaySinceLastOrder', ylabel='CashbackAmount'>
```



In [16]:
```
sns.scatterplot(x='NumberOfAddress', y='CashbackAmount', hue='Churn', data=df)
```

Out[16]:
```
<AxesSubplot:xlabel='NumberOfAddress', ylabel='CashbackAmount'>
```



Data Preprocessing Part 2

In [17]:
```
#Check missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[17]:
```
DaySinceLastOrder             5.452931
OrderAmountHikeFromlastYear   4.706927
Tenure                        4.689165
OrderCount                    4.582593
CouponUsed                    4.547069
HourSpendOnApp                4.529307
WarehouseToHome               4.458259
dtype: float64
```

In [18]:
```
# fill null value with median
df['HourSpendOnApp'].fillna(df['HourSpendOnApp'].median(), inplace=True)
df['OrderAmountHikeFromlastYear'].fillna(df['OrderAmountHikeFromlastYear'].median(), inplace=True)
df['Tenure'].fillna(df['Tenure'].median(), inplace=True)
df['WarehouseToHome'].fillna(df['WarehouseToHome'].median(), inplace=True)
df['DaySinceLastOrder'].fillna(df['DaySinceLastOrder'].median(), inplace=True)
df['OrderCount'].fillna(df['OrderCount'].median(), inplace=True)
df['CouponUsed'].fillna(df['CouponUsed'].median(), inplace=True)
```

In [19]:
```
#Check missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[19]:
```
Series([], dtype: float64)
```

Label Encoding for Object datatype

In [20]:
```
# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Print the column name and the unique values
    print(f"{col}: {df[col].unique()}")
```

```
PreferredLoginDevice: ['Mobile Phone' 'Phone' 'Computer']
PreferredPaymentMode: ['Debit Card' 'UPI' 'CC' 'Cash on Delivery' 'E wallet' 'COD' 'Credit Card']
Gender: ['Female' 'Male']
PreferedOrderCat: ['Laptop & Accessory' 'Mobile' 'Mobile Phone' 'Others' 'Fashion' 'Grocery']
MaritalStatus: ['Single' 'Divorced' 'Married']
```

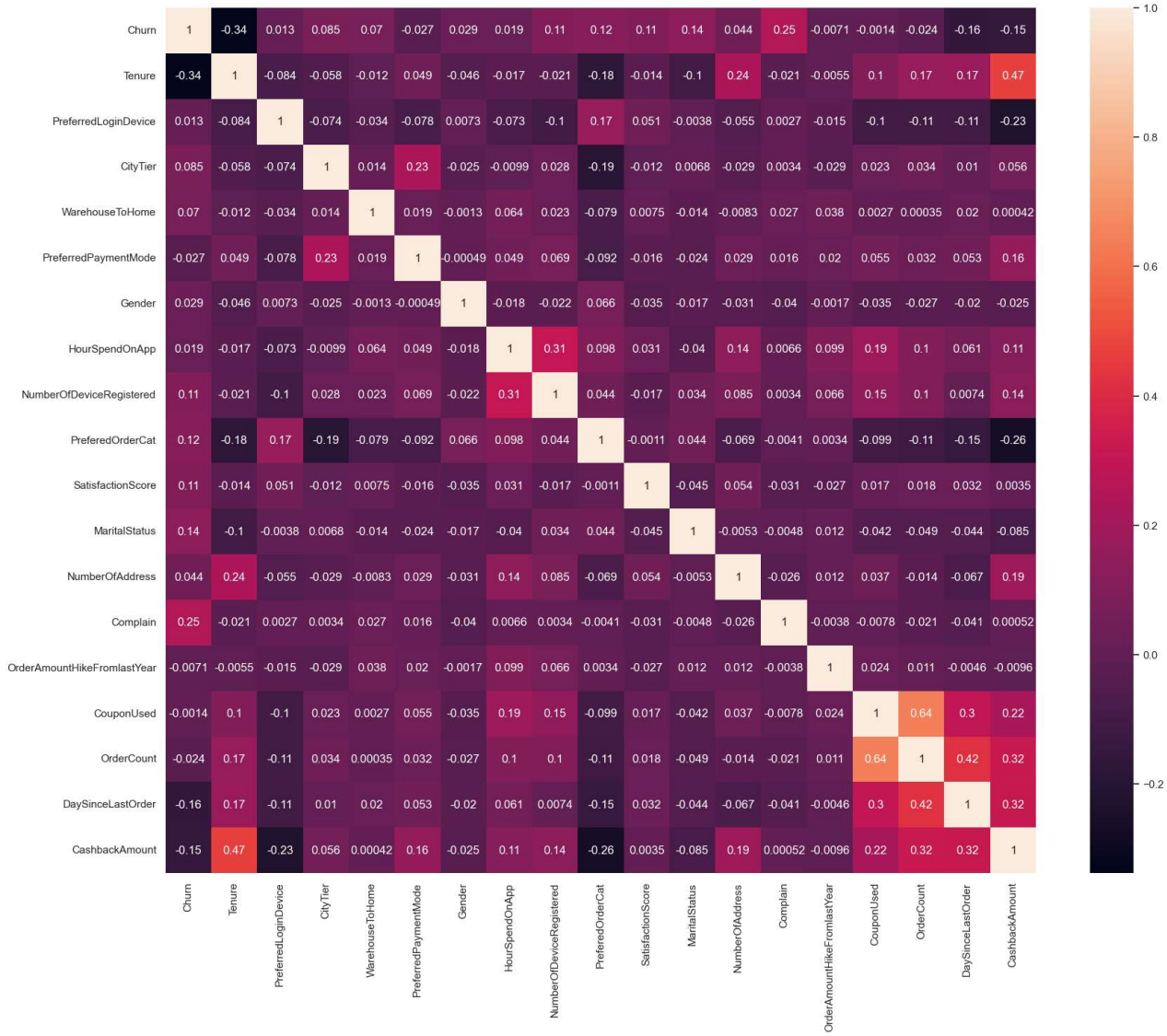
In [21]:
```
from sklearn import preprocessing

# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Initialize a LabelEncoder object
    label_encoder = preprocessing.LabelEncoder()

    # Fit the encoder to the unique values in the column
    label_encoder.fit(df[col].unique())

    # Transform the column using the encoder
    df[col] = label_encoder.transform(df[col])

    # Print the column name and the unique encoded values
    print(f"{col}: {df[col].unique()}")
```

```
PreferredLoginDevice: [1 2 0]
PreferredPaymentMode: [4 6 0 2 5 1 3]
Gender: [0 1]
PreferedOrderCat: [2 3 4 5 0 1]
MaritalStatus: [2 0 1]
```

Correlation Heatmap

In [22]:
```
#Correlation Heatmap
plt.figure(figsize=(20, 16))
sns.heatmap(df.corr(), fmt='.2g', annot=True)
```

Out[22]: <AxesSubplot:>



Train Test Split

In [24]:
```
from sklearn.model_selection import train_test_split
# Select the features (X) and the target variable (y)
X = df.drop('Churn', axis=1)
y = df['Churn']

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

Remove Outlier in Train Data using Z-Score

In [25]:
```
from sklearn.model_selection import train_test_split

# Select the column for outlier removal
selected_column = ['WarehouseToHome', 'DaySinceLastOrder', 'CouponUsed', 'OrderCount']

# Split the data into training and test sets
train_df, test_df = train_test_split(df, test_size=0.2, random_state=42)

# Calculate the z-scores for the selected column in the training set
train_z_scores = np.abs((train_df[selected_column] - train_df[selected_column].mean()) / train_df[s

# Set the threshold for defining outliers (e.g., z-score > 3)
threshold = 3

# Filter the training DataFrame, removing rows with z-scores above the threshold in the selected col
train_df_no_outliers = train_df[train_z_scores <= threshold]
```

Decision Tree

In [26]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
dtree = DecisionTreeClassifier(class_weight='balanced')
param_grid = {
    'max_depth': [3, 4, 5, 6, 7, 8],
    'min_samples_split': [2, 3, 4],
    'min_samples_leaf': [1, 2, 3, 4],
    'random_state': [0, 42]
}

# Perform a grid search with cross-validation to find the best hyperparameters
grid_search = GridSearchCV(dtree, param_grid, cv=5)
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print(grid_search.best_params_)
```

```
{'max_depth': 8, 'min_samples_leaf': 1, 'min_samples_split': 2, 'random_state': 42}
```

In [27]:
```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(random_state=42, max_depth=8, min_samples_leaf=1, min_samples_split=
dtree.fit(X_train, y_train)
```

Out[27]:
```
DecisionTreeClassifier(class_weight='balanced', max_depth=8, random_state=42)
```

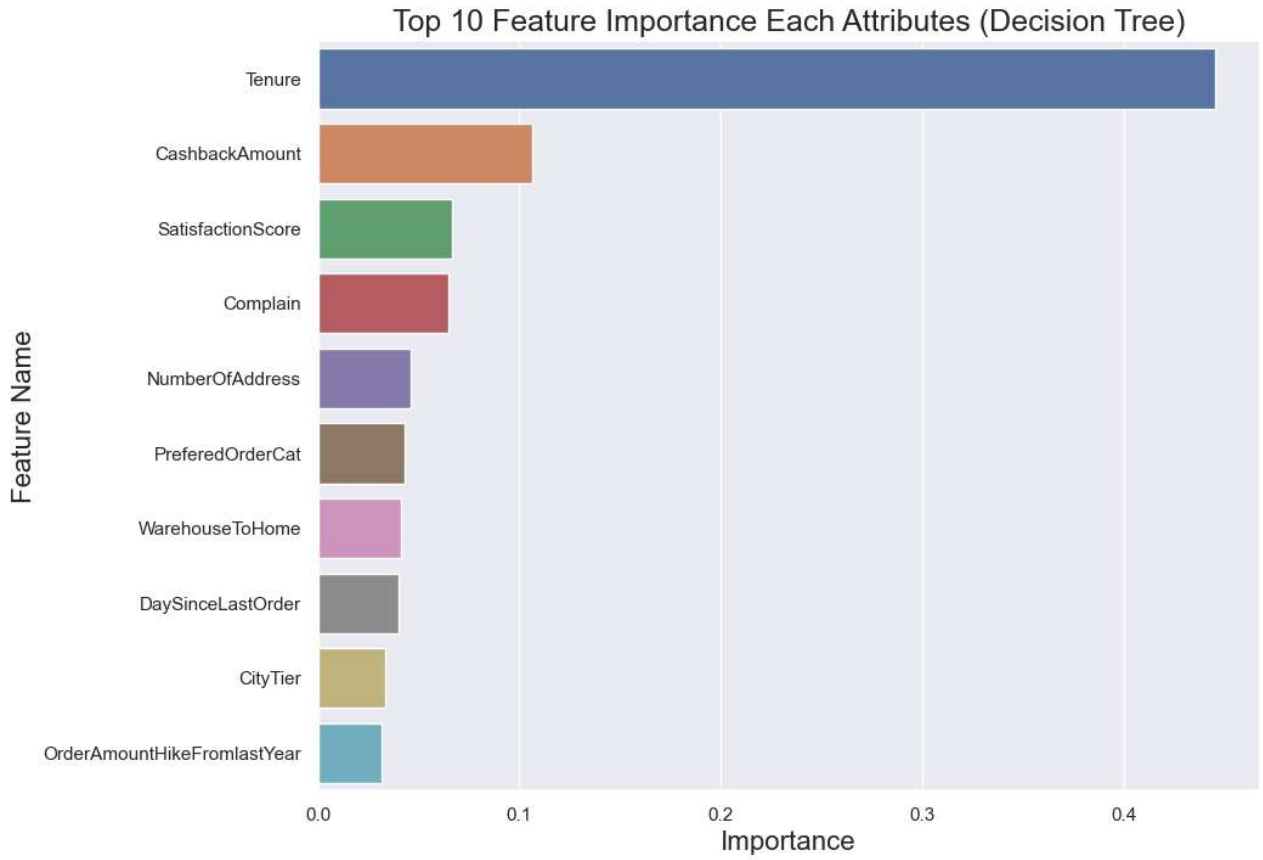
In [28]:
```
from sklearn.metrics import accuracy_score
y_pred = dtree.predict(X_test)
print("Accuracy Score :", round(accuracy_score(y_test, y_pred)*100 ,2), "%")
```

```
Accuracy Score : 88.01 %
```

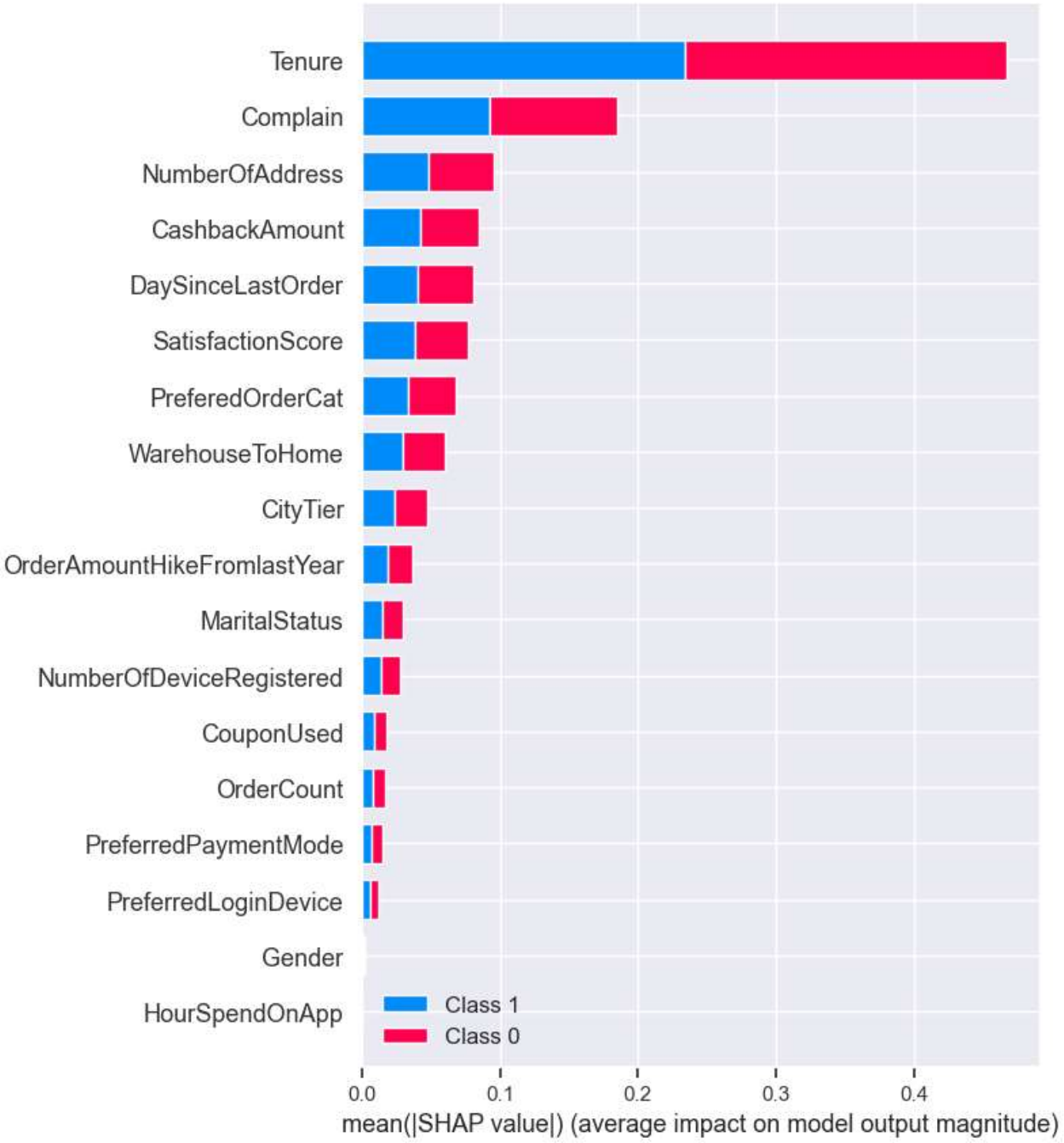
In [29]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score, jaccard_score,
print('F-1 Score : ',(f1_score(y_test, y_pred, average='micro')))
print('Precision Score : ',(precision_score(y_test, y_pred, average='micro')))
print('Recall Score : ',(recall_score(y_test, y_pred, average='micro')))
print('Jaccard Score : ',(jaccard_score(y_test, y_pred, average='micro')))
print('Log Loss : ',(log_loss(y_test, y_pred)))
```

```
F-1 Score :  0.8801065719360568
Precision Score :  0.8801065719360568
Recall Score :  0.8801065719360568
Jaccard Score :  0.7858842188739096
Log Loss :  4.141051836789631
```

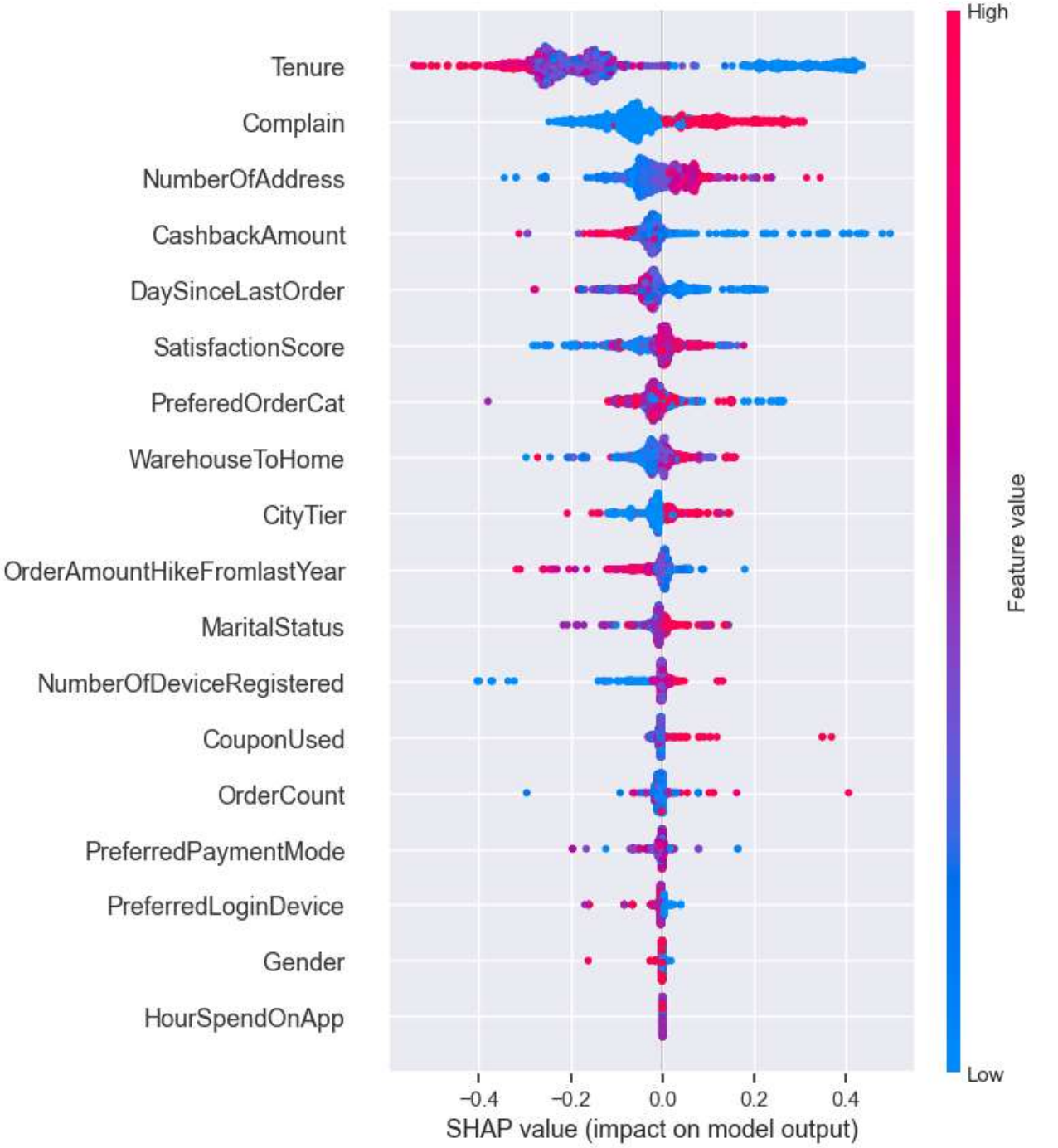
In [30]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": dtree.feature_importances_
})
fi = imp_df.sort_values(by="Importance", ascending=False)

fi2 = fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2, x='Importance', y='Feature Name')
plt.title('Top 10 Feature Importance Each Attributes (Decision Tree)', fontsize=18)
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```



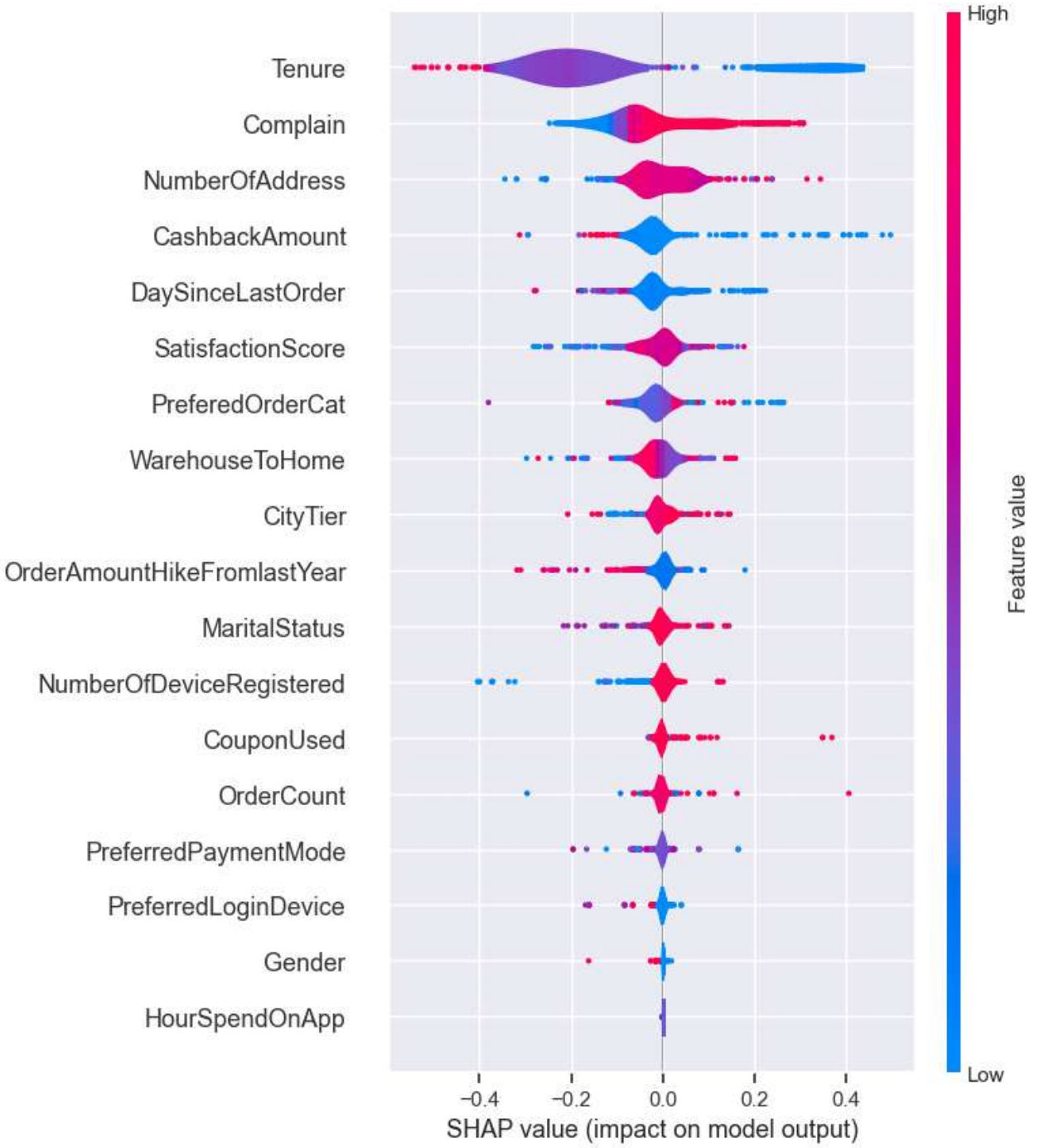
In [31]:
```
import shap
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```



In [32]:
```
# compute SHAP values
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns)
```

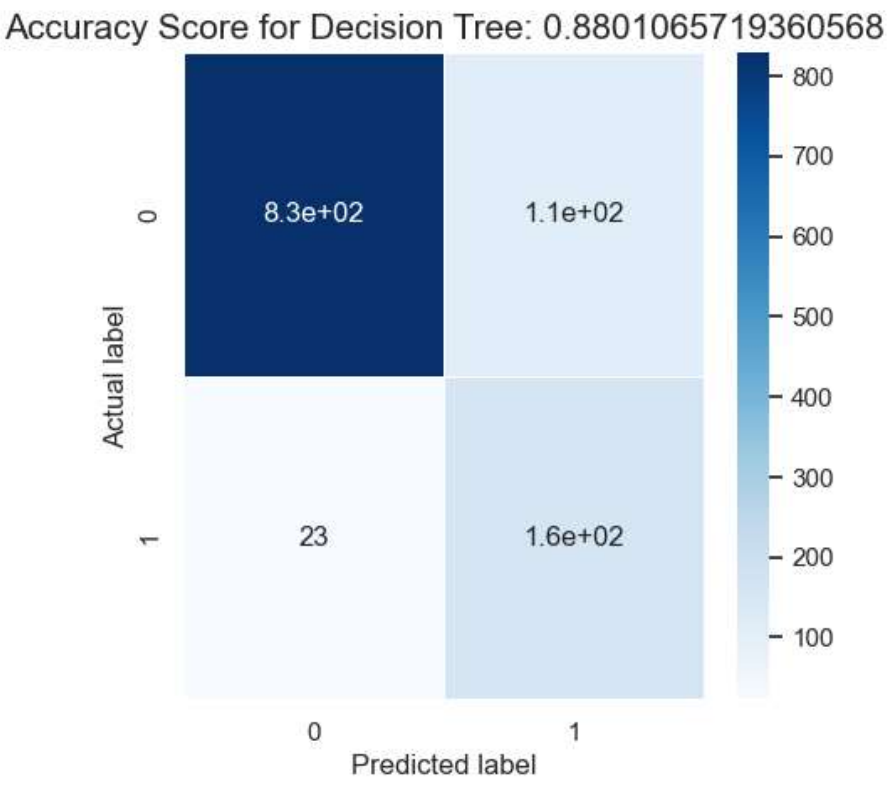


In [33]:
```
# compute SHAP values
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns, plot_type="violin"
```



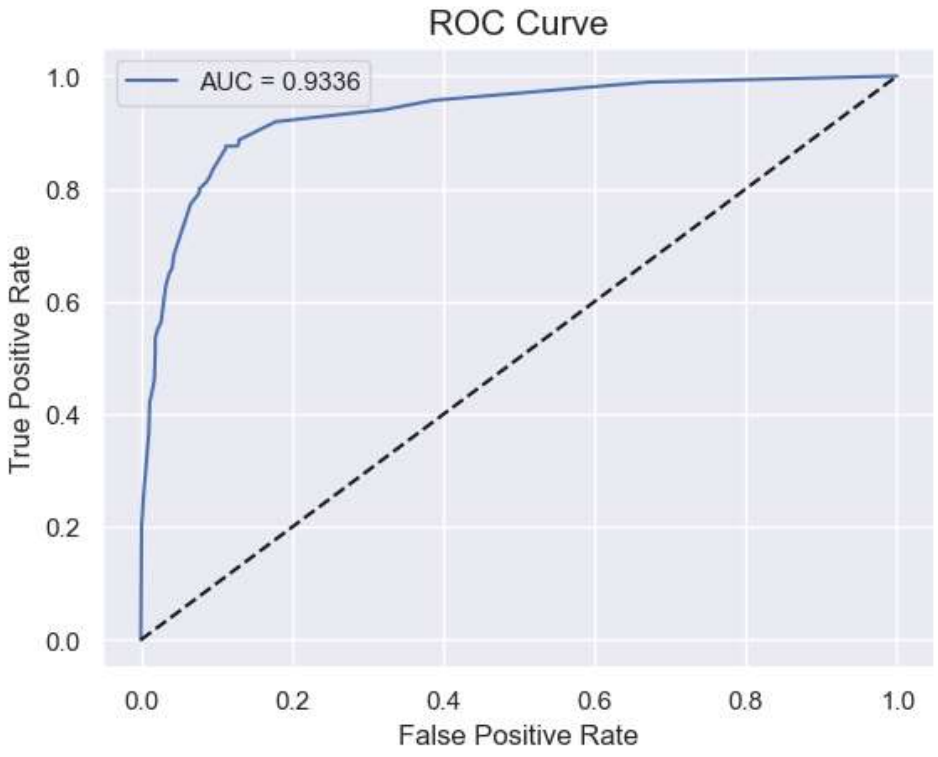
In [34]:
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,  cmap = 'Blues')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score for Decision Tree: {0}'.format(dtree.score(X_test, y_test))
plt.title(all_sample_title, size = 15)
```

Out[34]:
```
Text(0.5, 1.0, 'Accuracy Score for Decision Tree: 0.8801065719360568')
```



In [35]:
```
from sklearn.metrics import roc_curve, roc_auc_score
y_pred_proba = dtree.predict_proba(X_test)[:][:,1]

df_actual_predicted = pd.concat([pd.DataFrame(np.array(y_test), columns=['y_actual']), pd.DataFrame
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])

plt.plot(fpr, tpr, label='AUC = %0.4f' %auc)
plt.plot(fpr, fpr, linestyle = '--', color='k')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve', size = 15)
plt.legend()
```

Out[35]: <matplotlib.legend.Legend at 0x247eea3db20>



Random Forest

In [36]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
rfc = RandomForestClassifier(class_weight='balanced')
param_grid = {
    'n_estimators': [100, 200],
    'max_depth': [None, 5, 10],
    'max_features': ['sqrt', 'log2', None],
    'random_state': [0, 42]
}

# Perform a grid search with cross-validation to find the best hyperparameters
grid_search = GridSearchCV(rfc, param_grid, cv=5)
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print(grid_search.best_params_)
```

```
{'max_depth': None, 'max_features': 'sqrt', 'n_estimators': 100, 'random_state': 0}
```

In [37]:
```
from sklearn.ensemble import RandomForestClassifier
rfc = RandomForestClassifier(random_state=0, max_features='sqrt', n_estimators=100, class_weight='ba
rfc.fit(X_train, y_train)
```

Out[37]:
```
RandomForestClassifier(class_weight='balanced', max_features='sqrt',
                       random_state=0)
```

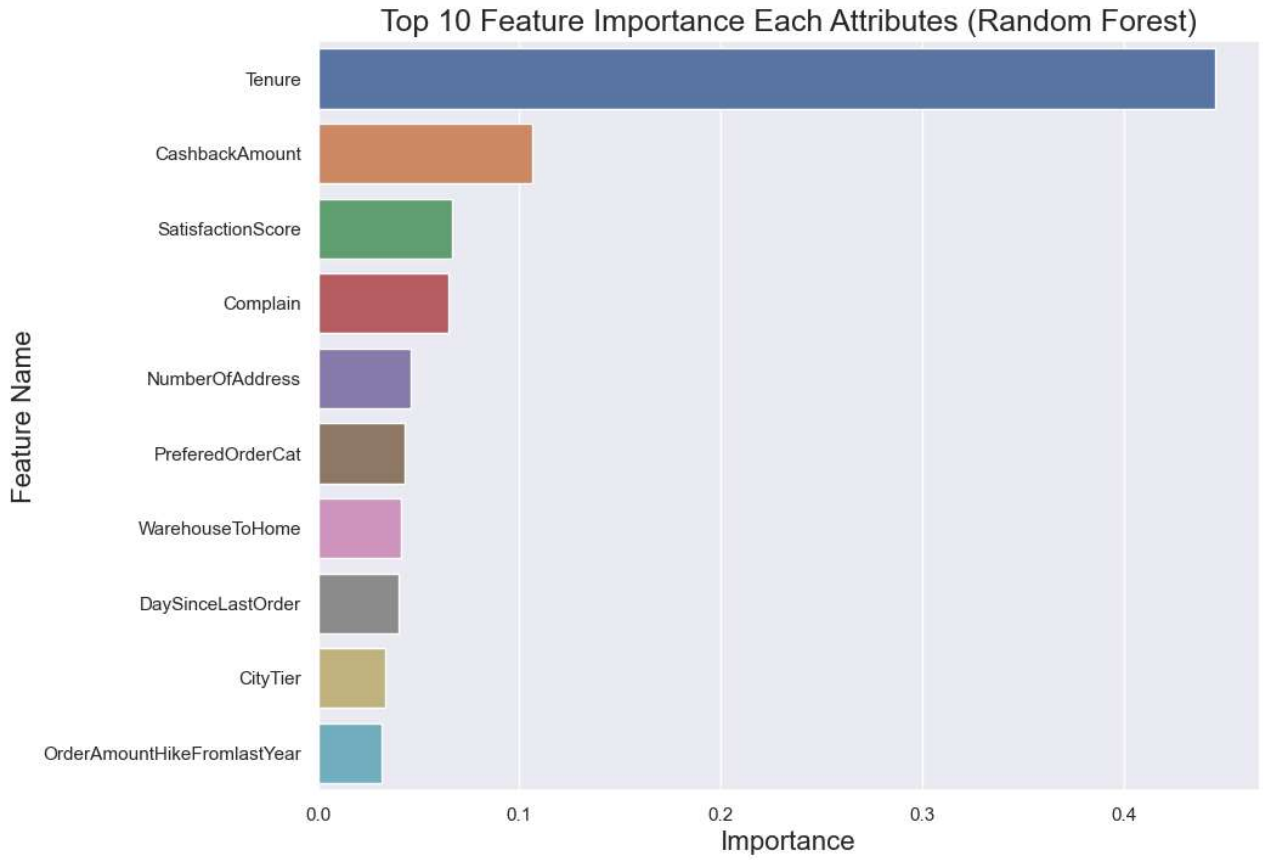
In [38]:
```
y_pred = rfc.predict(X_test)
print("Accuracy Score :", round(accuracy_score(y_test, y_pred)*100 ,2), "%")
```

```
Accuracy Score : 97.6 %
```

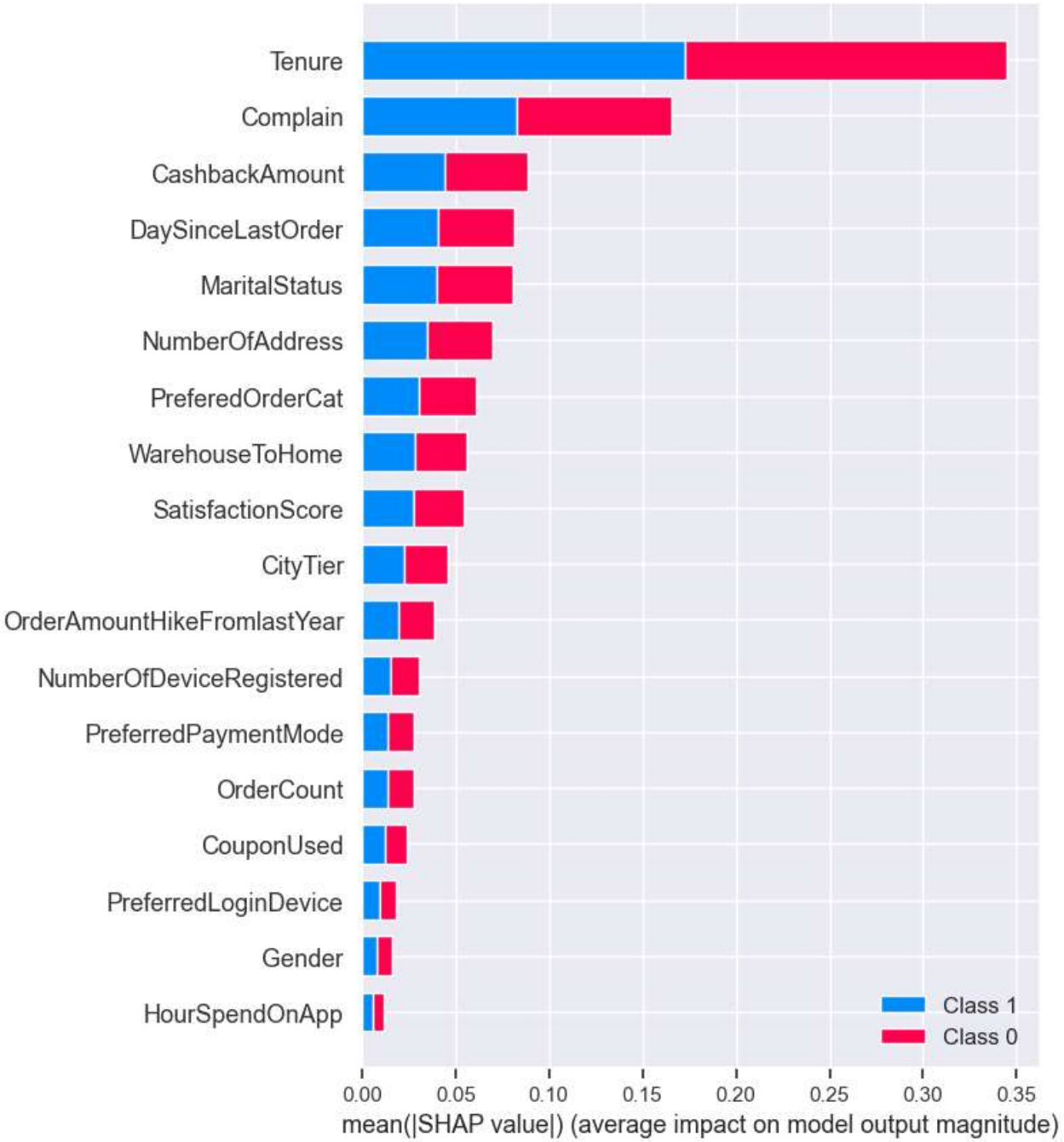
In [39]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score, jaccard_score,
print('F-1 Score : ',(f1_score(y_test, y_pred, average='micro')))
print('Precision Score : ',(precision_score(y_test, y_pred, average='micro')))
print('Recall Score : ',(recall_score(y_test, y_pred, average='micro')))
print('Jaccard Score : ',(jaccard_score(y_test, y_pred, average='micro')))
print('Log Loss : ',(log_loss(y_test, y_pred)))
```

```
F-1 Score :  0.9760213143872114
Precision Score :  0.9760213143872114
Recall Score :  0.9760213143872114
Jaccard Score :  0.9531656548135299
Log Loss :  0.8281958808680727
```

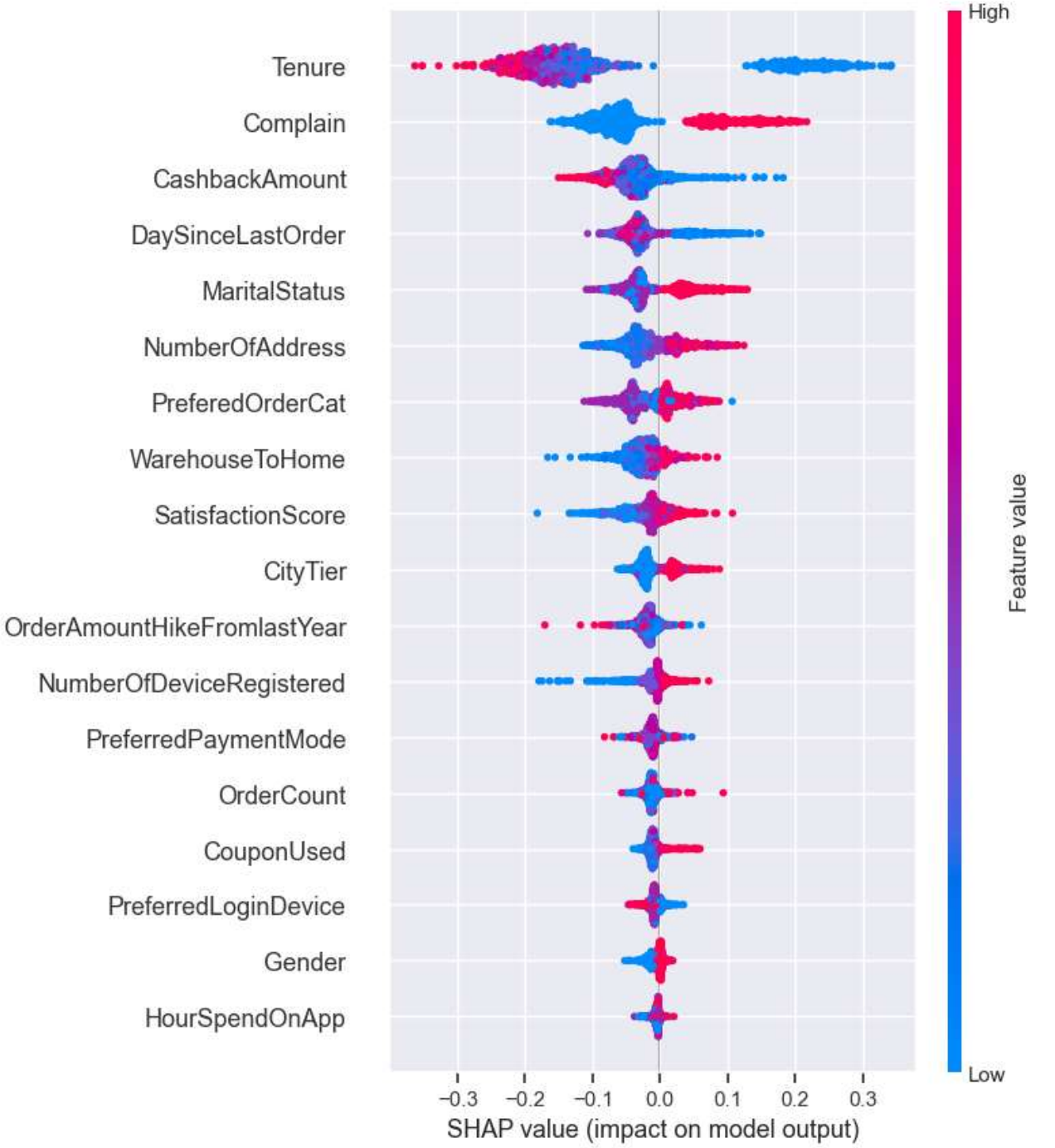
In [40]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": dtree.feature_importances_
})
fi = imp_df.sort_values(by="Importance", ascending=False)

fi2 = fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2, x='Importance', y='Feature Name')
plt.title('Top 10 Feature Importance Each Attributes (Random Forest)', fontsize=18)
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```



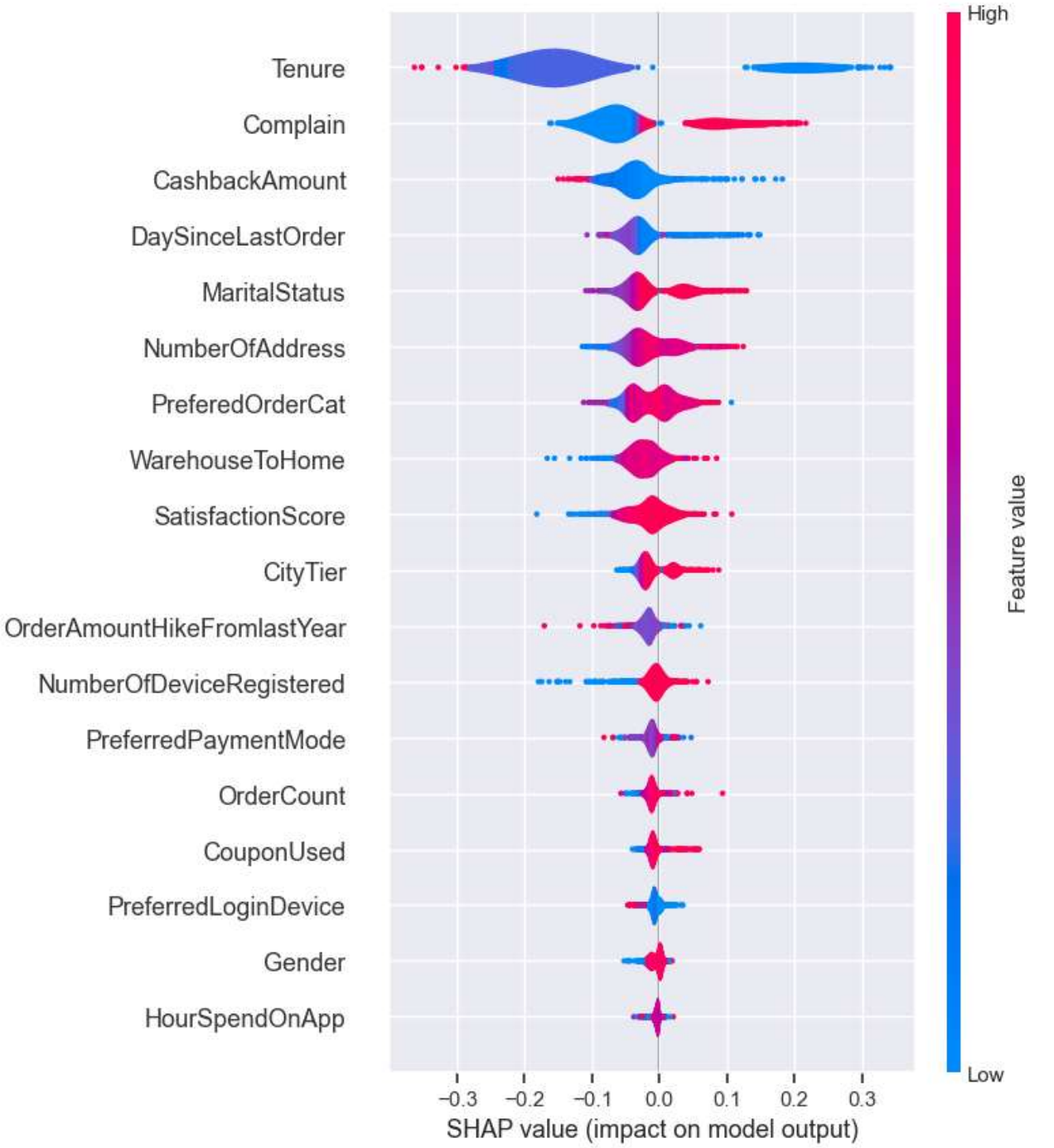
In [41]:
```
import shap
explainer = shap.TreeExplainer(rfc)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```



In [42]:
```
# compute SHAP values
explainer = shap.TreeExplainer(rfc)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns)
```

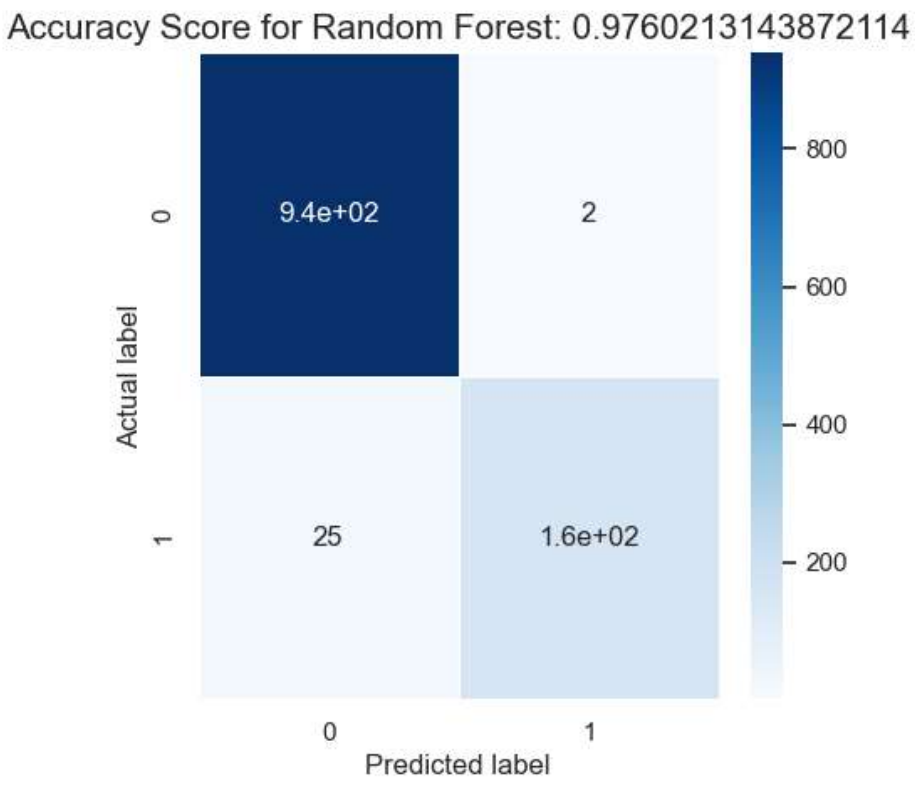


In [43]:
```
# compute SHAP values
explainer = shap.TreeExplainer(rfc)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns, plot_type="violin"
```



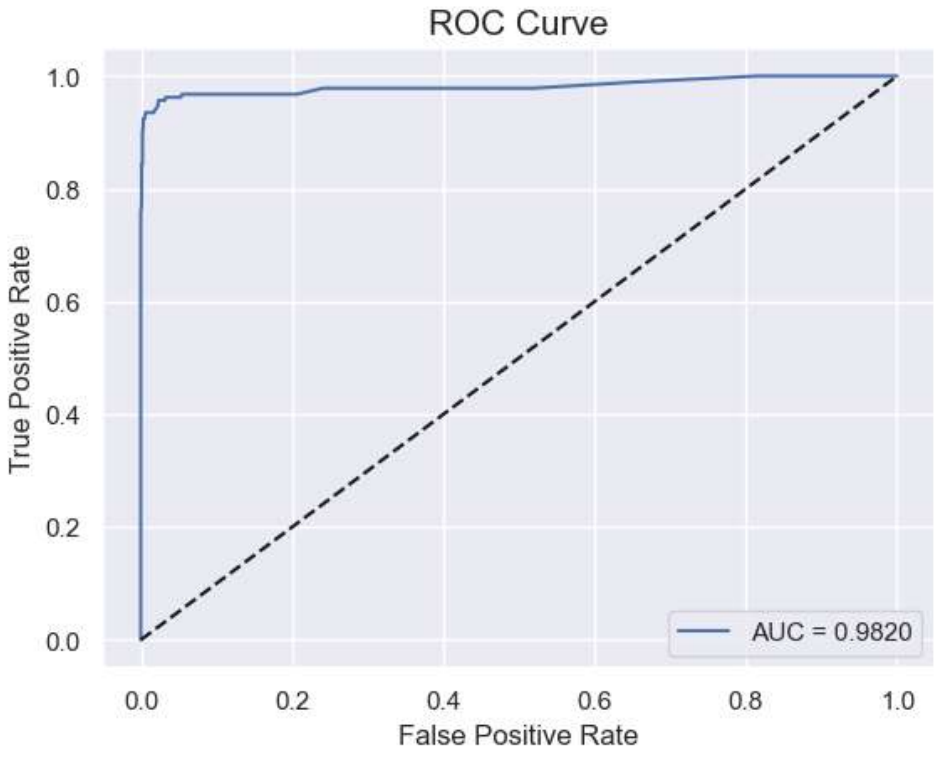
In [44]:
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,  cmap = 'Blues')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score for Random Forest: {0}'.format(rfc.score(X_test, y_test))
plt.title(all_sample_title, size = 15)
```

Out[44]:
```
Text(0.5, 1.0, 'Accuracy Score for Random Forest: 0.9760213143872114')
```



In [45]:
```
from sklearn.metrics import roc_curve, roc_auc_score
y_pred_proba = rfc.predict_proba(X_test)[:][:,1]

df_actual_predicted = pd.concat([pd.DataFrame(np.array(y_test), columns=['y_actual']), pd.DataFrame
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])

plt.plot(fpr, tpr, label='AUC = %0.4f' %auc)
plt.plot(fpr, fpr, linestyle = '--', color='k')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve', size = 15)
plt.legend()
```

Out[45]: <matplotlib.legend.Legend at 0x247ef5c1bb0>



XGBoost

In [46]:
```
from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier

# Create an XGBoost classifier
xgb = XGBClassifier()

# Define the parameter grid for grid search
param_grid = {
    'n_estimators': [100, 200],
    'max_depth': [3, 5, 7],
    'learning_rate': [0.1, 0.01, 0.001],
    'gamma': [0, 0.1, 0.2]
}

# Perform a grid search with cross-validation to find the best hyperparameters
grid_search = GridSearchCV(xgb, param_grid, cv=5)
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print(grid_search.best_params_)
```

```
{'gamma': 0, 'learning_rate': 0.1, 'max_depth': 7, 'n_estimators': 200}
```

In [47]:
```
from xgboost import XGBClassifier
xgb = XGBClassifier(gamma=0, learning_rate=0.1, max_depth=7, n_estimators=200)
xgb.fit(X_train, y_train)
```

Out[47]:
```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=0, gpu_id=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=0.1, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=7, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              n_estimators=200, n_jobs=None, num_parallel_tree=None,
              predictor=None, random_state=None, ...)
```

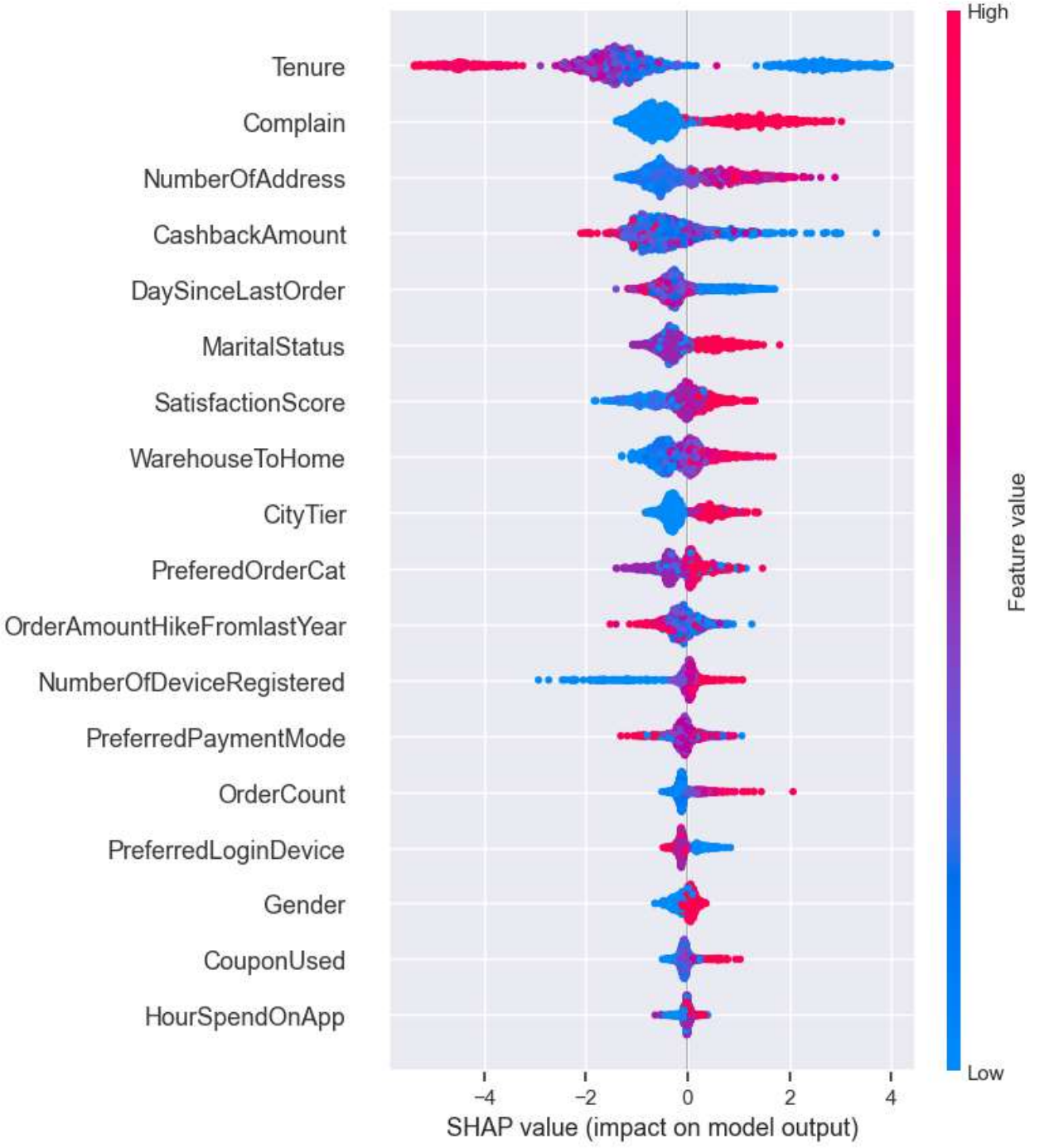
In [48]:
```
from sklearn.metrics import accuracy_score
y_pred = xgb.predict(X_test)
print("Accuracy Score :", round(accuracy_score(y_test, y_pred)*100 ,2), "%")
```

```
Accuracy Score : 97.78 %
```

In [49]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score, jaccard_score,
print('F-1 Score : ',(f1_score(y_test, y_pred, average='micro')))
print('Precision Score : ',(precision_score(y_test, y_pred, average='micro')))
print('Recall Score : ',(recall_score(y_test, y_pred, average='micro')))
print('Jaccard Score : ',(jaccard_score(y_test, y_pred, average='micro')))
print('Log Loss : ',(log_loss(y_test, y_pred)))
```

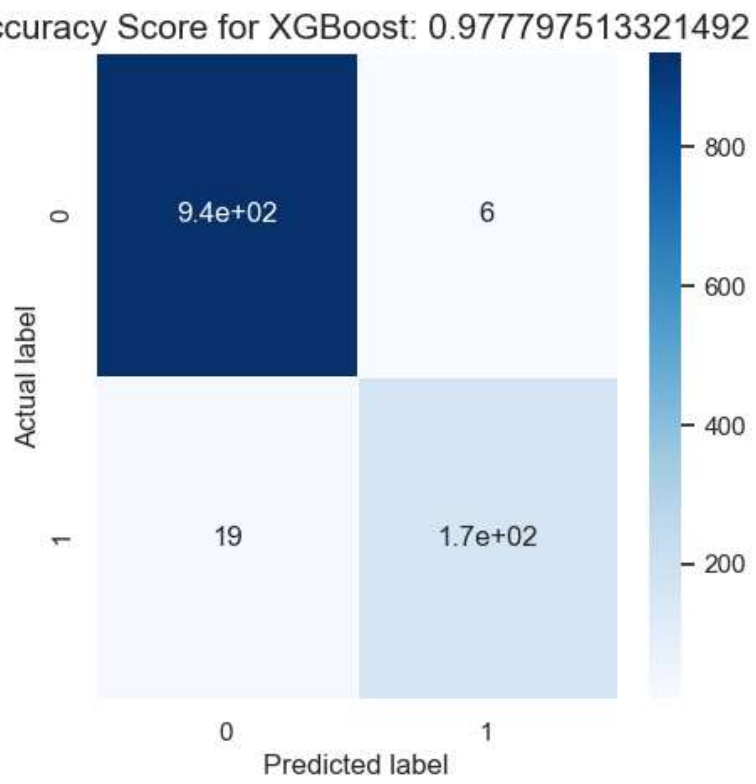
```
F-1 Score :  0.977797513321492
Precision Score :  0.977797513321492
Recall Score :  0.977797513321492
Jaccard Score :  0.9565595134665508
Log Loss :  0.7668509835322816
```

In [50]:
```
import shap
explainer = shap.TreeExplainer(xgb)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```



In [52]:
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,  cmap = 'Blues')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score for XGBoost: {0}'.format(xgb.score(X_test, y_test))
plt.title(all_sample_title, size = 15)
```

Out[52]:
```
Text(0.5, 1.0, 'Accuracy Score for XGBoost: 0.977797513321492')
```



In [53]:
```
from sklearn.metrics import roc_curve, roc_auc_score
y_pred_proba = xgb.predict_proba(X_test)[:][:,1]

df_actual_predicted = pd.concat([pd.DataFrame(np.array(y_test), columns=['y_actual']), pd.DataFrame
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])

plt.plot(fpr, tpr, label='AUC = %0.4f' %auc)
plt.plot(fpr, fpr, linestyle = '--', color='k')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve', size = 15)
plt.legend()
```

Out[53]: <matplotlib.legend.Legend at 0x247eeb33850>