In [1]:
```
import pandas as pd
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
sns.set_theme(color_codes=True)
pd.set_option('display.max_columns', None)
```

In [2]:
```
df = pd.read_csv('Invistico_Airline.csv')
df.head()
```

Out[2]:

Seat ıfort	Departure/Arrival time convenient	Food and drink	Gate location	Inflight wifi service	Inflight entertainment	Online support	Ease of Online booking	On-board service	Leg room service	Ba ha
0	0	0	2	2	4	2	3	3	0	
0	0	0	3	0	2	2	3	4	4	
0	0	0	3	2	0	2	2	3	3	
0	0	0	3	3	4	3	1	1	0	
0	0	0	3	4	3	4	2	2	0	

Data Preprocessing Part 1

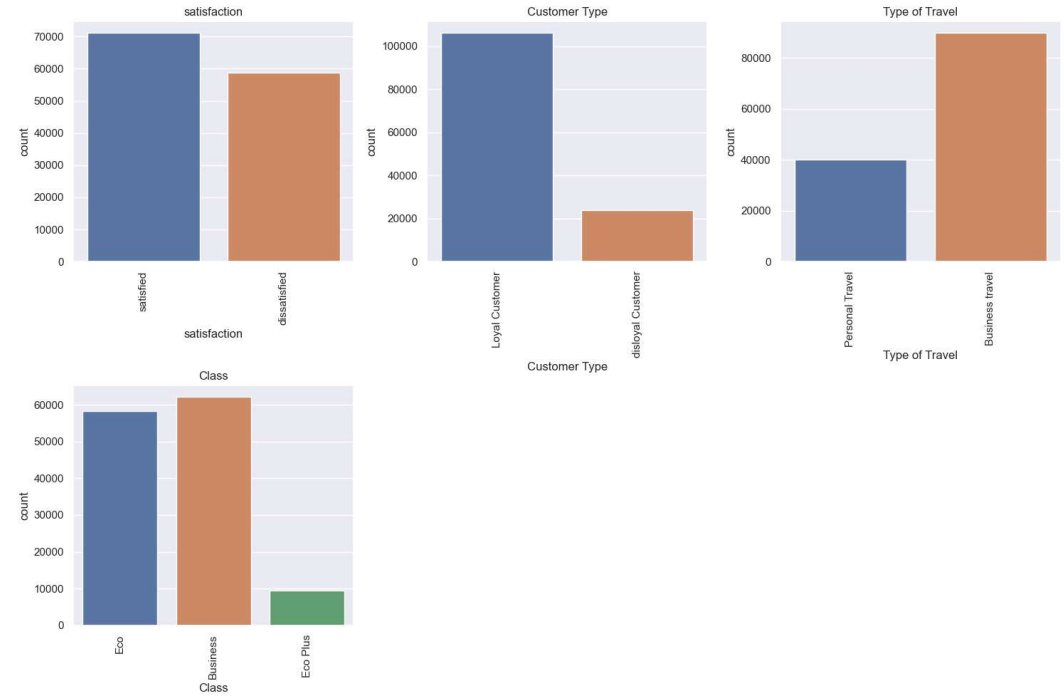
In [3]:
```
#Check the number of unique value from all of the object datatype
df.select_dtypes(include='object').nunique()
```

Out[3]:
```
satisfaction      2
Customer Type     2
Type of Travel    2
Class             3
dtype: int64
```

Exploratory Data Analysis

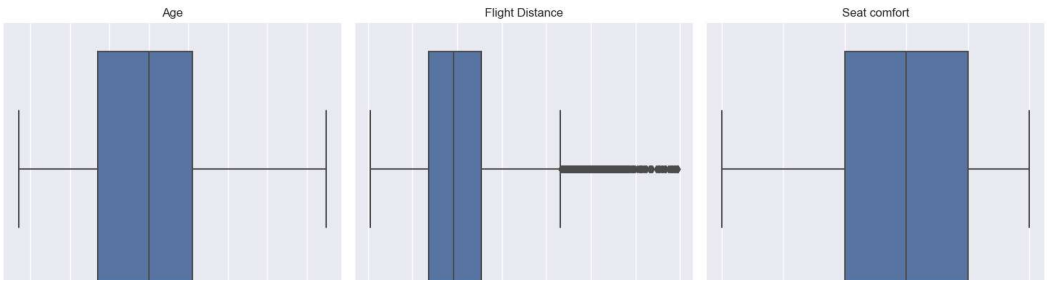
In [4]:
```
# Get the names of all columns with data type 'object' (categorical columns) excl
cat_vars = df.select_dtypes(include='object').columns.tolist()

# Create a figure with subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

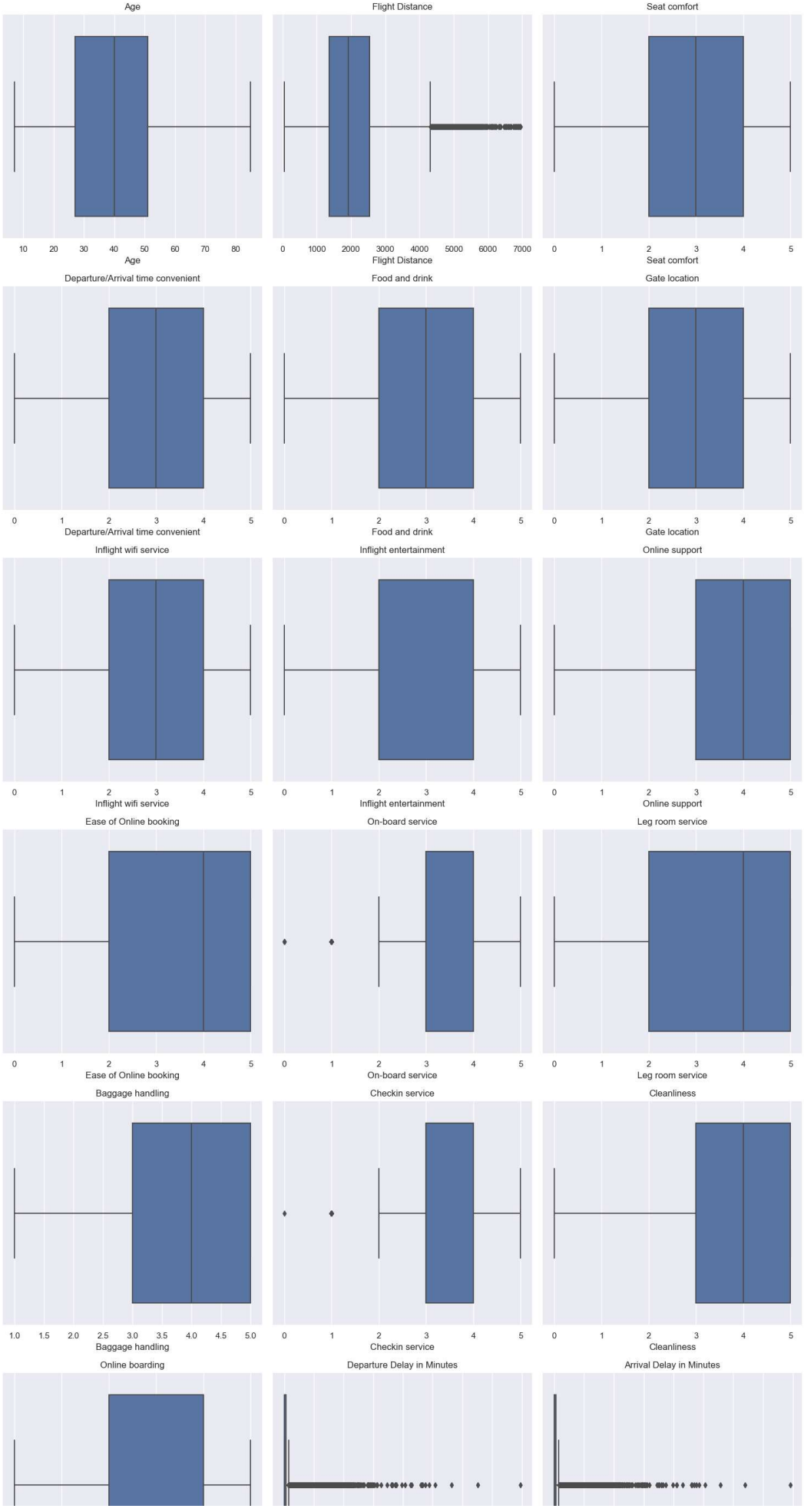
In [4]:
```
# Get the names of all columns with data type 'object' (categorical columns) excl
cat_vars = df.select_dtypes(include='object').columns.tolist()

# Create a figure with subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a countplot for the top 6 values of each categorical variable using Seab
for i, var in enumerate(cat_vars):
    top_values = df[var].value_counts().index
    filtered_df = df[df[var].isin(top_values)]
    sns.countplot(x=var, data=filtered_df, ax=axs[i])
    axs[i].set_title(var)
    axs[i].tick_params(axis='x', rotation=90)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

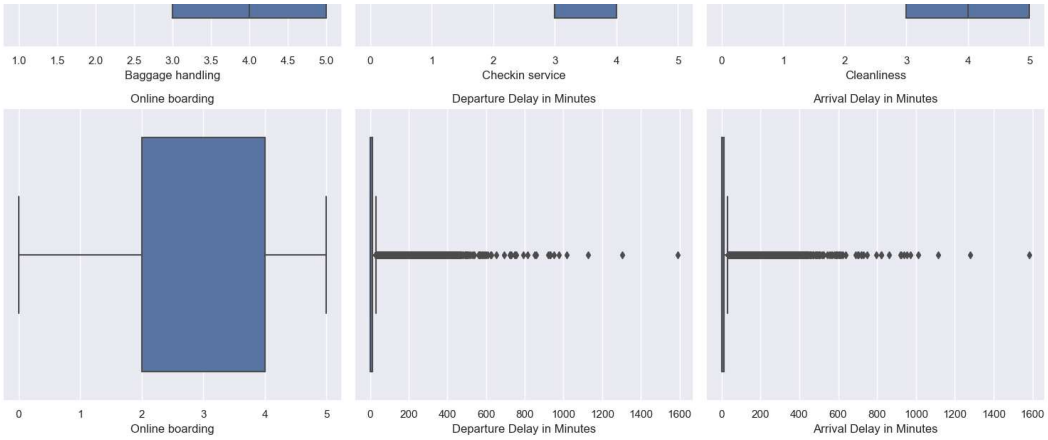


In [5]:
```
# Get the names of all columns with data type 'int' or 'float', excluding 'churn_
num_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(num_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

In [5]:
```
# Get the names of all columns with data type 'int' or 'float', excluding 'churn_
num_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(num_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a box plot for each numerical variable using Seaborn
for i, var in enumerate(num_vars):
    sns.boxplot(x=df[var], ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

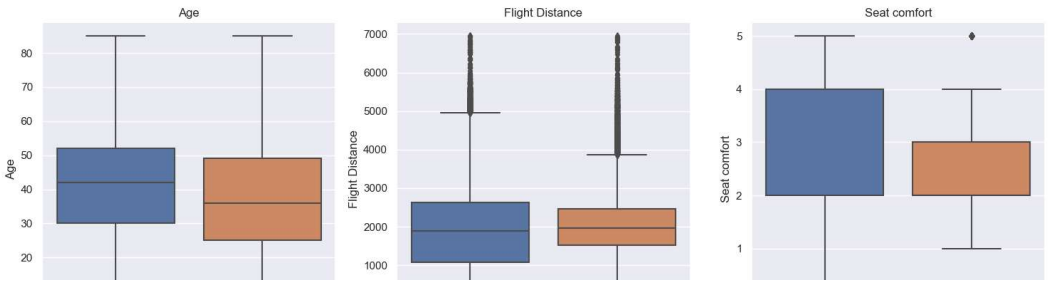

Age
Flight Distance
Seat comfort

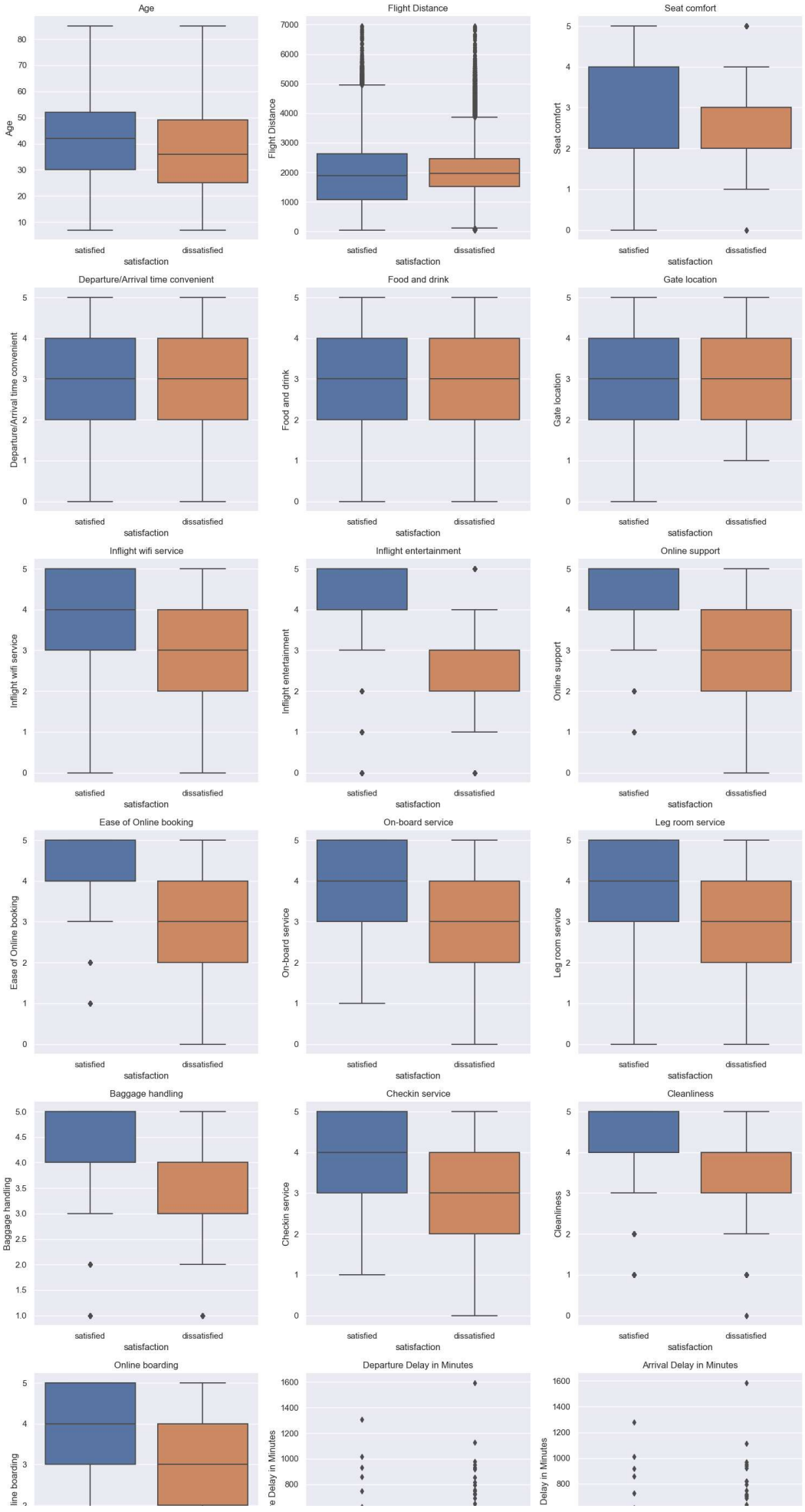

Age
10 20 30 40 50 60 70 80
Age
Flight Distance
0 1000 2000 3000 4000 5000 6000 7000
Flight Distance
Seat comfort
0 1 2 3 4 5
Seat comfort
Departure/Arrival time convenient
0 1 2 3 4 5
Departure/Arrival time convenient
Food and drink
0 1 2 3 4 5
Food and drink
Gate location
0 1 2 3 4 5
Gate location
Inflight wifi service
0 1 2 3 4 5
Inflight wifi service
Inflight entertainment
0 1 2 3 4 5
Inflight entertainment
Online support
0 1 2 3 4 5
Online support
Ease of Online booking
0 1 2 3 4 5
Ease of Online booking
On-board service
0 1 2 3 4 5
On-board service
Leg room service
0 1 2 3 4 5
Leg room service
Baggage handling
1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Baggage handling
Checkin service
0 1 2 3 4 5
Checkin service
Cleanliness
0 1 2 3 4 5
Cleanliness
Online boarding
Departure Delay in Minutes
Arrival Delay in Minutes

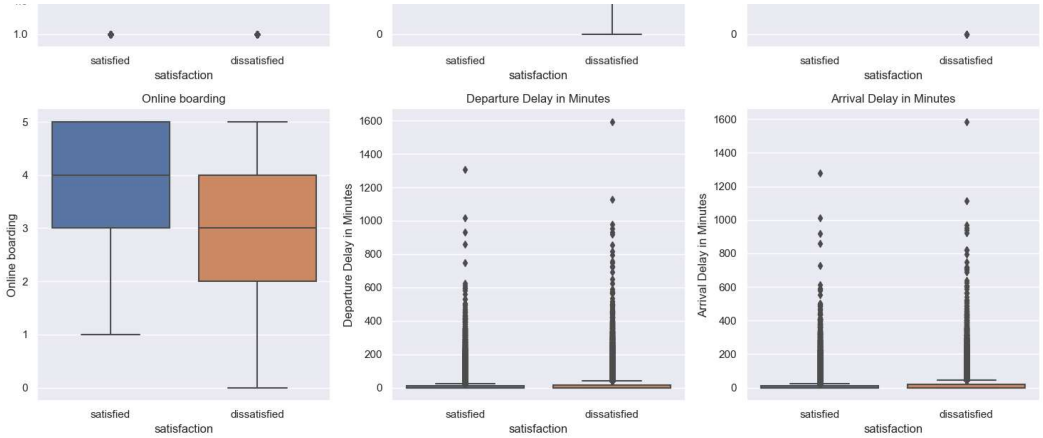


In [6]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()
int_vars = [col for col in num_vars if col != 'satisfaction']

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

In [6]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()
int_vars = [col for col in num_vars if col != 'satisfaction']

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a box plot for each integer variable using Seaborn with hue='attrition'
for i, var in enumerate(int_vars):
    sns.boxplot(y=var, x='satisfaction', data=df, ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

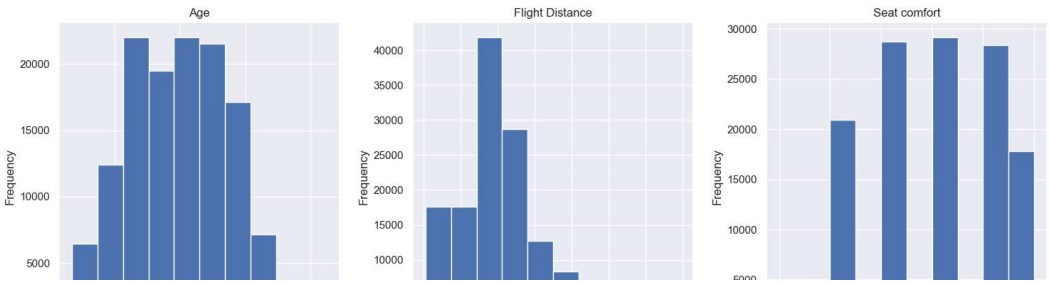

Age
Age
80
70
60
50
40
30
20
Flight Distance
Flight Distance
7000
6000
5000
4000
3000
2000
1000
Seat comfort
Seat comfort
5
4
3
2
1

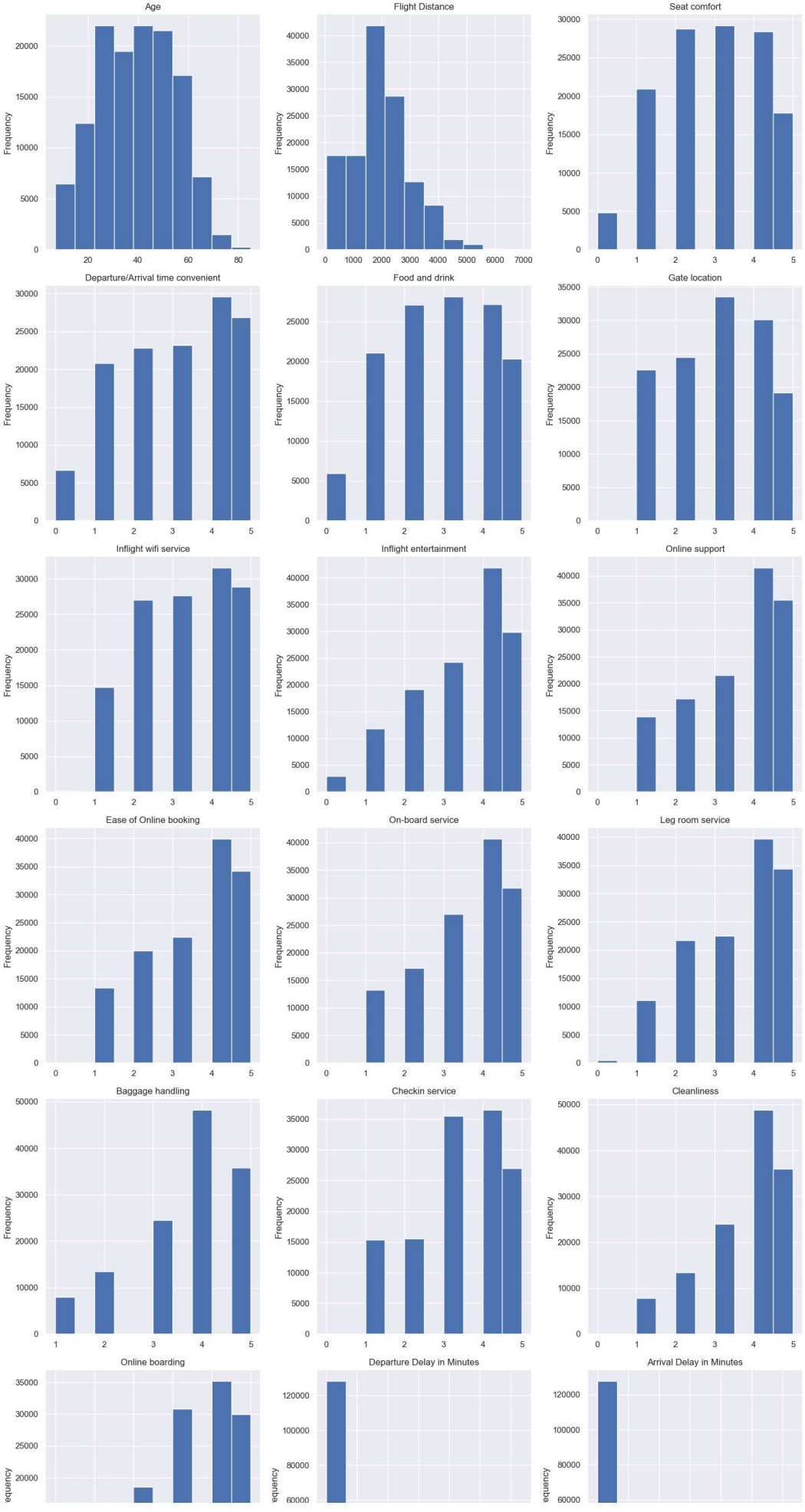

Age
Flight Distance
Seat comfort
Departure/Arrival time convenient
Food and drink
Gate location
Inflight wifi service
Inflight entertainment
Online support
Ease of Online booking
On-board service
Leg room service
Baggage handling
Checkin service
Cleanliness
Online boarding
Departure Delay in Minutes
Arrival Delay in Minutes
satisfied
dissatisfied
satisfaction

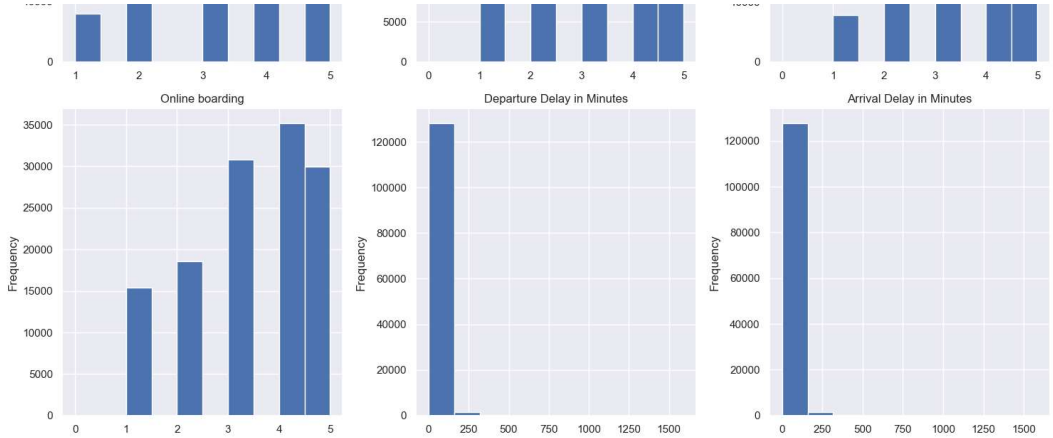


In [7]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

In [7]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a histogram for each integer variable
for i, var in enumerate(int_vars):
    df[var].plot.hist(ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

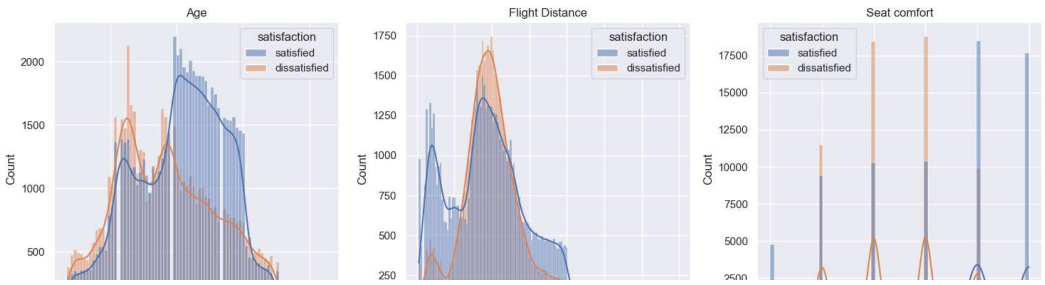

Age
Frequency
20000
15000
10000
5000
Flight Distance
Frequency
40000
35000
30000
25000
20000
15000
10000
Seat comfort
Frequency
30000
25000
20000
15000
10000

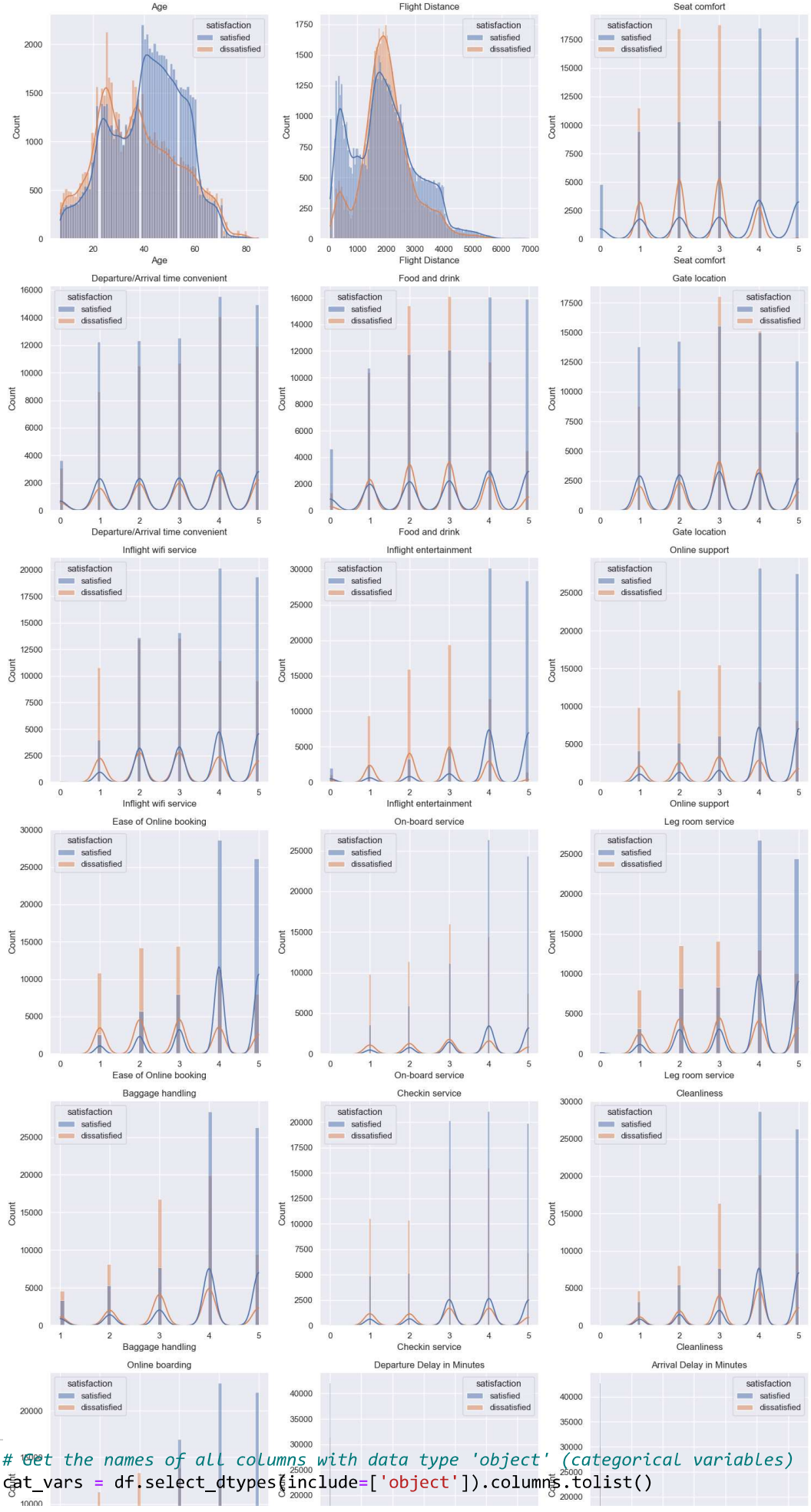

Age
Flight Distance
Seat comfort
Departure/Arrival time convenient
Food and drink
Gate location
Inflight wifi service
Inflight entertainment
Online support
Ease of Online booking
On-board service
Leg room service
Baggage handling
Checkin service
Cleanliness
Online boarding
Departure Delay in Minutes
Arrival Delay in Minutes
Frequency



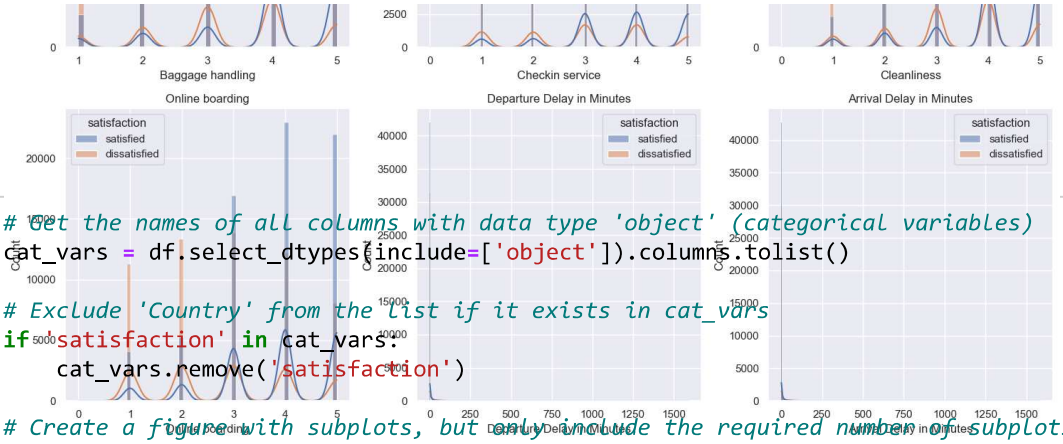
In [8]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()
int_vars = [col for col in num_vars if col != 'satisfaction']

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

In [8]:
```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()
int_vars = [col for col in num_vars if col != 'satisfaction']

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a histogram for each integer variable with hue='Attrition'
for i, var in enumerate(int_vars):
    sns.histplot(data=df, x=var, hue='satisfaction', kde=True, ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

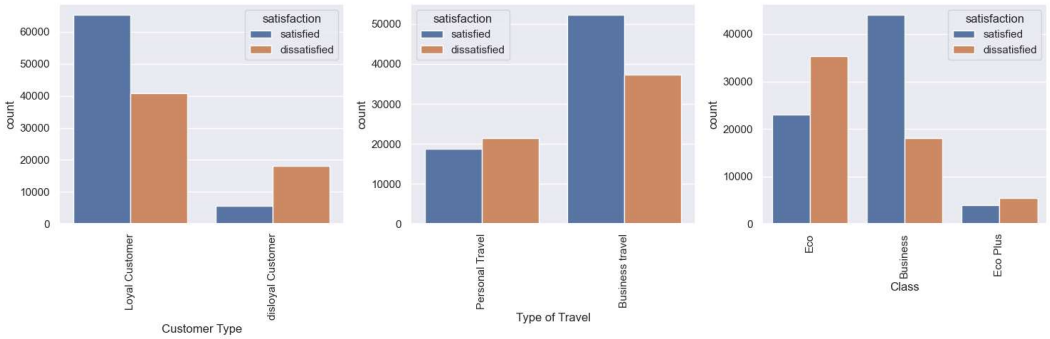

Age
satisfaction
satisfied
dissatisfied
Count
2000
1500
1000
500
Flight Distance
satisfaction
satisfied
dissatisfied
Count
1750
1500
1250
1000
750
500
250
Seat comfort
satisfaction
satisfied
dissatisfied
Count
17500
15000
12500
10000
7500
5000
2500



In [9]:
```
# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()
```

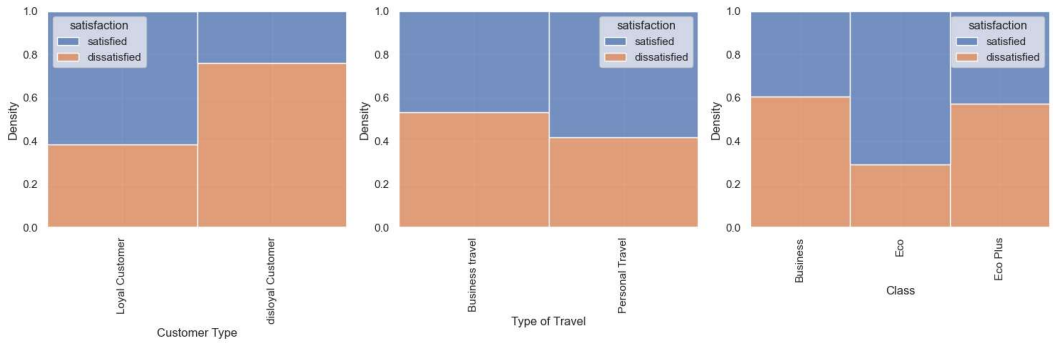


In [9]:
```
# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()

# Exclude 'Country' from the list if it exists in cat_vars
if 'satisfaction' in cat_vars:
    cat_vars.remove('satisfaction')

# Create a figure with subplots, but only include the required number of subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a count plot for each categorical variable
for i, var in enumerate(cat_vars):
    filtered_df = df[df[var].notnull()]  # Exclude rows with NaN values in the va
    sns.countplot(x=var, hue='satisfaction', data=filtered_df, ax=axs[i])
    axs[i].set_xticklabels(axs[i].get_xticklabels(), rotation=90)

# Remove any remaining blank subplots
for i in range(num_cols, len(axs)):
    fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

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



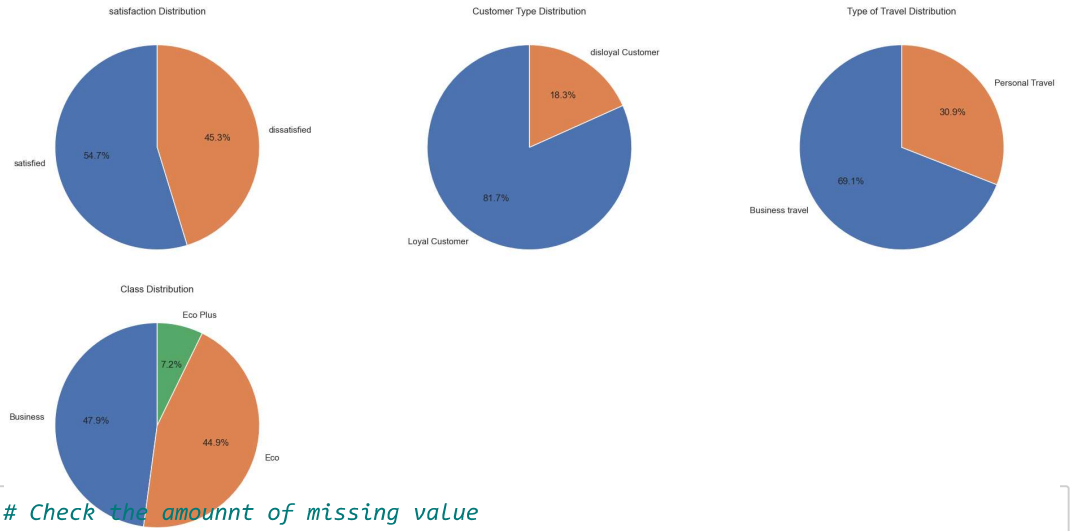
In [10]:
```
import warnings

# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()

# Exclude 'Attrition' from the list if it exists in cat_vars
if 'satisfaction' in cat_vars:
    cat_vars.remove('satisfaction')
```

In [10]:
```
import warnings

# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()

# Exclude 'Attrition' from the list if it exists in cat_vars
if 'satisfaction' in cat_vars:
    cat_vars.remove('satisfaction')

# Create a figure with subplots, but only include the required number of subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subp
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a count plot for the top 6 values of each categorical variable as a dens
for i, var in enumerate(cat_vars):
    top_values = df[var].value_counts().nlargest(6).index
    filtered_df = df[df[var].isin(top_values)]

    # Set x-tick positions explicitly
    tick_positions = range(len(top_values))
    axs[i].set_xticks(tick_positions)
    axs[i].set_xticklabels(top_values, rotation=90)  # Set x-tick labels

    sns.histplot(x=var, hue='satisfaction', data=filtered_df, ax=axs[i], multiple
    axs[i].set_xlabel(var)

# Remove any remaining blank subplots
for i in range(num_cols, len(axs)):
    fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

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



In [11]:
```
# Specify the maximum number of categories to show individually
max_categories = 5

# Filter categorical columns with 'object' data type
cat_cols = [col for col in df.columns if col != 'y' and df[col].dtype == 'object

# Create a figure with subplots
num_cols = len(cat_cols)
num_rows = (num_cols + 2) // 3
```

In [11]:
```
# Specify the maximum number of categories to show individually
max_categories = 5

# Filter categorical columns with 'object' data type
cat_cols = [col for col in df.columns if col != 'y' and df[col].dtype == 'object

# Create a figure with subplots
num_cols = len(cat_cols)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(20, 5*num_rows))

# Flatten the axs array for easier indexing
axs = axs.flatten()

# Create a pie chart for each categorical column
for i, col in enumerate(cat_cols):
    if i < len(axs):  # Ensure we don't exceed the number of subplots
        # Count the number of occurrences for each category
        cat_counts = df[col].value_counts()

        # Group categories beyond the top max_categories as 'Other'
        if len(cat_counts) > max_categories:
            cat_counts_top = cat_counts[:max_categories]
            cat_counts_other = pd.Series(cat_counts[max_categories:].sum(), index
            cat_counts = cat_counts_top.append(cat_counts_other)

        # Create a pie chart
        axs[i].pie(cat_counts, labels=cat_counts.index, autopct='%1.1f%%', starta
        axs[i].set_title(f'{col} Distribution')

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```



In [12]:
```
# Check the amounnt of missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[12]:
```
Arrival Delay in Minutes    0.302587
dtype: float64
```

Data Preprocessing Part 2

In [13]:
```
df.shape
```

In [12]:
```
# Check the amounnt of missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

Out[12]:
```
Arrival Delay in Minutes    0.302587
dtype: float64
```

Data Preprocessing Part 2

In [13]:
```
df.shape
```

Out[13]:
```
(129880, 22)
```

In [14]:
```
# Drop null value from Arrival Delay in Minutes columns because the null value is
df.dropna(subset=['Arrival Delay in Minutes'], inplace=True)
df.shape
```

Out[14]:
```
(129487, 22)
```

Label Encoding for Object Datatypes

In [15]:
```
# 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()}")
```

```
satisfaction: ['satisfied' 'dissatisfied']
Customer Type: ['Loyal Customer' 'disloyal Customer']
Type of Travel: ['Personal Travel' 'Business travel']
Class: ['Eco' 'Business' 'Eco Plus']
```

In [16]:
```
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()}")
```

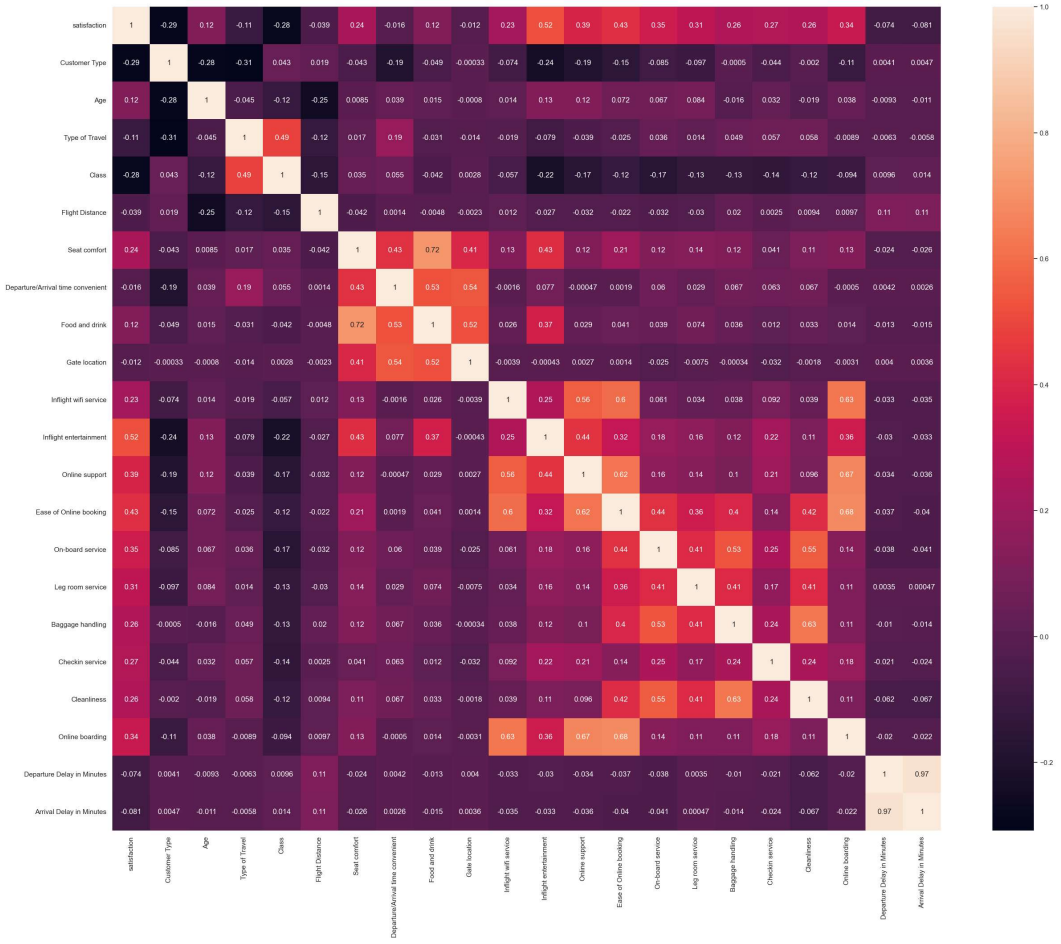
```
satisfaction: [1 0]
Customer Type: [0 1]
Type of Travel: [1 0]
Class: [1 0 2]
```

In [17]:
```
# Correlation Heatmap
plt.figure(figsize=(30, 24))
sns.heatmap(df.corr(), fmt='.2g', annot=True)
```

Out[17]:
```
<AxesSubplot:>
```

In [17]:
```
# Correlation Heatmap
plt.figure(figsize=(30, 24))
sns.heatmap(df.corr(), fmt='.2g', annot=True)
```

Out[17]: <AxesSubplot:>



Train Test Split

In [18]:
```
X = df.drop('satisfaction', axis=1)
y = df['satisfaction']
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.2,random_sta
```

In [19]:
```
from scipy import stats

# Define the columns for which you want to remove outliers
selected_columns = ['Departure Delay in Minutes', 'Arrival Delay in Minutes']

# Calculate the Z-scores for the selected columns in the training data
z_scores = np.abs(stats.zscore(X_train[selected_columns]))

# Set a threshold value for outlier detection (e.g., 3)
```

In [19]:
```
from scipy import stats

# Define the columns for which you want to remove outliers
selected_columns = ['Departure Delay in Minutes', 'Arrival Delay in Minutes']

# Calculate the Z-scores for the selected columns in the training data
z_scores = np.abs(stats.zscore(X_train[selected_columns]))

# Set a threshold value for outlier detection (e.g., 3)
threshold = 3

# Find the indices of outliers based on the threshold
outlier_indices = np.where(z_scores > threshold)[0]

# Remove the outliers from the training data
X_train = X_train.drop(X_train.index[outlier_indices])
y_train = y_train.drop(y_train.index[outlier_indices])
```

Decision Tree Classifier

In [20]:
```
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': 2, 'min_samples_split': 2, 'random_state':
42}
```

In [21]:
```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(random_state=42, max_depth=8, min_samples_leaf=2,
dtree.fit(X_train, y_train)
```

Out[21]:
```
DecisionTreeClassifier(class_weight='balanced', max_depth=8, min_samples_leaf=
2,
                       random_state=42)
```

In [22]:
```
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 : 90.61 %
```

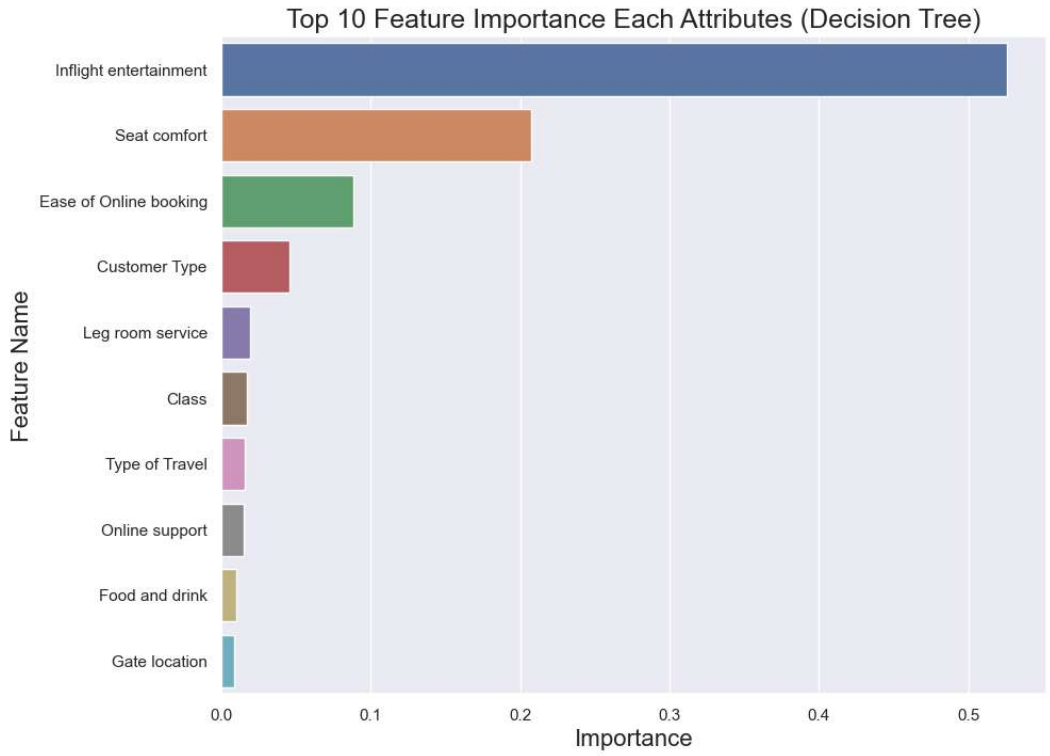
In [23]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_sc
print('F-1 Score : ',(f1_score(y_test, y_pred, average='micro')))
print('Precision Score : ',(precision_score(y_test, y_pred, average='micro')))
print('Recall Score : ',(recall_score(y_test, y_pred, average='micro')))
print('Jaccard Score : ',(jaccard_score(y_test, y_pred, average='micro')))
print('Log Loss : ',(log_loss(y_test, y_pred)))
```

```
F-1 Score :  0.9060931346049887
Precision Score :  0.9060931346049887
```

In [23]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_sc
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 :  0.9060931346049887
Precision Score :  0.9060931346049887
Recall Score :  0.9060931346049887
Jaccard Score :  0.8283092128485704
Log Loss :  3.243455982335027
```

In [24]:
```
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=1
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```

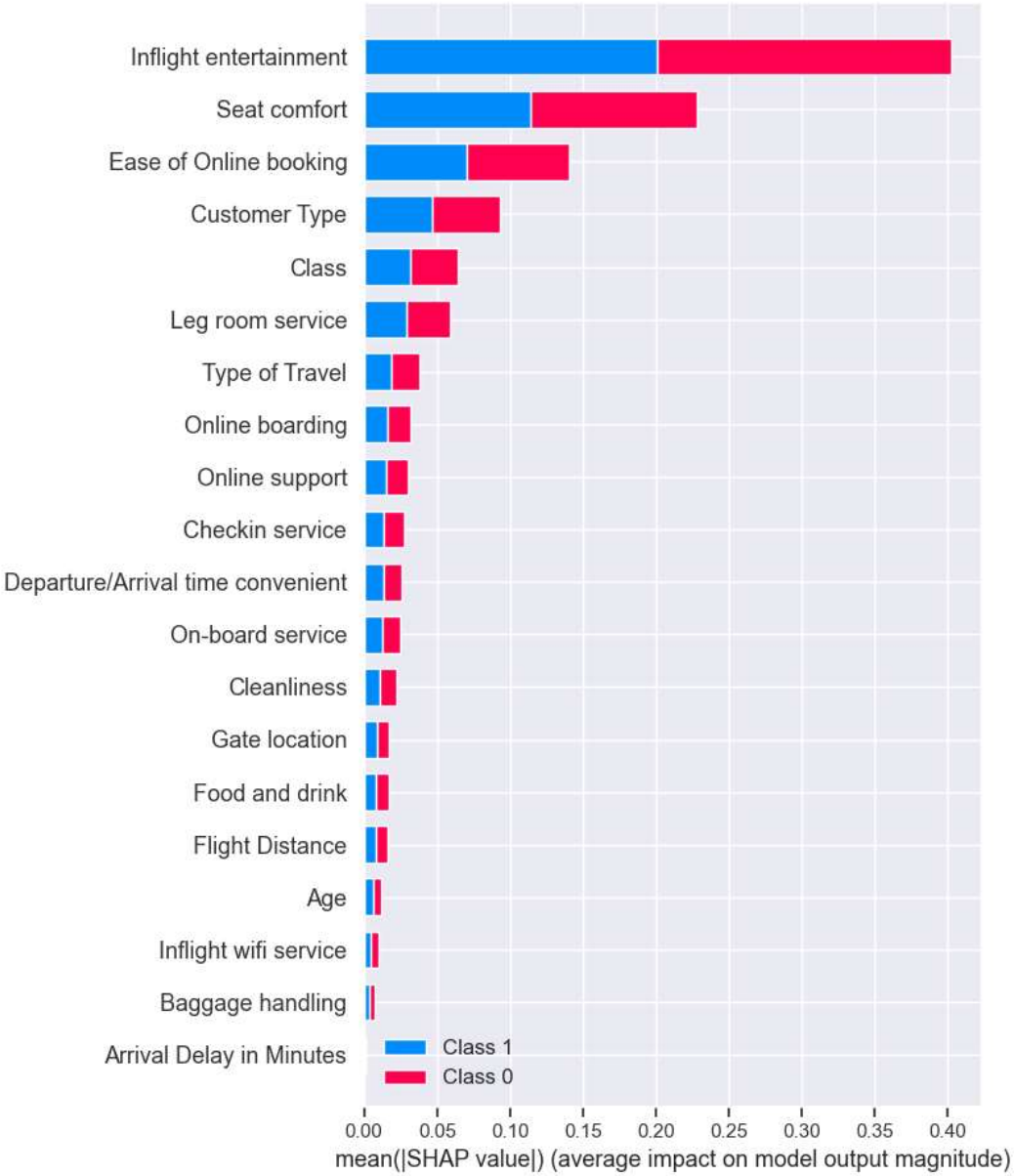


In [25]:
```
import shap
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```

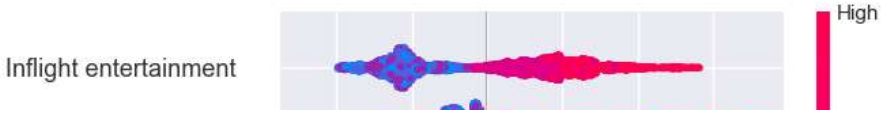
```
Using `tqdm.autonotebook.tqdm` in notebook mode. Use `tqdm.tqdm` instead to for
ce console mode (e.g. in jupyter console)
```

In [25]:
```
import shap
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```

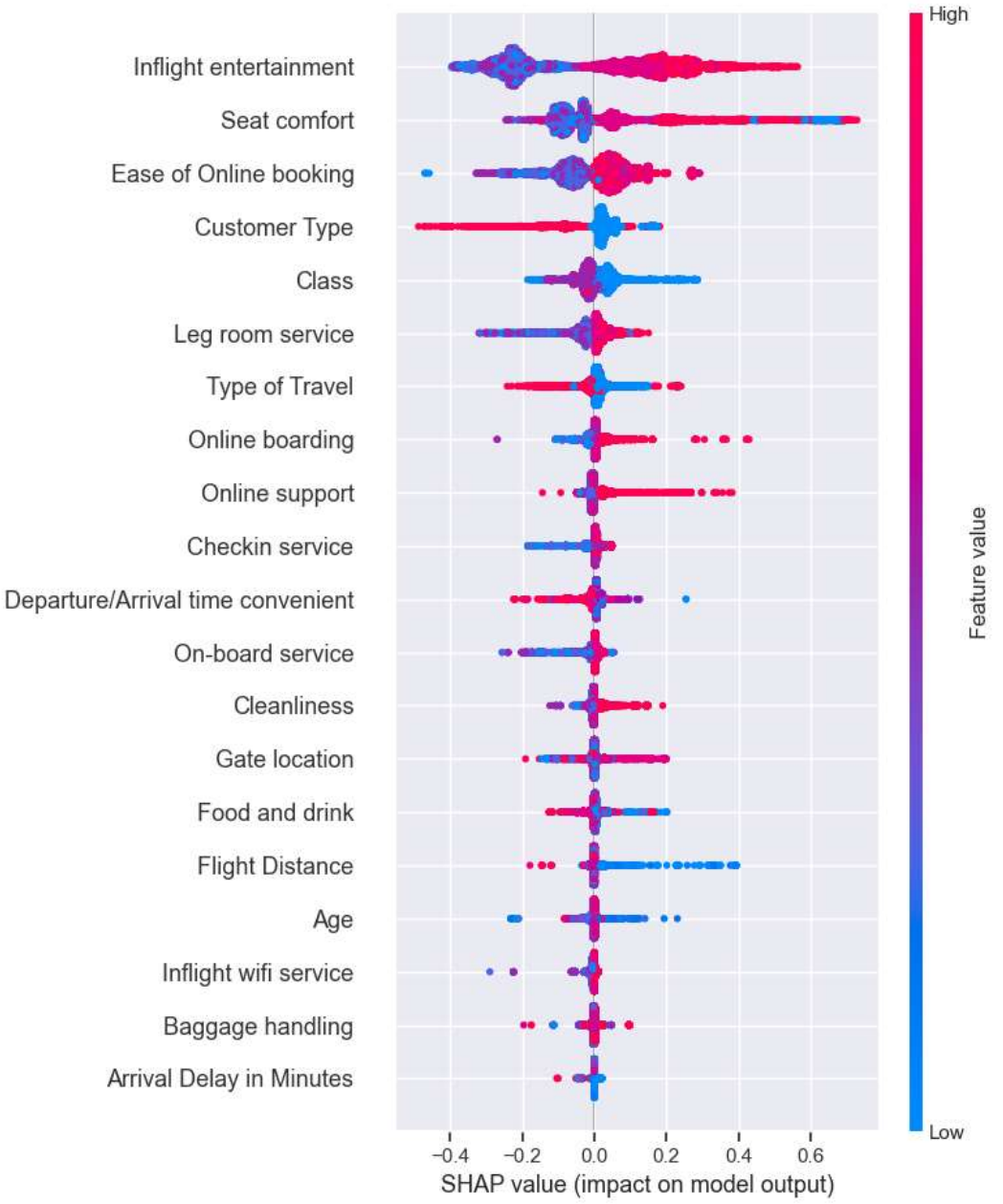
```
Using `tqdm.autonotebook.tqdm` in notebook mode. Use `tqdm.tqdm` instead to for
ce console mode (e.g. in jupyter console)
```



In [26]:
```
# 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)
```



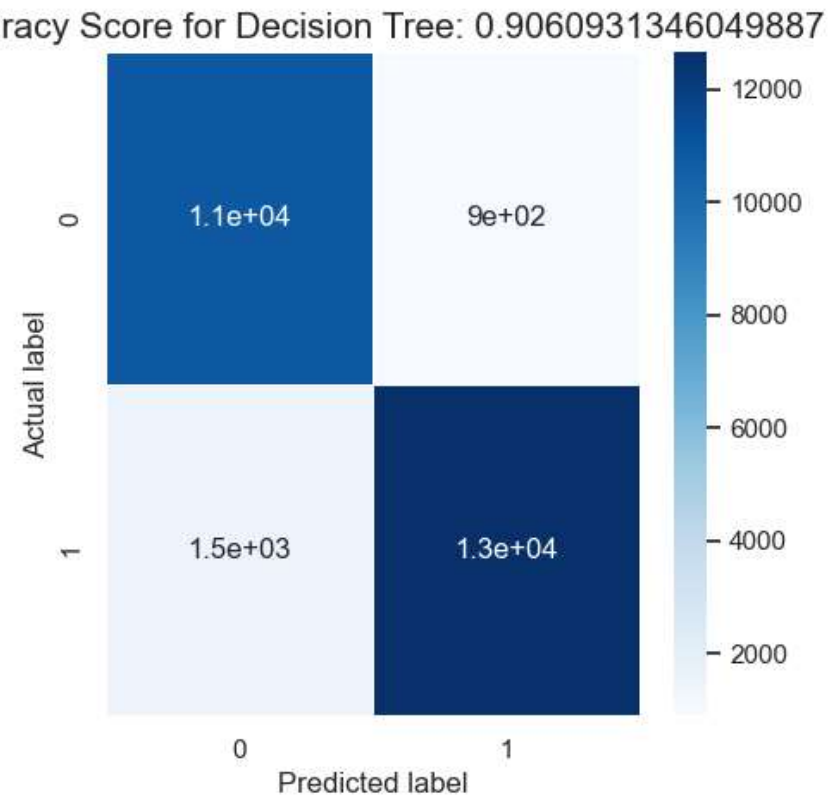
In [26]:
```
# compute SHAP values
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns)
```



In [27]:
```
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_t
plt.title(all_sample_title, size = 15)
```

In [27]:
```
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_t
plt.title(all_sample_title, size = 15)
```

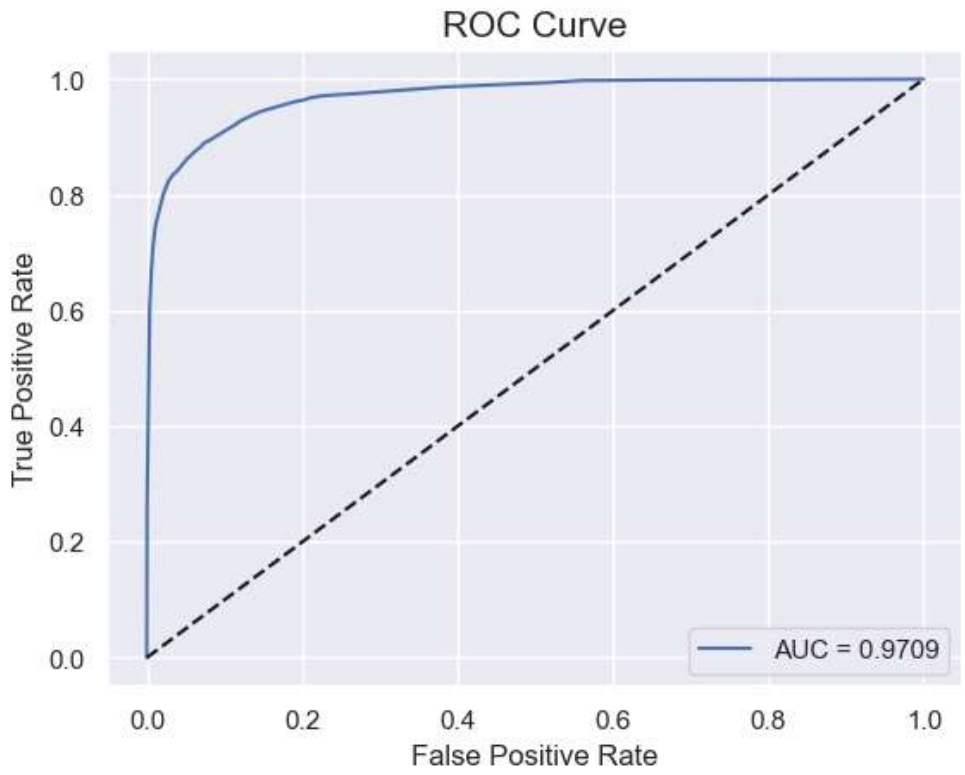
Out[27]:
```
Text(0.5, 1.0, 'Accuracy Score for Decision Tree: 0.9060931346049887')
```



In [28]:
```
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_actua
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_
```

In [28]:
```
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_actua
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_

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[28]: <matplotlib.legend.Legend at 0x2490475ddc0>



Random Forest Classifier

In [30]:
```
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]
}
```

In [30]:
```
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': 200, 'random_stat
e': 42}
```

In [31]:
```
from sklearn.ensemble import RandomForestClassifier
rfc = RandomForestClassifier(random_state=42, max_depth=None, max_features='sqrt'
rfc.fit(X_train, y_train)
```

Out[31]:
```
RandomForestClassifier(class_weight='balanced', max_features='sqrt',
                       n_estimators=200, random_state=42)
```

In [32]:
```
y_pred = rfc.predict(X_test)
print("Accuracy Score :", round(accuracy_score(y_test, y_pred)*100 ,2), "%")
```

```
Accuracy Score : 95.39 %
```

In [33]:
```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_sc
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 :  0.9538960537493243
Precision Score :  0.9538960537493243
Recall Score :  0.9538960537493243
Jaccard Score :  0.9118558984201979
Log Loss :  1.5923887104135401
```

In [34]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": rfc.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')
```

In [34]:
```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": rfc.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=1
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```