Importing Library

In [1]:
```
# Import necessary libraries
import numpy as np  # NumPy for numerical operations
import pandas as pd  # Pandas for data manipulation and analysis

import matplotlib.pyplot as plt  # Matplotlib for plotting
import seaborn as sns  # Seaborn for statistical data visualization

from sklearn.metrics import classification_report, confusion_matrix, accuracy_score  # Scikit-learn for m
from sklearn.ensemble import RandomForestClassifier  # Scikit-learn for RandomForestClassifier model

```

In [2]:
```
# Ignore warning messages to enhance code readability
import warnings
warnings.filterwarnings('ignore')
```

Data Gathering

In [3]:
```
# Set Pandas options to display all rows in the output
pd.set_option('display.max_rows', None)

# Set Pandas options to display all columns in the output
pd.set_option('display.max_columns', None)
```

In [4]:
```
# Read a CSV file into a Pandas DataFrame
df = pd.read_csv('Datasets.csv')

# Display the first few rows of the DataFrame to inspect the loaded data
df.head()
```

Out[4]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [ ]:
```

```

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In [5]:
```
# Display the shape of the DataFrame (number of rows and columns)
df.shape
```

Out[5]: (5472, 19)

In [6]:
```
1 df.head()
```

Out[6]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [ ]:
```
1
```

In [7]:
```
# Generate descriptive statistics of the DataFrame's numeric columns
df.describe()
```

Out[7]:

	Sender_Port	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS	TBS	
count	5472.000000	5472.000000	5472.000000	5472.000000	5472.000000	5472.000000	5.472000e+03	5472.000000	5.472(
mean	16649.802997	3544.247259	1.389072	12.964750	21.341809	317.964547	7.298220e+02	759.547332	1.300⁴
std	18265.060508	9404.524921	0.487584	305.059762	883.079233	3732.302430	1.863939e+04	6924.407943	1.847⁴
min	53.000000	21.000000	1.000000	0.000000	0.000000	0.000000	0.000000e+00	0.000000	0.000(
25%	2690.000000	53.000000	1.000000	0.050000	0.218569	0.000000	2.875000e+01	80.000000	0.000(
50%	4840.500000	80.000000	1.000000	0.480000	1.500000	49.000000	5.604888e+01	120.000000	1.010(
75%	32245.000000	139.000000	2.000000	3.060000	7.583472	103.000000	1.414228e+02	361.250000	6.792⁵
max	65522.000000	65500.000000	2.000000	22083.710000	65178.233330	156289.000000	1.062472e+06	325674.000000	8.986²

In [8]:
```
# Count the number of duplicated rows in the DataFrame
df.duplicated().sum()
```

Out[8]: 0

In [9]:
```
# Display concise information about the DataFrame, including data types and memory usage
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5472 entries, 0 to 5471
Data columns (total 19 columns):
 #   Column              Non-Null Count  Dtype  
---  ------              --------------  -----  
 0   ID                  5472 non-null   object 
 1   Sender_IP           5472 non-null   object 
 2   Sender_Port         5472 non-null   int64  
 3   Target_IP           5472 non-null   object 
 4   Target_Port         5472 non-null   int64  
 5   Transport_Protocol  5472 non-null   int64  
 6   Duration            5472 non-null   float64
 7   AvgDuration         5472 non-null   float64
 8   PBS                 5472 non-null   int64  
 9   AvgPBS              5472 non-null   float64
 10  TBS                 5472 non-null   int64  
 11  PBR                 5472 non-null   int64  
 12  AvgPBR              5472 non-null   float64
 13  TBR                 5472 non-null   int64  
 14  Missed_Bytes        5472 non-null   int64  
 15  Packets_Sent        5472 non-null   int64  
 16  Packets_Received    5472 non-null   int64  
 17  SRPR                5472 non-null   float64
 18  class               5472 non-null   int64  
dtypes: float64(5), int64(11), object(3)
memory usage: 812.4+ KB
```

In [10]:
```
# Display the column labels (names) of the DataFrame
df.columns
```

Out[10]:
```
Index(['ID', 'Sender_IP', 'Sender_Port', 'Target_IP', 'Target_Port',
       'Transport_Protocol', 'Duration', 'AvgDuration', 'PBS', 'AvgPBS', 'TBS',
       'PBR', 'AvgPBR', 'TBR', 'Missed_Bytes', 'Packets_Sent',
       'Packets_Received', 'SRPR', 'class'],
      dtype='object')
```

In [11]:
```
# Count the number of missing values in each column of the DataFrame
df.isna().sum()
```

Out[11]:
```
ID                  0
Sender_IP           0
Sender_Port         0
Target_IP           0
Target_Port         0
Transport_Protocol  0
Duration            0
AvgDuration         0
PBS                 0
AvgPBS              0
TBS                 0
PBR                 0
AvgPBR              0
TBR                 0
Missed_Bytes        0
Packets_Sent        0
Packets_Received    0
SRPR                0
class               0
dtype: int64
```

In [12]:
```
# Count the number of unique values in each column of the DataFrame
df.nunique()
```

Out[12]:
```
ID                    5220
Sender_IP              279
Sender_Port           3975
Target_IP             1940
Target_Port            542
Transport_Protocol       2
Duration              1313
AvgDuration           1996
PBS                    692
AvgPBS                1473
TBS                   1073
PBR                   1476
AvgPBR                1506
TBR                   1531
Missed_Bytes           132
Packets_Sent           145
Packets_Received       163
SRPR                   376
class                    2
dtype: int64
```

In [13]:
```
# Calculate the pairwise correlation coefficients between numeric columns in the DataFrame
df.corr()
```

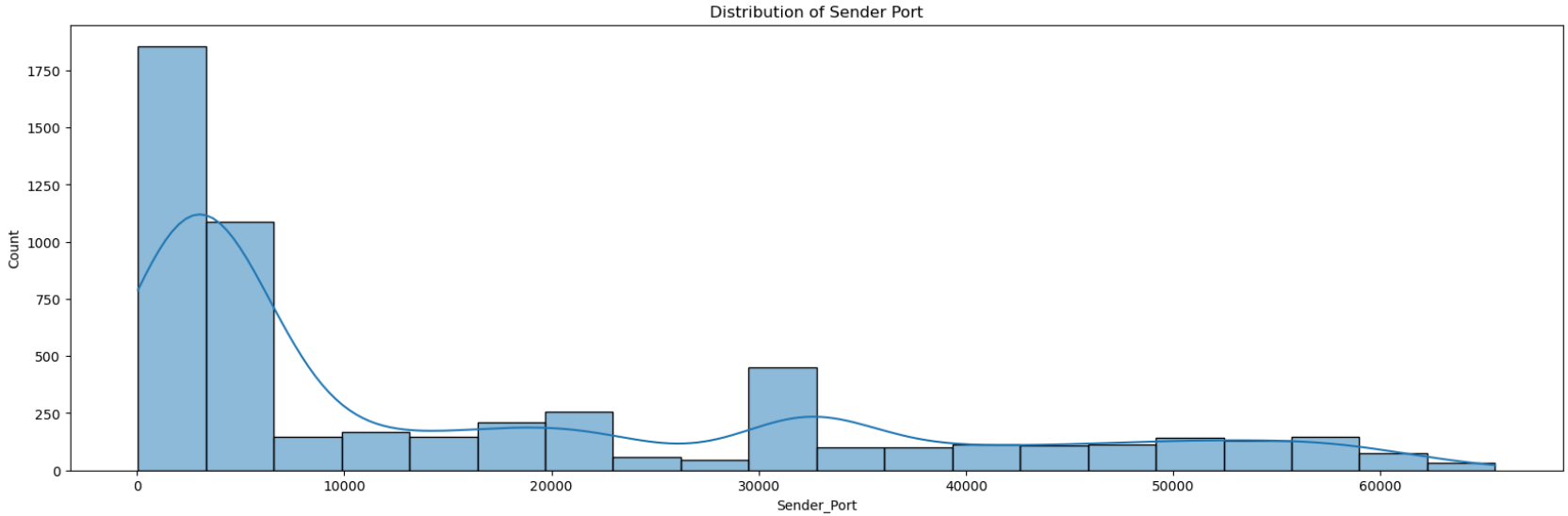
Out[13]:

	Sender_Port	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS	TBS	PBR	A
Sender_Port	1.000000	0.124804	0.513542	-0.011907	-0.012241	0.015047	-0.008215	-0.025016	-0.044665	-0.
Target_Port	0.124804	1.000000	0.331738	0.030885	0.013210	0.173476	0.079277	0.128563	-0.010766	-0.
Transport_Protocol	0.513542	0.331738	1.000000	-0.001063	-0.008008	-0.004522	-0.016184	-0.047389	-0.054726	-0.
Duration	-0.011907	0.030885	-0.001063	1.000000	0.989114	0.039593	0.019872	0.055096	0.006106	0.
AvgDuration	-0.012241	0.013210	-0.008008	0.989114	1.000000	0.023335	0.018573	0.049155	0.001236	0.
PBS	0.015047	0.173476	-0.004522	0.039593	0.023335	1.000000	0.116544	0.750853	0.009603	0.
AvgPBS	-0.008215	0.079277	-0.016184	0.019872	0.018573	0.116544	1.000000	0.082973	0.021932	0.
TBS	-0.025016	0.128563	-0.047389	0.055096	0.049155	0.750853	0.082973	1.000000	0.575823	0.
PBR	-0.044665	-0.010766	-0.054726	0.006106	0.001236	0.009603	0.021932	0.575823	1.000000	0.
AvgPBR	-0.064701	-0.000513	-0.076553	0.007366	0.004430	0.011466	0.182985	0.517525	0.910757	1.
TBR	-0.043742	-0.018215	-0.054312	0.005686	0.001633	0.009232	-0.000047	0.571466	0.994614	0.
Missed_Bytes	0.009802	0.018282	-0.021492	0.010464	0.001764	0.005377	0.235134	0.049074	0.091075	0.
Packets_Sent	-0.045337	0.012791	-0.056919	0.053390	0.048949	0.071862	0.028416	0.655166	0.942467	0.
Packets_Received	-0.053972	-0.012357	-0.068994	0.045934	0.042133	0.043168	0.006953	0.516409	0.943154	0.
SRPR	-0.123383	0.061065	-0.009993	0.006198	0.005702	0.021483	0.030487	0.052335	0.089188	0.
class	0.042804	-0.401458	-0.272599	-0.037100	-0.024742	-0.036707	-0.015457	-0.008202	0.007723	0.

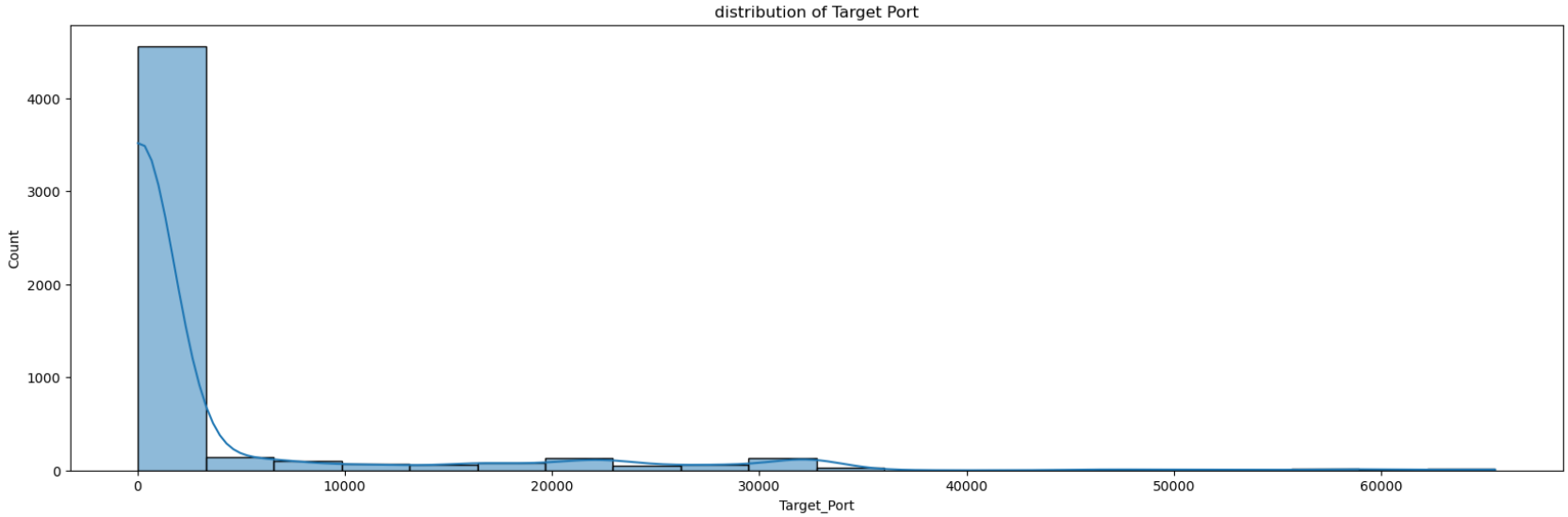
In [14]:
```
# Count the occurrences of each unique value in the "class" column (target column)
df["class"].value_counts()
```

Out[14]:
```
1    3447
0    2025
Name: class, dtype: int64
```

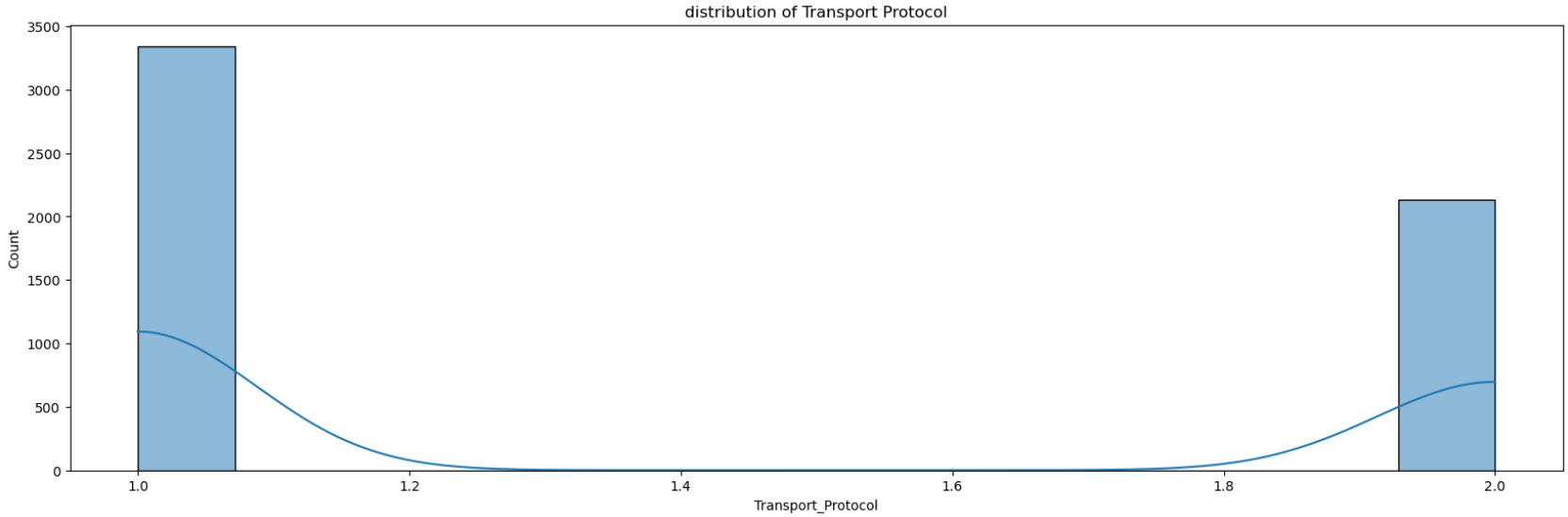
In [15]:
```
# Create a histogram plot for the distribution of values in the "Sender_Port" column

plt.figure(figsize=(20, 6))  # Set the figure size for better visualization
sns.histplot(df, x='Sender_Port', bins=20, kde=True)  # Use Seaborn to create a histogram with kernel den
plt.title('Distribution of Sender Port')  # Set the title of the plot
plt.show()  # Display the plot
```



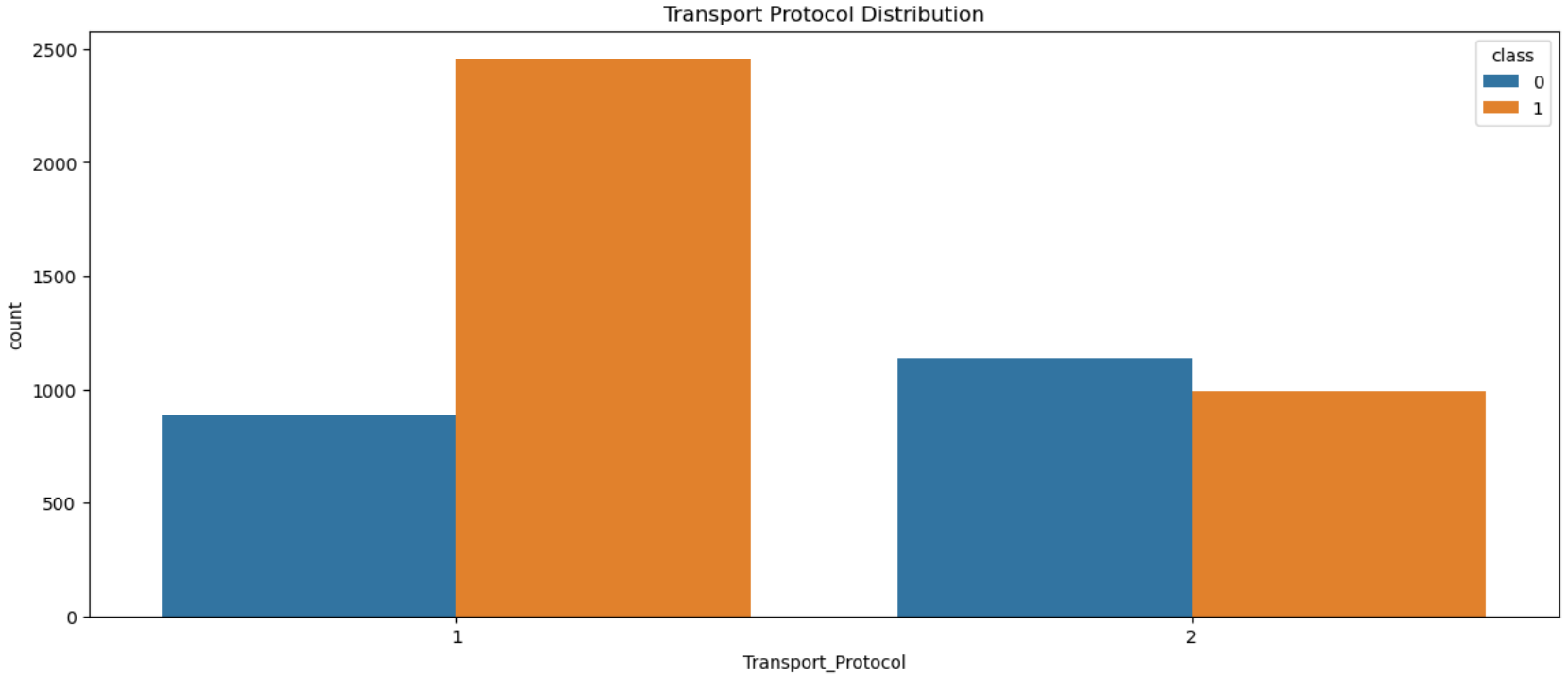
In [16]:
```
plt.figure(figsize=(20,6))
sns.histplot(df, x = 'Target_Port',bins = 20, kde = True)
plt.title('distribution of Target Port')
plt.show()
```



In [17]:
```
plt.figure(figsize=(20,6))
sns.histplot(df, x = 'Transport_Protocol', kde = True)
plt.title('distribution of Transport Protocol')
plt.show()
```



In [18]:
```
# Create a count plot for the distribution of "Transport_Protocol" with respect to the target variable "c

plt.figure(figsize=(15, 6))  # Set the figure size for better visualization
sns.countplot(data=df, x="Transport_Protocol", hue="class")  # Use Seaborn to create a count plot with hu
plt.title("Transport Protocol Distribution")  # Set the title of the plot
plt.show()  # Display the plot
```



In [19]:
```
# Find the minimum and maximum values in the "Duration" column
df['Duration'].min(), df['Duration'].max()
```

Out[19]: (0.0, 22083.71)

In [20]:
```
df['AvgDuration'].min(),df['AvgDuration'].max()
```

Out[20]: (0.0, 65178.23333)

In [21]:
```
1 df['PBS'].min(),df['PBS'].max()
```

Out[21]: (0, 156289)

In [22]:
```
1 df['AvgPBS'].min(),df['AvgPBS'].max()
```

Out[22]: (0.0, 1062471.727)

In [23]:
```
1 df.head()
```

Out[23]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [24]:
```
1 df['TBS'].min(),df['TBS'].max()
```

Out[24]: (0, 325674)

In [25]:
```
1 df['PBR'].min(),df['PBR'].max()
```

Out[25]: (0, 8986288)

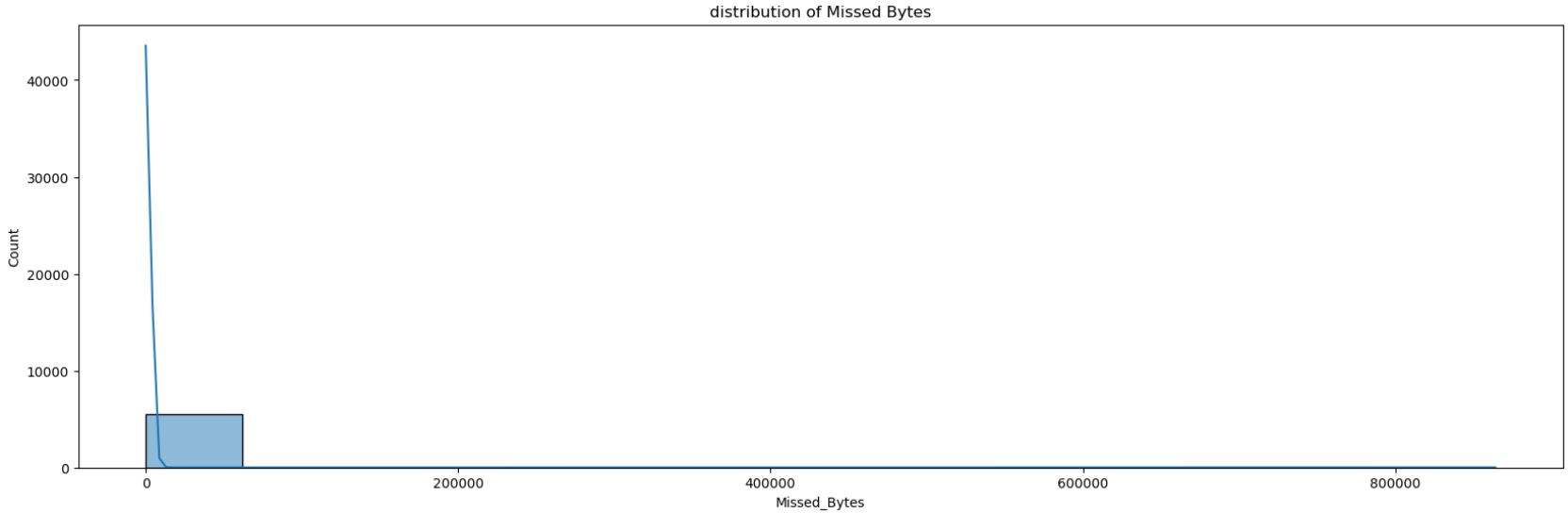
In [26]:
```
1 df['AvgPBR'].min(),df['AvgPBR'].max()
```

Out[26]: (0.0, 6142982.0)

In [27]:
```
1 df['TBR'].min(),df['TBR'].max()
```

Out[27]: (0, 9231445)

In [28]:
```
1 plt.figure(figsize=(20,6))
2 sns.histplot(df, x = 'Missed_Bytes', kde = True)
3 plt.title('distribution of Missed Bytes')
4 plt.show()
```



In [29]:
```
1 df.head()
```

Out[29]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [30]:
```
1 df['Packets_Sent'].min(),df['Packets_Sent'].max()
```

Out[30]: (0, 6561)

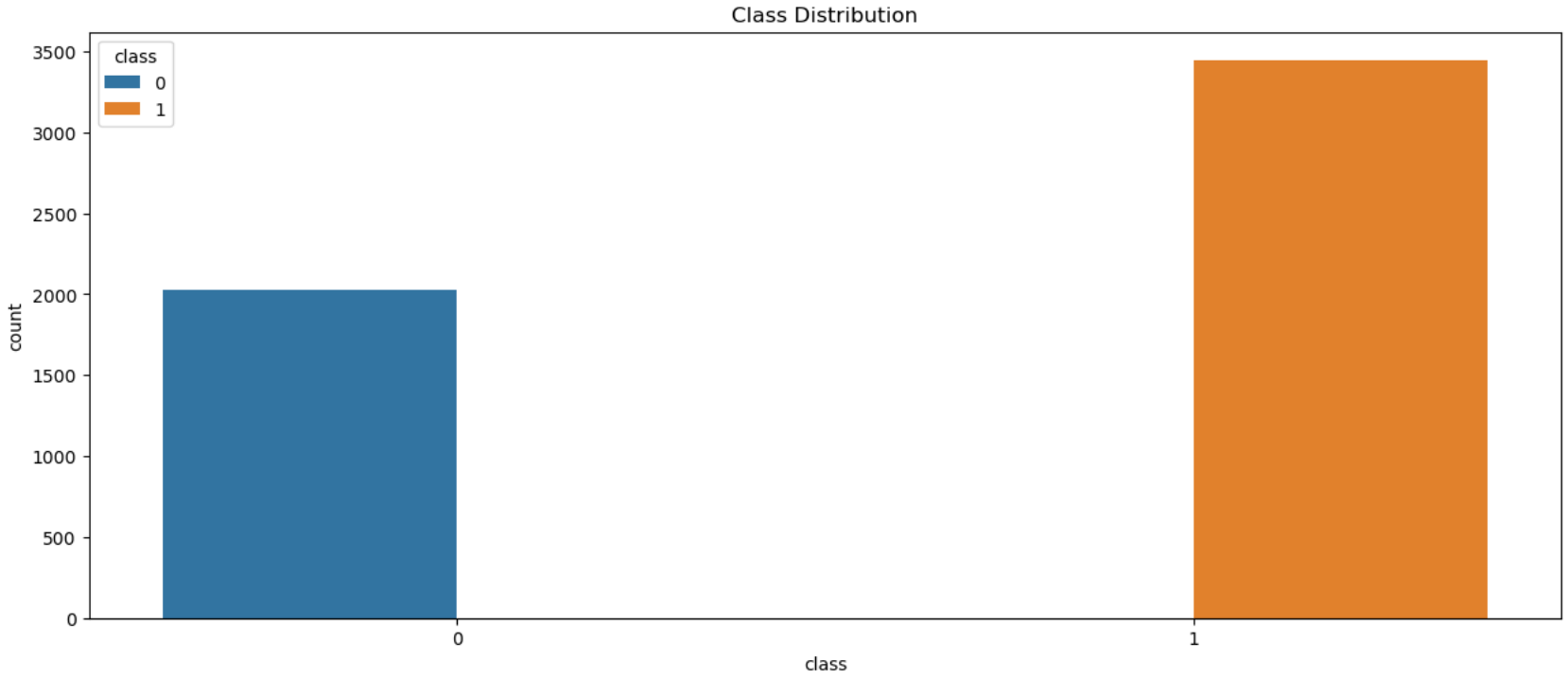
In [31]:
```
1 df['Packets_Received'].min(),df['Packets_Received'].max()
```

Out[31]: (0, 6510)

In [32]:
```
1 df['SRPR'].min(),df['SRPR'].max()
```

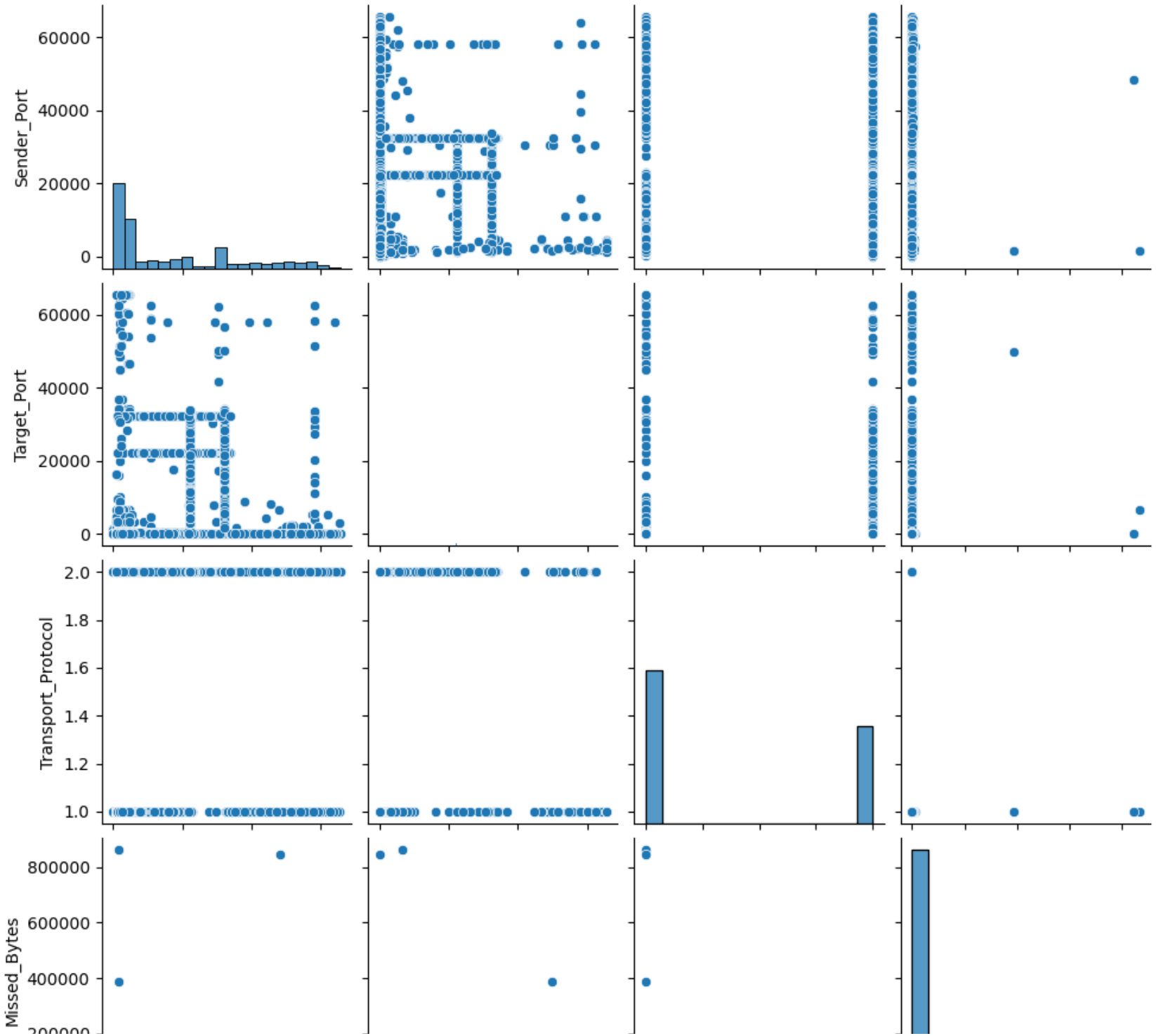
Out[32]: (0.0, 8.0)

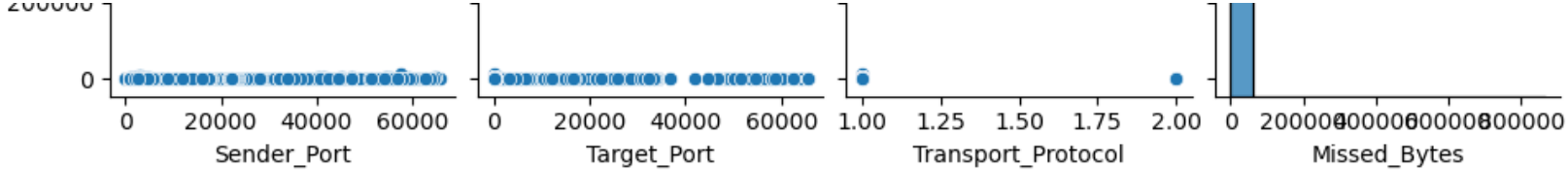
In [33]:
```
plt.figure(figsize=(15, 6))
sns.countplot(data=df, x="class", hue='class') #Categorical Variables
plt.title("Class Distribution")
plt.show()
```



In [34]:

```
# Create a pair plot to visualize pairwise relationships between selected columns
sns.pairplot(df[["Sender_Port", "Target_Port", "Transport_Protocol", "Missed_Bytes"]])

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

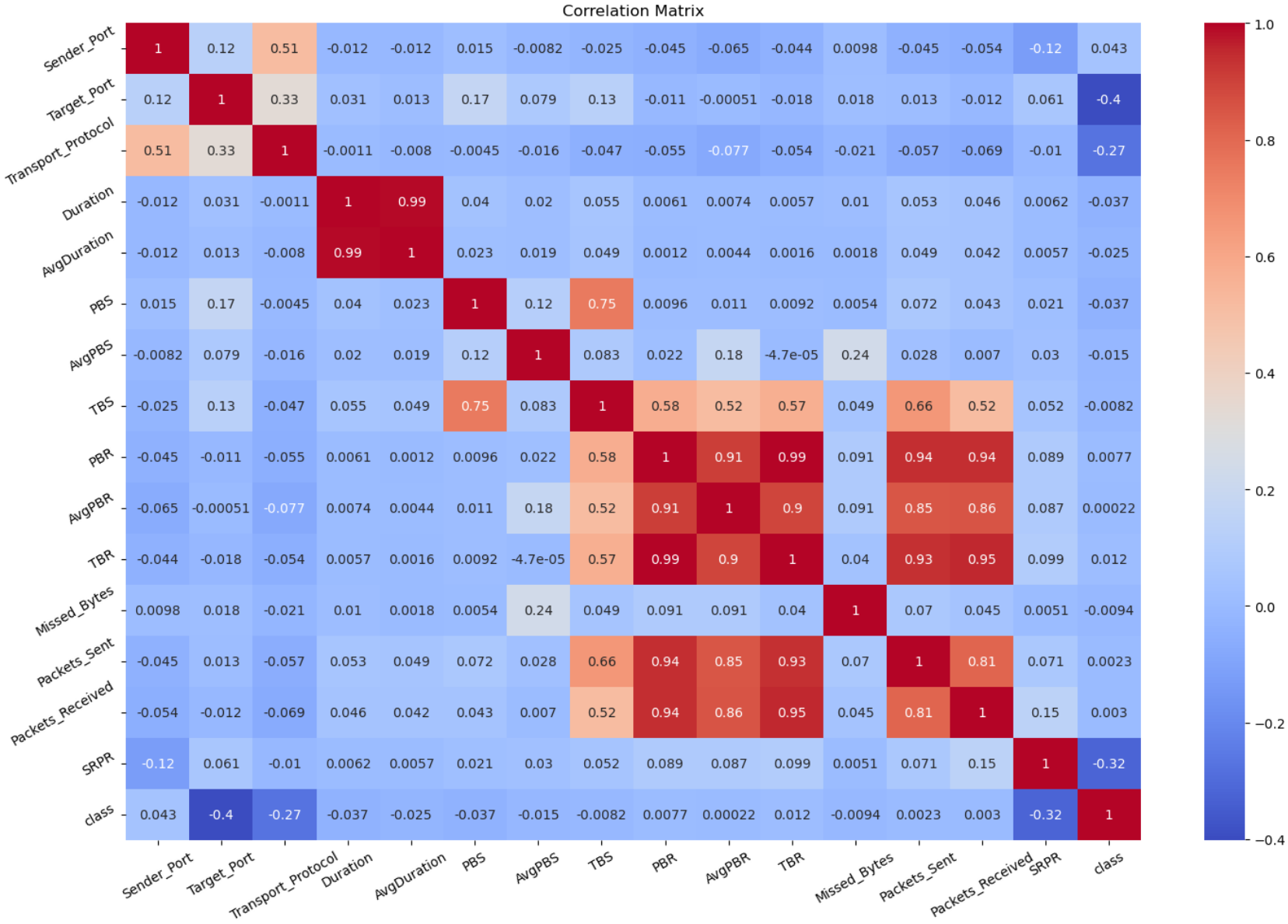

Sender_Port
Target_Port
Transport_Protocol
Missed_Bytes
0
20000
40000
60000
1.0
1.2
1.4
1.6
1.8
2.0
400000
600000
800000


0
0
20000
40000
60000
Sender_Port
0
20000
40000
60000
Target_Port
1.00
1.25
1.50
1.75
2.00
Transport_Protocol
0
Missed_Bytes

In [ ]:
```
1
```

In [35]:

```
# Create a heatmap to visualize the correlation matrix of numeric columns in the DataFrame

plt.figure(figsize=(15, 10))  # Set the figure size for better visualization
sns.heatmap(df.corr(), annot=True, cmap="coolwarm")  # Use Seaborn to create a heatmap with correlation v
plt.title("Correlation Matrix")  # Set the title of the plot
plt.xticks(rotation=30)  # Rotate x-axis labels for better readability
plt.yticks(rotation=30)  # Rotate y-axis labels for better readability
plt.tight_layout()  # Adjust layout for better spacing
plt.show()  # Display the heatmap
```


Correlation Matrix
Sender_Port 1 0.12 0.51 -0.012 -0.012 0.015 -0.0082 -0.025 -0.045 -0.065 -0.044 0.0098 -0.045 -0.054 -0.12 0.043
Target_Port 0.12 1 0.33 0.031 0.013 0.17 0.079 0.13 -0.011 -0.00051 -0.018 0.018 0.013 -0.012 0.061 -0.4
Transport_Protocol 0.51 0.33 1 -0.0011 -0.008 -0.0045 -0.016 -0.047 -0.055 -0.077 -0.054 -0.021 -0.057 -0.069 -0.01 -0.27
Duration -0.012 0.031 -0.0011 1 0.99 0.04 0.02 0.055 0.0061 0.0074 0.0057 0.01 0.053 0.046 0.0062 -0.037
AvgDuration -0.012 0.013 -0.008 0.99 1 0.023 0.019 0.049 0.0012 0.0044 0.0016 0.0018 0.049 0.042 0.0057 -0.025
PBS 0.015 0.17 -0.0045 0.04 0.023 1 0.12 0.75 0.0096 0.011 0.0092 0.0054 0.072 0.043 0.021 -0.037
AvgPBS -0.0082 0.079 -0.016 0.02 0.019 0.12 1 0.083 0.022 0.18 -4.7e-05 0.24 0.028 0.007 0.03 -0.015
TBS -0.025 0.13 -0.047 0.055 0.049 0.75 0.083 1 0.58 0.52 0.57 0.049 0.66 0.52 0.052 -0.0082
PBR -0.045 -0.011 -0.055 0.0061 0.0012 0.0096 0.022 0.58 1 0.91 0.99 0.091 0.94 0.94 0.089 0.0077
AvgPBR -0.065 -0.00051 -0.077 0.0074 0.0044 0.011 0.18 0.52 0.91 1 0.9 0.091 0.85 0.86 0.087 0.00022
TBR -0.044 -0.018 -0.054 0.0057 0.0016 0.0092 -4.7e-05 0.57 0.99 0.9 1 0.04 0.93 0.95 0.099 0.012
Missed_Bytes 0.0098 0.018 -0.021 0.01 0.0018 0.0054 0.24 0.049 0.091 0.091 0.04 1 0.07 0.045 0.0051 -0.0094
Packets_Sent -0.045 0.013 -0.057 0.053 0.049 0.072 0.028 0.66 0.94 0.85 0.93 0.07 1 0.81 0.071 0.0023
Packets_Received -0.054 -0.012 -0.069 0.046 0.042 0.043 0.007 0.52 0.94 0.86 0.95 0.045 0.81 1 0.15 0.003
SRPR -0.12 0.061 -0.01 0.0062 0.0057 0.021 0.03 0.052 0.089 0.087 0.099 0.0051 0.071 0.15 1 -0.32
class 0.043 -0.4 -0.27 -0.037 -0.025 -0.037 -0.015 -0.0082 0.0077 0.00022 0.012 -0.0094 0.0023 0.003 -0.32 1
Sender_Port Target_Port Transport_Protocol Duration AvgDuration PBS AvgPBS TBS PBR AvgPBR TBR Missed_Bytes Packets_Sent Packets_Received SRPR class
1.0 0.8 0.6 0.4 0.2 0.0 −0.2 −0.4

In [36]:
```
1 df.head()
```

Out[36]:

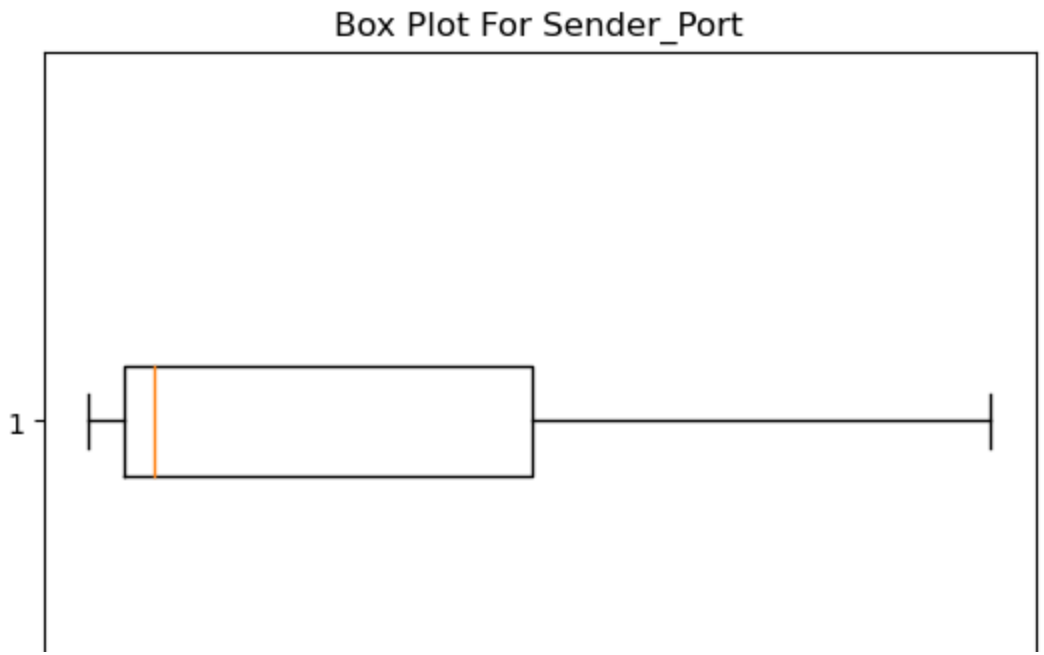
	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [37]:
```
1 #boxplot
```

In [38]:
```
1 max_outliers = ['Sender_Port','Target_Port','Transport_Protocol','Duration','AvgDuration','PBS','AvgPBR',
2                 ,'Missed_Bytes','Packets_Sent','Packets_Received','SRPR']
```

In [39]:

```
# Create box plots for columns with potential outliers

for column in max_outliers:
    plt.boxplot(df[column], vert=False)  # Create a horizontal box plot for the specified column
    plt.title(f'Box Plot For {column}')  # Set the title of the box plot
    plt.show()  # Display the box plot
    print('\n')  # Print a newline for better separation between box plots
```



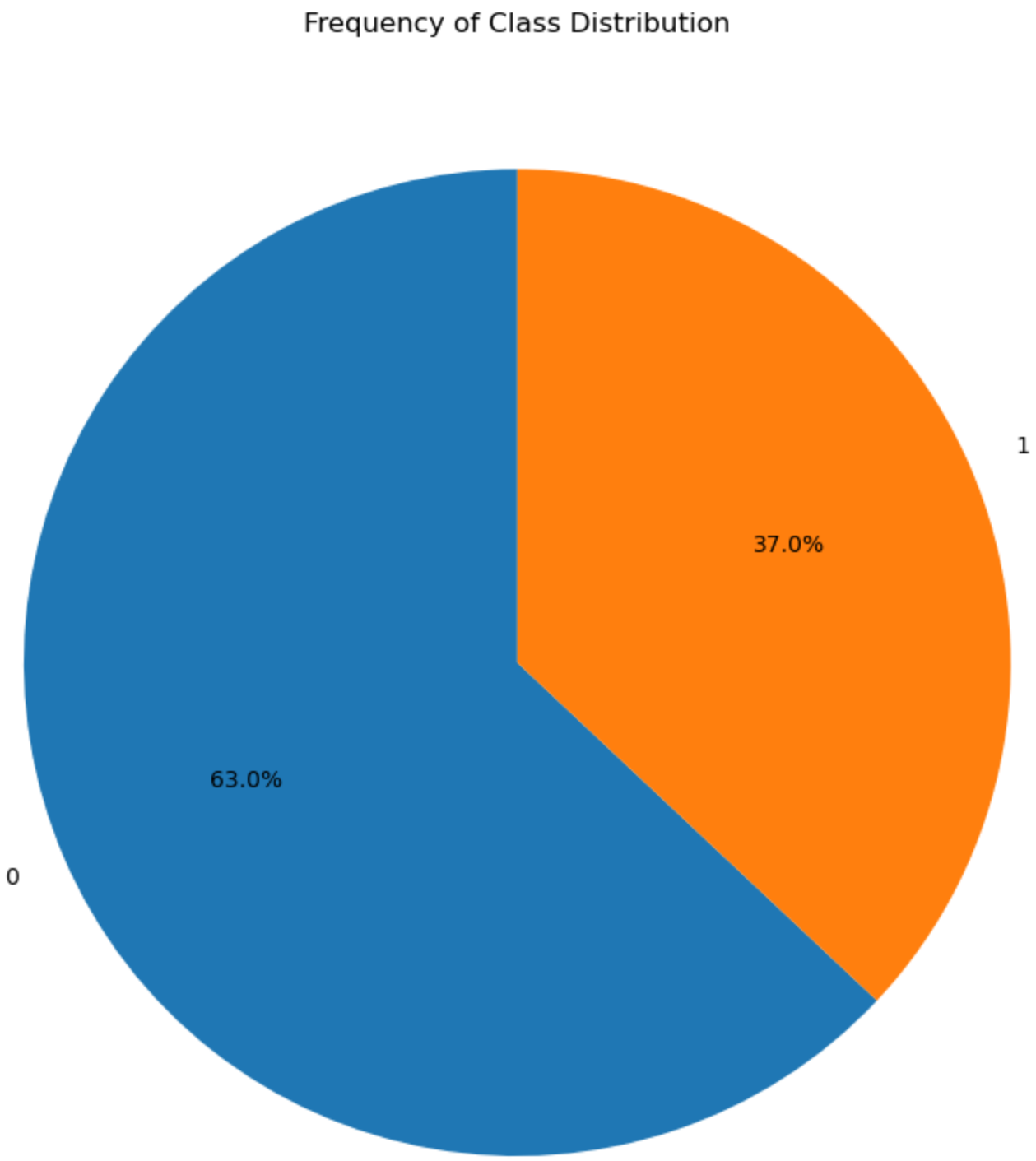
In [40]:
```
1 df.head()
```

Out[40]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000(
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000(
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000(
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000(

In [41]:

```python
# Create a pie chart to visualize the distribution of classes in the 'class' column
import matplotlib.pyplot as plt  # Import the Matplotlib library

# Create a figure and axis
fig, ax = plt.subplots(figsize=(8, 8))

# Generate a pie chart using the values and labels from the 'class' column
ax.pie(df['class'].value_counts(), autopct='%1.1f%%', startangle=90, labels=df['class'].unique())

# Set the title of the pie chart
ax.set_title('Frequency of Class Distribution')

# Adjust layout for better spacing
plt.tight_layout()

# Display the pie chart
plt.show()
```


Frequency of Class Distribution
1
37.0%
63.0%
0

In [42]:
```
1 df.shape
```

Out[42]: (5472, 19)

Feature Engineering

In [43]:
```
1 # Create a copy of the original DataFrame 'df' named 'df1'
2 df1 = df.copy()
```

In [44]:
```
1 # Display the shape of the copied DataFrame 'df1' (number of rows and columns)
2 df1.shape
```

Out[44]: (5472, 19)

In [45]:
```
1 df1.head()
```

Out[45]:

	ID	Sender_IP	Sender_Port	Target_IP	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS
0	10.42.0.211-104.97.95.172-59522-80-6	192.168.2.112	2142	75.126.101.175	443	1	4.28	6.039028	1174	856.83333
1	216.58.217.68-10.42.0.211-443-59345-6	147.32.84.170	2108	208.100.48.73	22	1	3.00	1.500000	0	0.00000
2	10.42.0.151-54.192.38.7-52510-443-6	147.32.84.170	3805	125.14.233.194	22	1	0.00	1.500000	0	0.00000
3	216.58.219.206-10.42.0.42-443-53294-6	147.32.84.180	3008	205.188.146.193	25	1	2.96	2.021923	0	0.00000
4	10.42.0.1-10.42.0.42-53-62597-17	147.32.84.160	11697	184.173.217.40	443	1	0.15	0.159373	0	0.00000

In [46]:
```
#Unwanted # Drop specified columns ('ID', 'Sender_IP', 'Target_IP') from the DataFrame 'f1'
df1.drop(columns=['ID', 'Sender_IP', 'Target_IP'], inplace=True)
```

In [47]:
```
df1.head()
```

Out[47]:

	Sender_Port	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS	TBS	PBR	AvgPBR	TBR	Missed_By
0	2142	443	1	4.28	6.039028	1174	856.833333	1894	11862	27450.72222	12462	
1	2108	22	1	3.00	1.500000	0	0.000000	192	0	0.00000	0	
2	3805	22	1	0.00	1.500000	0	0.000000	96	0	0.00000	0	
3	3008	25	1	2.96	2.021923	0	0.000000	96	0	0.00000	0	
4	11697	443	1	0.15	0.159373	0	0.000000	96	0	0.00000	40	

In [48]:
```
# Count the number of missing values in each column of the copied DataFrame 'df1'
df1.isna().sum()
```

Out[48]:
```
Sender_Port           0
Target_Port           0
Transport_Protocol    0
Duration              0
AvgDuration           0
PBS                   0
AvgPBS                0
TBS                   0
PBR                   0
AvgPBR                0
TBR                   0
Missed_Bytes          0
Packets_Sent          0
Packets_Received      0
SRPR                  0
class                 0
dtype: int64
```

Feature Selection

In [49]:
```
1 df1.head()
```

Out[49]:

	Sender_Port	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS	TBS	PBR	AvgPBR	TBR	Missed_By
0	2142	443	1	4.28	6.039028	1174	856.833333	1894	11862	27450.72222	12462	
1	2108	22	1	3.00	1.500000	0	0.000000	192	0	0.00000	0	
2	3805	22	1	0.00	1.500000	0	0.000000	96	0	0.00000	0	
3	3008	25	1	2.96	2.021923	0	0.000000	96	0	0.00000	0	
4	11697	443	1	0.15	0.159373	0	0.000000	96	0	0.00000	40	

In [50]:
```
1 df1.corr()
```

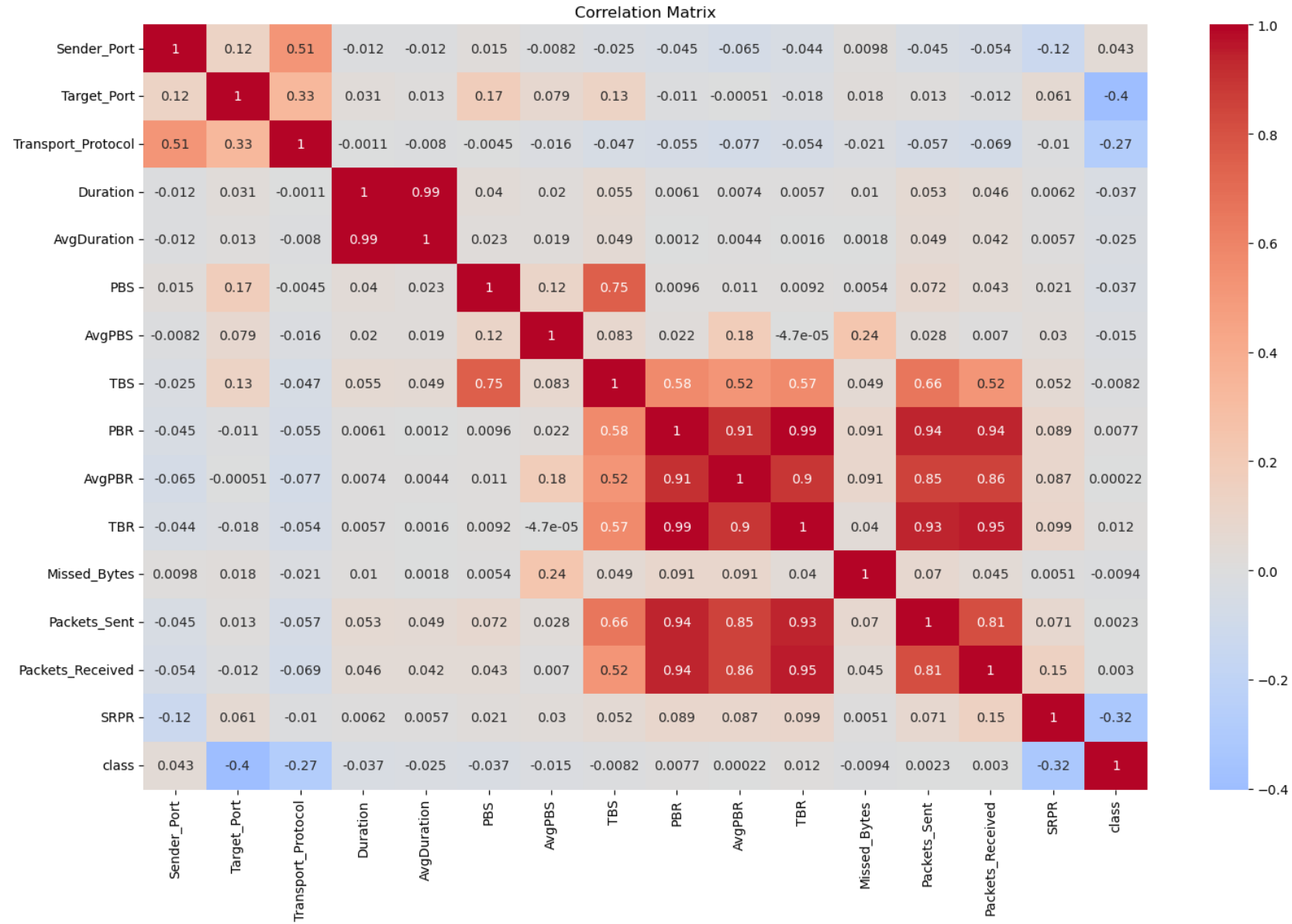
Out[50]:

	Sender_Port	Target_Port	Transport_Protocol	Duration	AvgDuration	PBS	AvgPBS	TBS	PBR	A
Sender_Port	1.000000	0.124804	0.513542	-0.011907	-0.012241	0.015047	-0.008215	-0.025016	-0.044665	-0.
Target_Port	0.124804	1.000000	0.331738	0.030885	0.013210	0.173476	0.079277	0.128563	-0.010766	-0.
Transport_Protocol	0.513542	0.331738	1.000000	-0.001063	-0.008008	-0.004522	-0.016184	-0.047389	-0.054726	-0.
Duration	-0.011907	0.030885	-0.001063	1.000000	0.989114	0.039593	0.019872	0.055096	0.006106	0.
AvgDuration	-0.012241	0.013210	-0.008008	0.989114	1.000000	0.023335	0.018573	0.049155	0.001236	0.
PBS	0.015047	0.173476	-0.004522	0.039593	0.023335	1.000000	0.116544	0.750853	0.009603	0.
AvgPBS	-0.008215	0.079277	-0.016184	0.019872	0.018573	0.116544	1.000000	0.082973	0.021932	0.
TBS	-0.025016	0.128563	-0.047389	0.055096	0.049155	0.750853	0.082973	1.000000	0.575823	0.
PBR	-0.044665	-0.010766	-0.054726	0.006106	0.001236	0.009603	0.021932	0.575823	1.000000	0.
AvgPBR	-0.064701	-0.000513	-0.076553	0.007366	0.004430	0.011466	0.182985	0.517525	0.910757	1.
TBR	-0.043742	-0.018215	-0.054312	0.005686	0.001633	0.009232	-0.000047	0.571466	0.994614	0.
Missed_Bytes	0.009802	0.018282	-0.021492	0.010464	0.001764	0.005377	0.235134	0.049074	0.091075	0.
Packets_Sent	-0.045337	0.012791	-0.056919	0.053390	0.048949	0.071862	0.028416	0.655166	0.942467	0.
Packets_Received	-0.053972	-0.012357	-0.068994	0.045934	0.042133	0.043168	0.006953	0.516409	0.943154	0.
SRPR	-0.123383	0.061065	-0.009993	0.006198	0.005702	0.021483	0.030487	0.052335	0.089188	0.
class	0.042804	-0.401458	-0.272599	-0.037100	-0.024742	-0.036707	-0.015457	-0.008202	0.007723	0.

In [ ]:
```
1
```

In [51]:

```
# Create a heatmap to visualize the correlation matrix of numeric columns in the copied DataFrame 'df1'

fig, ax = plt.subplots(figsize=(15, 10))  # Set the figure size for better visualization
sns.heatmap(df1.corr(), annot=True, cmap='coolwarm', center=0, ax=ax)  # Use Seaborn to create a heatmap
ax.set_title('Correlation Matrix')  # Set the title of the plot
plt.tight_layout()  # Adjust layout for better spacing
plt.show()  # Display the heatmap
```



Train Test Split

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

In [53]:
```
# Split the dataset into features (x) and target variable (y), and further into training and testing sets

x = df1.drop('class', axis=1)  # Features (independent variables) excluding the 'class' column
y = df1['class']  # Target variable (dependent variable)

# Split the dataset 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)
# test_size=0.2 specifies that 20% of the data will be used for testing, and random_state=42 ensures repr
```

Model Training

In [54]:
```
# Create a Random Forest Classifier model and fit it to the training data
rf_model = RandomForestClassifier(random_state=42)
rf_model.fit(x_train, y_train)
```

Out[54]:
```
RandomForestClassifier
RandomForestClassifier(random_state=42)
```

Evaluation

Training

In [55]:
```
# Make predictions on the training data using the trained Random Forest model
y_pred = rf_model.predict(x_train)

# Compute the confusion matrix
cnf_matrix = confusion_matrix(y_train, y_pred)
print('Confusion Matrix\n\n', cnf_matrix)

# Generate a classification report
clf_report = classification_report(y_train, y_pred)
print('\nClassification Report\n\n', clf_report)

# Calculate the accuracy of the model on the training data
accuracy = accuracy_score(y_train, y_pred)
print('Accuracy Model', round(accuracy, 2))
```

```
Confusion Matrix

 [[1618    0]
 [   0 2759]]

Classification Report

              precision    recall  f1-score   support

           0       1.00      1.00      1.00      1618
           1       1.00      1.00      1.00      2759

    accuracy                           1.00      4377
   macro avg       1.00      1.00      1.00      4377
weighted avg       1.00      1.00      1.00      4377

Accuracy Model 1.0
```

Testing

In [56]:
```
# Make predictions on the testing data using the trained Random Forest model
y_pred = rf_model.predict(x_test)

# Compute the confusion matrix
cnf_matrix = confusion_matrix(y_test, y_pred)
print('Confusion Matrix\n\n', cnf_matrix)

# Generate a classification report
clf_report = classification_report(y_test, y_pred)
print('\nClassification Report\n\n', clf_report)

# Calculate the accuracy of the model on the testing data
accuracy = accuracy_score(y_test, y_pred)
print('Accuracy Model', round(accuracy, 2))
```

```
Confusion Matrix

 [[339  68]
 [ 52 636]]

Classification Report

              precision    recall  f1-score   support

           0       0.87      0.83      0.85       407
           1       0.90      0.92      0.91       688

    accuracy                           0.89      1095
   macro avg       0.89      0.88      0.88      1095
weighted avg       0.89      0.89      0.89      1095

Accuracy Model 0.89
```

Hyperparameter Tuning

In [57]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV, train_test_split
```

In [58]:
```
param_grid_1 = {
    'n_estimators': [25, 50, 100, 150],
    'max_features': ['sqrt', 'log2', None],
    'max_depth': [3, 6, 9],
    'max_leaf_nodes': [3, 6, 9],
}
```

In [59]:
```
# Perform a Grid Search to find the best hyperparameters for the RandomForestClassifier
grid_search = GridSearchCV(RandomForestClassifier(), param_grid=param_grid_1)
grid_search.fit(x_train, y_train)
print(grid_search.best_estimator_)
```

```
RandomForestClassifier(max_depth=6, max_features='log2', max_leaf_nodes=9,
                       n_estimators=25)
```

In [60]:
```
#Training model on Hyperparamter
rf_model = RandomForestClassifier(max_depth=6, max_features='log2', max_leaf_nodes=9,
                          n_estimators=25)
rf_model.fit(x_train,y_train)
```

Out[60]:
```
RandomForestClassifier
RandomForestClassifier(max_depth=6, max_features='log2', max_leaf_nodes=9,
                       n_estimators=25)
```

In [61]:

```
y_pred = rf_model.predict(x_train)

cnf_matrix = confusion_matrix(y_train, y_pred)
print('Confusion Matrix\n\n', cnf_matrix)

clf_report = classification_report(y_train, y_pred)
print('\nClassification Report\n\n', clf_report)

accuracy = accuracy_score(y_train, y_pred)
print('Accuracy Model', round(accuracy, 2))
```

```
Confusion Matrix

 [[1062  556]
 [ 163 2596]]

Classification Report

              precision    recall  f1-score   support

           0       0.87      0.66      0.75      1618
           1       0.82      0.94      0.88      2759

    accuracy                           0.84      4377
   macro avg       0.85      0.80      0.81      4377
weighted avg       0.84      0.84      0.83      4377

Accuracy Model 0.84
```

In [62]:

```
y_pred = rf_model.predict(x_test)

cnf_matrix = confusion_matrix(y_test, y_pred)
print('Confusion Matrix\n\n', cnf_matrix)

clf_report = classification_report(y_test, y_pred)
print('\nClassification Report\n\n', clf_report)

accuracy = accuracy_score(y_test, y_pred)
print('Accuracy Model', round(accuracy, 2))
```

```
Confusion Matrix

 [[289 118]
 [ 48 640]]

Classification Report

              precision    recall  f1-score   support

           0       0.86      0.71      0.78       407
           1       0.84      0.93      0.89       688

    accuracy                           0.85      1095
   macro avg       0.85      0.82      0.83      1095
weighted avg       0.85      0.85      0.84      1095

Accuracy Model 0.85
```