5. Develop an anomaly detection system for high-dimensional network traffic data using the KDD Cup 1999 dataset.

In [2]:

```
import pandas as pd
import numpy as np
```

In [3]:

```
import requests

files = [
    ("https://kdd.ics.uci.edu/databases/kddcup99/kddcup.data_10_percent.gz", "kddcup.data_10_percent.gz"),
    ("https://kdd.ics.uci.edu/databases/kddcup99/kddcup.names", "kddcup.names")
]

for url, filename in files:
    print(f"Downloading {filename}...")
    response = requests.get(url)
    with open(filename, 'wb') as f:
        f.write(response.content)
    print(f"Downloaded {filename}")
```

```
Downloading kddcup.data_10_percent.gz...
Downloaded kddcup.data_10_percent.gz
Downloading kddcup.names...
Downloaded kddcup.names
```

In [4]:

```
with open("kddcup.names", 'r') as f:
    lines = f.readlines()

column_names = [line.split(':')[0].strip() for line in lines[1:]]
column_names.append("label")
```

In [5]:

```
df = pd.read_csv("kddcup.data_10_percent.gz", header=None, names=column_names)
```

In [9]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 494021 entries, 0 to 494020
Data columns (total 42 columns):
 #   Column                       Non-Null Count   Dtype  
---  ------                       --------------   -----  
 0   duration                     494021 non-null  int64  
 1   protocol_type                494021 non-null  object 
 2   service                      494021 non-null  object 
 3   flag                         494021 non-null  object 
 4   src_bytes                    494021 non-null  int64  
 5   dst_bytes                    494021 non-null  int64  
 6   land                         494021 non-null  int64  
 7   wrong_fragment               494021 non-null  int64  
 8   urgent                       494021 non-null  int64  
 9   hot                          494021 non-null  int64  
 10  num_failed_logins            494021 non-null  int64  
 11  logged_in                    494021 non-null  int64  
 12  num_compromised              494021 non-null  int64  
 13  root_shell                   494021 non-null  int64  
 14  su_attempted                 494021 non-null  int64  
 15  num_root                     494021 non-null  int64  
 16  num_file_creations           494021 non-null  int64  
 17  num_shells                   494021 non-null  int64  
 18  num_access_files             494021 non-null  int64  
 19  num_outbound_cmds            494021 non-null  int64  
 20  is_host_login                494021 non-null  int64  
 21  is_guest_login               494021 non-null  int64  
 22  count                        494021 non-null  int64  
 23  srv_count                    494021 non-null  int64  
 24  serror_rate                  494021 non-null  float64
 25  srv_serror_rate              494021 non-null  float64
 26  rerror_rate                  494021 non-null  float64
 27  srv_rerror_rate              494021 non-null  float64
 28  same_srv_rate                494021 non-null  float64
 29  diff_srv_rate                494021 non-null  float64
 30  srv_diff_host_rate           494021 non-null  float64
 31  dst_host_count               494021 non-null  int64  
 32  dst_host_srv_count           494021 non-null  int64  
 33  dst_host_same_srv_rate       494021 non-null  float64
 34  dst_host_diff_srv_rate       494021 non-null  float64
 35  dst_host_same_src_port_rate  494021 non-null  float64
 36  dst_host_srv_diff_host_rate  494021 non-null  float64
 37  dst_host_serror_rate         494021 non-null  float64
 38  dst_host_srv_serror_rate     494021 non-null  float64
 39  dst_host_rerror_rate         494021 non-null  float64
 40  dst_host_srv_rerror_rate     494021 non-null  float64
 41  label                        494021 non-null  object 
dtypes: float64(15), int64(23), object(4)
memory usage: 158.3+ MB
```

In [10]:

```
df['label'] = df['label'].astype('category')
```

In [11]:

```
df.head()
```

Out[11]:

	duration	protocol_type	service	flag	src_bytes	dst_bytes	land	wrong_fragment	urgent	hot	...	dst_host_srv_count	dst_host_same_srv_rate	dst_h
0	0	tcp	http	SF	181	5450	0	0	0	0	...	9	1.0	
1	0	tcp	http	SF	239	486	0	0	0	0	...	19	1.0	
2	0	tcp	http	SF	235	1337	0	0	0	0	...	29	1.0	
3	0	tcp	http	SF	219	1337	0	0	0	0	...	39	1.0	
4	0	tcp	http	SF	217	2032	0	0	0	0	...	49	1.0	

5 rows × 42 columns

In [12]:

```
print(df.isnull().sum())
```

```
duration                       0
protocol_type                  0
service                        0
flag                           0
src_bytes                      0
dst_bytes                      0
land                           0
wrong_fragment                 0
urgent                         0
hot                            0
num_failed_logins              0
logged_in                      0
num_compromised                0
root_shell                     0
su_attempted                   0
num_root                       0
num_file_creations             0
num_shells                     0
num_access_files               0
num_outbound_cmds              0
is_host_login                  0
is_guest_login                 0
count                          0
srv_count                      0
serror_rate                    0
srv_serror_rate                0
rerror_rate                    0
srv_rerror_rate                0
same_srv_rate                  0
diff_srv_rate                  0
srv_diff_host_rate             0
dst_host_count                 0
dst_host_srv_count             0
dst_host_same_srv_rate         0
dst_host_diff_srv_rate         0
dst_host_same_src_port_rate    0
dst_host_srv_diff_host_rate    0
dst_host_serror_rate           0
dst_host_srv_serror_rate       0
dst_host_rerror_rate           0
dst_host_srv_rerror_rate       0
label                          0
dtype: int64
```

In [13]:

```
from sklearn.preprocessing import LabelEncoder

for col in ["protocol_type", "service", "flag"]:
    le = LabelEncoder()
    df[col] = le.fit_transform(df[col])
```

In [16]:

```
from sklearn.preprocessing import StandardScaler

numeric_cols = df.select_dtypes(include=['number']).columns.tolist()

scaler = StandardScaler()
df[numeric_cols] = scaler.fit_transform(df[numeric_cols])
```

In [19]:

```
# Training an Isolation Forest Model
from sklearn.ensemble import IsolationForest

iso_forest = IsolationForest(contamination=0.1, random_state=42)
df['anomaly_score'] = iso_forest.fit_predict(df[numeric_cols])


df['anomaly'] = df['anomaly_score'].apply(lambda x: 1 if x == -1 else 0)

print(df['anomaly'].value_counts())
```

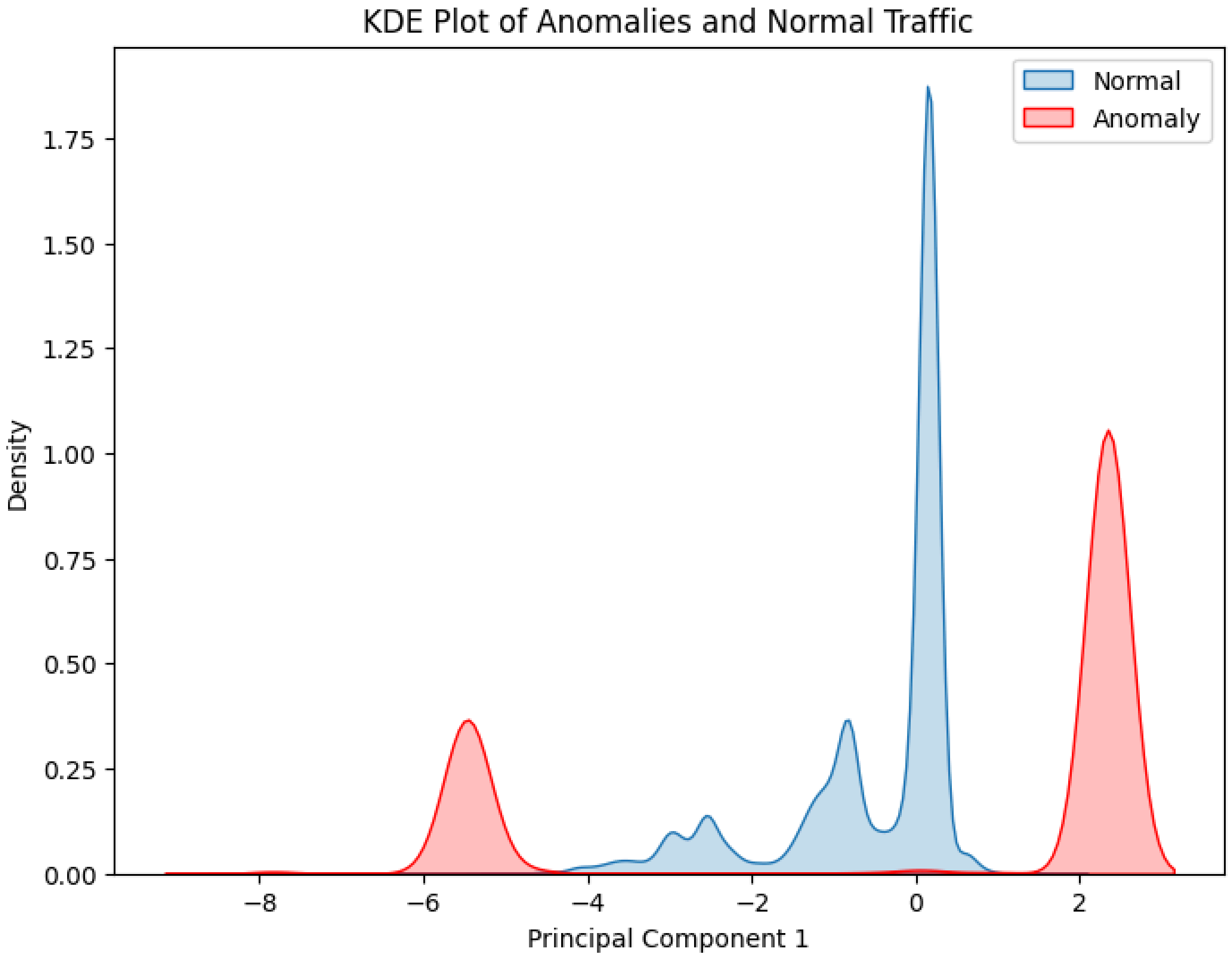
```
anomaly
0    444619
1     49402
Name: count, dtype: int64
```

In [20]:
```
from sklearn.metrics import classification_report, roc_auc_score, confusion_matrix

df['binary_label'] = df['label'].apply(lambda x: 1 if x != 'normal.' else 0)
```

In [21]:
```
print("Isolation Forest Metrics:")
print(classification_report(df['binary_label'], df['anomaly']))
print("AUC-ROC Score: ", roc_auc_score(df['binary_label'], df['anomaly']))
print("Confusion Matrix: \n", confusion_matrix(df['binary_label'], df['anomaly']))
```

```
Isolation Forest Metrics:
              precision    recall  f1-score   support

           0       0.18      0.80      0.29     97278
           1       0.61      0.08      0.14    396743

    accuracy                           0.22    494021
   macro avg       0.39      0.44      0.21    494021
weighted avg       0.52      0.22      0.17    494021

AUC-ROC Score:  0.43901137415494984
Confusion Matrix:
 [[ 78021  19257]
 [366598  30145]]
```

In [ ]:
```
# Dimensionality Reduction with PCA (OPTIONAL)

from sklearn.decomposition import PCA
import matplotlib.pyplot as plt
import seaborn as sns

pca = PCA(n_components=2)
df_pca = pca.fit_transform(df[numeric_cols])

df_pca = pd.DataFrame(df_pca, columns=['PC1', 'PC2'])

# Visualisation
df_pca['binary_label'] = df['label'].apply(lambda x: 1 if x != 'normal.' else 0)

plt.figure(figsize=(8, 6))
sns.kdeplot(df_pca[df_pca['binary_label']==0]['PC1'], label='Normal', fill=True)
sns.kdeplot(df_pca[df_pca['binary_label']==1]['PC1'], label='Anomaly', fill=True, color='r')
plt.xlabel('Principal Component 1')
plt.ylabel('Density')
plt.title("KDE Plot of Anomalies and Normal Traffic")
plt.legend()
plt.show()
```



In [ ]: