DCS 630

Week 12

Project Milestone 1 + Milestone 2 + Milestone 3 + Milestone 4

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In [ ]:
```
#Defining Libraries required for import
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime
import sklearn as sk
import textblob as tb
from nltk.sentiment.vader import SentimentIntensityAnalyzer
from nltk.stem import PorterStemmer
import operator
import unicodedata
import sys
import re
import os
from nltk.corpus import stopwords
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import cross_val_score
from sklearn.svm import LinearSVC
from sklearn.ensemble import RandomForestClassifier
import geopandas as gpd
from geopy.geocoders import Nominatim
from sklearn.linear_model import LinearRegression
```

```
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score, roc_auc_score, confusion_matrix,
from sklearn.metrics import mean_squared_error, r2_score, classification_report
import seaborn as sns
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.svm import SVR
from sklearn import tree
from sklearn.neighbors import KNeighborsClassifier
from sklearn.pipeline import Pipeline, FeatureUnion
from sklearn.metrics import confusion_matrix
from sklearn.inspection import DecisionBoundaryDisplay
from tqdm import tqdm
from sklearn.decomposition import PCA
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_samples, silhouette_score
import matplotlib.cm as cm
import warnings
import plotly.express as px
import plotly.io as pio
```

In [ ]:
```
DATASET_DIRECTORY = 'C:\\Users\\joshi\\OneDrive\\MS Data Sceinece\\DCS 630\\Week 6\\CICIoT2023\\'
```

Import Datasets

In [ ]:
```
df_sets = [k for k in os.listdir(DATASET_DIRECTORY) if k.endswith('.csv')]
df_sets.sort()
training_sets = df_sets[:int(len(df_sets)*.8)]
test_sets = df_sets[int(len(df_sets)*.8):]
```

In [ ]:
```
#select column names - the X ans the output
X_columns = [
    'flow_duration', 'Header_Length', 'Protocol Type', 'Duration',
       'Rate', 'Srate', 'Drate', 'fin_flag_number', 'syn_flag_number',
       'rst_flag_number', 'psh_flag_number', 'ack_flag_number',
       'ece_flag_number', 'cwr_flag_number', 'ack_count',
       'syn_count', 'fin_count', 'urg_count', 'rst_count',
    'HTTP', 'HTTPS', 'DNS', 'Telnet', 'SMTP', 'SSH', 'IRC', 'TCP',
       'UDP', 'DHCP', 'ARP', 'ICMP', 'IPv', 'LLC', 'Tot sum', 'Min',
       'Max', 'AVG', 'Std', 'Tot size', 'IAT', 'Number', 'Magnitue',
```

```
        'Radius', 'Covariance', 'Variance', 'Weight',
]
y_column = 'label'
```

Scaling

In [ ]:
```
#Load the dataset as a Pandas data frame.
from sklearn.preprocessing import MinMaxScaler, StandardScaler
scaler = StandardScaler()
```

In [ ]:
```
for train_set in tqdm(training_sets):
    scaler.fit(pd.read_csv(DATASET_DIRECTORY + train_set)[X_columns])
```

```
100%|██████████| 8/8 [00:04<00:00,  1.95it/s]
```

Classification: 34 (33+1) classes

In [ ]:
```
ML_models = [
        LogisticRegression(n_jobs=-1),
]

ML_neams = [
        "LogisticRegression",
]

for train_set in tqdm(training_sets):
    d = pd.read_csv(DATASET_DIRECTORY + train_set)
    d[X_columns] = scaler.transform(d[X_columns])
    for model in (ML_models):
        model.fit(d[X_columns], d[y_column])
```

```
100%|██████████| 8/8 [01:44<00:00, 13.07s/it]
```

In [ ]:
```
# Check for missing values
missing_values = d.isnull().sum()

# Check for duplicate rows
duplicates = d.duplicated().sum()
```

```
missing_values, duplicates
```

Out[ ]: (flow_duration 0
Header_Length 0
Protocol Type 0
Duration 0
Rate 0
Srate 0
Drate 0
fin_flag_number 0
syn_flag_number 0
rst_flag_number 0
psh_flag_number 0
ack_flag_number 0
ece_flag_number 0
cwr_flag_number 0
ack_count 0
syn_count 0
fin_count 0
urg_count 0
rst_count 0
HTTP 0
HTTPS 0
DNS 0
Telnet 0
SMTP 0
SSH 0
IRC 0
TCP 0
UDP 0
DHCP 0
ARP 0
ICMP 0
IPv 0
LLC 0
Tot sum 0
Min 0
Max 0
AVG 0
Std 0
Tot size 0
IAT 0
Number 0
Magnitue 0

```
Radius              0
Covariance          0
Variance            0
Weight              0
label               0
dtype: int64,
0)
```

In [ ]:
```
d.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 227910 entries, 0 to 227909
Data columns (total 47 columns):
 #   Column           Non-Null Count   Dtype
---  ------           --------------   -----
 0   flow_duration    227910 non-null  float64
 1   Header_Length    227910 non-null  float64
 2   Protocol Type    227910 non-null  float64
 3   Duration         227910 non-null  float64
 4   Rate             227910 non-null  float64
 5   Srate            227910 non-null  float64
 6   Drate            227910 non-null  float64
 7   fin_flag_number  227910 non-null  float64
 8   syn_flag_number  227910 non-null  float64
 9   rst_flag_number  227910 non-null  float64
 10  psh_flag_number  227910 non-null  float64
 11  ack_flag_number  227910 non-null  float64
 12  ece_flag_number  227910 non-null  float64
 13  cwr_flag_number  227910 non-null  float64
 14  ack_count        227910 non-null  float64
 15  syn_count        227910 non-null  float64
 16  fin_count        227910 non-null  float64
 17  urg_count        227910 non-null  float64
 18  rst_count        227910 non-null  float64
 19  HTTP             227910 non-null  float64
 20  HTTPS            227910 non-null  float64
 21  DNS              227910 non-null  float64
 22  Telnet           227910 non-null  float64
 23  SMTP             227910 non-null  float64
 24  SSH              227910 non-null  float64
 25  IRC              227910 non-null  float64
 26  TCP              227910 non-null  float64
 27  UDP              227910 non-null  float64
 28  DHCP             227910 non-null  float64
 29  ARP              227910 non-null  float64
 30  ICMP             227910 non-null  float64
 31  IPv              227910 non-null  float64
 32  LLC              227910 non-null  float64
 33  Tot sum          227910 non-null  float64
 34  Min              227910 non-null  float64
 35  Max              227910 non-null  float64
 36  AVG              227910 non-null  float64
```

```
 37  Std              227910 non-null  float64
 38  Tot size         227910 non-null  float64
 39  IAT              227910 non-null  float64
 40  Number           227910 non-null  float64
 41  Magnitue         227910 non-null  float64
 42  Radius           227910 non-null  float64
 43  Covariance       227910 non-null  float64
 44  Variance         227910 non-null  float64
 45  Weight           227910 non-null  float64
 46  label            227910 non-null  object
dtypes: float64(46), object(1)
memory usage: 81.7+ MB
```

In [ ]:
```python
y_test = []
preds = {i:[] for i in range(len(ML_models))}
for test_set in tqdm(test_sets):
    d_test = pd.read_csv(DATASET_DIRECTORY + test_set)
    d_test[X_columns] = scaler.transform(d_test[X_columns])

    y_test += list(d_test[y_column].values)

    for i in range(len(ML_models)):
        model = ML_models[i]
        y_pred = list(model.predict(d_test[X_columns]))
        preds[i] = preds[i] + y_pred
```

```
100%|██████████| 2/2 [00:01<00:00,  1.89it/s]
```

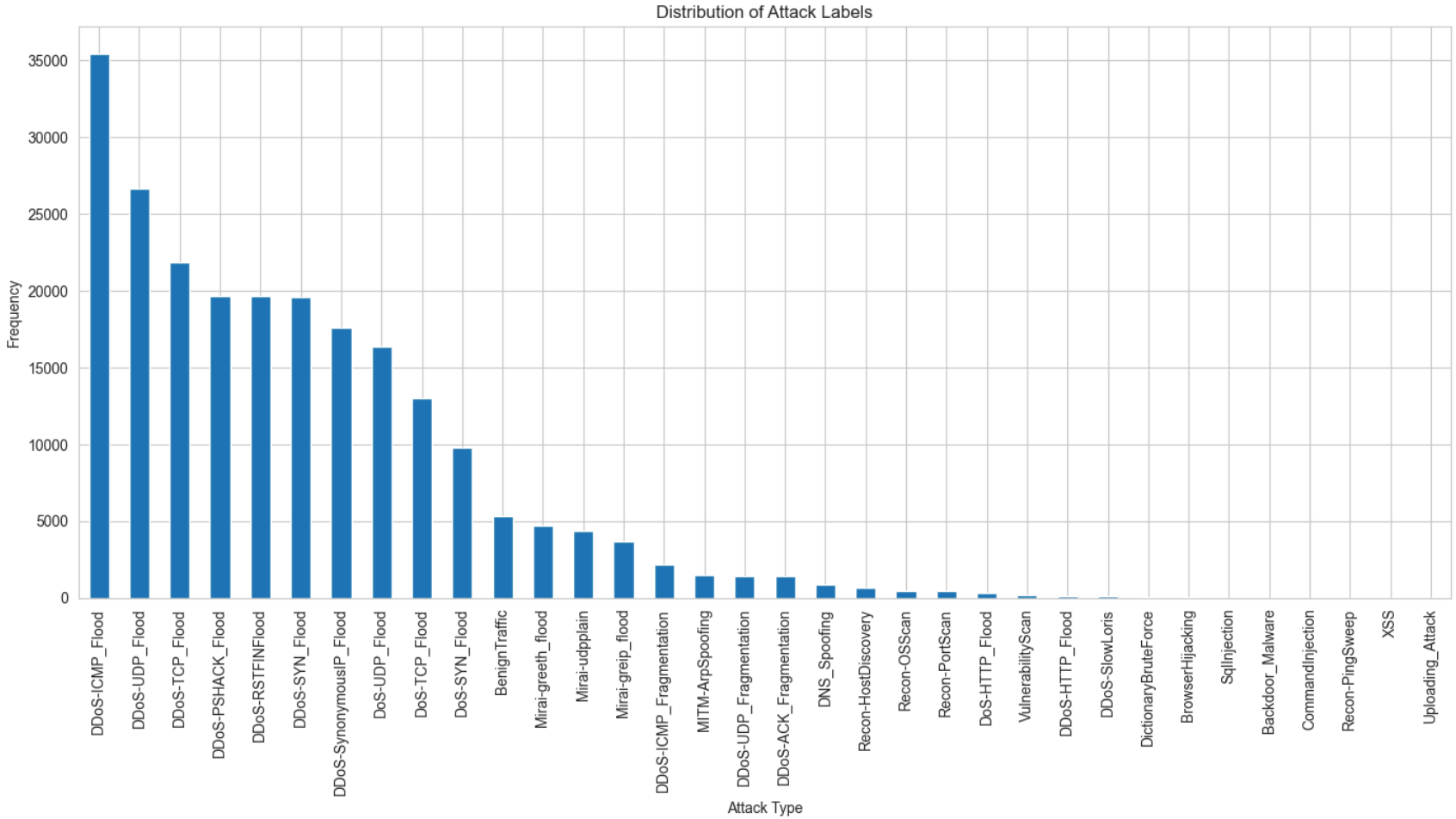
In [ ]:
```python
from sklearn.metrics import accuracy_score, recall_score, precision_score, f1_score
for k,v in preds.items():
    y_pred = v
    print(f"##### {ML_neams[k]} (34 classes) #####")
    print('accuracy_score: ', accuracy_score(y_pred, y_test))
    print('recall_score: ', recall_score(y_pred, y_test, average='macro'))
    print('precision_score: ', precision_score(y_pred, y_test, average='macro'))
    print('f1_score: ', f1_score(y_pred, y_test, average='macro'))
    print()
    print()
    print()
```

```
##### LogisticRegression (34 classes) #####
accuracy_score:  0.8016702430461047
```

```
c:\Users\joshi\AppData\Local\Programs\Python\Python312\Lib\site-packages\sklearn\metrics\_classification.py:1471: Und
efinedMetricWarning: Recall is ill-defined and being set to 0.0 in labels with no true samples. Use `zero_division` p
arameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
recall_score:  0.5855280514283756
precision_score:  0.48308193451950115
f1_score:  0.48969760075270646
```

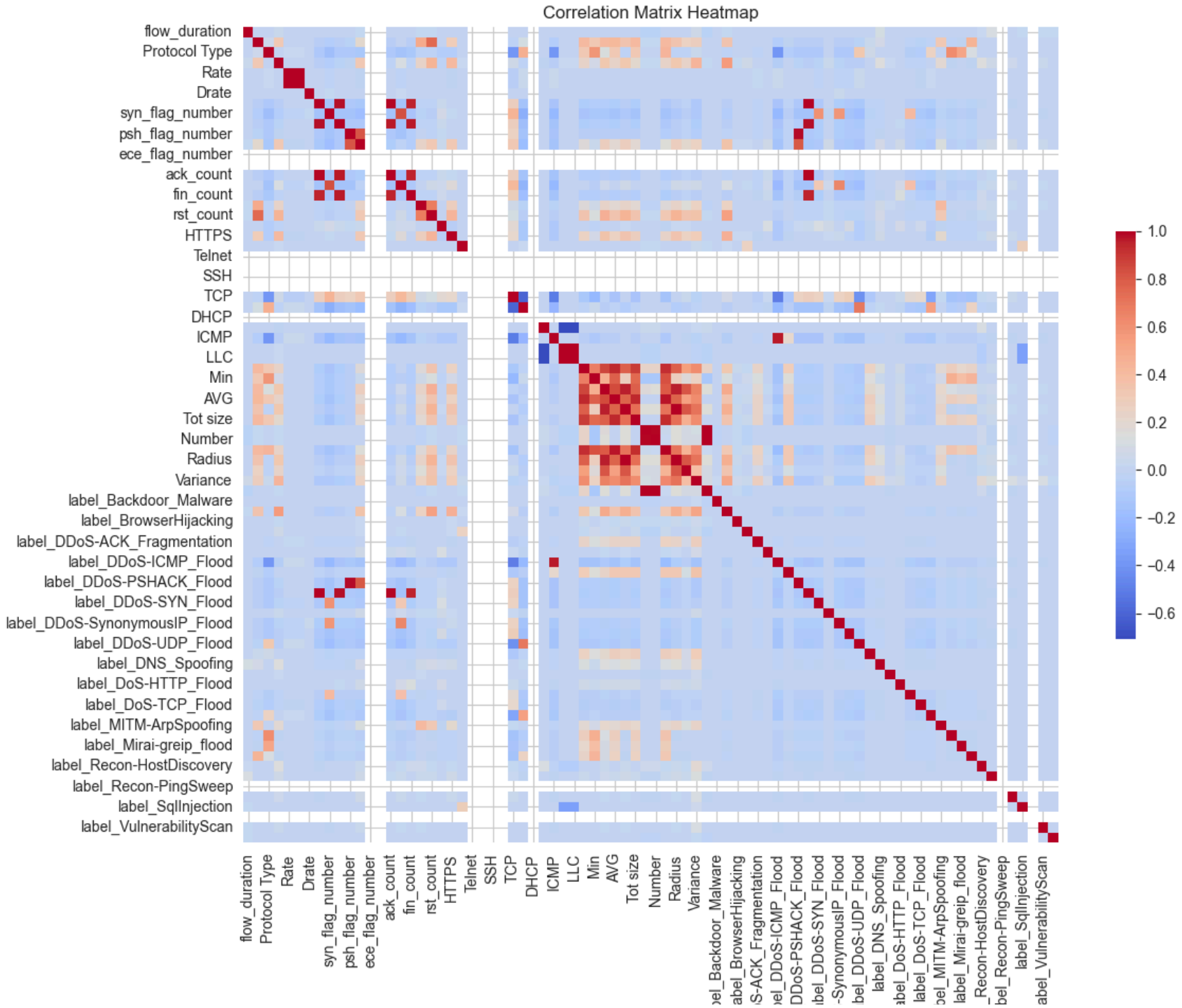
In [ ]:

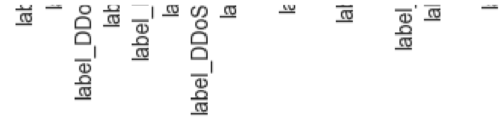
```python
# Distribution of attack labels

attack_label_counts = d['label'].value_counts()
# Set the aesthetic style of the plots
sns.set_style("whitegrid")

# Bar chart for the distribution of attack labels
plt.figure(figsize=(14, 8))
attack_label_counts.plot(kind='bar')
plt.title('Distribution of Attack Labels')
plt.xlabel('Attack Type')
plt.ylabel('Frequency')
plt.xticks(rotation=90)  # Rotate the x labels to show them clearly
plt.tight_layout()  # Adjust the plot to ensure everything fits without overlapping

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



In [ ]:
```
# Identify categorical variables
categorical_columns = d.select_dtypes(include=['object']).columns

# Apply one hot encoding to the categorical columns
df_encoded = pd.get_dummies(d, columns=categorical_columns)

# Sample a fraction of the data to avoid memory issues
df_sampled = df_encoded.sample(frac=0.1, random_state=1)

# Calculate the correlation matrix
corr_subset = df_sampled.corr()
```

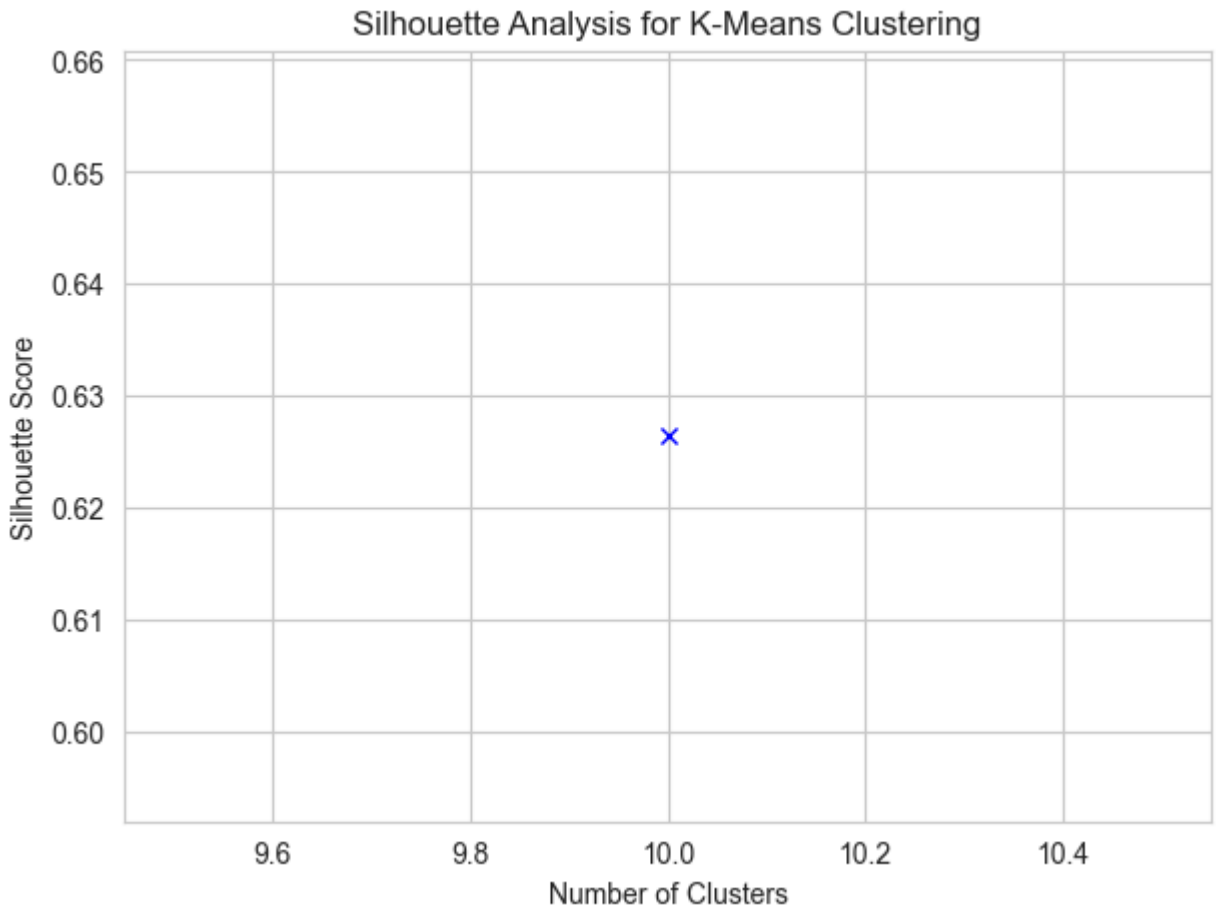
```
# Plot the heatmap
plt.figure(figsize=(14, 10))
sns.heatmap(corr_subset, annot=False, fmt=".2f", cmap='coolwarm', square=True, cbar_kws={"shrink": .5})
plt.title('Correlation Matrix Heatmap')
plt.show()
```


Correlation Matrix Heatmap
flow_duration
Protocol Type
Rate
Drate
syn_flag_number
psh_flag_number
ece_flag_number
ack_count
fin_count
rst_count
HTTPS
Telnet
SSH
TCP
DHCP
ICMP
LLC
Min
AVG
Tot size
Number
Radius
Variance
label_Backdoor_Malware
label_BrowserHijacking
label_DDoS-ACK_Fragmentation
label_DDoS-ICMP_Flood
label_DDoS-PSHACK_Flood
label_DDoS-SYN_Flood
label_DDoS-SynonymousIP_Flood
label_DDoS-UDP_Flood
label_DNS_Spoofing
label_DoS-HTTP_Flood
label_DoS-TCP_Flood
label_MITM-ArpSpoofing
label_Mirai-greip_flood
label_Recon-HostDiscovery
label_Recon-PingSweep
label_SqlInjection
label_VulnerabilityScan
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6



In [ ]:

```
d_test = d.drop(['label'], axis=1)
X = d_test
range_n_clusters = [10]
silhouette_avgs = []

# K-means clustering with different number of clusters
for n_clusters in range_n_clusters:
    clusterer = KMeans(n_clusters=n_clusters, random_state=10, n_init=10)
    cluster_labels = clusterer.fit_predict(X)

    # The silhouette_score gives the average value for all the samples.
    silhouette_avg = silhouette_score(X, cluster_labels)
    silhouette_avgs.append(silhouette_avg)

    # Compute the silhouette scores for each sample
    sample_silhouette_values = silhouette_samples(X, cluster_labels)

# Plot silhouette scores vs number of clusters
plt.figure(figsize=(7,5))
plt.plot(range_n_clusters, silhouette_avgs, 'bx-')
plt.xlabel('Number of Clusters')
plt.ylabel('Silhouette Score')
plt.title('Silhouette Analysis for K-Means Clustering')
plt.show()
```



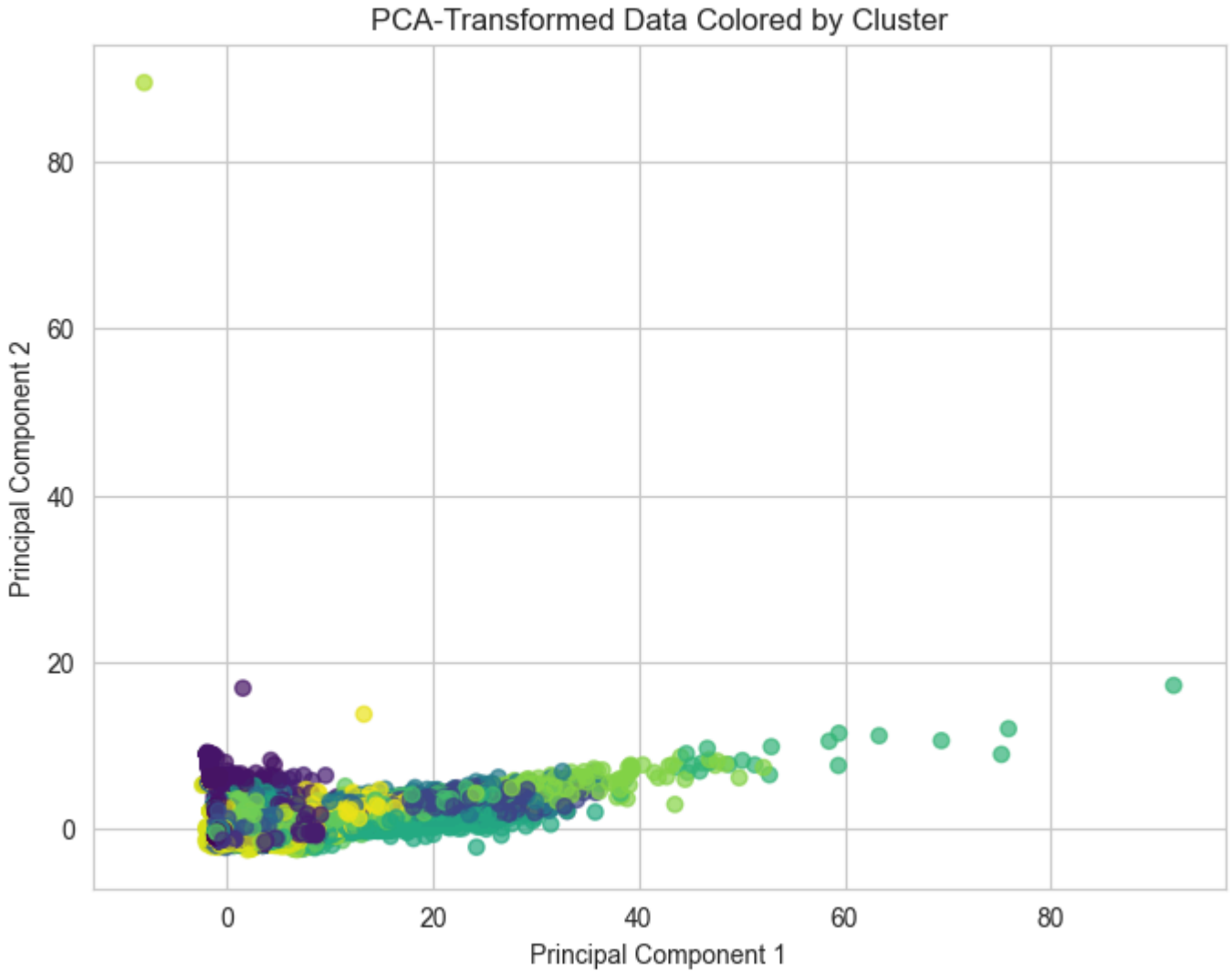
In [ ]:
```
X = d_test
silhouette_avgs = []

# K-means clustering with different number of clusters

clusterer = KMeans(n_clusters=34, random_state=10, n_init=10)
cluster_labels = clusterer.fit_predict(X)

# The silhouette_score gives the average value for all the samples.
silhouette_avg = silhouette_score(X, cluster_labels)
#silhouette_avgs.append(silhouette_avg)
```

```
# Compute the silhouette scores for each sample
sample_silhouette_values = silhouette_samples(X, cluster_labels)
```

In [ ]:
```
# Create a PCA object with n_components set to 2
pca = PCA(n_components=2)

# Fit the PCA model to the scaled data
pca.fit(d_test)

# Now you can use pca.transform(data) to transform new data
# OR
# Use pca.components_ to get the principal components
transformed_data = pca.transform(d_test)
principal_components = pca.components_

print("Shape of the transformed data:", transformed_data.shape)
print("Shape of the principal components:", principal_components.shape)
```

```
Shape of the transformed data: (227910, 2)
Shape of the principal components: (2, 46)
```

In [ ]:
```
# Create the scatterplot
plt.figure(figsize=(8, 6))
plt.scatter(transformed_data[:, 0], transformed_data[:, 1], c=cluster_labels, cmap='viridis', alpha=0.7)

# Label the axes based on the original feature names (optional)

plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')

plt.title('PCA-Transformed Data Colored by Cluster')
plt.show()
```

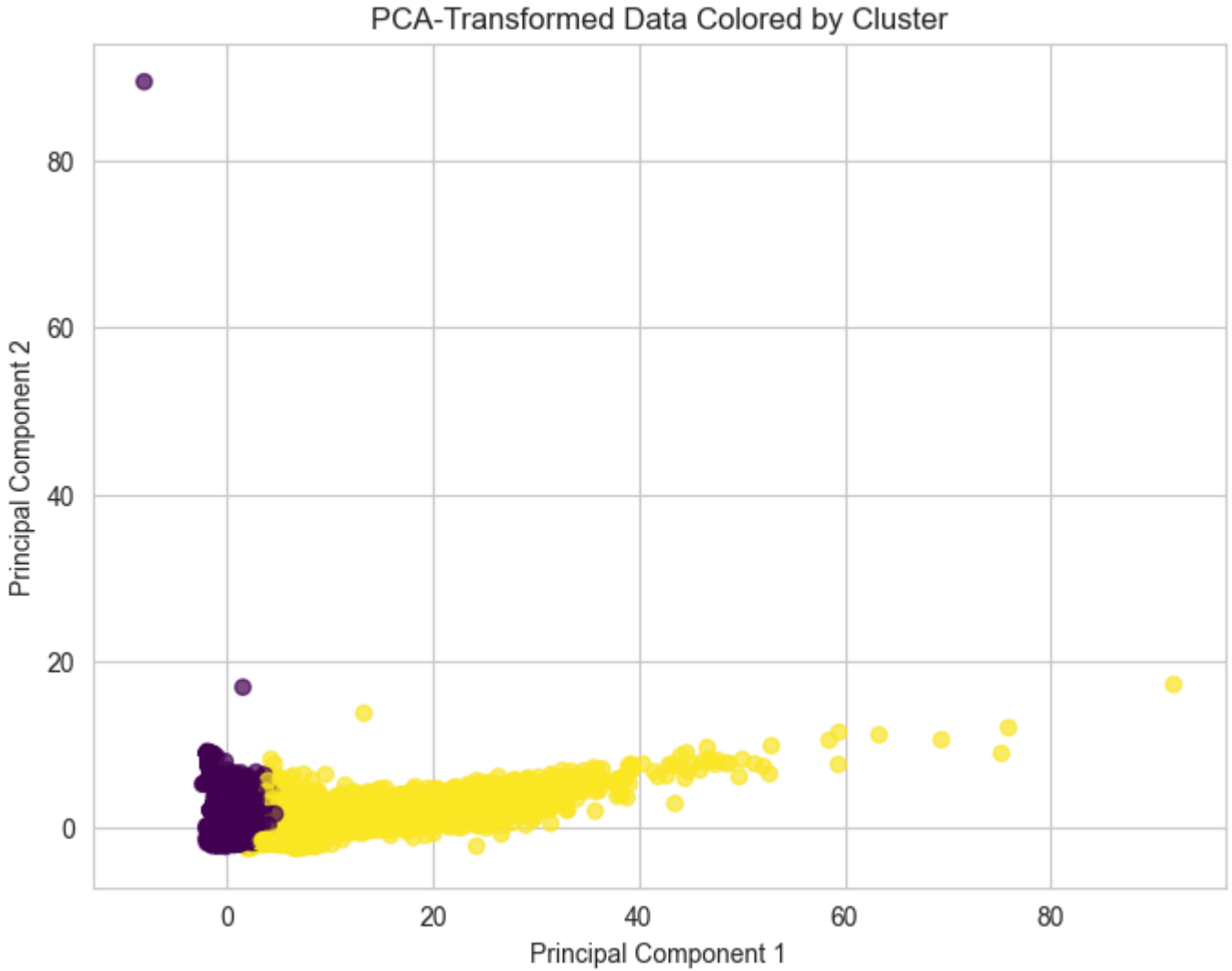


In [ ]:
```
X = d_test
silhouette_avgs = []

# K-means clustering with different number of clusters

clusterer = KMeans(n_clusters=2, random_state=10, n_init=10)
cluster_labels = clusterer.fit_predict(X)

# The silhouette_score gives the average value for all the samples.
```

```
silhouette_avg = silhouette_score(X, cluster_labels)
#silhouette_avgs.append(silhouette_avg)

# Compute the silhouette scores for each sample
sample_silhouette_values = silhouette_samples(X, cluster_labels)
```

In [ ]:

```
# Create the scatterplot
plt.figure(figsize=(8, 6))
plt.scatter(transformed_data[:, 0], transformed_data[:, 1], c=cluster_labels, cmap='viridis', alpha=0.7)

# Label the axes based on the original feature names (optional)

plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')

plt.title('PCA-Transformed Data Colored by Cluster')
plt.show()
```


PCA-Transformed Data Colored by Cluster
Principal Component 2
Principal Component 1
0
20
40
60
80
0
20
40
60
80