```
In [1]:  #Importing the required libraries
         import numpy as np
         import pandas as pd
         import seaborn as sns
         import matplotlib.pyplot as plt
         from sklearn.model_selection import train_test_split
         from sklearn.feature_extraction.text import TfidfVectorizer
         from sklearn.cluster import KMeans
         from sklearn.preprocessing import StandardScaler
         import sklearn.metrics
```

```
C:\Users\Dell\anaconda3\lib\site-packages\scipy\__init__.py:155: UserWarning: A Nu
mPy version >=1.18.5 and <1.25.0 is required for this version of SciPy (detected v
ersion 1.26.1
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"
```

```
In [2]:  # Loading Hadoop log file dataset into a Pandas DataFrame
         df = pd.read_csv('Hadoop_log.csv')
         df.head()
```

Out[2]:

	LineId	Date	Time	Level	Process	Component
0	1	18-10-2015	18:01:47,978	INFO	main	org.apache.hadoop.mapreduce.v2.app.MRAppMaster
1	2	18-10-2015	18:01:48,963	INFO	main	org.apache.hadoop.mapreduce.v2.app.MRAppMaster	Exe
2	3	18-10-2015	18:01:48,963	INFO	main	org.apache.hadoop.mapreduce.v2.app.MRAppMaster	YAR Ser
3	4	18-10-2015	18:01:49,228	INFO	main	org.apache.hadoop.mapreduce.v2.app.MRAppMaster	
4	5	18-10-2015	18:01:50,353	INFO	main	org.apache.hadoop.mapreduce.v2.app.MRAppMaster	Ou

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

Out[3]: (2000, 9)

```
In [4]:  # Extract relevant text data for TF-IDF vectorization
         text_data = df['EventTemplate'].tolist()

         # TF-IDF vectorization
         tfidf_vectorizer = TfidfVectorizer()
         tfidf_matrix = tfidf_vectorizer.fit_transform(text_data)

         # Convert the TF-IDF matrix to a DataFrame for better visualization
         tfidf_df = pd.DataFrame(data=tfidf_matrix.toarray(), columns=tfidf_vectorizer.get_f
         # Standardize the TF-IDF features
         scaler = StandardScaler()
         tfidf_scaled = scaler.fit_transform(tfidf_df)
         print("Scaled TF-ID:\n", tfidf_scaled)
```

```
Scaled TF-ID:
 [[-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02 -2.23662720e-02]
  [-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02 -2.23662720e-02]
  [-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02  4.47101778e+01]
  ...
  [-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02 -2.23662720e-02]
  [-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02 -2.23662720e-02]
  [-2.23662720e-02 -2.23662720e-02 -2.23662720e-02 ... -2.23662720e-02
   -3.84289452e-02 -2.23662720e-02]]
```

In [5]:
```python
# Choose the number of clusters (we may need to adjust this based on ourdata)
num_clusters = 3

# Perform k-means clustering on the TF-IDF features
model = KMeans(n_clusters=num_clusters, random_state=42)
clusters = model.fit_predict(tfidf_scaled)

# Add the cluster labels to the original DataFrame
df['cluster'] = clusters

# Calculate the distance of each instance to its cluster center
distances = model.transform(tfidf_scaled)
df['distance_to_cluster'] = distances.min(axis=1)

# Set a threshold for anomaly detection (adjust this based on your data)
anomaly_threshold = 2.0

# Mark instances with distance exceeding the threshold as anomalies
df['is_anomaly'] = df['distance_to_cluster'] > anomaly_threshold

# Print the instances marked as anomalies
anomalies = df[df['is_anomaly']]
print("Anomalies:")
print(anomalies[['LineId','distance_to_cluster']])
```

```
Anomalies:
      LineId  distance_to_cluster
0          1            82.108957
1          2            60.357977
2          3           131.117936
3          4            64.711470
4          5            84.805710
...        ...                  ...
1995     1996            4.705969
1996     1997            7.273342
1997     1998           12.197538
1998     1999            7.605110
1999     2000            4.705969

[1999 rows x 2 columns]
```

In [6]:
```python
# Visualization of distances for normal instances
plt.figure(figsize=(10, 6))
plt.hist(df[df['is_anomaly'] == False]['distance_to_cluster'], bins=50, color='blue
plt.hist(df[df['is_anomaly'] == True]['distance_to_cluster'], bins=50, color='red',
plt.title('Distribution of Distances to Cluster Centers')
plt.xlabel('Distance to Cluster Center')
plt.ylabel('Frequency')
```

```
plt.legend()
plt.show()
```


Distribution of Distances to Cluster Centers
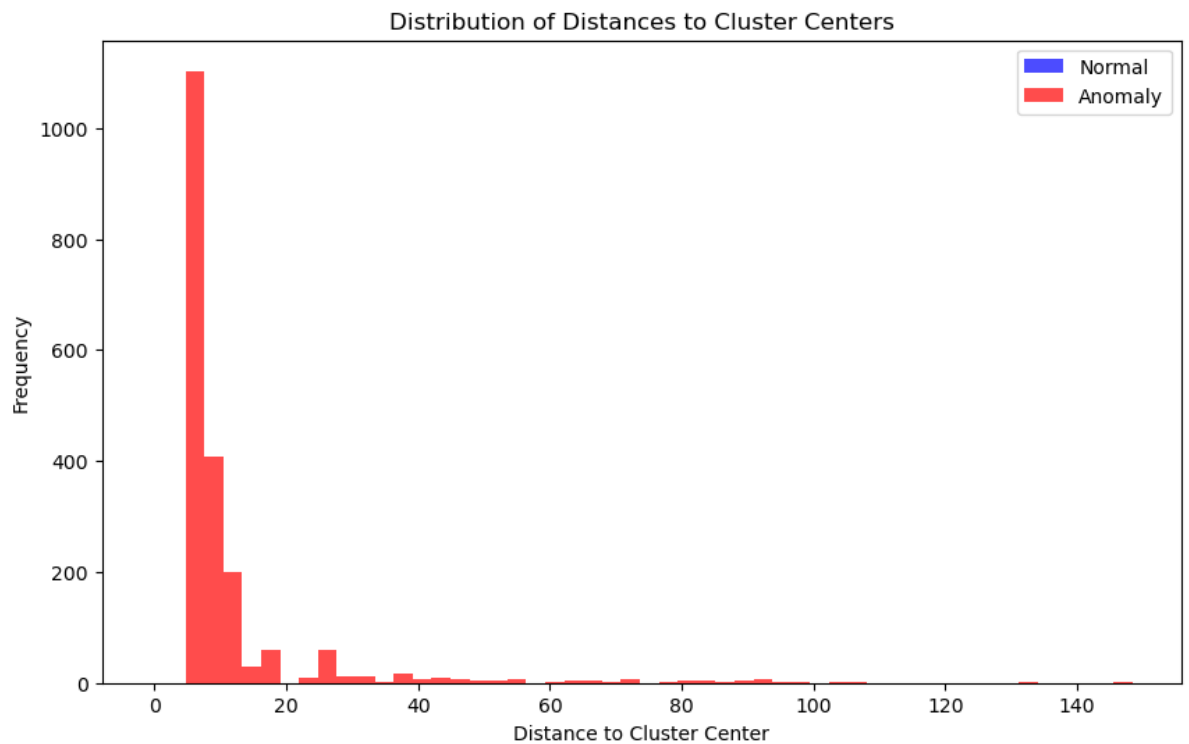
```
In [7]:  # Visualize the clustering
         plt.scatter(df['LineId'], df['distance_to_cluster'], c=df['cluster'], cmap='viridis
         plt.title('K-Means Clustering for Anomaly Detection, k = 3')
         plt.xlabel('LineId')
         plt.ylabel('Distance to Cluster Center')
         plt.show()
```


K-Means Clustering for Anomaly Detection, k = 3
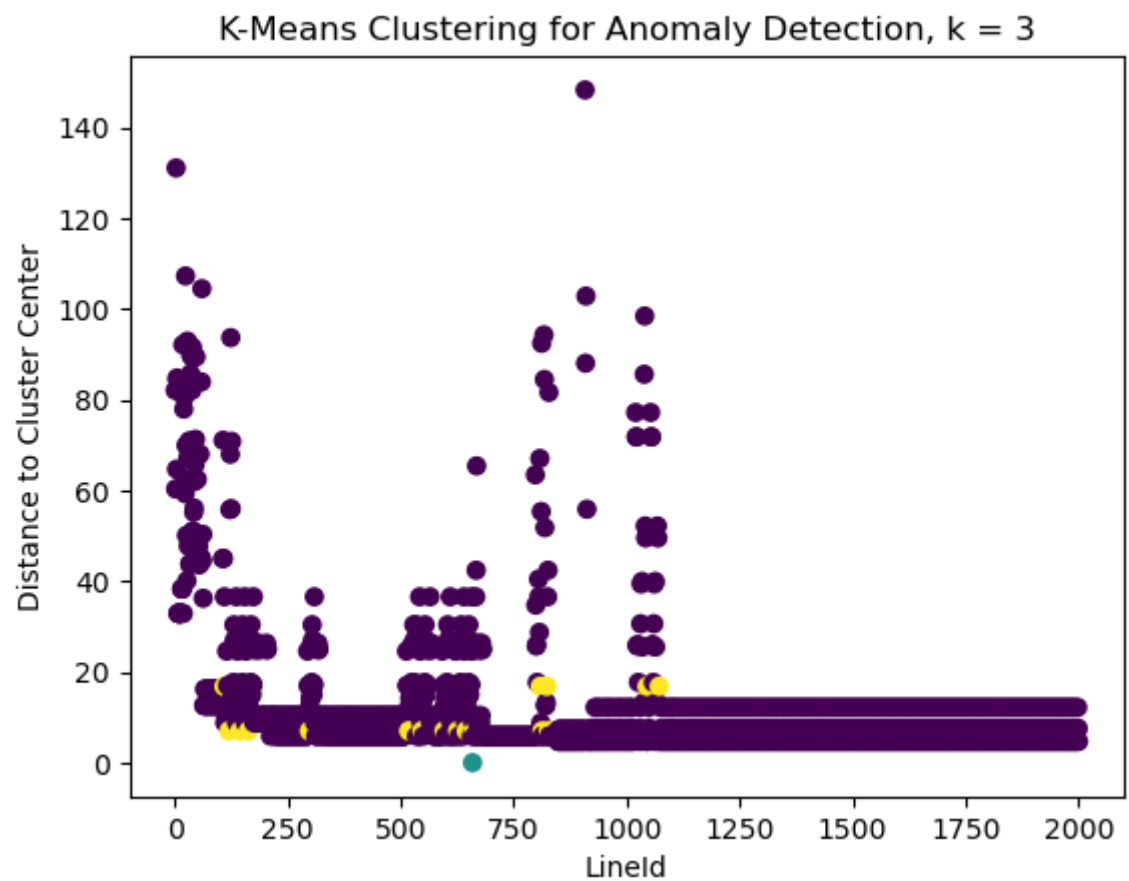
```
In [8]:  from sklearn.metrics import precision_score, recall_score, f1_score, confusion_matr

         true_labels = df['is_anomaly']

         # Predicted labels based on the given threshold
         predicted_labels = df['distance_to_cluster'] > anomaly_threshold

         # Calculate metrics
         precision = precision_score(true_labels, predicted_labels)
         recall = recall_score(true_labels, predicted_labels)
         f1 = f1_score(true_labels, predicted_labels)
         print("Precision:", precision)
         print("Recall:",recall)
         print("F1_Score:",f1)
         roc_auc = roc_auc_score(true_labels, df['distance_to_cluster'])
         print("Roc Auc:",roc_auc)
         conf_matrix = confusion_matrix(true_labels, predicted_labels)
         print("Confusion Matrix:\n",conf_matrix)
```

```
Precision: 1.0
Recall: 1.0
F1_Score: 1.0
Roc Auc: 1.0
Confusion Matrix:
 [[   1    0]
  [   0 1999]]
```

```
In [9]:  # Choose the number of clusters
         num_clusters = 4

         # Perform k-means clustering on the TF-IDF features
         model = KMeans(n_clusters=num_clusters, random_state=42)
         clusters = model.fit_predict(tfidf_scaled)

         # Add the cluster labels to the original DataFrame
         df['cluster'] = clusters

         # Calculate the distance of each instance to its cluster center
         distances = model.transform(tfidf_scaled)
         df['distance_to_cluster'] = distances.min(axis=1)

         # Set a threshold for anomaly detection
         anomaly_threshold = 2.0

         # Mark instances with distance exceeding the threshold as anomalies
         df['is_anomaly'] = df['distance_to_cluster'] > anomaly_threshold

         # Print the instances marked as anomalies
         anomalies = df[df['is_anomaly']]
         print("Anomalies:")
         print(anomalies[['LineId','distance_to_cluster']])
```

```
Anomalies:
        LineId  distance_to_cluster
0            1            82.103940
1            2            60.352533
2            3           131.112054
3            4            64.706644
4            5            84.800709
...        ...                  ...
1994      1995             4.581726
1995      1996             4.581726
1996      1997             7.230096
1998      1999             7.551529
1999      2000             4.581726

[1844 rows x 2 columns]
```

In [10]:
```python
# Visualize the clustering
plt.scatter(df['LineId'], df['distance_to_cluster'], c=df['cluster'], cmap='viridis
plt.title('K-Means Clustering for Anomaly Detection, k = 4')
plt.xlabel('LineId')
plt.ylabel('Distance to Cluster Center')
plt.show()
```
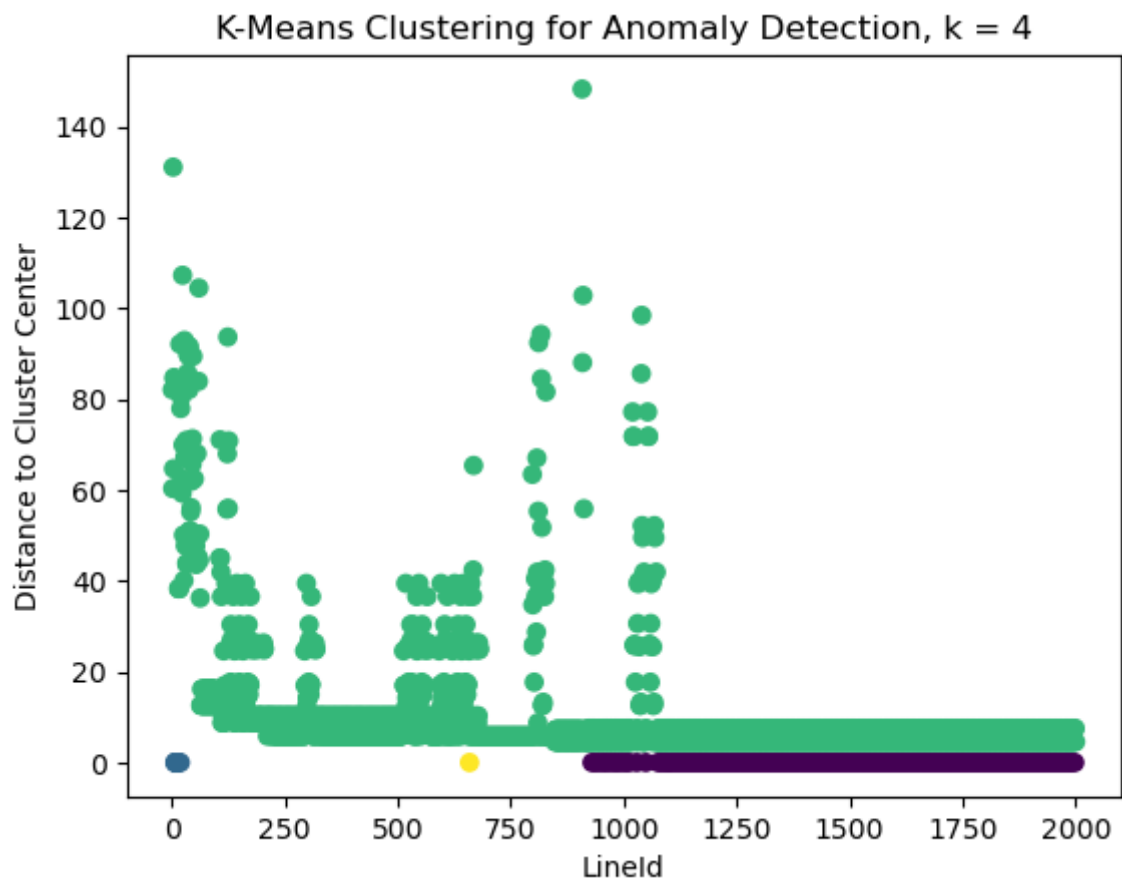

In [11]:
```python
# Choose the number of clusters
num_clusters = 5

# Perform k-means clustering on the TF-IDF features
model = KMeans(n_clusters=num_clusters, random_state=42)
clusters = model.fit_predict(tfidf_scaled)

# Add the cluster labels to the original DataFrame
df['cluster'] = clusters

# Calculate the distance of each instance to its cluster center
distances = model.transform(tfidf_scaled)
```

```
df['distance_to_cluster'] = distances.min(axis=1)

# Set a threshold for anomaly detection
anomaly_threshold = 2.0

# Mark instances with distance exceeding the threshold as anomalies
df['is_anomaly'] = df['distance_to_cluster'] > anomaly_threshold

# Print the instances marked as anomalies
anomalies = df[df['is_anomaly']]
print("Anomalies:")
print(anomalies[['LineId','distance_to_cluster']])
```

```
Anomalies:
      LineId  distance_to_cluster
0          1            82.104687
1          2            60.348552
3          4            64.703345
4          5            84.796028
5          6            84.371492
...        ...                ...
1994    1995             4.438133
1995    1996             4.438133
1997    1998            12.107555
1998    1999             7.502992
1999    2000             4.438133

[1672 rows x 2 columns]
```

In [12]:
```
# Visualize the clustering
plt.scatter(df['LineId'], df['distance_to_cluster'], c=df['cluster'], cmap='viridis
plt.title('K-Means Clustering for Anomaly Detection, k = 5')
plt.xlabel('LineId')
plt.ylabel('Distance to Cluster Center')
plt.show()
```
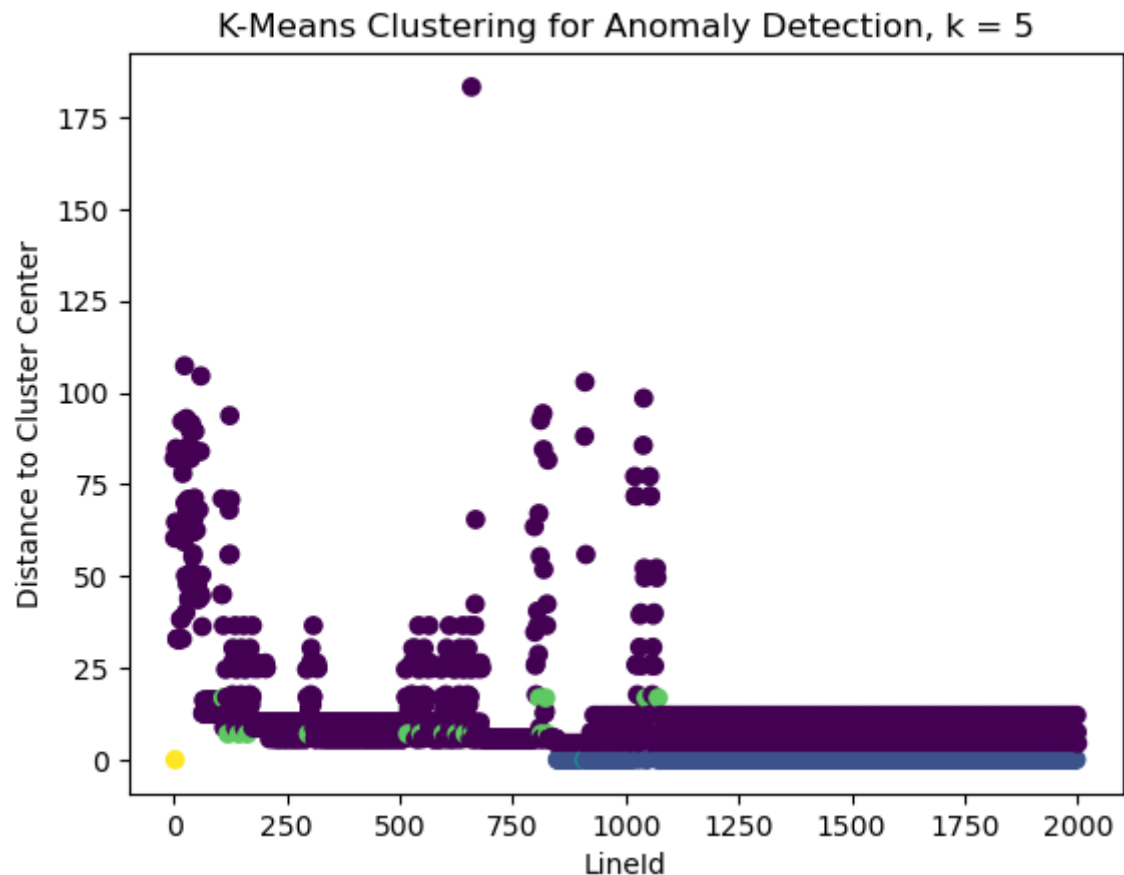
```python
In [13]:   from sklearn.model_selection import train_test_split

           # Assuming you have an event count matrix X
           # X is your feature data
           x = tfidf_scaled

           # Split the data into training and testing sets
           x_train, x_test = train_test_split(x, test_size=0.2, random_state=1)
```

```python
In [14]:   # The 'test_size' parameter specifies the proportion of the dataset to include in t
           # The 'random_state' parameter is used for reproducibility. You can set it to any i
           from sklearn.svm import OneClassSVM

           # Create an One-Class SVM model
           svm_model = OneClassSVM(nu=0.2)   # You can adjust the nu parameter

           # Train the model on the training data
           svm_model.fit(x_train)  # X_train is your training data (event count matrix)
```

```
Out[14]:   OneClassSVM(nu=0.2)
```

```python
In [15]:   # Predict anomalies in the testing data
           anomaly_predictions = svm_model.predict(x_test)# X_test is testing data (event cour
           print("Anomaly Predictions:",anomaly_predictions)
```

```
Anomaly Predictions: [-1  1  1  1  1  1  1  1  1 -1  1  1  1  1 -1  1 -1  1  1  1
  1  1  1  1
 -1 -1  1  1 -1  1  1  1  1  1  1  1  1 -1  1  1 -1  1  1 -1 -1  1  1  1
  1  1  1  1  1  1  1  1  1  1  1 -1 -1  1  1  1  1  1  1 -1  1  1  1  1
  1  1  1  1  1  1  1  1  1  1 -1 -1 -1  1  1 -1 -1 -1  1  1 -1  1  1 -1
  1  1  1  1  1 -1  1 -1  1  1  1  1  1  1 -1  1  1  1  1  1  1  1  1  1
 -1  1  1  1 -1  1  1  1  1  1  1  1  1 -1  1  1  1  1  1 -1  1  1  1  1
 -1  1  1  1  1  1  1 -1  1  1  1  1  1  1  1  1  1  1  1  1 -1  1 -1  1
  1  1  1  1 -1  1  1 -1  1  1 -1  1  1  1 -1  1  1  1  1  1  1 -1  1  1
  1  1 -1  1  1  1  1  1 -1  1  1  1  1  1  1  1  1  1  1  1  1 -1 -1 -1
  1  1  1  1  1  1  1 -1  1 -1  1 -1 -1  1  1  1  1  1  1  1  1  1  1  1
  1  1  1  1 -1 -1  1  1  1  1  1 -1  1  1  1  1 -1  1  1 -1  1  1 -1  1
  1  1  1  1  1  1  1  1 -1  1  1  1 -1  1  1  1  1  1  1  1  1  1  1  1
  1  1  1  1  1  1  1 -1  1  1  1 -1 -1  1  1  1  1  1  1  1  1  1  1 -1
 -1  1  1  1 -1  1 -1  1  1 -1 -1  1  1  1 -1  1 -1  1 -1  1  1 -1  1 -1
  1  1  1  1 -1 -1  1  1  1  1  1 -1  1  1 -1  1  1 -1 -1  1  1  1  1  1
  1  1  1  1  1 -1  1  1  1 -1  1  1 -1  1  1  1  1  1  1 -1 -1 -1  1
 -1  1  1  1  1  1 -1  1 -1  1  1  1  1 -1  1  1]
```

```python
In [16]:   anomaly_scores = svm_model.decision_function(x_test)
           print("\nAnomaly Scores:\n",anomaly_scores)
```

```
Anomaly Scores:
 [-4.96759952e+01  4.00280858e+00  4.00280858e+00  1.19250775e+01
  1.19250775e+01  4.00280858e+00  1.04532637e+01  5.21545703e-02
  1.19250775e+01 -7.47782731e+01  4.00280858e+00  4.00280858e+00
  1.85164592e-04  4.00280858e+00 -4.64176295e-04  1.19250775e+01
 -1.51025273e+01  1.19250775e+01  4.00280858e+00  4.00280858e+00
  1.04532637e+01  4.00280858e+00  4.00280858e+00  1.19250775e+01
 -2.89386167e+01 -4.64176295e-04  1.19250775e+01  1.04532637e+01
 -5.48588683e+01  5.21545703e-02  4.69516806e+00  4.00280858e+00
  4.00280858e+00  1.04532637e+01  1.04532637e+01  1.04532637e+01
  1.04532637e+01 -7.77780921e+01  4.00280858e+00  1.19250775e+01
 -4.96359709e+01  5.21545703e-02  1.19250775e+01 -7.47782731e+01
 -7.80973730e+01  1.19250775e+01  1.04532637e+01  1.19250775e+01
  4.69516806e+00  1.19250775e+01  1.19250775e+01  1.19250775e+01
  1.04532637e+01  5.21545703e-02  1.04532637e+01  1.04532637e+01
  1.04532637e+01  1.19250775e+01  4.00280858e+00 -7.47782731e+01
 -5.71233393e+01  1.85446218e-04  4.00280858e+00  4.69516806e+00
  4.00280858e+00  4.00280858e+00  4.69516806e+00 -5.71233393e+01
  1.04532637e+01  1.85164592e-04  4.00280858e+00  4.00280858e+00
  4.00280858e+00  1.19250775e+01  4.00280858e+00  4.00280858e+00
  1.19250775e+01  4.00280858e+00  1.85164592e-04  1.04532637e+01
  1.04532637e+01  1.04532637e+01 -3.42285730e+00 -5.80808868e+00
 -7.51994552e+01  1.85164592e-04  1.19250775e+01 -7.79930744e+01
 -4.64176295e-04 -4.64176295e-04  5.21545703e-02  4.00280858e+00
 -4.64176295e-04  1.19250775e+01  1.19250775e+01 -4.96359709e+01
  1.85164592e-04  4.00280858e+00  1.19250775e+01  1.85446218e-04
  4.00280858e+00 -7.47782731e+01  1.85164592e-04 -7.72499207e+01
  1.04532637e+01  4.00280858e+00  4.00280858e+00  4.00280858e+00
  1.04532637e+01  4.00280858e+00 -9.97945090e+00  5.21545703e-02
  4.69516806e+00  4.00280858e+00  1.04532637e+01  1.19250775e+01
  1.04532637e+01  1.19250775e+01  1.19250775e+01  1.19250775e+01
 -2.89386167e+01  1.19250775e+01  1.85164592e-04  4.00280858e+00
 -7.82505814e+01  4.00280858e+00  4.00280858e+00  4.69516806e+00
  4.00280858e+00  1.04532637e+01  4.00280858e+00  1.04532637e+01
  1.04532637e+01 -4.64176295e-04  1.04532637e+01  1.85446218e-04
  4.00280858e+00  1.04532637e+01  4.00280858e+00 -5.71233393e+01
  1.19250775e+01  5.21545703e-02  1.19250775e+01  1.19250775e+01
 -4.97905355e+01  1.19250775e+01  1.19250775e+01  1.19250775e+01
  1.19250775e+01  1.19250775e+01  5.21545703e-02 -4.64176295e-04
  4.00280858e+00  1.85164592e-04  5.21545703e-02  1.19250775e+01
  1.19250775e+01  1.19250775e+01  1.04532637e+01  1.19250775e+01
  4.69516806e+00  1.19250775e+01  4.00280858e+00  5.21545703e-02
 -4.64176295e-04  1.19250775e+01 -4.64176295e-04  5.21545703e-02
  1.85164592e-04  1.04532637e+01  1.04532637e+01  4.00280858e+00
 -4.96359709e+01  1.19250775e+01  5.21545703e-02 -5.01075657e+01
  4.69516806e+00  1.04532637e+01 -4.96759952e+01  4.00280858e+00
  1.19250775e+01  1.19250775e+01 -6.94944351e+01  1.85164592e-04
  1.04532637e+01  4.00280858e+00  4.69516806e+00  1.19250775e+01
  5.21545703e-02 -6.94944351e+01  5.21545703e-02  1.19250775e+01
  1.19250775e+01  1.19250775e+01 -4.64176295e-04  1.85446218e-04
  5.21545703e-02  5.21545703e-02  1.19250775e+01  1.04532637e+01
 -6.54618636e+01  4.00280858e+00  1.19250775e+01  4.00280858e+00
  4.00280858e+00  4.00280858e+00  1.19250775e+01  1.19250775e+01
  1.19250775e+01  1.04532637e+01  4.69516806e+00  4.69516806e+00
  1.04532637e+01 -4.64176295e-04 -6.54618636e+01 -1.53984548e+01
  1.19250775e+01  1.04532637e+01  1.19250775e+01  1.19250775e+01
  4.00280858e+00  1.85164592e-04  1.19250775e+01 -6.94944351e+01
  4.00280858e+00 -7.82460499e+01  1.19250775e+01 -7.80973730e+01
 -4.64176295e-04  1.19250775e+01  1.19250775e+01  1.19250775e+01
  1.85164592e-04  1.19250775e+01  1.04532637e+01  1.04532637e+01
  1.04532637e+01  1.19250775e+01  1.19250775e+01  4.69516806e+00
  1.19250775e+01  5.21545703e-02  1.04532637e+01  1.19250775e+01
 -6.57604220e+01 -6.94944351e+01  1.04532637e+01  4.69516806e+00
  1.19250775e+01  4.00280858e+00  1.04532637e+01 -4.64176295e-04
```

```
      1.85164592e-04  4.00280858e+00  4.00280858e+00  4.69516806e+00
     -7.82505834e+01  1.19250775e+01  1.04532637e+01 -5.48588683e+01
      1.85164592e-04  4.00280858e+00 -7.74543743e+01  4.00280858e+00
      1.19250775e+01  1.19250775e+01  1.04532637e+01  4.69516806e+00
      4.00280858e+00  1.19250775e+01  1.04532637e+01  4.00280858e+00
     -7.82191692e+01  1.19250775e+01  1.19250775e+01  4.00280858e+00
     -3.42285730e+00  1.85164592e-04  1.04532637e+01  1.04532637e+01
      1.85446218e-04  4.00280858e+00  1.85446218e-04  1.19250775e+01
      4.69516806e+00  1.85164592e-04  1.85164592e-04  1.04532637e+01
      1.19250775e+01  1.19250775e+01  1.19250775e+01  1.85446218e-04
      1.19250775e+01  4.00280858e+00  4.00280858e+00 -3.42285730e+00
      1.04532637e+01  1.85446218e-04  4.00280858e+00 -4.64176295e-04
     -4.64176295e-04  4.00280858e+00  1.19250775e+01  1.19250775e+01
      1.19250775e+01  4.00280858e+00  4.69516806e+00  1.19250775e+01
      4.00280858e+00  1.19250775e+01  1.85164592e-04 -2.60029668e+01
     -4.64176295e-04  1.19250775e+01  1.85164592e-04  1.85446218e-04
     -4.64176295e-04  4.00280858e+00 -6.57604220e+01  4.00280858e+00
      1.19250775e+01 -7.65787744e+01 -4.64176295e-04  4.00280858e+00
      1.19250775e+01  1.19250775e+01 -4.64176295e-04  4.00280858e+00
     -7.77780921e+01  1.04532637e+01 -1.25426290e+01  4.00280858e+00
      1.19250775e+01 -9.97945090e+00  1.19250775e+01 -2.89386167e+01
      4.00280858e+00  1.04532637e+01  1.04532637e+01  5.21545703e-02
     -4.64176295e-04 -4.64176295e-04  1.19250775e+01  1.85164592e-04
      1.19250775e+01  1.04532637e+01  1.04532637e+01 -7.82489442e+01
      1.85164592e-04  4.69516806e+00 -2.60029668e+01  1.04532637e+01
      1.19250775e+01 -6.94944351e+01 -7.82505838e+01  1.04532637e+01
      1.04532637e+01  1.19250775e+01  1.04532637e+01  4.00280858e+00
      1.04532637e+01  1.04532637e+01  1.19250775e+01  4.00280858e+00
      4.69516806e+00 -5.80808868e+00  1.85164592e-04  1.19250775e+01
      1.04532637e+01 -2.89386167e+01  1.85164592e-04  4.69516806e+00
     -4.64176295e-04  1.04532637e+01  4.00280858e+00  1.04532637e+01
      1.19250775e+01  4.00280858e+00  4.00280858e+00  5.21545703e-02
     -2.33035076e+01 -5.01075657e+01 -2.89386167e+01  1.19250775e+01
     -7.82471554e+01  4.00280858e+00  1.19250775e+01  1.04532637e+01
      1.19250775e+01  4.69516806e+00 -3.42285730e+00  1.04532637e+01
     -2.33035076e+01  4.69516806e+00  1.19250775e+01  1.04532637e+01
      1.04532637e+01 -4.64176295e-04  4.00280858e+00  1.19250775e+01]
```

In [17]:
```python
# Scatter plot for anomaly predictions
plt.scatter(range(len(anomaly_predictions)), anomaly_predictions, color='red', labe

# Horizontal line at the decision threshold (adjust threshold if needed)
decision_threshold = 0
plt.axhline(y=decision_threshold, color='blue', linestyle='--', label='Decision Thr

plt.title('One-Class SVM Anomaly Scores')
plt.xlabel('Data Point Index')
plt.ylabel('Anomaly Score')
plt.legend()
plt.show()
```

One-Class SVM Anomaly Scores
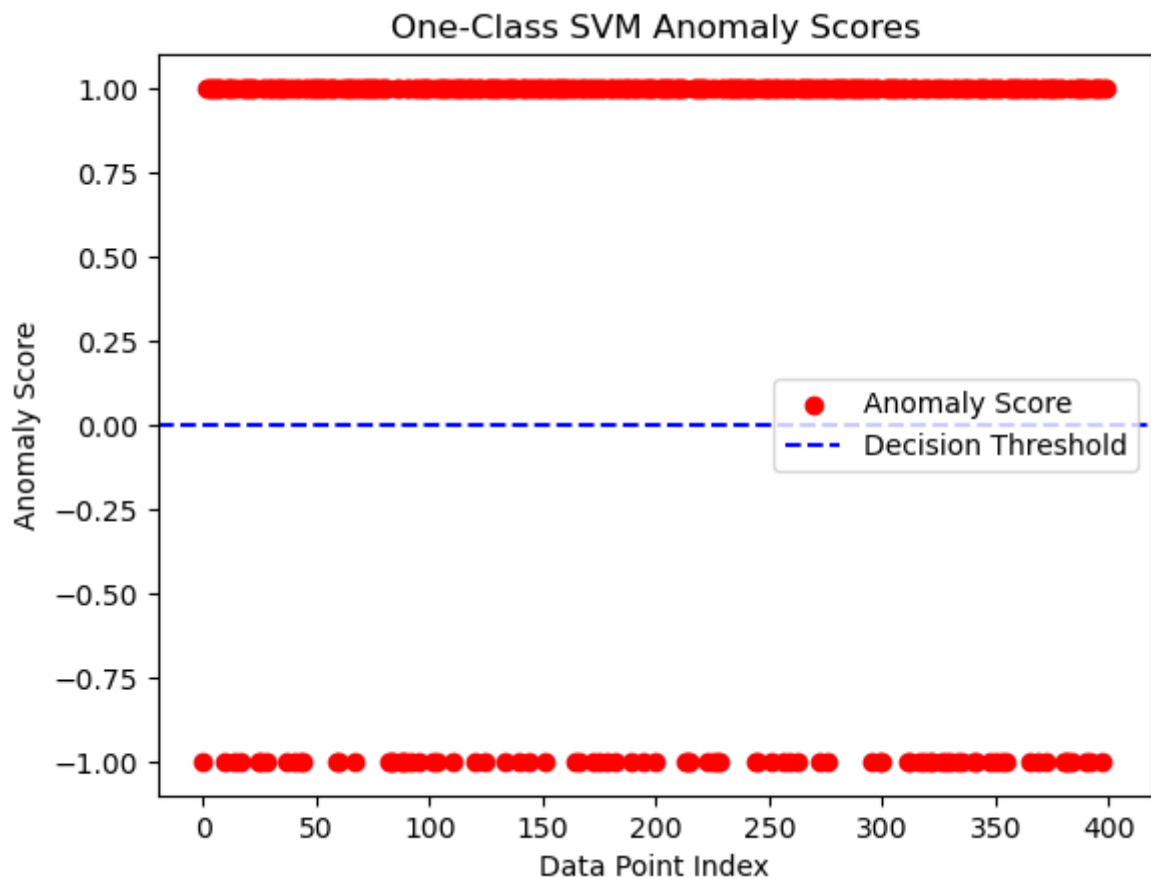

```
In [18]:  import matplotlib.pyplot as plt

          # Plot the distribution of anomaly scores
          plt.hist(anomaly_scores, bins=50)
          plt.title('Anomaly Score Distribution')
          plt.xlabel('Anomaly Score')
          plt.ylabel('Frequency')
          plt.show()

          # Adjust the threshold based on the distribution
          threshold = 0.2 # Choose a threshold based on the plot and your application

          # Label instances as anomalies based on the threshold
          predicted_labels = anomaly_scores < threshold

          # Visualize instances with high anomaly scores
          high_anomaly_instances = x_test[predicted_labels]
          print("High Anomaly Instances:", high_anomaly_instances)
```

Anomaly Score Distribution
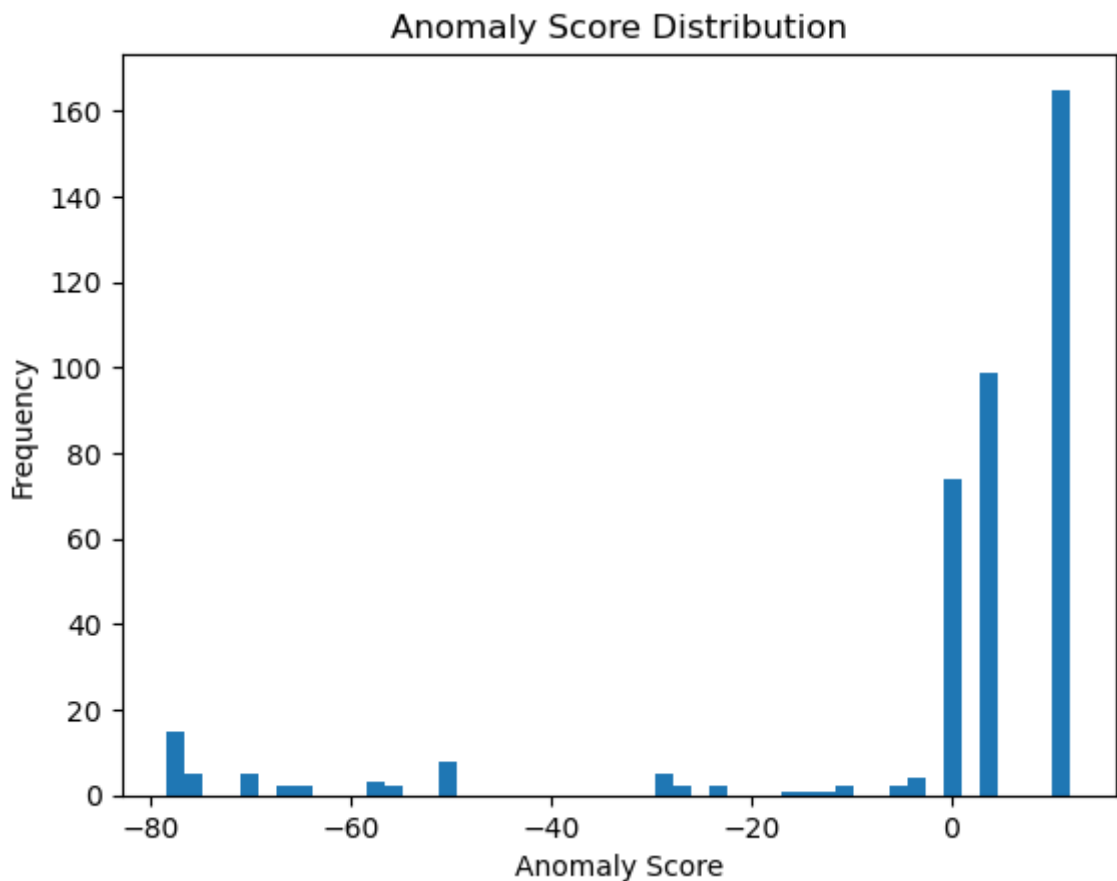
```
High Anomaly Instances: [[-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.0
3842895
  -0.02236627]
 [-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.03842895
  -0.02236627]
 [-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.03842895
  -0.02236627]
 ...
 [-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.03842895
  -0.02236627]
 [-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.03842895
  -0.02236627]
 [-0.02236627 -0.02236627 -0.02236627 ... -0.02236627 -0.03842895
  -0.02236627]]
```

In [19]:
```python
import numpy as np
import pandas as pd
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

log_data = pd.read_csv("Hadoop_log.csv")

# Assuming 'log_entry' is a column containing log messages
log_entries = log_data['Content'].values

# Convert log entries to numerical features (you may use TF-IDF, word embeddings, e
# Example: TF-IDF transformation
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer = TfidfVectorizer()
tfidf_features = tfidf_vectorizer.fit_transform(log_entries)

# Standardize the features
scaler = StandardScaler()
scaled_features = scaler.fit_transform(tfidf_features.toarray())
```

```python
# Train/test split
X_train, X_test = train_test_split(scaled_features, test_size=0.2, random_state=42)

# Define the autoencoder model
model = Sequential()

# Encoder
model.add(Dense(64, activation='relu', input_shape=(X_train.shape[1],)))
model.add(Dense(32, activation='relu'))

# Decoder
model.add(Dense(64, activation='relu'))
model.add(Dense(X_train.shape[1], activation='linear'))  # Output layer with linear

# Compile the model
model.compile(optimizer='adam', loss='mse')  # Mean Squared Error loss for reconstr

# Train the model
model.fit(X_train, X_train, epochs=10, batch_size=32, validation_data=(X_test, X_te

# Make predictions on the test set
predictions = model.predict(X_test)
```

```
Epoch 1/10
50/50 [==============================] - 4s 21ms/step - loss: 1.0074 - val_loss:
0.9979
Epoch 2/10
50/50 [==============================] - 1s 10ms/step - loss: 0.9740 - val_loss:
0.9642
Epoch 3/10
50/50 [==============================] - 1s 11ms/step - loss: 0.9299 - val_loss:
0.9233
Epoch 4/10
50/50 [==============================] - 1s 15ms/step - loss: 0.8912 - val_loss:
0.8970
Epoch 5/10
50/50 [==============================] - 1s 11ms/step - loss: 0.8629 - val_loss:
0.8815
Epoch 6/10
50/50 [==============================] - 0s 10ms/step - loss: 0.8394 - val_loss:
0.8747
Epoch 7/10
50/50 [==============================] - 0s 9ms/step - loss: 0.8210 - val_loss: 0.
8730
Epoch 8/10
50/50 [==============================] - 0s 9ms/step - loss: 0.8102 - val_loss: 0.
8701
Epoch 9/10
50/50 [==============================] - 0s 9ms/step - loss: 0.8023 - val_loss: 0.
8671
Epoch 10/10
50/50 [==============================] - 0s 8ms/step - loss: 0.7881 - val_loss: 0.
8692
13/13 [==============================] - 0s 4ms/step
```

In [20]:
```python
# Calculate reconstruction error (MSE)
mse = np.mean(np.square(X_test - predictions), axis=1)
# Choose a quantile as the threshold (e.g., 95th percentile)
threshold = np.percentile(mse, 95)
print("Threshold:",threshold)
```

```
Threshold: 2.2300953845105838
```

```python
In [21]:  # Set a threshold for anomaly detection based on the reconstruction error
          threshold = 2.3  # Adjust this based on your data and experimentation

          # Identify anomalies
          anomalies = mse > threshold

          # Print or visualize the anomalies
          print("Number of anomalies:", np.sum(anomalies))
          print("Anomaly indices:", np.where(anomalies)[0])
```

```
Number of anomalies: 14
Anomaly indices: [ 10  29  33  40  54 112 184 194 209 285 296 309 320 354]
```

```python
In [23]:  # Choose a threshold (e.g., 95th percentile)
          threshold = np.percentile(mse, 75)
          print("Threshold:", threshold)
```

```
Threshold: 1.3782640715437946
```

```python
In [25]:  # Set a threshold for anomaly detection based on the reconstruction error
          threshold = 1.5  # You need to adjust this based on your data and experimentation

          # Identify anomalies
          anomalies = mse > threshold

          # Print or visualize the anomalies
          print("Number of anomalies:", np.sum(anomalies))
          print("Anomaly indices:", np.where(anomalies)[0])
```

```
Number of anomalies: 96
Anomaly indices: [  0   4  10  12  16  18  21  28  29  31  33  38  40  49  52  54
  55  56
  83  94  97 103 111 112 117 120 122 126 127 129 134 135 137 138 143 144
 165 168 175 176 178 182 183 184 185 192 193 194 207 209 214 215 217 226
 231 236 237 240 241 243 244 246 247 249 252 259 262 264 265 272 274 280
 285 292 296 302 305 309 311 319 320 328 331 336 348 349 351 352 354 362
 366 373 378 379 383 392]
```

```python
In [26]:  # Assuming 'X_train' and 'X_test' are your input data
          predictions_train = model.predict(X_train)
          mse_train = np.mean(np.square(X_train - predictions_train), axis=1)

          predictions_test = model.predict(X_test)
          mse_test = np.mean(np.square(X_test - predictions_test), axis=1)
```

```
50/50 [==============================] - 0s 4ms/step
13/13 [==============================] - 0s 4ms/step
```

```python
In [32]:  from sklearn.metrics import precision_score, recall_score, f1_score

          # Assuming true_labels are the ground truth labels for anomalies
          # Make sure true_labels and anomalies have the same length
          min_length = min(len(true_labels), len(anomalies))
          true_labels = true_labels[:min_length]
          anomalies = anomalies[:min_length]

          precision = precision_score(true_labels, anomalies)
          recall = recall_score(true_labels, anomalies)
          f1 = f1_score(true_labels, anomalies)

          print("Precision:", precision)
          print("Recall:", recall)
          print("F1 Score:", f1)
```

```
Precision: 1.0
Recall: 0.24
F1 Score: 0.3870967741935484
```

In [28]:
```python
# Calculate overall MSE on the test set
overall_mse = np.mean(np.square(X_test - predictions))

print("Overall MSE on Test Set:", overall_mse)
```

```
Overall MSE on Test Set: 0.8691734993555639
```

In [29]:
```python
import random

# Choose random samples from the test set
num_samples_to_visualize = 5
random_indices = random.sample(range(len(X_test)), num_samples_to_visualize)

# Visualize original and reconstructed samples
for index in random_indices:
    original_sample = X_test[index]
    reconstructed_sample = predictions[index]

    # Compare the original and reconstructed samples visually or using any other me
    print("Original:", original_sample)
    print("Reconstructed:", reconstructed_sample)
    print("-----------------------")
```

```
Original: [-0.02236627 -0.04438075 -0.02236627 -0.02236627 -0.02236627 -0.02236627
  1.5425592  -0.02236627 -0.2806219  -0.02236627 -0.02236627 -0.02236627
 -0.06093248 -0.03802596 -0.02236627 -0.02236627 -0.02236627 -0.02236627
 -0.02236627 -0.02236627 -0.07088812 -0.03875891 -0.06337243 -0.0592646
 -0.03875891 -0.03875891 -0.03875891 -0.05006262 -0.03875891 -0.02236627
 -0.02236627 -0.02236627 -0.02236627 -0.05926376 -0.02236627 -0.02236627
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 -0.02236627 -0.02236627 -0.02236627 -0.03972693 -0.02236627 -0.02236627
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 -0.03875891 -0.02236627 -0.02236627 -0.02236627 -0.02236627 -0.02236627
 -0.07436678 -0.02236627 -0.02236627 -0.02236627 -0.07436678 -0.10172187
 -0.02236627 -0.03091211  1.69807657 -0.02236627 -0.02236627 -0.02236627
```

```
-0.02236627 -0.02236627 -0.03875891 -0.0316386  -0.0316386  -0.0316386
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-0.02236627 -0.05457698 -0.02236627 -0.04476615 -0.03875891 -0.02236627
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-0.02236627 -0.07088812 -0.2806219  -0.03163622 -0.03163622 -0.03163622
-0.02236627 -0.02236627 -0.0971983  -0.02236627 -0.06721723 -0.02236627
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-0.09255678 -0.09255678 -0.04428564 -0.04468209 -0.16670341 -0.02236627
-0.19159702 -0.03141818 -0.19018168 -0.03141818 -0.16582721 -0.11330021
-0.11330021 -0.11330789 -0.10872845 -0.10383788 -0.10622062 -0.02236627
-0.07088406 -0.02236627 -0.07088812 -0.02236627 -0.02236627 -0.05005466
-0.02236627 -0.03052958 -0.03052958 -0.02236627 -0.03052958 -0.07429899
-0.02236627 -0.0316386  -0.02236627  1.76875281 -0.08332185 -0.0316386
-0.02236627 -0.02236627 -0.18268751 -0.02236627 -0.02236627 -0.02236627
-0.02236627 -0.02236627 -0.03875199 -0.09255678 -0.26366402 -0.09255678
-0.0316386  -0.02236627 -0.02236627 -0.2806219  -0.02236627 -0.28165726
-0.12044696 -0.03768113 -0.04365605 -0.04365737 -0.04919064 -0.03792912
-0.03792912 -0.03792912 -0.03793569 -0.03782963 -0.03782567 -0.03489886
-0.03875891 -0.07088369 -0.02236627 -0.02236627 -0.07282404 -0.02236627
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-0.03163622 -0.09255678 -0.18268751 -0.02236627 -0.02236627 -0.02236627
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-0.4481085  -0.0316386  -0.18268751 -0.02236627 -0.05393674 -0.02236627
-0.03871851 -0.07757564 -0.09088219 -0.47935122 -0.19486609 -0.03161485
-0.05485248 -0.07757564 -0.07088465 -0.02236627 -0.07088812 -0.02236627
-0.10791822 -0.04688589 -0.26373726 -0.03162071 -0.05485248 -0.09255678
-0.05149141 -0.03100977 -0.10485412 -0.02236627 -0.02236627 -0.28347712
-0.05485248 -0.03157204 -0.0312009  -0.02236627 -0.04452738 -0.52430911
-0.02236627 -0.03154741 -0.06296869 -0.031119   -0.02236627 -0.02236627
-0.07055857 -0.09467835 -0.02236627 -0.03870453 -0.02236627 -0.02236627
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-0.03163447 -0.03162955 -0.03162955 -0.03162955 -0.03162888 -0.03162812
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-1.23076394e-01 -1.27965674e-01 -5.45981787e-02 -1.12334594e-01
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-1.82007104e-02 -3.92527059e-02  1.22201368e-02 -4.94934916e-02
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 1.67099905e+00 -4.09747027e-02 -1.04369588e-01  2.56351754e-02
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```

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        1.39860553e-03 -1.72739848e-03 -7.65626878e-02 -2.61730831e-02]
       -----------------------
```

In [30]:
```python
# Access training history
history = model.fit(X_train, X_train, epochs=10, batch_size=32, validation_data=(X_

# Plot training and validation loss
plt.plot(history.history['loss'], label='Training Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.title('Training and Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Mean Squared Error (MSE)')
plt.legend()
plt.show()
```

```
Epoch 1/10
50/50 [==============================] - 1s 11ms/step - loss: 0.7779 - val_loss:
0.8666
Epoch 2/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7663 - val_loss: 0.
8664
Epoch 3/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7607 - val_loss: 0.
8648
Epoch 4/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7551 - val_loss: 0.
8673
Epoch 5/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7481 - val_loss: 0.
8633
Epoch 6/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7361 - val_loss: 0.
8662
Epoch 7/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7340 - val_loss: 0.
8633
Epoch 8/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7291 - val_loss: 0.
8632
Epoch 9/10
50/50 [==============================] - 0s 10ms/step - loss: 0.7263 - val_loss:
0.8652
Epoch 10/10
50/50 [==============================] - 0s 9ms/step - loss: 0.7247 - val_loss: 0.
8618
```
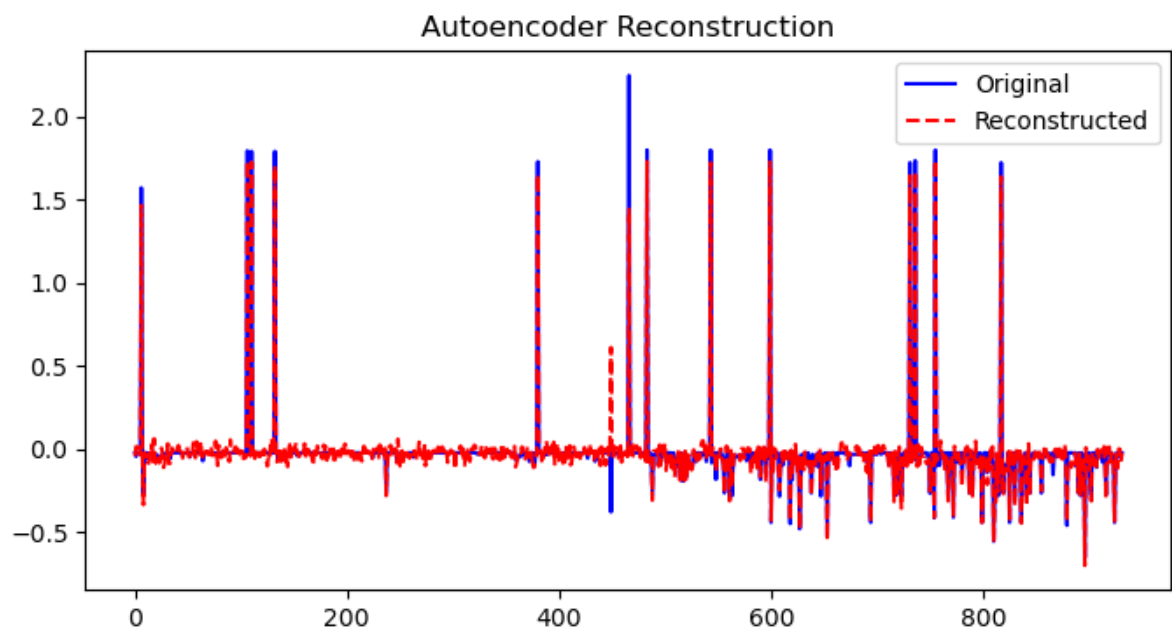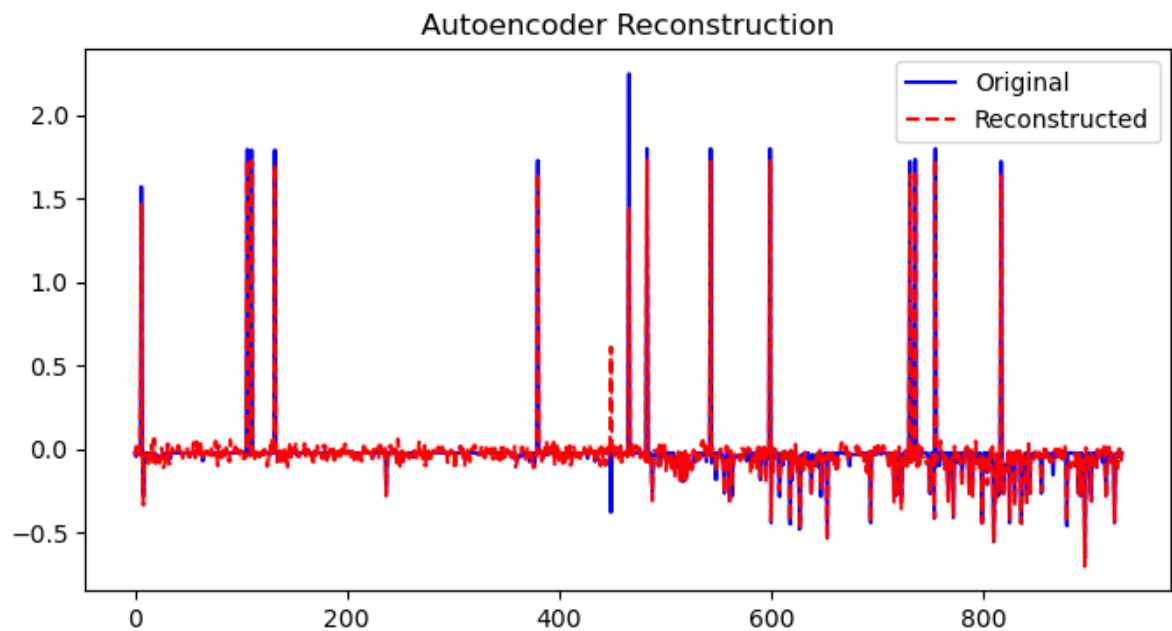

Training and Validation Loss
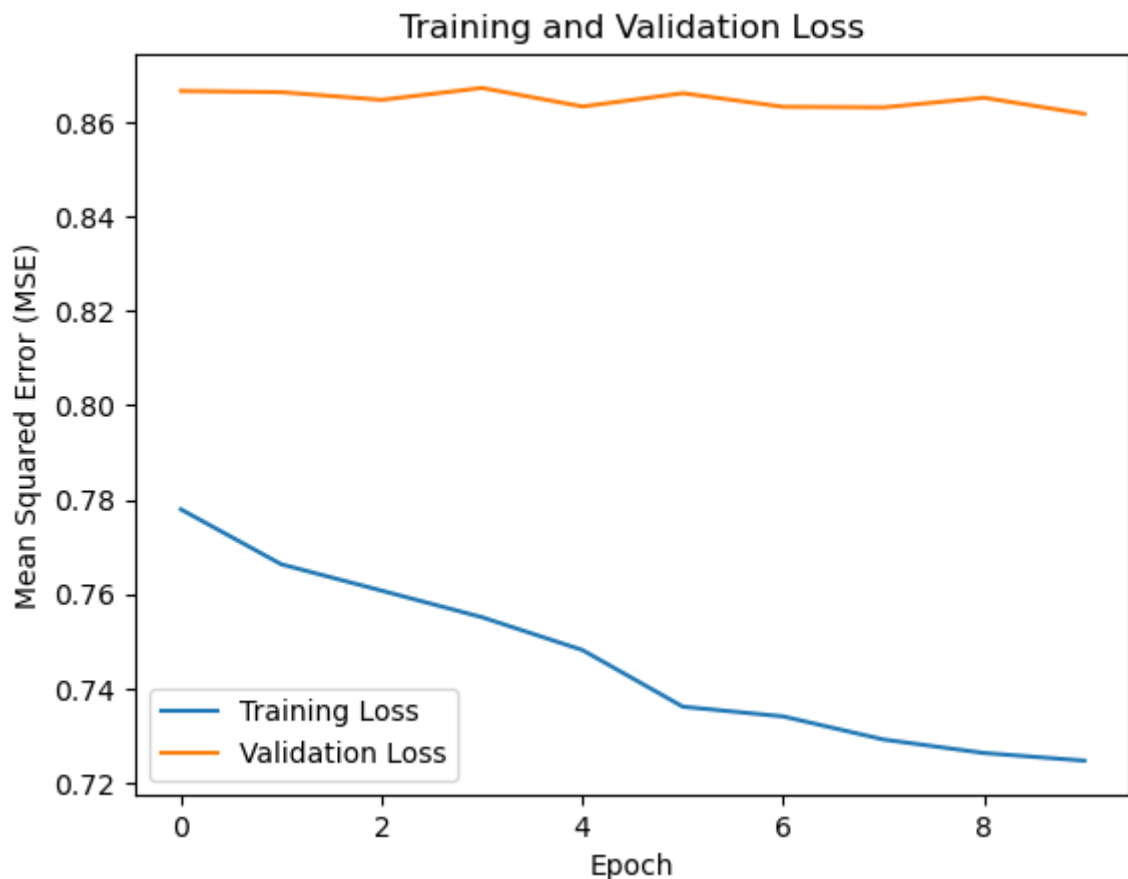
In [31]:
```python
import matplotlib.pyplot as plt

# Choose random samples from the test set
num_samples_to_visualize = 5
random_indices = np.random.choice(len(X_test), num_samples_to_visualize, replace=Fa
```
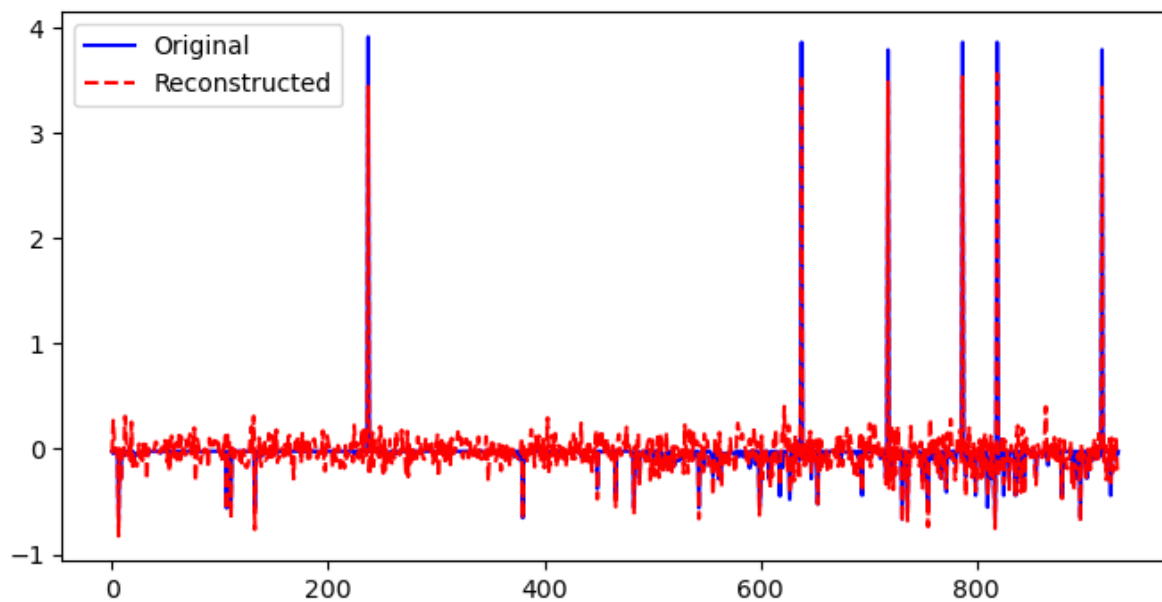
```python
# Visualize original and reconstructed samples
for index in random_indices:
    original_sample = X_test[index].reshape(tfidf_features.shape[1],)
    reconstructed_sample = predictions[index]

    # Plot the original and reconstructed samples
    plt.figure(figsize=(8, 4))
    plt.plot(original_sample, label='Original', color='blue')
    plt.plot(reconstructed_sample, label='Reconstructed', color='red', linestyle='-
    plt.title('Autoencoder Reconstruction')
    plt.legend()
    plt.show()
```
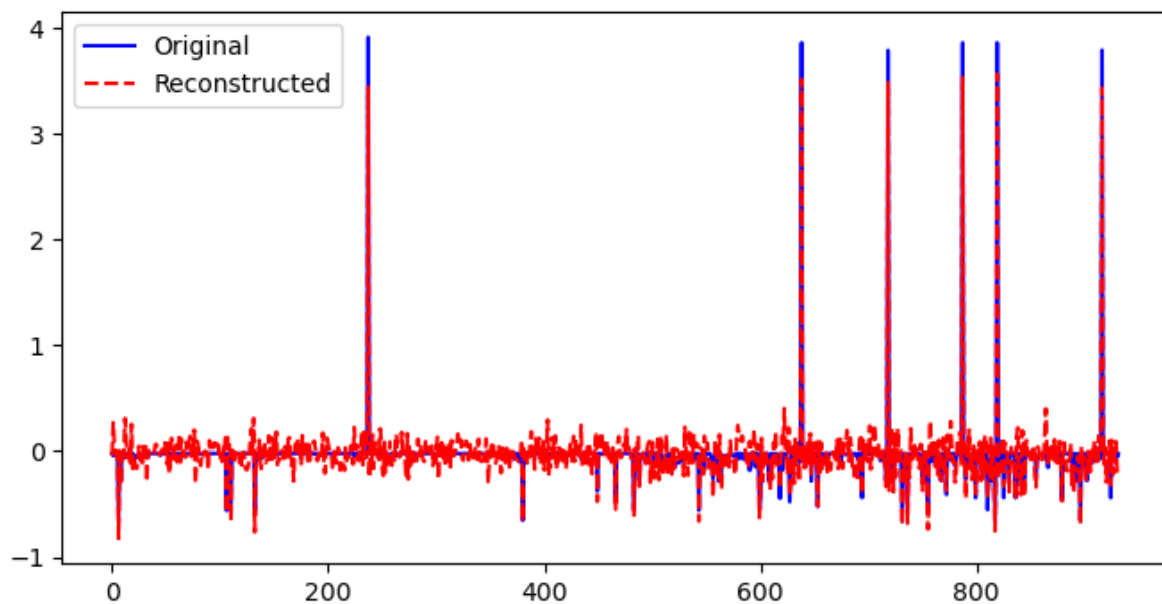
Autoencoder Reconstruction

Autoencoder Reconstruction

Autoencoder Reconstruction