Real-time Sentiment Analysis and Trend Detection in Social Media Data using Machine Learning and Natural Language Processing.

Importing necessary libraries and setting up constants

In [1]:
```
from apify_client import ApifyClient
import requests
import pandas as pd
import time

MAX_RETRIES = 10  # Adjust as necessary
SLEEP_INTERVAL = 120  # 120 seconds, adjust as necessary

API_TOKEN = "apify_api_n0Nir3H5vg8WpscPwRIg69fk7374Zn3iGRLh"
ACTOR_URL = f"https://api.apify.com/v2/acts/quacker~twitter-scraper/runs?
```

Defining functions for actor control and data collection

In [2]:
```
def start_actor():
    """
    Start the actor.
    """
    data = {
        "addUserInfo": True,
        "handles": ["BBCNews", "TelegraphNews", "GuardianNews", "SkyNews"
        "proxyConfig": {"useApifyProxy": True},
        "tweetsDesired": 100
    }

    details = fetch_run_details()

    if details.get('data', {}).get('status') == "RUNNING":
        print("Last run is still active. Not starting a new actor job.")
    else:
        response = requests.post(ACTOR_URL, json=data)
        if response.status_code == 201:
            print("Actor started successfully!")
        else:
            print(f"Failed to start the actor. Error: {response.text}")

def fetch_run_details():
    """
    Fetch the details of the last run of the actor.
    """
    details_url = f"https://api.apify.com/v2/acts/quacker~twitter-scraper
    return requests.get(details_url).json()

def fetch_dataset():
    """
    Fetch the dataset items from the last run.
    """
    dataset_url = f"https://api.apify.com/v2/acts/quacker~twitter-scraper
    return requests.get(dataset_url).json()

def data_collection():
    """
    Handles the data collection process.

    Returns:
        DataFrame: Returns a pandas DataFrame with the fetched data or No
    """
    client = ApifyClient(token=API_TOKEN)

    retries = 0
    while retries < MAX_RETRIES:
        details = fetch_run_details()

        if details.get('data', {}).get('status') == "SUCCEEDED":
            data = fetch_dataset()
            df = pd.DataFrame(data)
            print(df.head())
            return df

        elif details.get('data', {}).get('status') == "ERROR":
            print("Actor job errored out. Stopping data collection.")
            return None

        else:
            print(f"Job still running... Waiting for {SLEEP_INTERVAL} sec
            time.sleep(SLEEP_INTERVAL)
            retries += 1

    print("Max retries reached. Job might still be running or there might
    return None
```

Starting the actor and collecting data

In [3]:
```
start_actor()
data = data_collection()
print(data.head())
```

```
Actor started successfully!
Job still running... Waiting for 120 seconds before checking again.
                                                user                    id
\
0  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1325112684644347904
1  {'created_at': '2007-02-09T00:35:02.000Z', 'de...   866570583114489856
```

```
2  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1176159504288886785
3  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1565436402707435522
4  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1266315061221613569

       conversation_id                                          full_text
\
0  1325112684644347904  BREAKING: JOE BIDEN WINS\n\nJoe Biden will be ...
1   866570583114489856  Bigger than Bieber? A Korean pop group beats U...
2  1176159504288886785  "You have stolen my dreams and my childhood wi...
3  1565436402707435522                                      breaking news
4  1266315061221613569  Minnesota police arrest CNN reporter and camer...

   reply_count  retweet_count  favorite_count       hashtags symbols  \
0         8007         124891          409103  [CNNElection]      []
1         2849         124093          308717             []      []
2        17289          68995          218350             []      []
3         8165          30133          223487             []      []
4        11899         102707          199353             []      []

                                       user_mentions  ...  \
0                                                 []  ...
1  [{'id_str': '110458336', 'name': 'CNN Entertai...  ...
2                                                 []  ...
3                                                 []  ...
4                                                 []  ...

           #sort_index quote_count is_quote_tweet is_retweet is_pinned  \
0  1699415282558173184       49823          False      False     False
1  1699415282558173183        3920          False      False     False
2  1699415282558173182       12588          False      False     False
3  1699415282558173181       11731          False      False     False
4  1699415282558173180       39207          False      False     False

   is_truncated                             startUrl  view_count  \
0         False  https://twitter.com/CNN/with_replies         NaN
1         False  https://twitter.com/CNN/with_replies         NaN
2         False  https://twitter.com/CNN/with_replies  13407844.0
3         False  https://twitter.com/CNN/with_replies         NaN
4         False  https://twitter.com/CNN/with_replies  31359490.0

   replying_to_tweet  quoted_tweet
0                NaN           NaN
1                NaN           NaN
2                NaN           NaN
3                NaN           NaN
4                NaN           NaN

[5 rows x 24 columns]
                                                user                   id
\
0  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1325112684644347904
1  {'created_at': '2007-02-09T00:35:02.000Z', 'de...   866570583114489856
2  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1176159504288886785
```

```
3  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1565436402707435522
4  {'created_at': '2007-02-09T00:35:02.000Z', 'de...  1266315061221613569

       conversation_id                                         full_text  
\
0  1325112684644347904  BREAKING: JOE BIDEN WINS\n\nJoe Biden will be ...  
1   866570583114489856  Bigger than Bieber? A Korean pop group beats U...  
2  1176159504288886785  "You have stolen my dreams and my childhood wi...  
3  1565436402707435522                                     breaking news  
4  1266315061221613569  Minnesota police arrest CNN reporter and camer...  

   reply_count  retweet_count  favorite_count       hashtags symbols  \
0         8007         124891          409103  [CNNElection]      []   
1         2849         124093          308717             []      []   
2        17289          68995          218350             []      []   
3         8165          30133          223487             []      []   
4        11899         102707          199353             []      []   

                                       user_mentions  ...  \
0                                                 []  ...   
1  [{'id_str': '110458336', 'name': 'CNN Entertai...  ...   
2                                                 []  ...   
3                                                 []  ...   
4                                                 []  ...   

           #sort_index quote_count is_quote_tweet is_retweet is_pinned  \
0  1699415282558173184       49823          False      False     False   
1  1699415282558173183        3920          False      False     False   
2  1699415282558173182       12588          False      False     False   
3  1699415282558173181       11731          False      False     False   
4  1699415282558173180       39207          False      False     False   

   is_truncated                              startUrl  view_count  \
0         False  https://twitter.com/CNN/with_replies         NaN   
1         False  https://twitter.com/CNN/with_replies         NaN   
2         False  https://twitter.com/CNN/with_replies  13407844.0   
3         False  https://twitter.com/CNN/with_replies         NaN   
4         False  https://twitter.com/CNN/with_replies  31359490.0   

   replying_to_tweet  quoted_tweet  
0                NaN           NaN  
1                NaN           NaN  
2                NaN           NaN  
3                NaN           NaN  
4                NaN           NaN  

[5 rows x 24 columns]
```

Natural Language Processing (NLP) and Text Processing

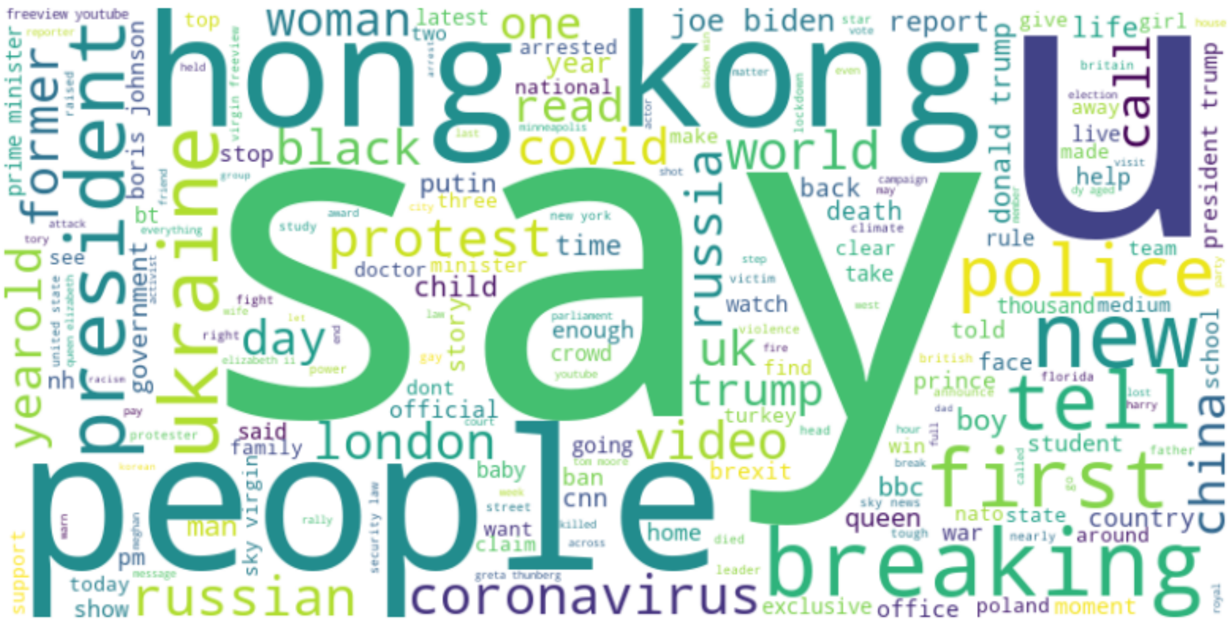
In [4]:
```
import nltk
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.stem import WordNetLemmatizer
import re

# Download required datasets if not already downloaded
nltk.download('punkt')
nltk.download('wordnet')
nltk.download('stopwords')

# Initialize stopwords and lemmatizer outside the function
STOP_WORDS = set(stopwords.words('english'))
LEMMATIZER = WordNetLemmatizer()

def preprocess_text(text):
    # Noise Removal
    text = re.sub(r'http\S+', '', text)  # Remove URLs
    text = re.sub(r'@\S+', '', text)  # Remove mentions
    text = re.sub(r'#', '', text)  # Remove hashtags
    text = re.sub(r'[^A-Za-z\s]', '', text)  # Remove numbers and punctua
    text = re.sub(r'\bRT\b', '', text)  # Remove RT (retweet indicators)

    # Text Normalization
    text = text.lower()  # Convert to lowercase

    # Tokenization
    tokens = word_tokenize(text)

    # Stopword Removal
    tokens = [token for token in tokens if token not in STOP_WORDS]

    # Lemmatization
    tokens = [LEMMATIZER.lemmatize(token) for token in tokens]

    # Convert tokens back to string
    preprocessed_text = ' '.join(tokens)

    return preprocessed_text

# Process each text in the dataset
processed_texts = [preprocess_text(text) for text in data['full_text']]
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     /Users/tejeshraorb/nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     /Users/tejeshraorb/nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/tejeshraorb/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Generating Word Cloud

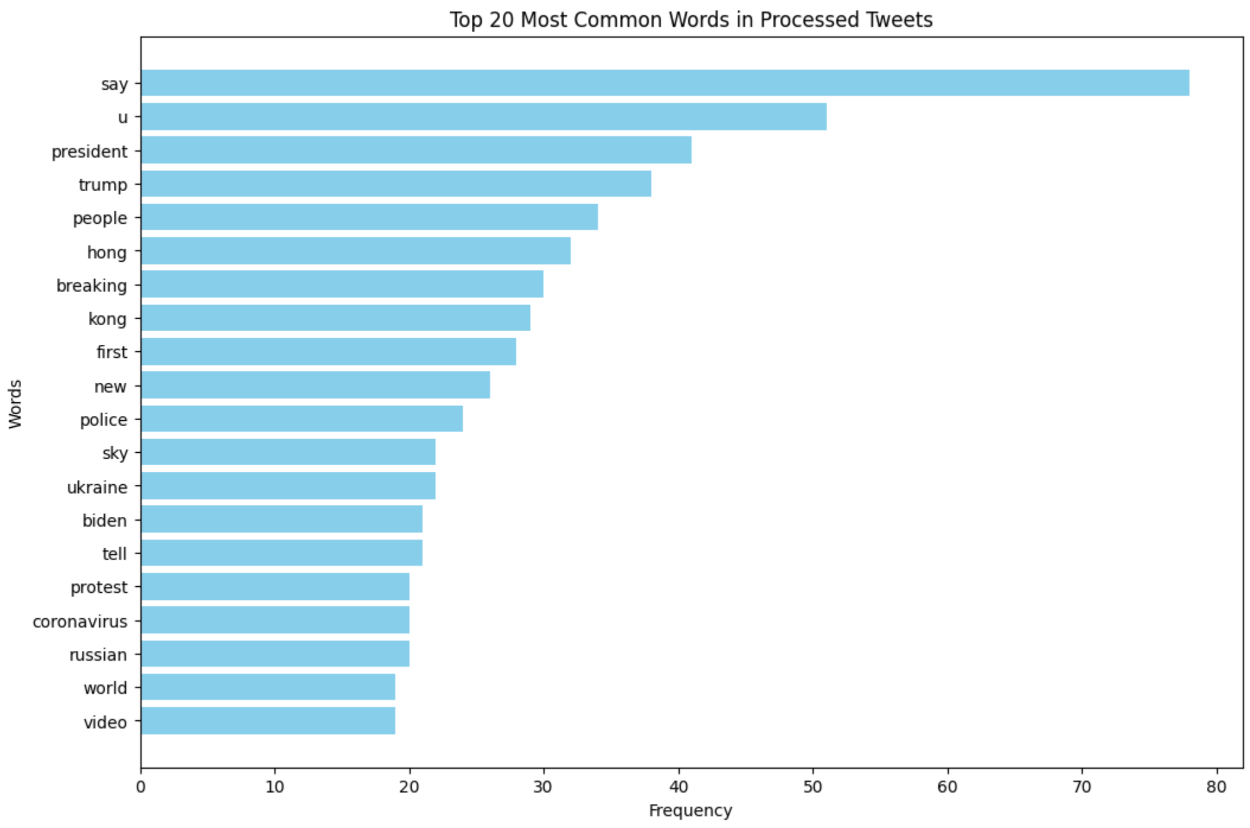
In [ ]:
```python
import matplotlib.pyplot as plt
from wordcloud import WordCloud

# Concatenate all processed texts
all_words = ' '.join(processed_texts)

# Generate the word cloud
wordcloud = WordCloud(width=800, height=400, background_color="white").ge

# Plot the word cloud
plt.figure(figsize=(10, 6))
plt.imshow(wordcloud, interpolation="bilinear")
plt.axis("off")
plt.title("Word Cloud of Processed Tweets")
plt.show()
```

Word Cloud of Processed Tweets



Analyzing Word Frequencies

In [6]:
```
from collections import Counter
import matplotlib.pyplot as plt

# Tokenize the processed_texts
all_tokens = [word for text in processed_texts for word in text.split()]

# Count the frequency of each word
word_freq = Counter(all_tokens)

# Get the top 20 most common words
top_words = word_freq.most_common(20)

# Unzip the word-frequency pairs into two lists
words, frequencies = zip(*top_words)

# Plot the bar chart
plt.figure(figsize=(12, 8))
plt.barh(words, frequencies, color='skyblue')
plt.xlabel("Frequency")
plt.ylabel("Words")
plt.title("Top 20 Most Common Words in Processed Tweets")
plt.gca().invert_yaxis()  # To display the word with the highest frequenc
plt.show()
```

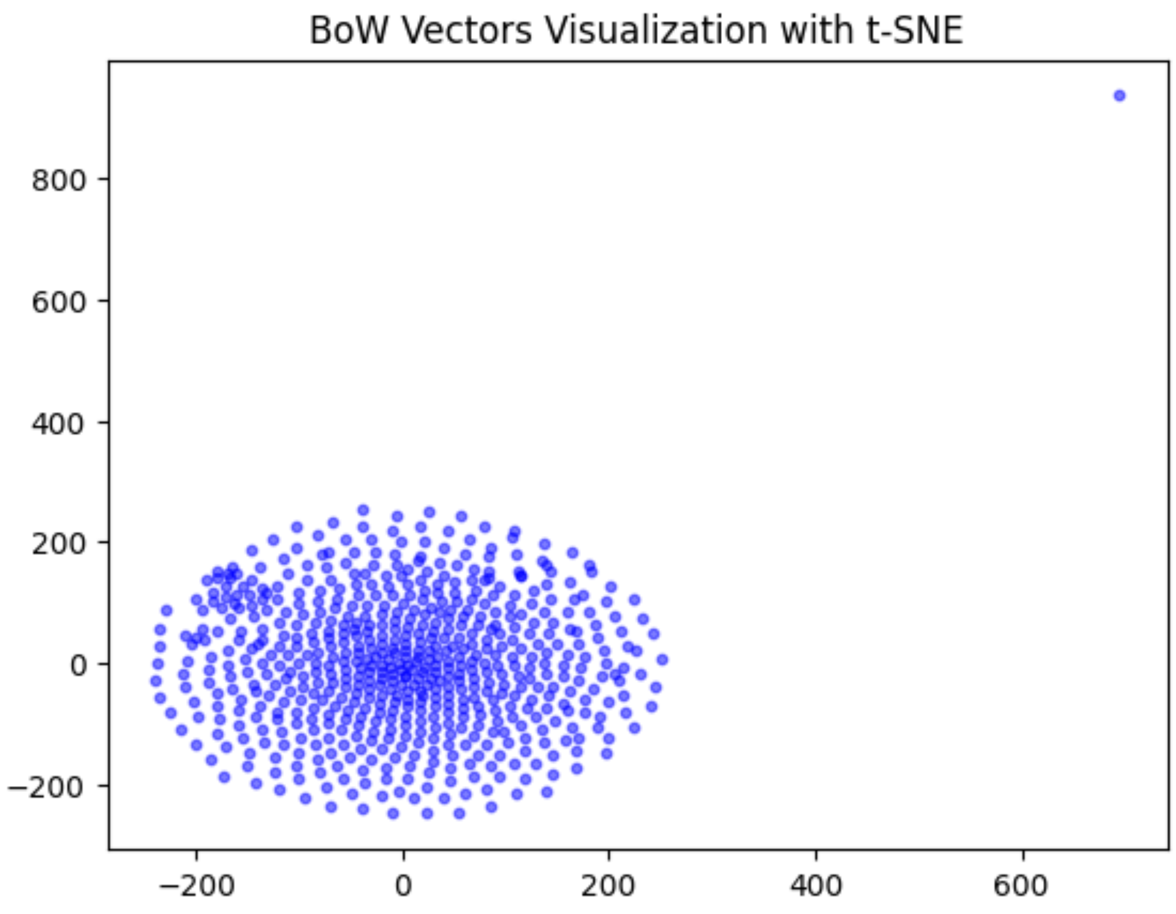


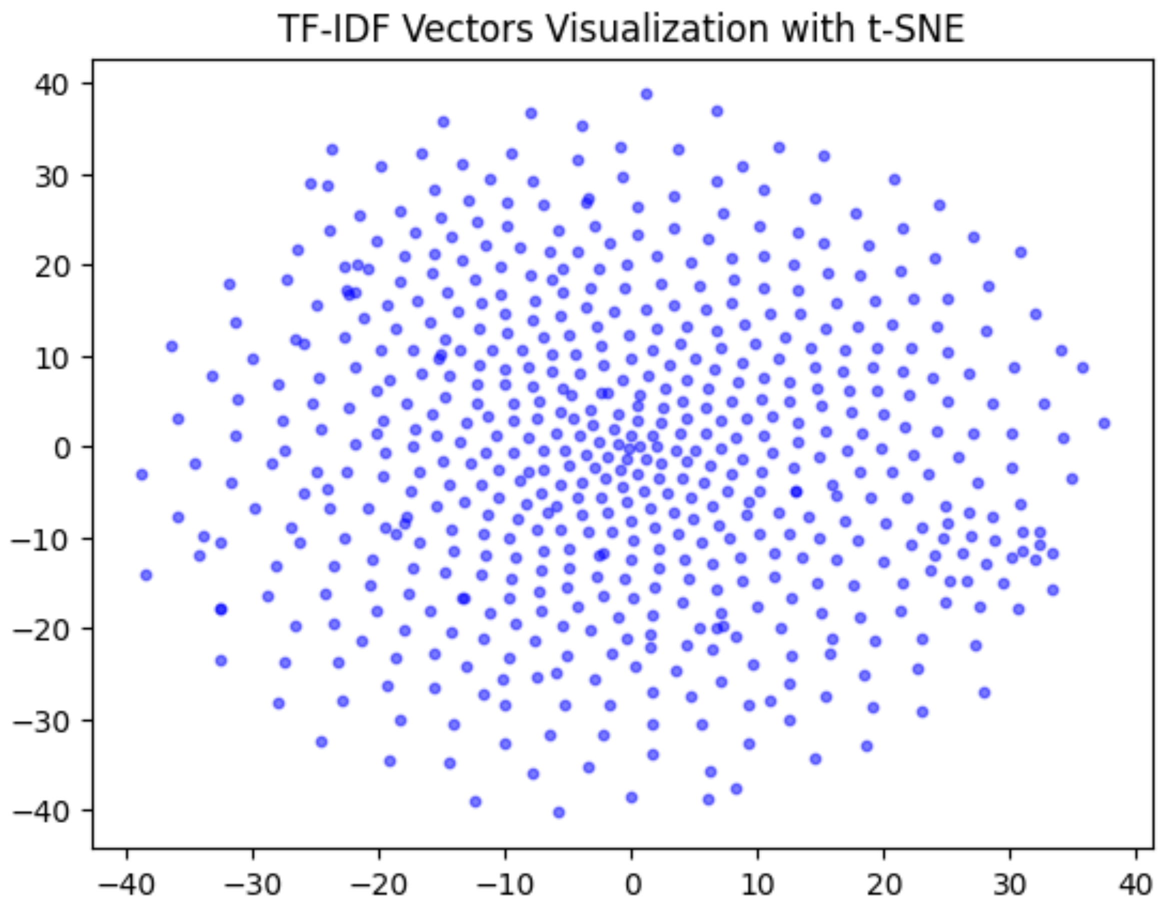
Feature Extraction (BoW and TF-IDF)

In [7]:
```
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectori

# Bag of Words (BoW) transformation
vectorizer = CountVectorizer()
X_bow = vectorizer.fit_transform(processed_texts)

# TF-IDF transformation
tfidf_vectorizer = TfidfVectorizer()
X_tfidf = tfidf_vectorizer.fit_transform(processed_texts)
```

Visualizing Text Data with t-SNE

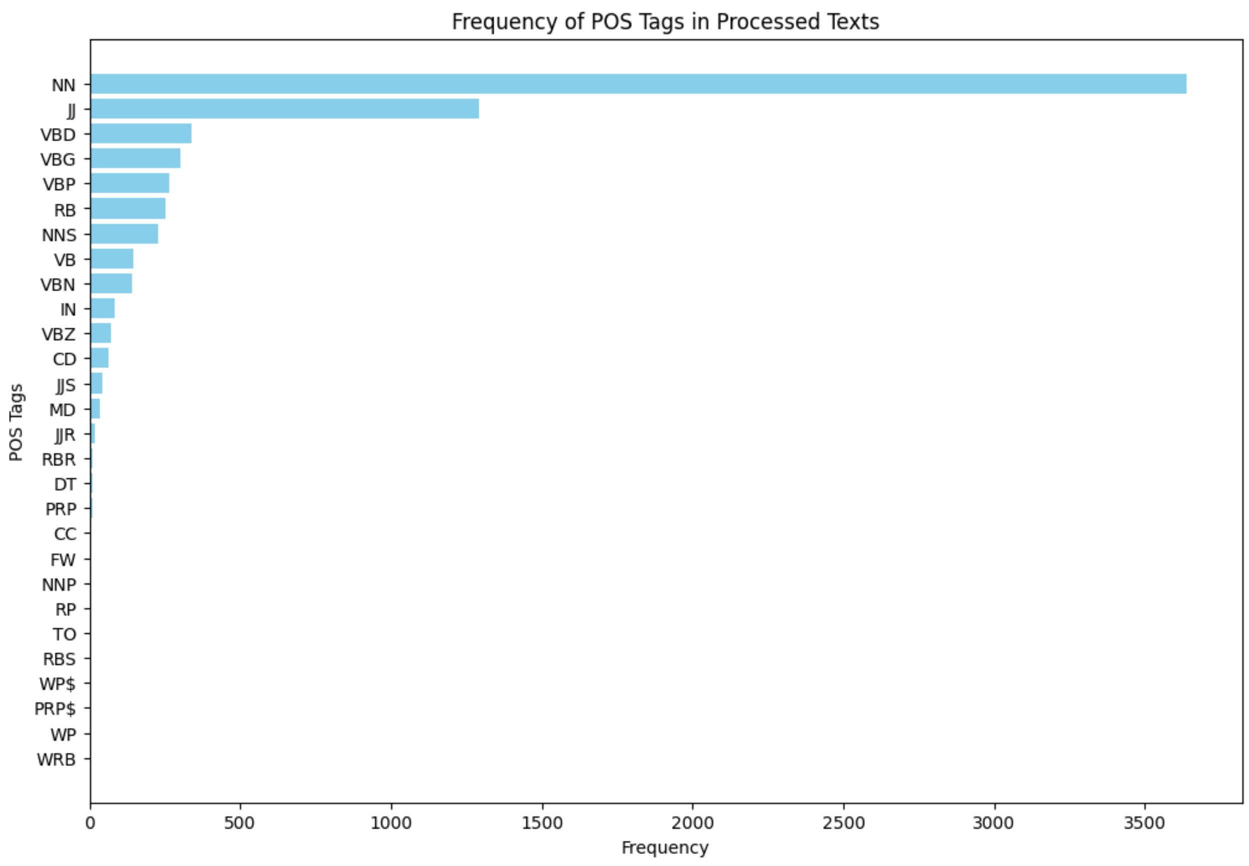
In [8]:
```
from sklearn.manifold import TSNE
import matplotlib.pyplot as plt

def visualize_vectors(X, title):
    tsne = TSNE(n_components=2, random_state=0)
    reduced = tsne.fit_transform(X.toarray())  # Convert sparse matrix to

    plt.scatter(reduced[:, 0], reduced[:, 1], s=10, c='b', alpha=0.5)
    plt.title(title)
    plt.show()

# Visualizing BoW vectors
visualize_vectors(X_bow, "BoW Vectors Visualization with t-SNE")

# Visualizing TF-IDF vectors
visualize_vectors(X_tfidf, "TF-IDF Vectors Visualization with t-SNE")
```


BoW Vectors Visualization with t-SNE
800
600
400
200
0
−200
−200
0
200
400
600


TF-IDF Vectors Visualization with t-SNE
40
30
20
10
0
−10
−20
−30
−40
−40
−30
−20
−10
0
10
20
30
40

Part-of-Speech Tagging and Visualization

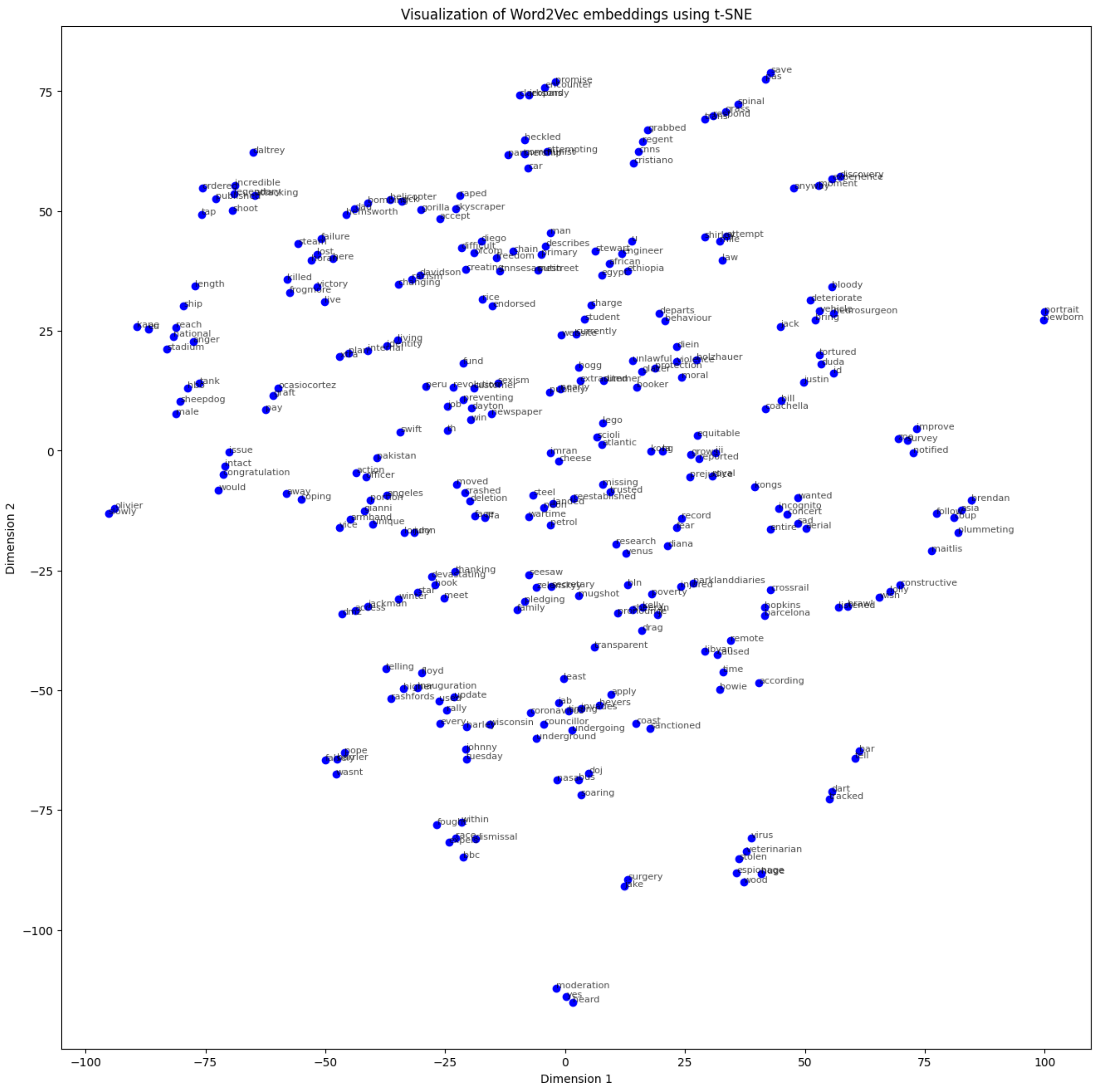
In [9]:
```
import nltk

def pos_tags(text):
    """Extracts and returns the part-of-speech tags from the given text."
    return ' '.join([tag for word, tag in nltk.pos_tag(word_tokenize(text

# Apply the pos_tags function to each processed text
processed_texts_pos = [pos_tags(text) for text in processed_texts]

from collections import Counter
import matplotlib.pyplot as plt

def visualize_pos(tags_list):
    all_tags = ' '.join(tags_list).split()
    tag_freq = Counter(all_tags)

    tags, frequencies = zip(*tag_freq.most_common())

    plt.figure(figsize=(12, 8))
    plt.barh(tags, frequencies, color='skyblue')
    plt.xlabel("Frequency")
    plt.ylabel("POS Tags")
    plt.title("Frequency of POS Tags in Processed Texts")
    plt.gca().invert_yaxis()
    plt.show()

visualize_pos(processed_texts_pos)
```



Word2Vec Embeddings and Visualization

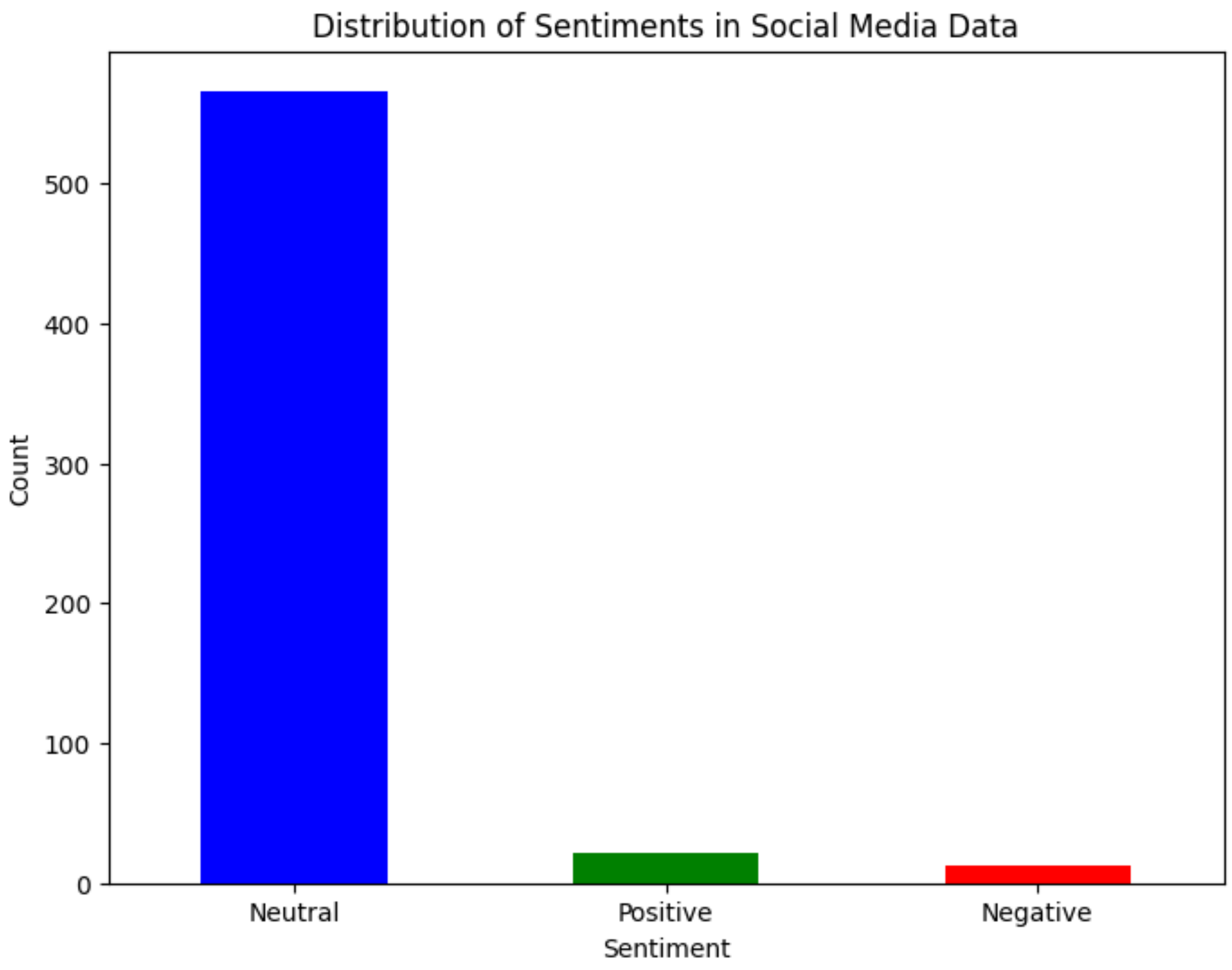
In [10]:
```
from gensim.models import Word2Vec

# Tokenizing the processed texts
tokens = [word_tokenize(text) for text in processed_texts]

# Training Word2Vec model
model_w2v = Word2Vec(sentences=tokens, vector_size=100, window=5, min_cou
model_w2v.save("word2vec.model")

print(f"Number of unique words in the model's vocabulary: {len(model_w2v.

# Display most similar words to the word "example"
print(model_w2v.wv.most_similar("covid", topn=5))

from sklearn.manifold import TSNE
import numpy as np
import matplotlib.pyplot as plt

def visualize_word2vec(model, words=None, sample_size=300):
    """Visualize Word2Vec embeddings using t-SNE."""

    # If no word list is given, randomly sample from the model's vocabula
    if not words:
        words = list(model.wv.index_to_key)
        words = [words[i] for i in np.random.choice(len(words), sample_si

    word_vectors = [model.wv[word] for word in words]

    # Convert word_vectors to a NumPy array
    word_vectors = np.array(word_vectors)

    tsne = TSNE(n_components=2, random_state=0, n_iter=5000, perplexity=3
    tsne_values = tsne.fit_transform(word_vectors)

    plt.figure(figsize=(16, 16))
    for i in range(len(tsne_values)):
        plt.scatter(tsne_values[i][0], tsne_values[i][1], color='blue')
        plt.annotate(words[i], (tsne_values[i][0], tsne_values[i][1]), fo

    plt.xlabel("Dimension 1")
    plt.ylabel("Dimension 2")
    plt.title("Visualization of Word2Vec embeddings using t-SNE")
    plt.show()

# Visualize a random subset of 300 words from the trained model's vocabul
visualize_word2vec(model_w2v)
```

```
Number of unique words in the model's vocabulary: 3124


[('embassy', 0.3516392707824707), ('demonstrator', 0.3398902714252472), ('
wait', 0.3113839030265808), ('woe', 0.3081211447715759), ('bunker', 0.2935
427725315094)]
```



Sentiment Analysis

In [11]:
```
from textblob import TextBlob
import matplotlib.pyplot as plt
import pandas as pd

# Function to perform sentiment analysis
def get_sentiment(text):
    polarity = TextBlob(text).sentiment.polarity
    if polarity < -0.5:
        return "Negative"
    elif polarity > 0.5:
        return "Positive"
    else:
        return "Neutral"

# Apply sentiment analysis to each processed text
sentiments_categorical = [get_sentiment(text) for text in processed_texts

# Create a DataFrame to analyze sentiment distribution
sentiments_df = pd.DataFrame(sentiments_categorical, columns=["Sentiment"
sentiment_counts = sentiments_df["Sentiment"].value_counts()

# Define colors for each sentiment category
colors = {
    "Negative": "red",
    "Positive": "green",
    "Neutral": "blue"
}

# Plot the sentiment distribution with custom colors
plt.figure(figsize=(8, 6))
sentiment_counts.plot(kind='bar', color=[colors[sent] for sent in sentime
plt.xlabel("Sentiment")
plt.ylabel("Count")
plt.title("Distribution of Sentiments in Social Media Data")
plt.xticks(rotation=0)
plt.show()
```

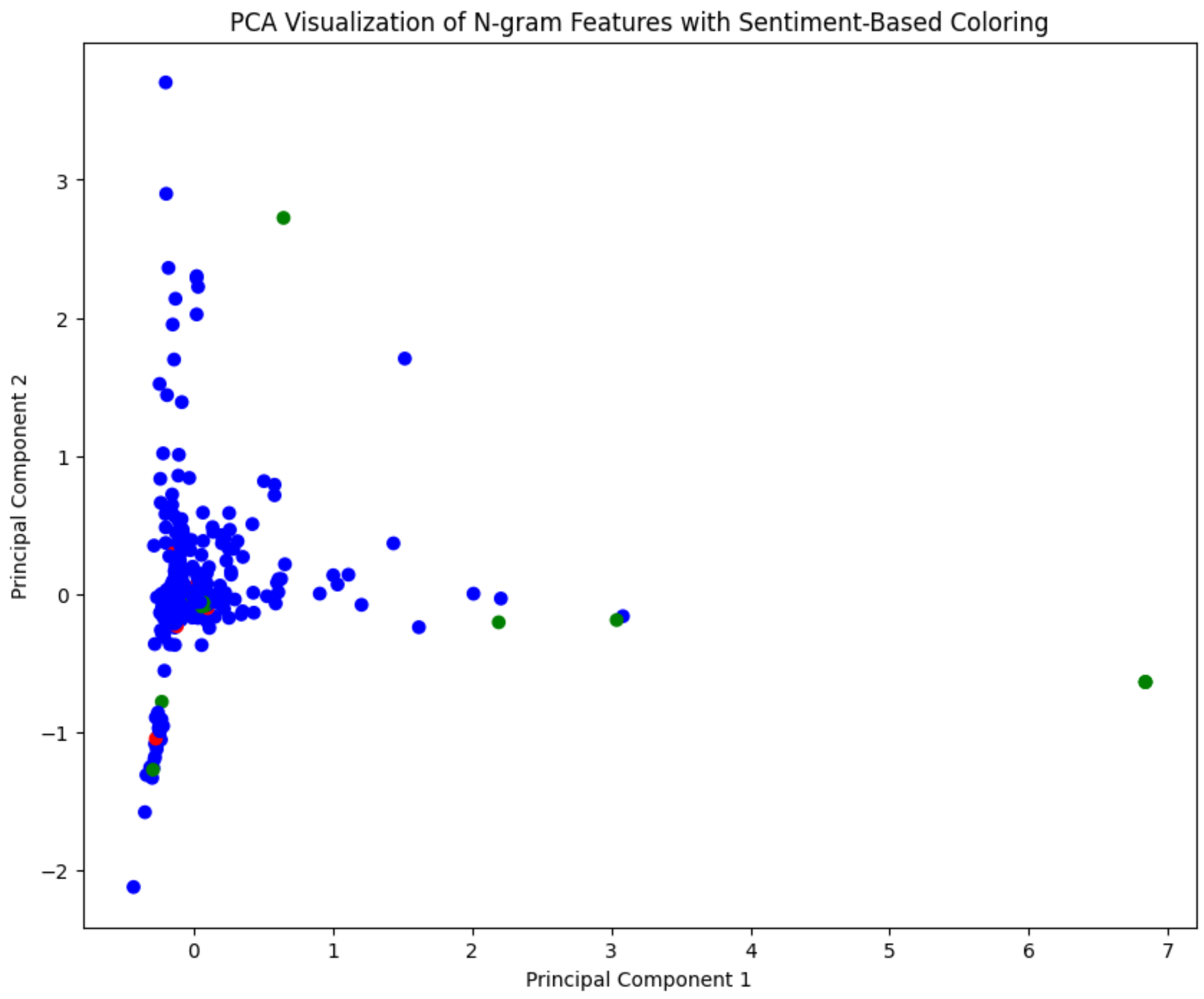


N-grams Feature Extraction

In [12]:
```
from sklearn.feature_extraction.text import CountVectorizer

# Create a CountVectorizer with n-gram range (1, 3)
ngram_vectorizer = CountVectorizer(ngram_range=(1, 3))

# Fit and transform the processed texts to generate n-gram features
X_ngrams = ngram_vectorizer.fit_transform(processed_texts)
```

Dimensionality Reduction (PCA)

In [13]:
```
from sklearn.decomposition import PCA
import matplotlib.pyplot as plt

# Define a color map for sentiment labels
sentiment_colors = {
    "Neutral": "blue",
    "Positive": "green",
    "Negative": "red"
}

# Map sentiment labels to colors
sentiment_colors_mapped = [sentiment_colors[sentiment] for sentiment in s

# Perform PCA to reduce dimensionality
pca = PCA(n_components=2)
X_pca = pca.fit_transform(X_ngrams.toarray())

# Visualize the PCA-transformed data with sentiment-based coloring
plt.figure(figsize=(10, 8))
plt.scatter(X_pca[:, 0], X_pca[:, 1], c=sentiment_colors_mapped)
plt.xlabel("Principal Component 1")
plt.ylabel("Principal Component 2")
plt.title("PCA Visualization of N-gram Features with Sentiment-Based Colo
plt.show()
```



Text Classification with Machine Learning

In [14]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report

# Splitting the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X_bow, sentiments_cat

# Logistic Regression
lr = LogisticRegression()
lr.fit(X_train, y_train)
y_pred_lr = lr.predict(X_test)

print("Logistic Regression Classification Report:")
print(classification_report(y_test, y_pred_lr))

# Support Vector Machine
svc = SVC()
svc.fit(X_train, y_train)
y_pred_svc = svc.predict(X_test)

print("Support Vector Machine Classification Report:")
print(classification_report(y_test, y_pred_svc))

# Random Forest
rf = RandomForestClassifier()
rf.fit(X_train, y_train)
y_pred_rf = rf.predict(X_test)

print("Random Forest Classification Report:")
print(classification_report(y_test, y_pred_rf))
```

```
Logistic Regression Classification Report:
              precision    recall  f1-score   support

    Negative       0.00      0.00      0.00         2
     Neutral       0.92      1.00      0.96       110
    Positive       1.00      0.12      0.22         8

    accuracy                           0.93       120
   macro avg       0.64      0.38      0.39       120
weighted avg       0.91      0.93      0.90       120

Support Vector Machine Classification Report:
              precision    recall  f1-score   support

    Negative       0.00      0.00      0.00         2
     Neutral       0.92      1.00      0.96       110
    Positive       1.00      0.12      0.22         8

    accuracy                           0.93       120
   macro avg       0.64      0.38      0.39       120
weighted avg       0.91      0.93      0.90       120

Random Forest Classification Report:
              precision    recall  f1-score   support

    Negative       0.00      0.00      0.00         2
     Neutral       0.92      1.00      0.96       110
    Positive       1.00      0.12      0.22         8

    accuracy                           0.93       120
   macro avg       0.64      0.38      0.39       120
weighted avg       0.91      0.93      0.90       120
```

```
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/opt/homebrew/lib/python3.11/site-packages/sklearn/metrics/_classification
.py:1344: UndefinedMetricWarning: Precision and F-score are ill-defined an
d being set to 0.0 in labels with no predicted samples. Use `zero_division
` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Text Classification with BERT

In [15]:
```
import tensorflow as tf
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
from sklearn.preprocessing import LabelEncoder
import numpy as np

# Tokenization and padding
tokenizer = Tokenizer(num_words=10000, oov_token="<OOV>")
tokenizer.fit_on_texts(processed_texts)
sequences = tokenizer.texts_to_sequences(processed_texts)
padded = pad_sequences(sequences, padding='post')

# Encode sentiment labels
label_encoder = LabelEncoder()
sentiments_encoded = label_encoder.fit_transform(sentiments_categorical)

# Define the CNN model
model = tf.keras.Sequential([
    tf.keras.layers.Embedding(10000, 64, input_length=len(padded[0])),
    tf.keras.layers.Conv1D(128, 5, activation='relu'),
    tf.keras.layers.GlobalMaxPooling1D(),
    tf.keras.layers.Dense(24, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])

# Compile the model
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['acc

# Fit the model on the data
model.fit(padded, sentiments_encoded, epochs=10, validation_split=0.2)
```

```
Epoch 1/10
15/15 [==============================] - 0s 9ms/step - loss: 0.4818 - accu
racy: 0.9354 - val_loss: 0.1724 - val_accuracy: 0.9500
Epoch 2/10
15/15 [==============================] - 0s 5ms/step - loss: 0.0569 - accu
racy: 0.9417 - val_loss: -0.1598 - val_accuracy: 0.9500
Epoch 3/10
15/15 [==============================] - 0s 5ms/step - loss: -0.0786 - acc
uracy: 0.9417 - val_loss: -0.2707 - val_accuracy: 0.9500
Epoch 4/10
15/15 [==============================] - 0s 5ms/step - loss: -0.1232 - acc
uracy: 0.9417 - val_loss: -0.3739 - val_accuracy: 0.9500
Epoch 5/10
15/15 [==============================] - 0s 5ms/step - loss: -0.1808 - acc
uracy: 0.9417 - val_loss: -0.5164 - val_accuracy: 0.9500
Epoch 6/10
15/15 [==============================] - 0s 5ms/step - loss: -0.2643 - acc
uracy: 0.9417 - val_loss: -0.6347 - val_accuracy: 0.9500
Epoch 7/10
15/15 [==============================] - 0s 5ms/step - loss: -0.3846 - acc
uracy: 0.9417 - val_loss: -0.8730 - val_accuracy: 0.9500
Epoch 8/10
15/15 [==============================] - 0s 6ms/step - loss: -0.6102 - acc
uracy: 0.9417 - val_loss: -1.1311 - val_accuracy: 0.9500
Epoch 9/10
15/15 [==============================] - 0s 6ms/step - loss: -0.9488 - acc
uracy: 0.9417 - val_loss: -1.6040 - val_accuracy: 0.9500
Epoch 10/10
15/15 [==============================] - 0s 6ms/step - loss: -1.4942 - acc
uracy: 0.9417 - val_loss: -2.3994 - val_accuracy: 0.9500
```

```
Out[15]: <keras.src.callbacks.History at 0x2abb20a10>
```

K-Means Clustering

```
In [16]: from sklearn.cluster import KMeans

         # Apply KMeans clustering
         kmeans = KMeans(n_clusters=3).fit(X_bow)
         data['cluster'] = kmeans.labels_
```

```
/opt/homebrew/lib/python3.11/site-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto'
in 1.4. Set the value of `n_init` explicitly to suppress the warning
  warnings.warn(
```

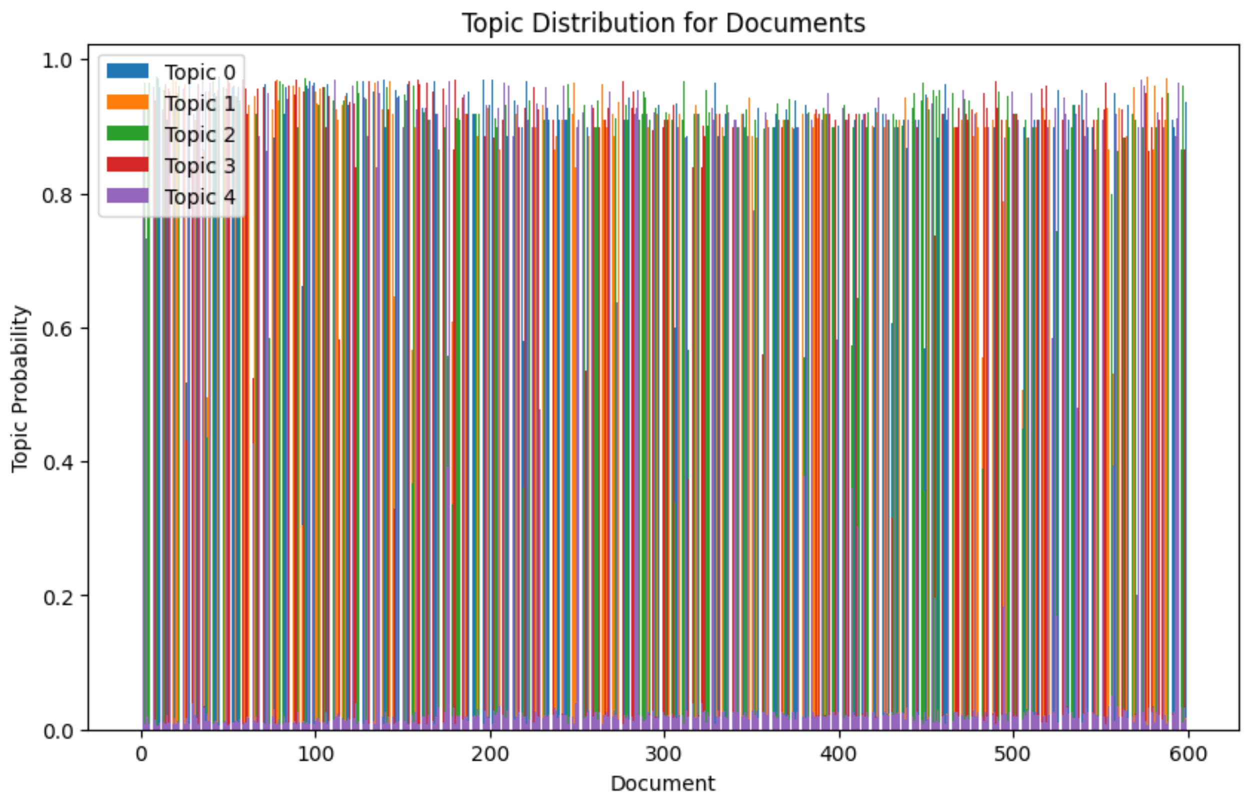
Latent Dirichlet Allocation (LDA)

In [17]:
```
from sklearn.decomposition import LatentDirichletAllocation as LDA

# Create an instance of LDA with the desired number of topics (e.g., 5)
lda = LDA(n_components=5)
lda.fit(X_bow)  # Fit LDA to your bag-of-words data (X_bow)

# Function to print the top words for each topic
def print_top_words(model, feature_names, n_top_words):
    for topic_idx, topic in enumerate(model.components_):
        print("\nTopic #%d:" % topic_idx)
        print(" ".join([feature_names[i] for i in topic.argsort()[:-n_top

# Call the function to print the top words for each topic
print_top_words(lda, vectorizer.get_feature_names_out(), 10)
```

```
Topic #0:
president trump say biden state joe breaking office new cnn

Topic #1:
say president trump prince sky queen youtube minister country new

Topic #2:
hong kong protest police first china london security law day

Topic #3:
say uk people putin russian boy former russia woman going

Topic #4:
say breaking people news video coronavirus sky first london like
```

Visualization of LDA Topics

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

# Get the topic distribution for each document
topic_distribution = lda.transform(X_bow)

# Create a bar plot to visualize the distribution of topics
plt.figure(figsize=(10, 6))
for i in range(topic_distribution.shape[1]):
    plt.bar(range(len(topic_distribution)), topic_distribution[:, i], lab
plt.xlabel("Document")
plt.ylabel("Topic Probability")
plt.title("Topic Distribution for Documents")
plt.legend()
plt.show()
```



BERT Text Classification

```
In [19]: from transformers import InputExample, InputFeatures, BertTokenizer, TFBe
import tensorflow as tf

# Initialize the BERT tokenizer and model
tokenizer = BertTokenizer.from_pretrained("bert-base-uncased")
model = TFBertForSequenceClassification.from_pretrained("bert-base-uncase

# Define your training sentences and labels
train_sentences = ["Hello world!", "Machine learning is fun.", "BERT is p
train_labels = [0, 1, 1]  # Assuming two classes: 0 and 1

# Create InputExample objects from your sentences and labels
input_examples = [InputExample(guid="", text_a=sentence, text_b=None, lab

# Function to convert InputExamples to a TensorFlow dataset
def convert_examples_to_tf_dataset(examples, tokenizer, max_length=128):
    features = []

    for e in examples:
        input_dict = tokenizer.encode_plus(
            e.text_a,
            add_special_tokens=True,
            max_length=max_length,
            return_token_type_ids=True,
            return_attention_mask=True,
            padding='max_length',
            truncation=True
        )

        input_ids, token_type_ids, attention_mask = (input_dict["input_id
            input_dict["token_type_ids"], input_dict["attention_mask"])
        features.append(
            InputFeatures(
                input_ids=input_ids, attention_mask=attention_mask, token
            )
        )

    def gen():
        for f in features:
            yield (
                {
                    "input_ids": f.input_ids,
                    "attention_mask": f.attention_mask,
                    "token_type_ids": f.token_type_ids,
                },
                f.label,
            )

    return tf.data.Dataset.from_generator(
        gen,
        ({"input_ids": tf.int32, "attention_mask": tf.int32, "token_type_
        (
            {
                "input_ids": tf.TensorShape([None]),
                "attention_mask": tf.TensorShape([None]),
                "token_type_ids": tf.TensorShape([None]),
            },
            tf.TensorShape([]),
        ),
    )

# Convert InputExamples to a TensorFlow dataset
train_dataset = convert_examples_to_tf_dataset(input_examples, tokenizer)

# Compile and train the BERT model
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', m
model.fit(train_dataset, epochs=2)
```

```
/opt/homebrew/lib/python3.11/site-packages/tqdm/auto.py:21: TqdmWarning: I
Progress not found. Please update jupyter and ipywidgets. See https://ipyw
idgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
All PyTorch model weights were used when initializing TFBertForSequenceCla
ssification.

Some weights or buffers of the TF 2.0 model TFBertForSequenceClassificatio
n were not initialized from the PyTorch model and are newly initialized: [
'classifier.weight', 'classifier.bias']
You should probably TRAIN this model on a down-stream task to be able to u
se it for predictions and inference.
```

```
Epoch 1/2
1/1 [==============================] - 8s 8s/step - loss: 0.6931 - accurac
y: 0.6667
Epoch 2/2
1/1 [==============================] - 1s 973ms/step - loss: 0.6931 - accu
racy: 0.6667
```

Out[19]:

```
<keras.src.callbacks.History at 0x2af6d0dd0>
```

Model Evaluation: Cross-validation of BERT model

In [20]:

```python
from transformers import InputExample, InputFeatures, BertTokenizer, TFBe
import tensorflow as tf
from sklearn.model_selection import StratifiedKFold
import numpy as np

# Initialize the BERT tokenizer and model
tokenizer = BertTokenizer.from_pretrained("bert-base-uncased")
model = TFBertForSequenceClassification.from_pretrained("bert-base-uncase

# Define your actual training sentences and labels
train_sentences = ["Sentence 1", "Sentence 2", "Sentence 3", "Sentence 4"
train_labels = [0, 1, 1, 0, 1, 0]  # Assuming two classes: 0 and 1

# Create InputExample objects from your sentences and labels
input_examples = [InputExample(guid="", text_a=sentence, text_b=None, lab

# Function to convert InputExamples to a TensorFlow dataset
def convert_examples_to_tf_dataset(examples, tokenizer, max_length=128):
    features = []

    for e in examples:
        input_dict = tokenizer.encode_plus(
            e.text_a,
            add_special_tokens=True,
            max_length=max_length,
            return_token_type_ids=True,
            return_attention_mask=True,
            padding='max_length',
            truncation=True
        )

        input_ids, token_type_ids, attention_mask = (input_dict["input_id
            input_dict["token_type_ids"], input_dict["attention_mask"])
        features.append(
            InputFeatures(
                input_ids=input_ids, attention_mask=attention_mask, token
            )
        )

    def gen():
        for f in features:
            yield (
                {
                    "input_ids": f.input_ids,
                    "attention_mask": f.attention_mask,
                    "token_type_ids": f.token_type_ids,
                },
                f.label,
            )

    return tf.data.Dataset.from_generator(
        gen,
        ({"input_ids": tf.int32, "attention_mask": tf.int32, "token_type_
        (
            {
                "input_ids": tf.TensorShape([None]),
                "attention_mask": tf.TensorShape([None]),
                "token_type_ids": tf.TensorShape([None]),
            },
            tf.TensorShape([]),
        ),
    )

# Perform stratified k-fold cross-validation
kfold = StratifiedKFold(n_splits=3, shuffle=True, random_state=42)
accuracy_scores = []

for train_indices, val_indices in kfold.split(train_sentences, train_labe
    # Split the dataset into train and validation sets
    train_set = [input_examples[i] for i in train_indices]
    val_set = [input_examples[i] for i in val_indices]

    # Convert InputExamples to TensorFlow datasets
    train_dataset = convert_examples_to_tf_dataset(train_set, tokenizer).
    val_dataset = convert_examples_to_tf_dataset(val_set, tokenizer).batc

    # Compile and train the BERT model
    model.compile(optimizer='adam', loss='sparse_categorical_crossentropy
    model.fit(train_dataset, epochs=2, verbose=0)  # Training for simplic

    # Evaluate the model on the validation set
    val_results = model.evaluate(val_dataset)
    accuracy_scores.append(val_results[1])  # Accuracy is at index 1

# Calculate and print the average accuracy across folds
average_accuracy = np.mean(accuracy_scores)
print(f"Average Accuracy Across Folds: {average_accuracy:.2%}")
```

```
All PyTorch model weights were used when initializing TFBertForSequenceCla
ssification.

Some weights or buffers of the TF 2.0 model TFBertForSequenceClassificatio
n were not initialized from the PyTorch model and are newly initialized: [
'classifier.weight', 'classifier.bias']
You should probably TRAIN this model on a down-stream task to be able to u
se it for predictions and inference.
```

```
1/1 [==============================] - 1s 1s/step - loss: 0.6931 - accurac
y: 0.5000
1/1 [==============================] - 1s 1s/step - loss: 0.6931 - accurac
y: 0.5000
WARNING:tensorflow:5 out of the last 157 calls to <function Model.make_tra
in_function.<locals>.train_function at 0x2ea286520> triggered tf.function 
retracing. Tracing is expensive and the excessive number of tracings could
be due to (1) creating @tf.function repeatedly in a loop, (2) passing tens
ors with different shapes, (3) passing Python objects instead of tensors. 
For (1), please define your @tf.function outside of the loop. For (2), @tf
.function has reduce_retracing=True option that can avoid unnecessary retr
acing. For (3), please refer to https://www.tensorflow.org/guide/function#
controlling_retracing and https://www.tensorflow.org/api_docs/python/tf/fu
nction for  more details.
1/1 [==============================] - 2s 2s/step - loss: 0.6931 - accurac
y: 0.5000
Average Accuracy Across Folds: 50.00%
```