In [1]:
```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.naive_bayes import MultinomialNB
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import f1_score, precision_score, recall_score, confusi
import re
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords
from sklearn.feature_extraction.text import ENGLISH_STOP_WORDS
from sklearn.feature_extraction.text import TfidfVectorizer
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import cross_val_score
```

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

In [2]:
```
column_names = ['Target', 'id', 'Date', 'Flag', 'User', 'Text']
df = pd.read_csv('training.1600000.processed.noemoticon.csv', encoding='ISO-
df.index = df.index + 1
df.head()
```

Out[2]:

	Target	id	Date	Flag	User	Text
1	0	1467810369	Mon Apr 06 22:19:45 PDT 2009	NO_QUERY	_TheSpecialOne_	@switchfoot http://twitpic.com/2y1zl - Awww, t...
2	0	1467810672	Mon Apr 06 22:19:49 PDT 2009	NO_QUERY	scotthamilton	is upset that he can't update his Facebook by ...
3	0	1467810917	Mon Apr 06 22:19:53 PDT 2009	NO_QUERY	mattycus	@Kenichan I dived many times for the ball. Man...
4	0	1467811184	Mon Apr 06 22:19:57 PDT 2009	NO_QUERY	ElleCTF	my whole body feels itchy and like its on fire
5	0	1467811193	Mon Apr 06 22:19:57 PDT 2009	NO_QUERY	Karoli	@nationwideclass no, it's not behaving at all....

Data PreProcessing

Data Extraction

In [30]:
```
req_d = df[['Target','Text']]
req_d.head(10)
```

Out[30]:

	Target	Text
1	0	@switchfoot http://twitpic.com/2y1zl - Awww, t...
2	0	is upset that he can't update his Facebook by ...
3	0	@Kenichan I dived many times for the ball. Man...
4	0	my whole body feels itchy and like its on fire
5	0	@nationwideclass no, it's not behaving at all....
6	0	@Kwesidei not the whole crew
7	0	Need a hug
8	0	@LOLTrish hey long time no see! Yes.. Rains a...
9	0	@Tatiana_K nope they didn't have it
10	0	@twittera que me muera ?

Data Cleaning

In [5]:
```
def text_cleaning(text):
    text = re.sub(r'@[A-Za-z0-9]+', '', text)  # Removing mentions
    text = re.sub(r'https?://[A-Za-z0-9./]+', '', text)  # Removing URLs
    text = re.sub(r'[^a-zA-Z]', ' ', text)  # Removing non-alphabetic charac
    text = ' '.join([word for word in text.split() if word.lower() not in st
    return text.lower()
req_d['Text'] = req_d['Text'].apply(text_cleaning)
```

```
/var/folders/gx/l9lsx5qn4yvgkddyh12mxt9h0000gn/T/ipykernel_95144/430986170.
py:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-doc
s/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  req_d['Text'] = req_d['Text'].apply(text_cleaning)
```

In [6]:
```
req_d.head()
```

Out[6]:

	Target	Text
1	0	awww bummer shoulda got david carr day
2	0	upset update facebook texting result school to...
3	0	dived times ball managed save rest bounds
4	0	body feels itchy like
5	0	behaving mad

Split the dataset into training and testing sets

In [37]:
```
text_test,text_train,tar_test,tar_train = train_test_split(req_d['Text'],re
print(tar_train,text_train)
```

```
541201     0
751        0
766712     0
285056     0
705996     0
          ..
967371     4
918521     4
1292839    4
326643     0
195520     0
Name: Target, Length: 528000, dtype: int64 541201                @chrishasb
oobs AHHH I HOPE YOUR OK!!!
751        @misstoriblack cool , i have no tweet apps  fo...
766712     @TiannaChaos i know  just family drama. its la...
285056     School email won't open  and I have geography ...
705996                                upper airways problem
                                 ...
967371     Such a good vibe here in twitter-land... alway...
918521     ...and a big bag to take up as well as a rain ...
1292839              happy no doubt day. i am pretty excited
326643     Just bought a shirt that says &quot;wave goodb...
195520     @tommcfly plz say &quot;Happy Birthday Or , Ro...
Name: Text, Length: 528000, dtype: object
```

Feature Extraction (Bag of Words)

In [8]:
```
bow = CountVectorizer()
text_train_bow = bow.fit_transform(text_train)
text_test_bow = bow.transform(text_test)
```

Implementation of Sentiment Analysis

NB (Naive Bayes)

In [9]:
```
nb_clf = MultinomialNB()
nb_clf.fit(text_train_bow , tar_train)
nb_pred = nb_clf.predict(text_test_bow)
```

LR (Logistic Regression)

In [10]:
```
lr_clf = LogisticRegression(max_iter=1000)
lr_clf.fit(text_train_bow , tar_train)
lr_pred = lr_clf.predict(text_test_bow)
```

DT (Decision Tree)

In [16]:
```
dt_clf = DecisionTreeClassifier()
dt_clf.fit(text_train_bow , tar_train)
dt_pred = dt_clf.predict(text_test_bow)
```

Evaluation

In [17]:
```
def evaluate_model(y_true, y_pred, model_name):
    f1 = f1_score(y_true, y_pred, pos_label=4)
    precision = precision_score(y_true, y_pred, pos_label=4)
    recall = recall_score(y_true, y_pred, pos_label=4)

    print(f"{model_name} Evaluation Metrics:")
    print(f"F1-Score: {f1}")
    print(f"Precision: {precision}")
    print(f"Recall: {recall}")
    print("Confusion Matrix:")
    print(confusion_matrix(y_true, y_pred))
```

In [18]:
```
evaluate_model(tar_test, nb_pred ,"Naive Bayes")
```

```
Naive Bayes Evaluation Metrics:
F1-Score: 0.7585531905337579
Precision: 0.7599169858437241
Recall: 0.7571942815619039
Confusion Matrix:
[[408618 128061]
 [129979 405342]]
```

In [19]:
```
evaluate_model(tar_test, lr_pred ,"Logistic Regression")
```

```
Logistic Regression Evaluation Metrics:
F1-Score: 0.7720450818889432
Precision: 0.7522356001828886
Recall: 0.792926113490784
Confusion Matrix:
[[396871 139808]
 [110851 424470]]
```

In [20]:
```
evaluate_model(tar_test, dt_pred ,"Decision Tree")
```

```
Decision Tree Evaluation Metrics:
F1-Score: 0.6973659543881763
Precision: 0.7034085769343332
Recall: 0.6914262657358856
Confusion Matrix:
[[380612 156067]
 [165186 370135]]
```

Comparison and Discussion

Naive Bayes vs. Logistic Regression:

F1-Score:

Naive Bayes: 0.7586

Logistic Regression: 0.7720

Logistic Regression performs slightly better in terms of F1-Score.

Precision:

Naive Bayes: 0.7599

Logistic Regression: 0.7522

Naive Bayes has a slightly higher precision.

Recall:

Naive Bayes: 0.7572
Logistic Regression: 0.7929
Logistic Regression has a higher recall.

Findings and Analysis

Logistic Regression has higher F1 score. It suggests that it maintains a better balance between Precision and Recall. It implies that LR is more effective at identifying both Positive and Negative sentiments

It's Higher Recall suggests that it is more effective at finding out Positives out of all the positives

This is because LR is a Discriminative model, more flexible and measures relationship between output variable

However generative model like NB reach their asymptotic faster and require less computational expense

For Large Datasets LR in most cases is better than NB

Extra Credit

Using different feature extraction

Tfidf using unigrams and bigrams

```
tfidf = TfidfVectorizer(max_features=5000, ngram_range= (1,2)) text_train_tfidf =
tfidf.fit_transform(text_train) text_test_tfidf = tfidf.transform(text_test)
nb_clf.fit(text_train_tfidf , tar_train) nb_pred2 = nb_clf.predict(text_test_tfidf)
lr_clf.fit(text_train_tfidf , tar_train) lr_pred2 = lr_clf.predict(text_test_tfidf)
evaluate_model(tar_test, nb_pred2 ,"Naive Bayes")
evaluate_model(tar_test, lr_pred2 ,"Logistic Regression")
```

They have different scores from before

Visualization

Heatmap using confusion matrix

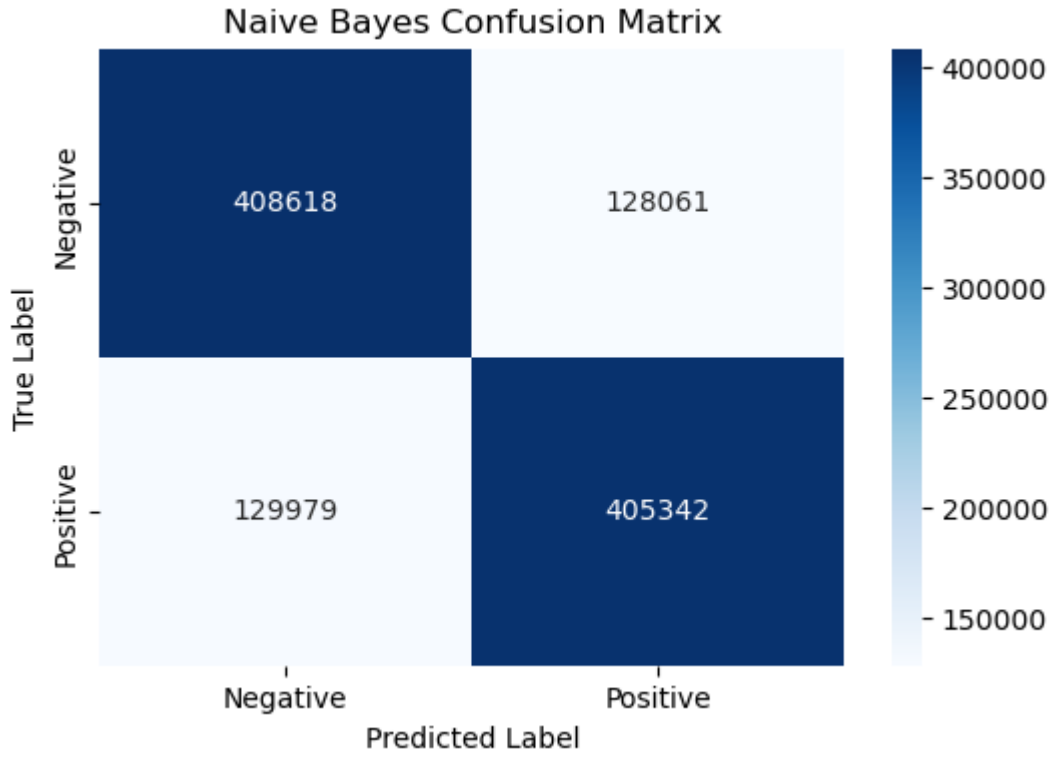
In [21]:
```
# Confusion Matrix for Naive Bayes
cm_nb = confusion_matrix(tar_test, nb_pred)

# Confusion Matrix for Logistic Regression
cm_lr = confusion_matrix(tar_test, lr_pred)

# Confusion Matrix for Decision Tree
cm_dt = confusion_matrix(tar_test, dt_pred)
```

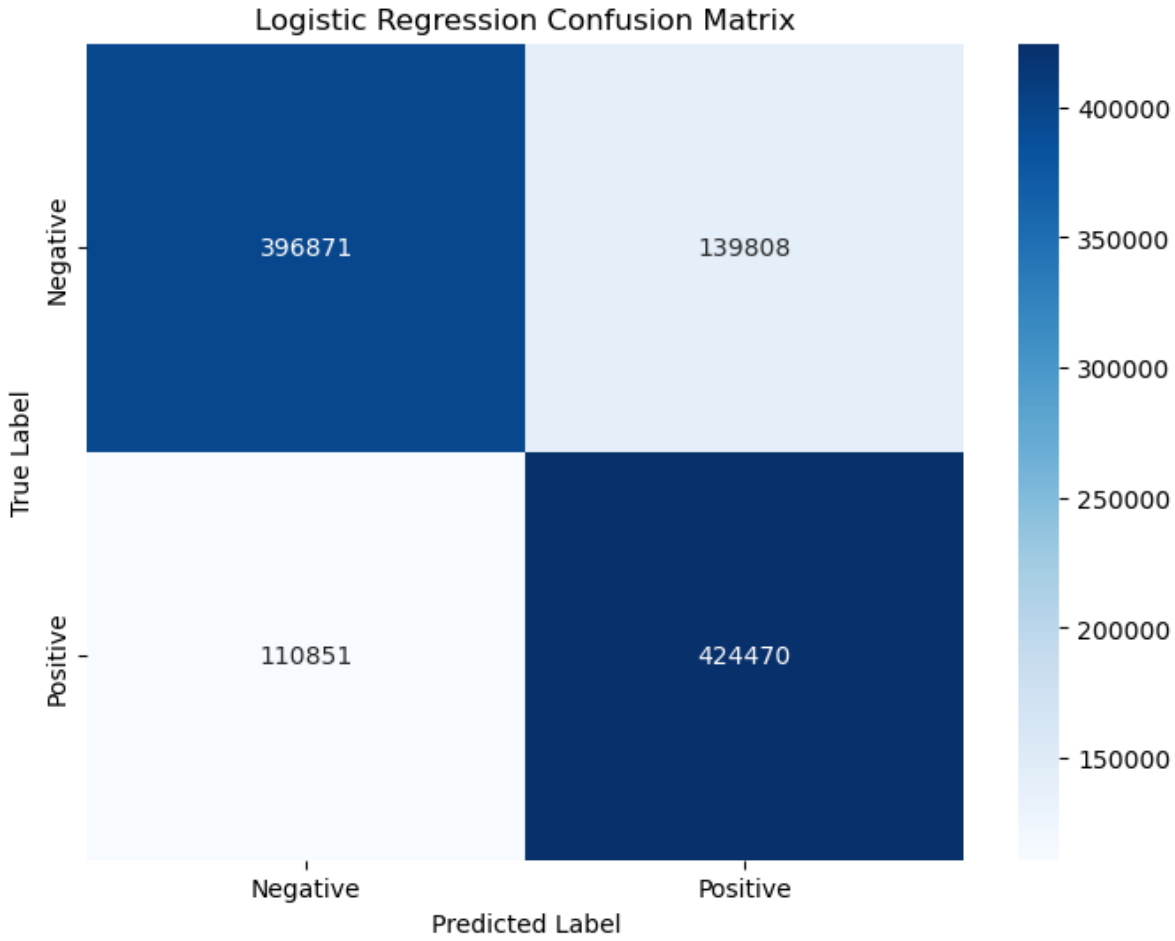
In [38]:
```
plt.figure(figsize=(6, 4))
sns.heatmap(cm_nb, annot=True, fmt='d', cmap='Blues', xticklabels=['Negative
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Naive Bayes Confusion Matrix')
```

Out[38]:
```
Text(0.5, 1.0, 'Naive Bayes Confusion Matrix')
```



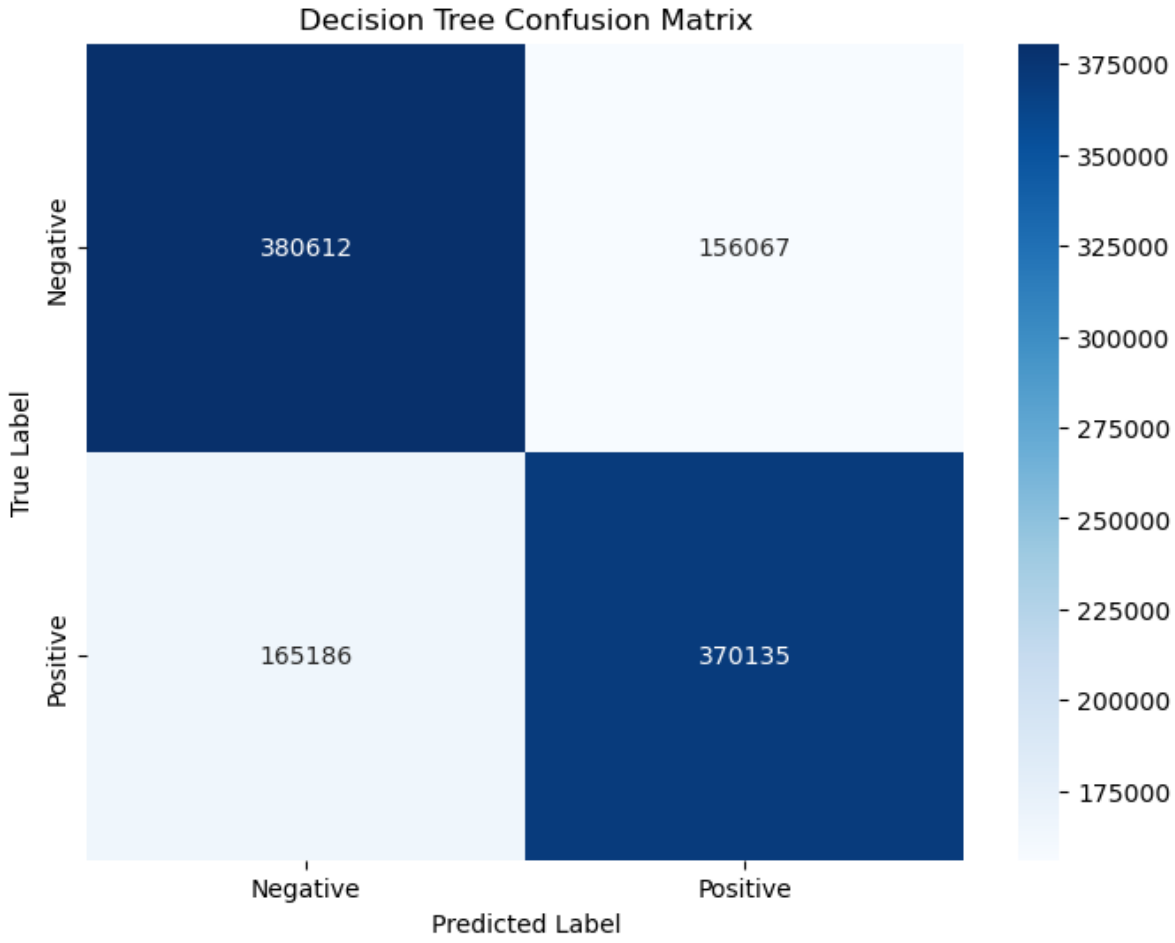
In [23]:
```
plt.figure(figsize=(8, 6))
sns.heatmap(cm_lr, annot=True, fmt='d', cmap='Blues', xticklabels=['Negative
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Logistic Regression Confusion Matrix')
```

Out[23]:
```
Text(0.5, 1.0, 'Logistic Regression Confusion Matrix')
```



In [24]:
```
plt.figure(figsize=(8, 6))
sns.heatmap(cm_dt, annot=True, fmt='d', cmap='Blues', xticklabels=['Negative
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Decision Tree Confusion Matrix')
```

Out[24]:
```
Text(0.5, 1.0, 'Decision Tree Confusion Matrix')
```



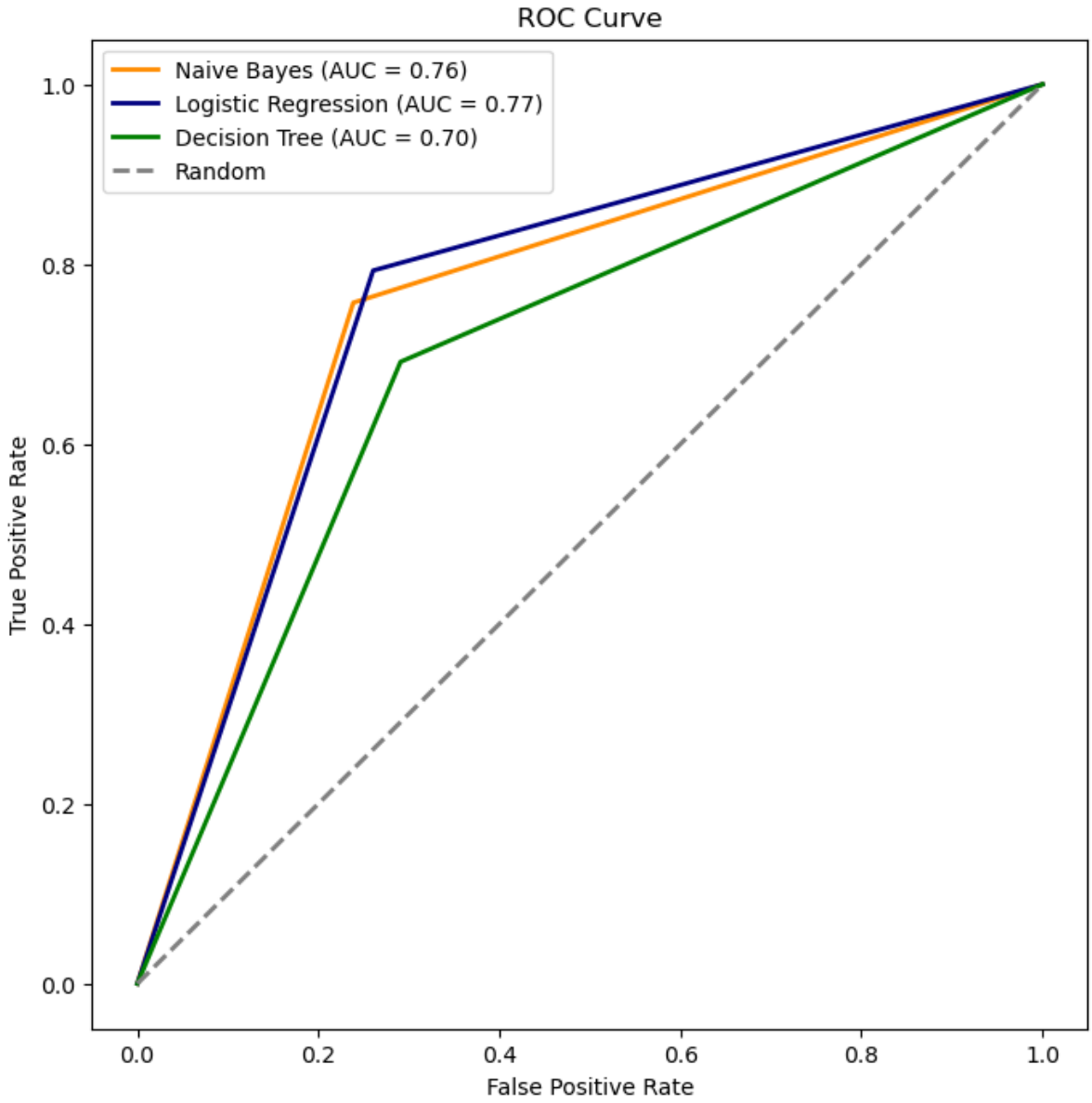
Roc-Auc curve

In [25]:
```
# ROC Curve for Naive Bayes
fpr_nb, tpr_nb, _ = roc_curve(tar_test, nb_pred, pos_label= 4)
roc_auc_nb = auc(fpr_nb, tpr_nb)

# ROC Curve for Logistic Regression
fpr_lr, tpr_lr, _ = roc_curve(tar_test, lr_pred, pos_label= 4)
roc_auc_lr = auc(fpr_lr, tpr_lr)

# ROC Curve for Decision Tree
fpr_dt, tpr_dt, _ = roc_curve(tar_test, dt_pred, pos_label= 4)
roc_auc_dt = auc(fpr_dt, tpr_dt)

# Plot ROC Curves
plt.figure(figsize=(8,8))
plt.plot(fpr_nb, tpr_nb, color='darkorange', lw=2, label=f'Naive Bayes (AUC
plt.plot(fpr_lr, tpr_lr, color='navy', lw=2, label=f'Logistic Regression (AU
plt.plot(fpr_dt, tpr_dt, color='green', lw=2, label=f'Decision Tree (AUC = 
plt.plot([0, 1], [0, 1], color='gray', lw=2, linestyle='--', label='Random')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend()
plt.show()
```



Logistic Regression's ROC have more Area Under the Curve(AUC). That implies it is better at classifying this dataset.

Cross Validation

In [28]:
```
# Define the scorer with pos_label
f1_scorer = make_scorer(f1_score, pos_label=4)

# Cross-validation for Naive Bayes
nb_cv_scores = cross_val_score(nb_clf, text_train_bow, tar_train, scoring=f1

# Cross-validation for Logistic Regression
lr_cv_scores = cross_val_score(lr_clf, text_train_bow, tar_train, scoring=f1

# Cross-validation for Decision Tree
dt_cv_scores = cross_val_score(dt_clf, text_train_bow, tar_train, scoring=f1

# Print cross-validation scores
print(f'Naive Bayes Cross-Validation Scores: {nb_cv_scores}')
print(f'Logistic Regression Cross-Validation Scores: {lr_cv_scores}')
print(f'Decision Tree Cross-Validation Scores: {dt_cv_scores}')
```

```
Naive Bayes Cross-Validation Scores: [0.75931273 0.75864552 0.75987082 0.75
771902 0.75903991]
Logistic Regression Cross-Validation Scores: [0.77046977 0.77135762 0.77271
39  0.7704743  0.77326271]
Decision Tree Cross-Validation Scores: [0.69426206 0.69587414 0.69692083 0.
69626445 0.69714253]
```

Both Classifiers seems to be consistent but

Logistic Regression have higher values

Therefore LR is better for this Dataset

In [48]:
```
ran_text = input("Enter a text: ")
prediction = lr_clf.predict(bow.transform([text_cleaning(ran_text)]))
if(prediction):
    print("Output: Positive")
else:
    print("Output: Negative")
```

```
Enter a text: my whole body feels itchy and like its on fire
Output: Negative
```

References

https://docs.python.org/3/library/re.html

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