Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews

EDA: https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

Given a review, determine whether the review is positive (rating of 4 or 5) or negative (rating of 1 or 2).

[Q] How to determine if a review is positive or negative?

[Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

[1]. Reading Data

[1.1] Loading the data

The dataset is available in two forms

1. .csv file
2. SQLite Database

In order to load the data, We have used the SQLITE dataset as it is easier to query the data and visualise the data efficiently.

Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignore all Scores equal to 3. If the score is above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

In [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")


import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
```

```
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn import metrics
from sklearn.metrics import roc_curve, auc, f1_score
from nltk.stem.porter import PorterStemmer
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import confusion_matrix,roc_curve, auc,f1_score
from sklearn.tree import DecisionTreeClassifier, export_graphviz
import graphviz

import re
from bs4 import BeautifulSoup
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os
```

In [2]:

```
# using SQLite Table to read data.
con = sqlite3.connect('./dataset/database.sqlite')

# filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
# SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 50
0000 data points
# you can change the number to any other number based on your computing
 power
```

```
# filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Sco
re != 3 LIMIT 500000""", con)
# for tsne assignment you can take 5k data points

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score
 != 3""", con)

# Give reviews with Score>3 a positive rating(1), and reviews with a sc
ore<3 a negative rating(0).
def partition(x):
    if x < 3:
        return 0
    return 1

def findMinorClassPoints(df):
    posCount = df[df['Score']==1].shape[0];
    negCount = df[df['Score']==0].shape[0];
    if negCount < posCount:
        return negCount
    return posCount

#changing reviews with score less than 3 to be positive and vice-versa
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative

#Performing Downsampling
samplingCount = findMinorClassPoints(filtered_data)
postive_df = filtered_data[filtered_data['Score'] == 1].sample(n=sampli
ngCount)
negative_df = filtered_data[filtered_data['Score'] == 0].sample(n=sampl
ingCount)

filtered_data = pd.concat([postive_df, negative_df])

print("Number of data points in our data", filtered_data.shape)
filtered_data.head(3)
```

```
Number of data points in our data (164074, 10)
```

Out[2]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpf
451137	487779	B000LKTJ9C	A3PAMF9DX1QWO6	Elf	0	
251383	272549	B007OXJL0G	AZQA8ZIGS01FG	teejay	0	
164676	178590	B005GYJUK6	A360V40BYDEUVQ	"Tuttie"	1	

In [3]:
```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [4]:
```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[4]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

In [5]:
```
display[display['UserId']=='AZY10LLTJ71NX']
```

Out[5]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	5	I was recommended to try green tea extract to ...	5

In [6]:
```
display['COUNT(*)'].sum()
```

Out[6]:
```
393063
```

[2] Exploratory Data Analysis

[2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

In [7]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND UserId="AR5J8UI46CURR"
ORDER BY ProductID
""", con)
display.head()
```

Out[7]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenon
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that

ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8)

ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

In [8]:
```
#Sorting data according to ProductId in ascending order
sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')
```

In [9]:
```
#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='first', inplace=False)
final.shape
```

Out[9]:
```
(128427, 10)
```

In [10]:
```
#Checking to see how much % of data still remains
(final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

Out[10]: 78.27382766312762

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

In [11]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND Id=44737 OR Id=64422
ORDER BY ProductID
""", con)

display.head()
```

Out[11]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenom
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	

In [12]:
```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [13]:
```
#Before starting the next phase of preprocessing lets see the number of
 entries left
print(final.shape)
```

```
#How many positive and negative reviews are present in our dataset?
final['Score'].value_counts()
```

```
(128427, 10)
```

Out[13]:
```
1    71317
0    57110
Name: Score, dtype: int64
```

[3] Preprocessing

[3.1]. Preprocessing Review Text

Now that we have finished deduplication our data requires some preprocessing before we go on further with analysis and making the prediction model.

Hence in the Preprocessing phase we do the following in the order below:-

1. Begin by removing the html tags
2. Remove any punctuations or limited set of special characters like , or . or # etc.
3. Check if the word is made up of english letters and is not alpha-numeric
4. Check to see if the length of the word is greater than 2 (as it was researched that there is no adjective in 2-letters)
5. Convert the word to lowercase
6. Remove Stopwords
7. Finally Snowball Stemming the word (it was obsereved to be better than Porter Stemming)

After which we collect the words used to describe positive and negative reviews

In [14]:
```
# printing some random reviews
sent_0 = final['Text'].values[0]
print(sent_0)
print("="*50)

sent_1000 = final['Text'].values[1000]
```

```
print(sent_1000)
print("="*50)

sent_1500 = final['Text'].values[1500]
print(sent_1500)
print("="*50)

sent_4900 = final['Text'].values[4900]
print(sent_4900)
print("="*50)
```

```
These days, when a person says, "chicken soup" they're probably going t
o follow up those words with, "for the soul" or maybe "for the teenaged
soul".  Didn't used to be that way.  Why I can remember a time when if
a person said, "chicken soup" those words were followed by an enthusias
tic "with rice!".  Such was the power of Maurice Sendak's catchy 1962 c
hildren's book.  I am pleased to report that if you care to read this b
ook again today, you will find it hasn't dimished a jot in terms of fro
licksome fun.  In this book we are led through a whirlwind chicken soup
year with our host, a boy who bears no little resemblance to Sendak's o
ther great rhyming tale "Pierre" (in looks if not demeanor).  It's a ca
tchy flouncy bouncy combo of soup and the people who love it so.<br /><
br />This is ostensibly a book meant to teach your children the differe
nt months of the year.  Each month gets its own rhythmic poem and accom
panying illustration.  These are fairly simple pen and ink drawings wit
h the occasional splash of blue (in varying shades), yellow, gray, and
green.  You may wonder how an author could ever hope to come up with tw
elve highly original soup-related poems.  I mean, honestly, how much is
there to say about even the fanciest soup, let alone chicken soup with
rice?  Quite a lot, as it happens.  In the cold winter months soup is s
upped while sliding on ice, while celebrating the birthday of a snowma
n, and in a gusty gale as a whale.  In the spring there's robin's nest
soup, soup to cure drooping roses, and soup stolen by jealous March win
ds.  Our hero postulates the potential joys that could come of being a
cooking pot, stewing soup or (oddly enough) as "a baubled bangled Chris
tmas tree".<br /><br />Not to degrade the reading skills of parents eve
rywhere, but I cannot recommend enough getting an audio version of this
tale to accompany your child's reading.  Though I am now a wise and cul
tured 26 year-old (the years have been kind to me in this, my old age)
I can still remember the chicken soup with rice tune.  Heck, I read thi
```

```
s entire book recently and found I could do the song perfectly with eac
h and every line.  Now maybe you have your own particular chicken soup
with rice song style that you're just loathe to give up.  If so, fine.
I understand why you might not want to taint your already existing chic
ken soup melody.  But if you haven't found a jingle to accompany this b
ook, get the audio version immediately, if not sooner.  Until you can s
ing "Whoopy once, whoopy twice, whoopy chicken soup with rice" with the
correct oomph, you're missing out.<br /><br />I take my "Chicken Soup W
ith Rice" readings seriously.  This book was the "Chicka Chicka Boom Bo
om" of its day, and still remains the catchiest method to teach kids th
e months of the year.  It is also seriously in danger of being forgotte
n.  So pull out your old accordion and strap on your dancing shoes.  Th
e time for yukkin' it up to a merry dance of poultry broth is here.  I
t's Sendak at his finest.
==================================================
DO NOT BUY THIS! Thought this was a great idea. sounded quick and a fun
way to add color to cakes. It did give color to the cake but the smell
was horrible. Smells<br />like hair spray. Not something I want to eat
or let my children eat.
==================================================
Picture a straight stick, lopped off at the top, with a few bare branch
es a few tiny bits of green, and you have this "bonsai" plant. Very wel
l packed, but pathetic when unpacked, the only resemblance to the photo
s on the Amazon page would be the pot, which is identical. We received
this as sympathy gift after death in family. Hard to imagine a more abs
urd item. Noted this to the sender, who apparently complained and got a
second sent, very similar to the first. Deceptive photo, this item need
s a strong disclaimer against use as a gift.
==================================================
I have been buying the catnip at my local pet store. It is expensive. T
hen I decided to do some comparative price shopping on Amazon.com. I fo
und this company sells the same Cosmic catnip for a much cheaper price.
It is identical to the catnip I have previously purchased at the pet st
ore. I would definitely recommend buying your Cosmic catnip from this c
ompany, especially if you go through a lot of catnip.  You can save a b
undle of money.
==================================================
```

In [15]:
```
# remove urls from text python: https://stackoverflow.com/a/40823105/40
```

```
84039
sent_0 = re.sub(r"http\S+", "", sent_0)
sent_1000 = re.sub(r"http\S+", "", sent_1000)
sent_150 = re.sub(r"http\S+", "", sent_1500)
sent_4900 = re.sub(r"http\S+", "", sent_4900)

print(sent_0)
```

```
These days, when a person says, "chicken soup" they're probably going t
o follow up those words with, "for the soul" or maybe "for the teenaged
soul".  Didn't used to be that way.  Why I can remember a time when if
a person said, "chicken soup" those words were followed by an enthusias
tic "with rice!".  Such was the power of Maurice Sendak's catchy 1962 c
hildren's book.  I am pleased to report that if you care to read this b
ook again today, you will find it hasn't dimished a jot in terms of fro
licksome fun.  In this book we are led through a whirlwind chicken soup
year with our host, a boy who bears no little resemblance to Sendak's o
ther great rhyming tale "Pierre" (in looks if not demeanor).  It's a ca
tchy flouncy bouncy combo of soup and the people who love it so.<br /><
br />This is ostensibly a book meant to teach your children the differe
nt months of the year.  Each month gets its own rhythmic poem and accom
panying illustration.  These are fairly simple pen and ink drawings wit
h the occasional splash of blue (in varying shades), yellow, gray, and
green.  You may wonder how an author could ever hope to come up with tw
elve highly original soup-related poems.  I mean, honestly, how much is
there to say about even the fanciest soup, let alone chicken soup with
rice?  Quite a lot, as it happens.  In the cold winter months soup is s
upped while sliding on ice, while celebrating the birthday of a snowma
n, and in a gusty gale as a whale.  In the spring there's robin's nest
soup, soup to cure drooping roses, and soup stolen by jealous March win
ds.  Our hero postulates the potential joys that could come of being a
cooking pot, stewing soup or (oddly enough) as "a baubled bangled Chris
tmas tree".<br /><br />Not to degrade the reading skills of parents eve
rywhere, but I cannot recommend enough getting an audio version of this
tale to accompany your child's reading.  Though I am now a wise and cul
tured 26 year-old (the years have been kind to me in this, my old age)
I can still remember the chicken soup with rice tune.  Heck, I read thi
s entire book recently and found I could do the song perfectly with eac
h and every line.  Now maybe you have your own particular chicken soup
with rice song style that you're just loathe to give up.  If so, fine.
```

```
I understand why you might not want to taint your already existing chic
ken soup melody.  But if you haven't found a jingle to accompany this b
ook, get the audio version immediately, if not sooner.  Until you can s
ing "Whoopy once, whoopy twice, whoopy chicken soup with rice" with the
correct oomph, you're missing out.<br /><br />I take my "Chicken Soup W
ith Rice" readings seriously.  This book was the "Chicka Chicka Boom Bo
om" of its day, and still remains the catchiest method to teach kids th
e months of the year.  It is also seriously in danger of being forgotte
n.  So pull out your old accordion and strap on your dancing shoes.  Th
e time for yukkin' it up to a merry dance of poultry broth is here.  I
t's Sendak at his finest.
```

In [16]:

```
# https://stackoverflow.com/questions/16206380/python-beautifulsoup-how
-to-remove-all-tags-from-an-element

soup = BeautifulSoup(sent_0, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1000, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1500, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_4900, 'lxml')
text = soup.get_text()
print(text)
```

```
These days, when a person says, "chicken soup" they're probably going t
o follow up those words with, "for the soul" or maybe "for the teenaged
soul".  Didn't used to be that way.  Why I can remember a time when if
a person said, "chicken soup" those words were followed by an enthusias

tic "with rice!"  Such was the power of Maurice Sendak's catchy 1962 c
```

tic "with rice!". Such was the power of Maurice Sendak's catchy 1962 c
hildren's book. I am pleased to report that if you care to read this b
ook again today, you will find it hasn't dimished a jot in terms of fro
licksome fun. In this book we are led through a whirlwind chicken soup
year with our host, a boy who bears no little resemblance to Sendak's o
ther great rhyming tale "Pierre" (in looks if not demeanor). It's a ca
tchy flouncy bouncy combo of soup and the people who love it so.This is
ostensibly a book meant to teach your children the different months of
the year. Each month gets its own rhythmic poem and accompanying illus
tration. These are fairly simple pen and ink drawings with the occasio
nal splash of blue (in varying shades), yellow, gray, and green. You m
ay wonder how an author could ever hope to come up with twelve highly o
riginal soup-related poems. I mean, honestly, how much is there to say
about even the fanciest soup, let alone chicken soup with rice? Quite
a lot, as it happens. In the cold winter months soup is supped while s
liding on ice, while celebrating the birthday of a snowman, and in a gu
sty gale as a whale. In the spring there's robin's nest soup, soup to
cure drooping roses, and soup stolen by jealous March winds. Our hero
postulates the potential joys that could come of being a cooking pot, s
tewing soup or (oddly enough) as "a baubled bangled Christmas tree".Not
to degrade the reading skills of parents everywhere, but I cannot recom
mend enough getting an audio version of this tale to accompany your chi
ld's reading. Though I am now a wise and cultured 26 year-old (the yea
rs have been kind to me in this, my old age) I can still remember the c
hicken soup with rice tune. Heck, I read this entire book recently and
found I could do the song perfectly with each and every line. Now mayb
e you have your own particular chicken soup with rice song style that y
ou're just loathe to give up. If so, fine. I understand why you might
not want to taint your already existing chicken soup melody. But if yo
u haven't found a jingle to accompany this book, get the audio version
immediately, if not sooner. Until you can sing "Whoopy once, whoopy tw
ice, whoopy chicken soup with rice" with the correct oomph, you're miss
ing out.I take my "Chicken Soup With Rice" readings seriously. This bo
ok was the "Chicka Chicka Boom Boom" of its day, and still remains the
catchiest method to teach kids the months of the year. It is also seri
ously in danger of being forgotten. So pull out your old accordion and
strap on your dancing shoes. The time for yukkin' it up to a merry dan
ce of poultry broth is here. It's Sendak at his finest.
==========

DO NOT BUY THIS! Thought this was a great idea, sounded quick and a fun

```
DO NOT BUY THIS! Thought this was a great idea. Sounded quick and a fun
way to add color to cakes. It did give color to the cake but the smell
was horrible. Smellslike hair spray. Not something I want to eat or let
my children eat.
==================================================
Picture a straight stick, lopped off at the top, with a few bare branch
es a few tiny bits of green, and you have this "bonsai" plant. Very wel
l packed, but pathetic when unpacked, the only resemblance to the photo
s on the Amazon page would be the pot, which is identical. We received
this as sympathy gift after death in family. Hard to imagine a more abs
urd item. Noted this to the sender, who apparently complained and got a
second sent, very similar to the first. Deceptive photo, this item need
s a strong disclaimer against use as a gift.
==================================================
I have been buying the catnip at my local pet store. It is expensive. T
hen I decided to do some comparative price shopping on Amazon.com. I fo
und this company sells the same Cosmic catnip for a much cheaper price.
It is identical to the catnip I have previously purchased at the pet st
ore. I would definitely recommend buying your Cosmic catnip from this c
ompany, especially if you go through a lot of catnip.  You can save a b
undle of money.
```

In [17]:

```python
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
```

```
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [18]:
```
sent_1500 = decontracted(sent_1500)
print(sent_1500)
print("="*50)
```

```
Picture a straight stick, lopped off at the top, with a few bare branch
es a few tiny bits of green, and you have this "bonsai" plant. Very wel
l packed, but pathetic when unpacked, the only resemblance to the photo
s on the Amazon page would be the pot, which is identical. We received
this as sympathy gift after death in family. Hard to imagine a more abs
urd item. Noted this to the sender, who apparently complained and got a
second sent, very similar to the first. Deceptive photo, this item need
s a strong disclaimer against use as a gift.
==================================================
```

In [19]:
```
#remove words with numbers python: https://stackoverflow.com/a/1808237
0/4084039
sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
print(sent_0)
```

```
These days, when a person says, "chicken soup" they're probably going t
o follow up those words with, "for the soul" or maybe "for the teenaged
soul".  Didn't used to be that way.  Why I can remember a time when if
a person said, "chicken soup" those words were followed by an enthusias
tic "with rice!".  Such was the power of Maurice Sendak's catchy  child
ren's book.  I am pleased to report that if you care to read this book
again today, you will find it hasn't dimished a jot in terms of frolick
some fun.  In this book we are led through a whirlwind chicken soup yea
r with our host, a boy who bears no little resemblance to Sendak's othe
r great rhyming tale "Pierre" (in looks if not demeanor).  It's a catch
y flouncy bouncy combo of soup and the people who love it so.<br /><br
/>This is ostensibly a book meant to teach your children the different
months of the year.  Each month gets its own rhythmic poem and accompan
ying illustration.  These are fairly simple pen and ink drawings with t
he occasional splash of blue (in varying shades), yellow, gray, and gre
en.  You may wonder how an author could ever hope to come up with twelv
e highly original soup-related poems.  I mean, honestly, how much is th
```

```
ere to say about even the fanciest soup, let alone chicken soup with ri
ce?  Quite a lot, as it happens.  In the cold winter months soup is sup
ped while sliding on ice, while celebrating the birthday of a snowman,
and in a gusty gale as a whale.  In the spring there's robin's nest sou
p, soup to cure drooping roses, and soup stolen by jealous March winds.
  Our hero postulates the potential joys that could come of being a coo
king pot, stewing soup or (oddly enough) as "a baubled bangled Christma
s tree".<br /><br />Not to degrade the reading skills of parents everyw
here, but I cannot recommend enough getting an audio version of this ta
le to accompany your child's reading.  Though I am now a wise and cultu
red  year-old (the years have been kind to me in this, my old age) I ca
n still remember the chicken soup with rice tune.  Heck, I read this en
tire book recently and found I could do the song perfectly with each an
d every line.  Now maybe you have your own particular chicken soup with
rice song style that you're just loathe to give up.  If so, fine.  I un
derstand why you might not want to taint your already existing chicken
soup melody.  But if you haven't found a jingle to accompany this book,
get the audio version immediately, if not sooner.  Until you can sing
"Whoopy once, whoopy twice, whoopy chicken soup with rice" with the cor
rect oomph, you're missing out.<br /><br />I take my "Chicken Soup With
Rice" readings seriously.  This book was the "Chicka Chicka Boom Boom"
of its day, and still remains the catchiest method to teach kids the mo
nths of the year.  It is also seriously in danger of being forgotten.
So pull out your old accordion and strap on your dancing shoes.  The ti
me for yukkin' it up to a merry dance of poultry broth is here.  It's S
endak at his finest.
```

In [20]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
print(sent_1500)
```

```
Picture a straight stick lopped off at the top with a few bare branches
a few tiny bits of green and you have this bonsai plant Very well packe
d but pathetic when unpacked the only resemblance to the photos on the
Amazon page would be the pot which is identical We received this as sym
pathy gift after death in family Hard to imagine a more absurd item Not
ed this to the sender who apparently complained and got a second sent v
ery similar to the first Deceptive photo this item needs a strong discl
aimer against use as a gift
```

In [21]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'no
t'
# <br /><br /> ==> after the above steps, we are getting "br br"
# we are including them into stop words list
# instead of <br /> if we have <br/> these tags would have revmoved in
 the 1st step

stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'o
urs', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselve
s', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'it
s', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'th
is', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'h
ave', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or',
 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between',
'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out',
'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'h
ow', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 's
o', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should',
"should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't",
'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "is
n't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn',
 "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"])
```

In [22]:
```
# Combining all the above stundents
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentance in tqdm(final['Text'].values):
    sentance = re.sub(r"http\S+", "", sentance)
    sentance = BeautifulSoup(sentance, 'lxml').get_text()
    sentance = decontracted(sentance)
    sentance = re.sub("\S*\d\S*", "", sentance).strip()
    sentance = re.sub('[^A-Za-z]+', ' ', sentance)
    # https://gist.github.com/sebleier/554280
    sentance = ' '.join(e.lower() for e in sentance.split() if e.lower
() not in stopwords)
    preprocessed_reviews.append(sentance.strip())
```

```
100%|██████████| 128427/128427 [00:50<00:00, 2548.79it/s]
```

In [23]:
```
preprocessed_reviews[1500]
```

Out[23]:
```
'picture straight stick lopped top bare branches tiny bits green bonsai
plant well packed pathetic unpacked resemblance photos amazon page woul
d pot identical received sympathy gift death family hard imagine absurd
item noted sender apparently complained got second sent similar first d
eceptive photo item needs strong disclaimer use gift'
```

[3.2] Preprocessing Review Summary

In [24]:
```
## Similartly you can do preprocessing for review summary also.
def concatenateSummaryWithText(str1, str2):
    return str1 + ' ' + str2

preprocessed_summary = []
# tqdm is for printing the status bar
for sentence in tqdm(final['Summary'].values):
    sentence = re.sub(r"http\S+", "", sentence)
    #sentence = BeautifulSoup(sentence, 'lxml').get_text()
    sentence = decontracted(sentence)
    sentence = re.sub("\S*\d\S*", "", sentence).strip()
```

```
    sentence = re.sub('[^A-Za-z]+', ' ', sentence)
    # https://gist.github.com/sebleier/554280
    sentence = ' '.join(e.lower() for e in sentence.split() if e.lower
() not in stopwords)
    preprocessed_summary.append(sentence.strip())

preprocessed_reviews = list(map(concatenateSummaryWithText, preprocesse
d_reviews, preprocessed_summary))
final['CleanedText'] = preprocessed_reviews
final['CleanedText'] = final['CleanedText'].astype('str')
```

```
100%|██████████| 128427/128427 [00:02<00:00, 50626.94it/s]
```

[4] Featurization

[4.1] BAG OF WORDS

In [25]:
```
# #BoW
# count_vect = CountVectorizer() #in scikit-learn
# count_vect.fit(preprocessed_reviews)
# print("some feature names ", count_vect.get_feature_names()[:10])
# print('='*50)

# final_counts = count_vect.transform(preprocessed_reviews)
# print("the type of count vectorizer ",type(final_counts))
# print("the shape of out text BOW vectorizer ",final_counts.get_shape
())
# print("the number of unique words ", final_counts.get_shape()[1])
```

[4.2] Bi-Grams and n-Grams.

In [26]:
```
# #bi-gram, tri-gram and n-gram

# #removing stop words like "not" should be avoided before building n-g
```

```
rams
# # count_vect = CountVectorizer(ngram_range=(1,2))
# # please do read the CountVectorizer documentation http://scikit-lear
n.org/stable/modules/generated/sklearn.feature_extraction.text.CountVec
torizer.html

# # you can choose these numebrs min_df=10, max_features=5000, of your
 choice
# count_vect = CountVectorizer(ngram_range=(1,2), min_df=10, max_featur
es=5000)
# final_bigram_counts = count_vect.fit_transform(preprocessed_reviews)
# print("the type of count vectorizer ",type(final_bigram_counts))
# print("the shape of out text BOW vectorizer ",final_bigram_counts.get
_shape())
# print("the number of unique words including both unigrams and bigrams
 ", final_bigram_counts.get_shape()[1])
```

[4.3] TF-IDF

In [27]:
```
# tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
# tf_idf_vect.fit(preprocessed_reviews)
# print("some sample features(unique words in the corpus)",tf_idf_vect.
get_feature_names()[0:10])
# print('='*50)

# final_tf_idf = tf_idf_vect.transform(preprocessed_reviews)
# print("the type of count vectorizer ",type(final_tf_idf))
# print("the shape of out text TFIDF vectorizer ",final_tf_idf.get_shap
e())
# print("the number of unique words including both unigrams and bigrams
 ", final_tf_idf.get_shape()[1])
```

[4.4] Word2Vec

In [28]:
```
# # Train your own Word2Vec model using your own text corpus
```

```
# i=0
# list_of_sentance=[]
# for sentance in preprocessed_reviews:
#     list_of_sentance.append(sentance.split())
```

In [29]:

```
# # Using Google News Word2Vectors

# # in this project we are using a pretrained model by google
# # its 3.3G file, once you load this into your memory
# # it occupies ~9Gb, so please do this step only if you have >12G of r
am
# # we will provide a pickle file wich contains a dict ,
# # and it contains all our courpus words as keys and  model[word] as v
alues
# # To use this code-snippet, download "GoogleNews-vectors-negative300.
bin"
# # from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/e
dit
# # it's 1.9GB in size.


# # http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W
17SRFAzZPY
# # you can comment this whole cell
# # or change these varible according to your need

# is_your_ram_gt_16g=False
# want_to_use_google_w2v = False
# want_to_train_w2v = True

# if want_to_train_w2v:
#     # min_count = 5 considers only words that occured atleast 5 times
#     w2v_model=Word2Vec(list_of_sentance,min_count=5,size=50, workers=
4)
#     print(w2v_model.wv.most_similar('great'))
#     print('='*50)
#     print(w2v_model.wv.most_similar('worst'))

# elif want_to_use_google_w2v and is_your_ram_gt_16g:
```

```
#     if os.path.isfile('GoogleNews-vectors-negative300.bin'):
#         w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vecto
rs-negative300.bin', binary=True)
#         print(w2v_model.wv.most_similar('great'))
#         print(w2v_model.wv.most_similar('worst'))
#     else:
#         print("you don't have gogole's word2vec file, keep want_to_tr
ain_w2v = True, to train your own w2v ")
```

In [30]:
```
# w2v_words = list(w2v_model.wv.vocab)
# print("number of words that occured minimum 5 times ",len(w2v_words))
# print("sample words ", w2v_words[0:50])
```

[4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

In [31]:
```
# # average Word2Vec
# # compute average word2vec for each review.
# sent_vectors = []; # the avg-w2v for each sentence/review is stored i
n this list
# for sent in tqdm(list_of_sentance): # for each review/sentence
#     sent_vec = np.zeros(50) # as word vectors are of zero length 50,
 you might need to change this to 300 if you use google's w2v
#     cnt_words =0; # num of words with a valid vector in the sentence/
review
#     for word in sent: # for each word in a review/sentence
#         if word in w2v_words:
#             vec = w2v_model.wv[word]
#             sent_vec += vec
#             cnt_words += 1
#     if cnt_words != 0:
#         sent_vec /= cnt_words
#     sent_vectors.append(sent_vec)
```

```
# print(len(sent_vectors))
# print(len(sent_vectors[0]))
```

[4.4.1.2] TFIDF weighted W2v

In [32]:
```
# # S = ["abc def pqr", "def def def abc", "pqr pqr def"]
# model = TfidfVectorizer()
# tf_idf_matrix = model.fit_transform(preprocessed_reviews)
# # we are converting a dictionary with word as a key, and the idf as a
 value
# dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [33]:
```
# # TF-IDF weighted Word2Vec
# tfidf_feat = model.get_feature_names() # tfidf words/col-names
# # final_tf_idf is the sparse matrix with row= sentence, col=word and
 cell_val = tfidf

# tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is
 stored in this list
# row=0;
# for sent in tqdm(list_of_sentance): # for each review/sentence
#     sent_vec = np.zeros(50) # as word vectors are of zero length
#     weight_sum =0; # num of words with a valid vector in the sentenc
e/review
#     for word in sent: # for each word in a review/sentence
#         if word in w2v_words and word in tfidf_feat:
#             vec = w2v_model.wv[word]
# #             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
#             # to reduce the computation we are
#             # dictionary[word] = idf value of word in whole courpus
#             # sent.count(word) = tf valeus of word in this review
#             tf_idf = dictionary[word]*(sent.count(word)/len(sent))
#             sent_vec += (vec * tf_idf)
#             weight_sum += tf_idf
#     if weight_sum != 0:
#         sent_vec /= weight_sum
```

```
#     tfidf_sent_vectors.append(sent_vec)
#     row += 1
```

[5] Assignment 8: Decision Trees

1. **Apply Decision Trees on these feature sets**

    - SET 1:Review text, preprocessed one converted into vectors using (BOW)
    - SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
    - SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)
    - SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)

2. **The hyper paramter tuning (best `depth` in range [1, 5, 10, 50, 100, 500, 100], and the best `min_samples_split` in range [5, 10, 100, 500])**

    - Find the best hyper parameter which will give the maximum AUC value
    - Find the best hyper paramter using k-fold cross validation or simple cross validation data
    - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

3. **Graphviz**

    - Visualize your decision tree with Graphviz. It helps you to understand how a decision is being made, given a new vector.
    - Since feature names are not obtained from word2vec related models, visualize only BOW & TFIDF decision trees using Graphviz
    - Make sure to print the words in each node of the decision tree instead of printing its index.
    - Just for visualization purpose, limit max_depth to 2 or 3 and either embed the generated images of graphviz in your notebook, or directly upload them as .png files.

4. **Feature importance**

- Find the top 20 important features from both feature sets Set 1 and Set 2 using `feature_importances_` method of Decision Tree Classifier and print their corresponding feature names

5. **Feature engineering**

- To increase the performance of your model, you can also experiment with with feature engineering like :
  - Taking length of reviews as another feature.
  - Considering some features from review summary as well.

6. **Representation of results**

- You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.

Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.

Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

7. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.

3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

Applying Decision Trees

In [34]:
```
global result_report
result_report = pd.DataFrame(columns=['VECTORIZER', 'DATASET-SIZE', 'MA
X-DEPTH(HYPERPARAMETER)', 'MIN_SPLIT(HYPERPARAMETER)', 'F1_SCORE', 'AU
C'])
```

In [35]:
```
#Sorting according to the time for time-based splitting
final['Time'] = pd.to_datetime(final['Time'], unit='s')
final = final.sort_values(by='Time', ascending=True)
```

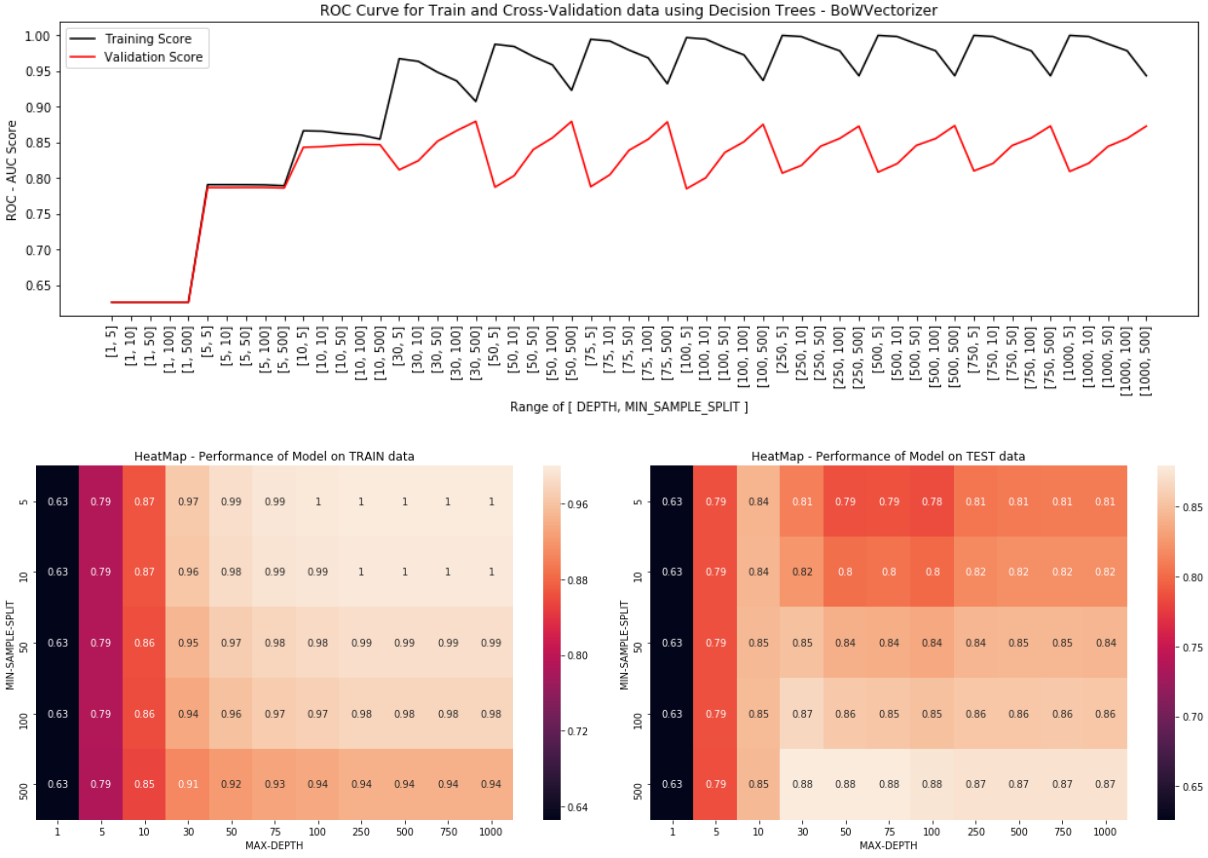
In [36]:
```
#Using only 100k points for Decision Trees
min_final = final.sample(n=100000)
x_train, x_test, y_train, y_test = train_test_split(min_final['CleanedT
ext'], min_final['Score'], test_size=0.30)

depth_range = [1, 5, 10, 30, 50, 75, 100, 250, 500, 750, 1000]
min_split_range = [5, 10, 50, 100, 500]
tot_hyp_length = np.arange(0, len(depth_range) * len(min_split_range))
```

[5.1] Applying Decision Trees on BOW, SET 1

In [37]:
```
# Applying BOW Vectorizer
bow_model = CountVectorizer(ngram_range=(1,2), min_df=0.0001, max_featu
res=4000)
bow_model.fit(x_train)

x_train_bow = bow_model.transform(x_train)
x_test_bow = bow_model.transform(x_test)
```

In [38]:
```
# Applying DecisionTreeClassifier using GridSearch CV=10
dtc = DecisionTreeClassifier()
parameters = {'max_depth': depth_range, 'min_samples_split': min_split_
range}
clf = GridSearchCV(dtc, parameters, cv=10, scoring = 'roc_auc', return_
train_score=True)
clf.fit(x_train_bow, y_train)

mean_train_score = clf.cv_results_['mean_train_score']
mean_test_score = clf.cv_results_['mean_test_score']

param_arr = list(map(lambda obj: list([obj['max_depth'], obj['min_sampl
es_split']]), clf.cv_results_['params']))

plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(tot_hyp_length, mean_train_score, label='Training Score', colo
r='black')
plt.plot(tot_hyp_length, mean_test_score, label='Validation Score', col
or='red')
plt.xticks(tot_hyp_length, param_arr, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Decision
 Trees - BoWVectorizer")
plt.xlabel("Range of [ DEPTH, MIN_SAMPLE_SPLIT ]")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")

m_train_score = clf.cv_results_['mean_train_score'].reshape((len(depth_
range), len(min_split_range))).T
m_test_score = clf.cv_results_['mean_test_score'].reshape((len(depth_ra
nge), len(min_split_range))).T

plt.figure(figsize=(18,6))
plt.subplot(1, 2, 1)
plt.title('HeatMap - Performance of Model on TRAIN data')
```

```
ax1 = sns.heatmap(m_train_score, annot=True, xticklabels=depth_range, y
ticklabels=min_split_range)
ax1.set_xlabel('MAX-DEPTH')
ax1.set_ylabel('MIN-SAMPLE-SPLIT')

plt.subplot(1, 2, 2)
plt.title('HeatMap - Performance of Model on TEST data')
ax2 = sns.heatmap(m_test_score, annot=True, xticklabels=depth_range, yt
icklabels=min_split_range)
ax2.set_xlabel('MAX-DEPTH')
ax2.set_ylabel('MIN-SAMPLE-SPLIT')

plt.tight_layout()
plt.show()
```

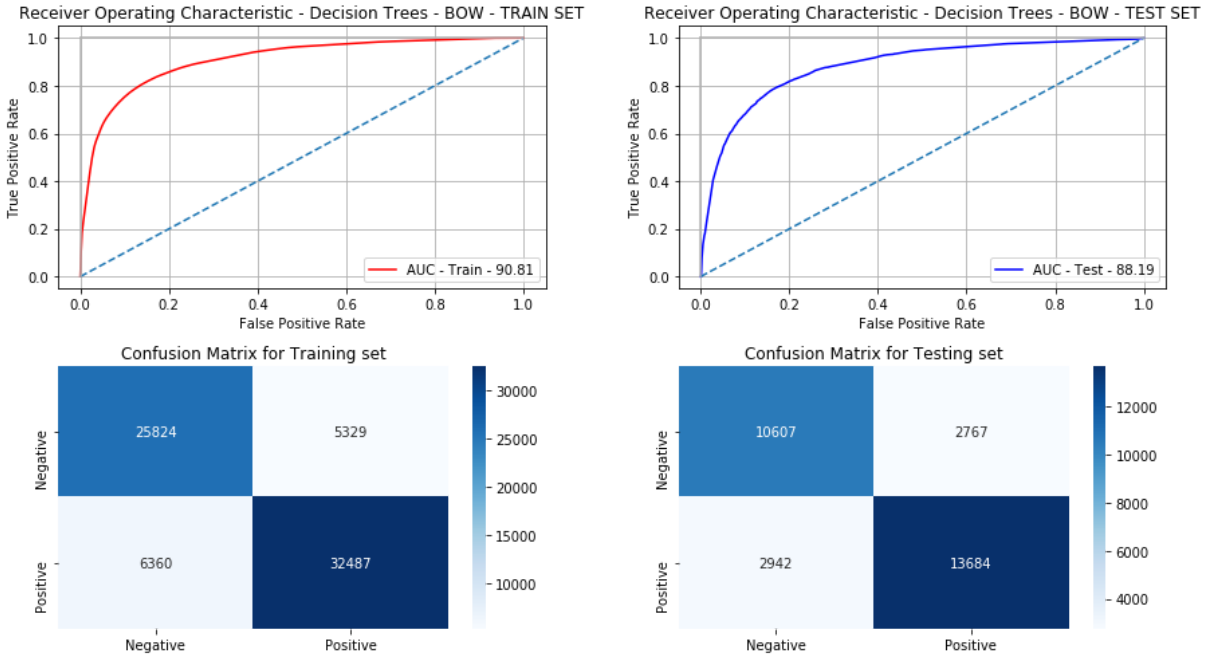


In [39]:
```
optimal_depth = clf.best_params_['max_depth']
optimal_min_split = clf.best_params_['min_samples_split']

clf = DecisionTreeClassifier(max_depth = optimal_depth, min_samples_spl
it = optimal_min_split)
clf.fit(x_train_bow, y_train)

# Get predicted values for test data
pred_train = clf.predict(x_train_bow)
pred_test = clf.predict(x_test_bow)
pred_proba_train = clf.predict_proba(x_train_bow)[:,1]
pred_proba_test = clf.predict_proba(x_test_bow)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_
train, pos_label=1)
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test
, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Depth: {} with Min_Split: {} with AUC: {:.2f}%".format(o
ptimal_depth, optimal_min_split, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Bag of Words(BoW)'
,
                                      'MAX-DEPTH(HYPERPARAMETER)': opti
mal_depth,
                                      'MIN_SPLIT(HYPERPARAMETER)': opti
mal_min_split,
                                      'DATASET-SIZE': '{0:,.0f}'.format
(int(min_final.shape[0])),
                                      'F1_SCORE': f1_sc,
                                      'AUC': auc_sc
                                     }, ignore_index=True)
```

```
plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Decision Trees - BOW - T
RAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}
'.format(float(auc_sc_train * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Decision Trees - BOW - T
EST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.
format(float(auc_sc * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
```

```
                    columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
plt.show()
```

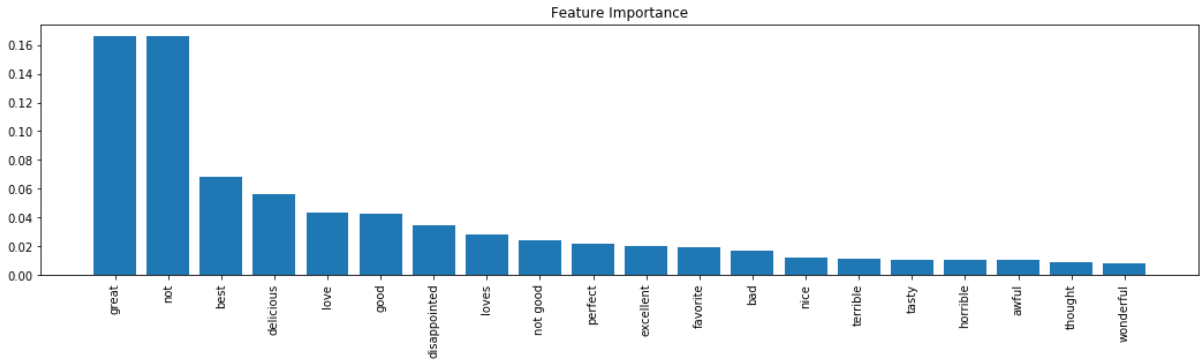
```
Optimal Depth: 30 with Min_Split: 500 with AUC: 88.19%
```



[5.1.1] Top 20 important features from SET 1

In [40]:
```
feature_imp_values = clf.feature_importances_
bow_features_names = bow_model.get_feature_names()

indices = np.argsort(feature_imp_values)[::-1]
names = [bow_features_names[i] for i in indices]

# Create plot
plt.figure(figsize=(18,4))
```

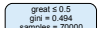
```
plt.title("Feature Importance")
# Add bars
plt.bar(range(20), feature_imp_values[indices][:20])
# Add feature names as x-axis labels
plt.xticks(range(20), names[:20], rotation=90)
plt.show()
```

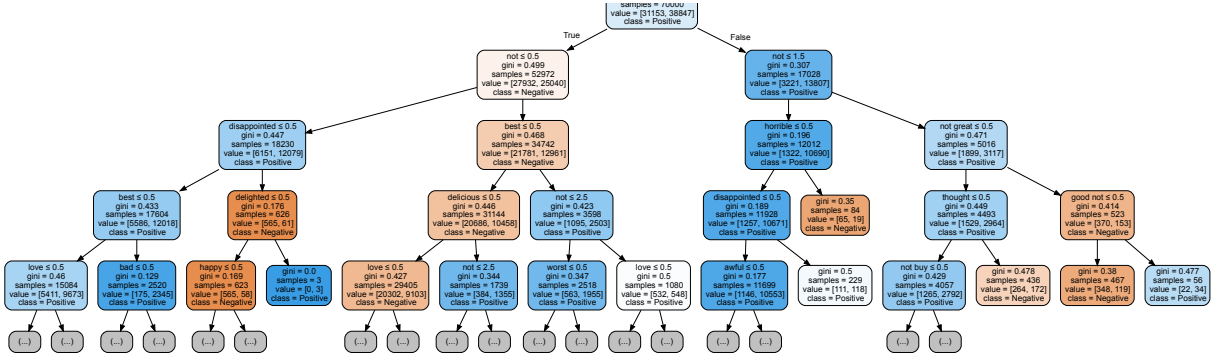


[5.1.2] Graphviz visualization of Decision Tree on BOW, SET 1

In [41]:
```
dot_data = export_graphviz(clf, out_file=None, max_depth=4,
                           feature_names=bow_features_names,
                           class_names=["Negative", "Positive"],
                           filled=True, rounded=True,special_characters
=True)
graph = graphviz.Source(dot_data)
graph.render('graphviz-bow')
graph
```

Out[41]:



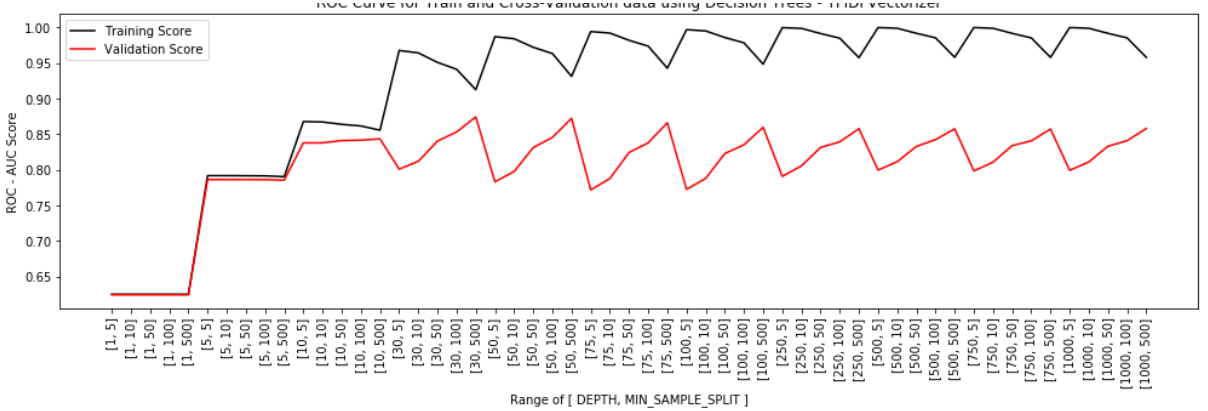


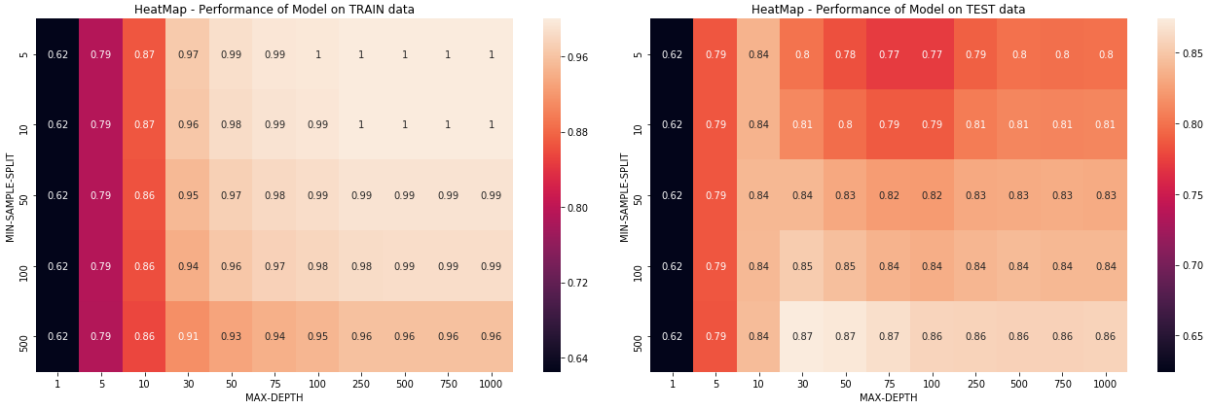
[5.2] Applying Decision Trees on TFIDF, SET 2

In [42]:
```
# Applying TFIDF Vectorizer
tfidf_model = TfidfVectorizer(ngram_range=(1,2), min_df=0.0001, max_fea
tures=4000)
tfidf_model.fit(x_train)

x_train_tfidf = tfidf_model.transform(x_train)
x_test_tfidf = tfidf_model.transform(x_test)
```

In [43]:
```
# Applying DecisionTreeClassifier using GridSearch CV=10
dtc = DecisionTreeClassifier()
parameters = {'max_depth': depth_range, 'min_samples_split': min_split_
range}
clf = GridSearchCV(dtc, parameters, cv=10, scoring = 'roc_auc', return_
train_score=True)
clf.fit(x_train_tfidf, y_train)

mean_train_score = clf.cv_results_['mean_train_score']
mean_test_score = clf.cv_results_['mean_test_score']

param_arr = list(map(lambda obj: list([obj['max_depth'], obj['min_sampl
es_split']]), clf.cv_results_['params']))

plt.figure(figsize=(14, 5))
```

```
#Plot mean accuracy for train and cv set scores
plt.plot(tot_hyp_length, mean_train_score, label='Training Score', colo
r='black')
plt.plot(tot_hyp_length, mean_test_score, label='Validation Score', col
or='red')
plt.xticks(tot_hyp_length, param_arr, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Decision
 Trees - TFIDFVectorizer")
plt.xlabel("Range of [ DEPTH, MIN_SAMPLE_SPLIT ]")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")

m_train_score = clf.cv_results_['mean_train_score'].reshape((len(depth_
range), len(min_split_range))).T
m_test_score = clf.cv_results_['mean_test_score'].reshape((len(depth_ra
nge), len(min_split_range))).T

plt.figure(figsize=(18,6))
plt.subplot(1, 2, 1)
plt.title('HeatMap - Performance of Model on TRAIN data')
ax1 = sns.heatmap(m_train_score, annot=True, xticklabels=depth_range, y
ticklabels=min_split_range)
ax1.set_xlabel('MAX-DEPTH')
ax1.set_ylabel('MIN-SAMPLE-SPLIT')

plt.subplot(1, 2, 2)
plt.title('HeatMap - Performance of Model on TEST data')
ax2 = sns.heatmap(m_test_score, annot=True, xticklabels=depth_range, yt
icklabels=min_split_range)
ax2.set_xlabel('MAX-DEPTH')
ax2.set_ylabel('MIN-SAMPLE-SPLIT')

plt.tight_layout()
plt.show()
```



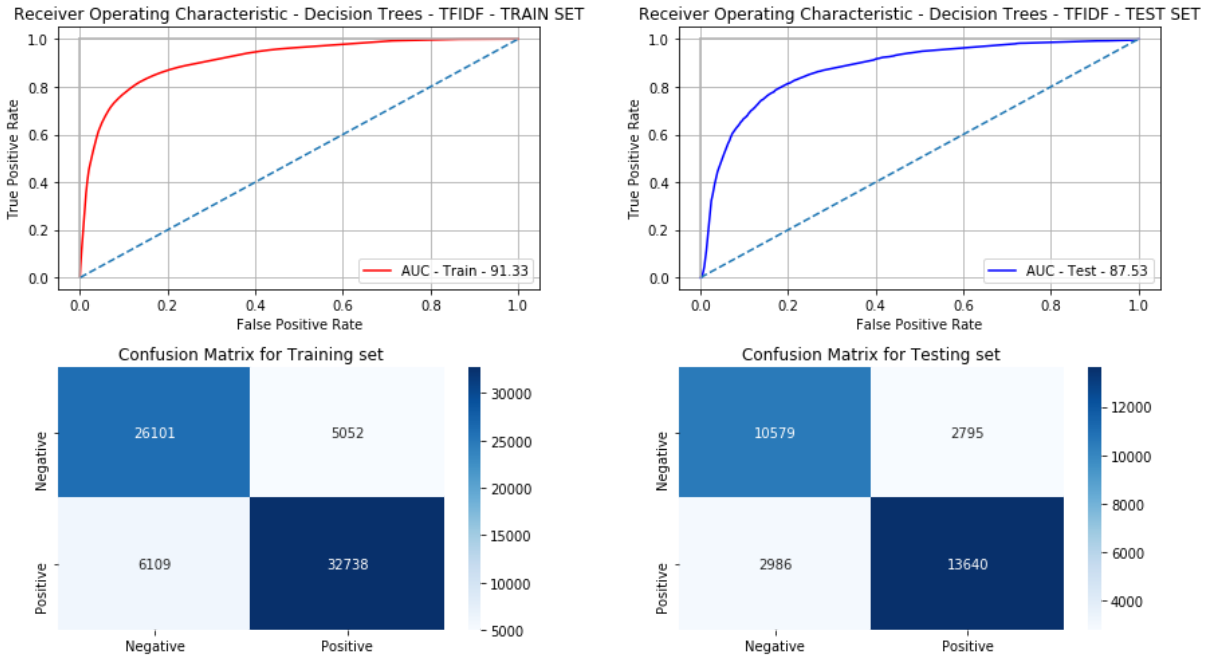


In [44]:
```
optimal_depth = clf.best_params_['max_depth']
optimal_min_split = clf.best_params_['min_samples_split']

clf = DecisionTreeClassifier(max_depth = optimal_depth, min_samples_spl
it = optimal_min_split)
clf.fit(x_train_tfidf, y_train)

# Get predicted values for test data
pred_train = clf.predict(x_train_tfidf)
pred_test = clf.predict(x_test_tfidf)
pred_proba_train = clf.predict_proba(x_train_tfidf)[:,1]
pred_proba_test = clf.predict_proba(x_test_tfidf)[:,1]
```

```
fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_
train, pos_label=1)
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test
, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Depth: {} with Min_Split: {} with AUC: {:.2f}%".format(o
ptimal_depth, optimal_min_split, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TF-IDF',
                                      'MAX-DEPTH(HYPERPARAMETER)': opti
mal_depth,
                                      'MIN_SPLIT(HYPERPARAMETER)': opti
mal_min_split,
                                      'DATASET-SIZE': '{0:,.0f}'.format
(int(min_final.shape[0])),
                                      'F1_SCORE': f1_sc,
                                      'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Decision Trees - TFIDF -
 TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}
'.format(float(auc_sc_train * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')
```

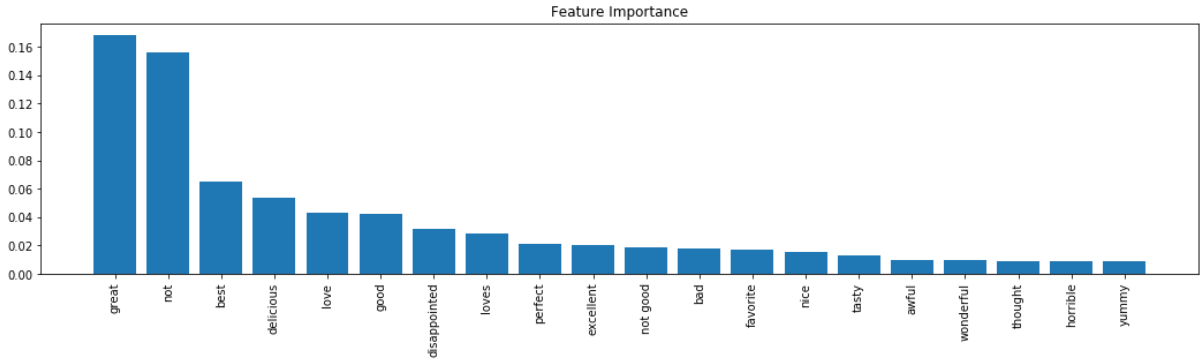
```
# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Decision Trees - TFIDF -
 TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.
format(float(auc_sc * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
plt.show()
```

```
Optimal Depth: 30 with Min_Split: 500 with AUC: 87.53%
```



[5.2.1] Top 20 important features from SET 2

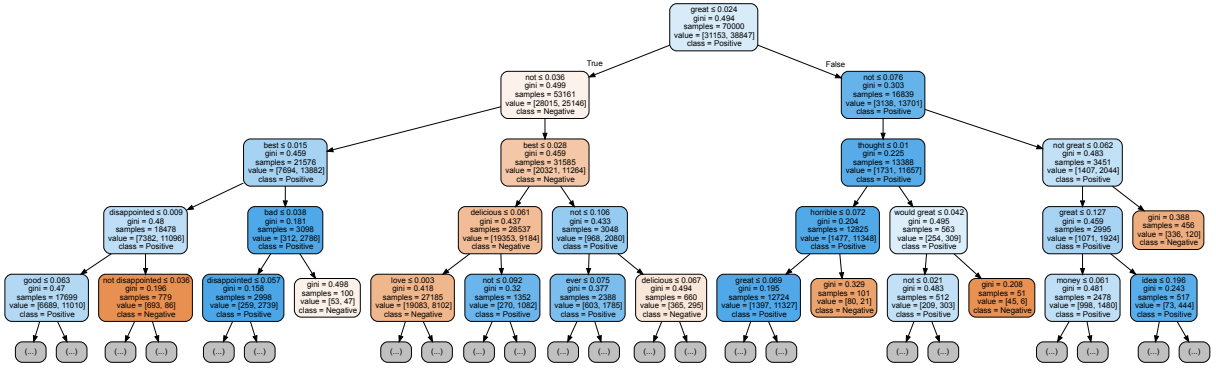
In [45]:
```
feature_imp_values = clf.feature_importances_
tfidf_features_names = tfidf_model.get_feature_names()

indices = np.argsort(feature_imp_values)[::-1]
names = [tfidf_features_names[i] for i in indices]

# Create plot
plt.figure(figsize=(18,4))
plt.title("Feature Importance")
# Add bars
plt.bar(range(20), feature_imp_values[indices][:20])
# Add feature names as x-axis labels
plt.xticks(range(20), names[:20], rotation=90)
plt.show()
```



[5.2.2] Graphviz visualization of Decision Tree on TFIDF, SET 2

In [46]:
```
dot_data = export_graphviz(clf, out_file=None, max_depth=4,
                           feature_names=tfidf_features_names,
                           class_names=["Negative", "Positive"],
                           filled=True, rounded=True,special_characters
=True)
graph = graphviz.Source(dot_data)
graph.render('graphviz-tfidf')
graph
```

Out[46]:



[5.3] Applying Decision Trees on AVG W2V, SET 3

In [47]:
```
list_of_sent_train = []
list_of_sent_test = []

for sent in x_train:
    list_of_sent_train.append(sent.split())
for sent in x_test:
    list_of_sent_test.append(sent.split())

w2v_model=Word2Vec(list_of_sent_train,min_count=5,size=50)
w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))
print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  16878
sample words  ['cranberries', 'rita', 'smokiness', 'particularly', 'dri
er', 'exiting', 'cellulose', 'degrade', 'unwilling', 'lately', 'canal',
'lengths', 'swore', 'crunchiest', 'grief', 'messed', 'song', 'dissolvin
g', 'sacrifice', 'smile', 'inedible', 'brain', 'beginners', 'bottles',
'drugs', 'runner', 'stunned', 'pikes', 'ripen', 'marvel', 'morsel', 'po
ng', 'undrinkable', 'canola', 'gratification', 'superbly', 'majority',
'grower', 'carnation', 'hirts', 'travels', 'puking', 'refried', 'hurr
y', 'agreement', 'claw', 'mousse', 'supervise', 'emperor', 'translucen
t']
```

In [48]:
```
# compute average word2vec for each review for train data
avgw2v_train = [] # the avg-w2v for each sentence/review is stored in t
his list
for sent in tqdm(list_of_sent_train, ascii=True, desc="Training Set W2
V"): # for each review/sentence
    sent_vec = np.zeros(50)
    cnt_words = 0 # num of words with a valid vector in the sentence/re
view
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
```

```
    avgw2v_train.append(sent_vec)

# compute average word2vec for each review for test data
avgw2v_test = [] # the avg-w2v for each sentence/review is stored in th
is list
for sent in tqdm(list_of_sent_test, ascii=True, desc="Testing Set W2V"
): # for each review/sentence
    sent_vec = np.zeros(50)
    cnt_words = 0 # num of words with a valid vector in the sentence/re
view
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    avgw2v_test.append(sent_vec)
```

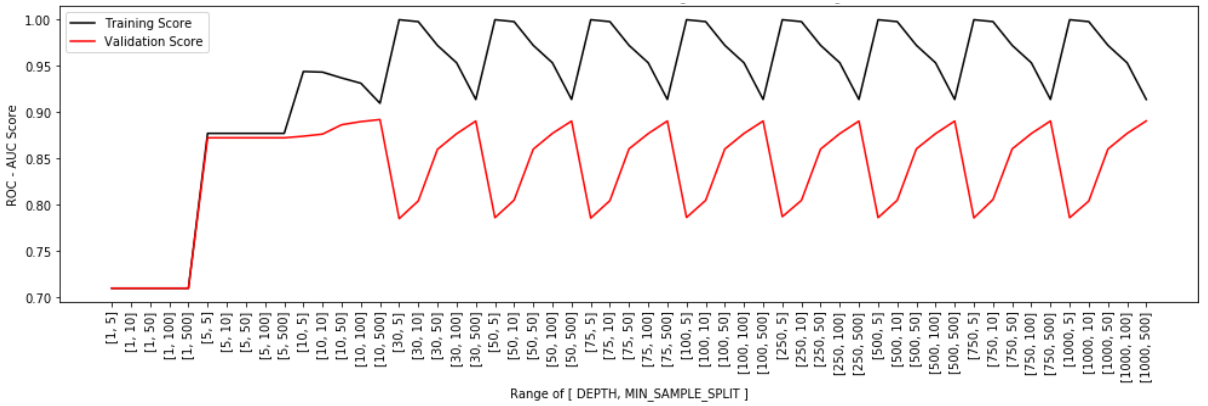
```
Training Set W2V: 100%|##########| 70000/70000 [18:04<00:00, 64.53it/s]
Testing Set W2V: 100%|##########| 30000/30000 [07:44<00:00, 64.52it/s]
```

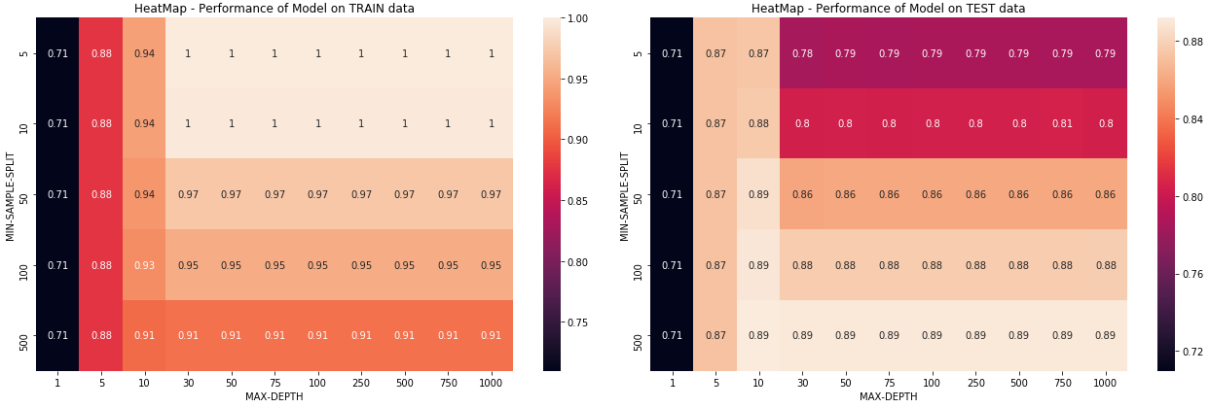
In [49]:

```
# Applying DecisionTreeClassifier using GridSearch CV=10
dtc = DecisionTreeClassifier()
parameters = {'max_depth': depth_range, 'min_samples_split': min_split_
range}
clf = GridSearchCV(dtc, parameters, cv=10, scoring = 'roc_auc', return_
train_score=True)
clf.fit(avgw2v_train, y_train)

mean_train_score = clf.cv_results_['mean_train_score']
mean_test_score = clf.cv_results_['mean_test_score']

param_arr = list(map(lambda obj: list([obj['max_depth'], obj['min_sampl
es_split']]), clf.cv_results_['params']))

plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(tot_hyp_length, mean_train_score, label='Training Score', colo
```

```
r='black')
plt.plot(tot_hyp_length, mean_test_score, label='Validation Score', col
or='red')
plt.xticks(tot_hyp_length, param_arr, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Decision
 Trees - AvgW2v Vectorizer")
plt.xlabel("Range of [ DEPTH, MIN_SAMPLE_SPLIT ]")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")

m_train_score = clf.cv_results_['mean_train_score'].reshape((len(depth_
range), len(min_split_range))).T
m_test_score = clf.cv_results_['mean_test_score'].reshape((len(depth_ra
nge), len(min_split_range))).T

plt.figure(figsize=(18,6))
plt.subplot(1, 2, 1)
plt.title('HeatMap - Performance of Model on TRAIN data')
ax1 = sns.heatmap(m_train_score, annot=True, xticklabels=depth_range, y
ticklabels=min_split_range)
ax1.set_xlabel('MAX-DEPTH')
ax1.set_ylabel('MIN-SAMPLE-SPLIT')

plt.subplot(1, 2, 2)
plt.title('HeatMap - Performance of Model on TEST data')
ax2 = sns.heatmap(m_test_score, annot=True, xticklabels=depth_range, yt
icklabels=min_split_range)
ax2.set_xlabel('MAX-DEPTH')
ax2.set_ylabel('MIN-SAMPLE-SPLIT')

plt.tight_layout()
plt.show()
```

ROC Curve for Train and Cross-Validation data using Decision Trees - AvgW2v Vectorizer



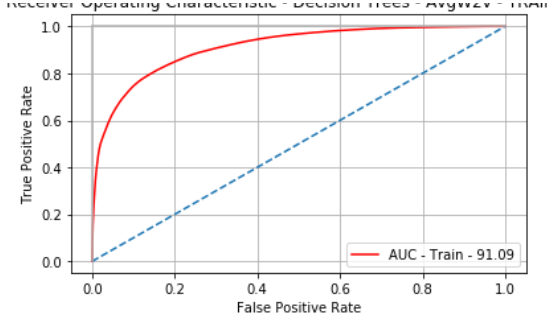


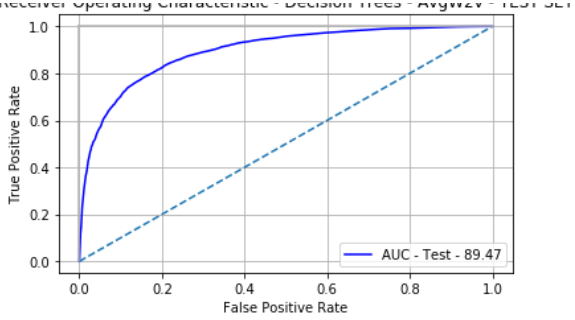
In [50]:
```
optimal_depth = clf.best_params_['max_depth']
optimal_min_split = clf.best_params_['min_samples_split']

clf = DecisionTreeClassifier(max_depth = optimal_depth, min_samples_spl
it = optimal_min_split)
clf.fit(avgw2v_train, y_train)

# Get predicted values for test data
pred_train = clf.predict(avgw2v_train)
pred_test = clf.predict(avgw2v_test)
pred_proba_train = clf.predict_proba(avgw2v_train)[:,1]
pred_proba_test = clf.predict_proba(avgw2v_test)[:,1]
```

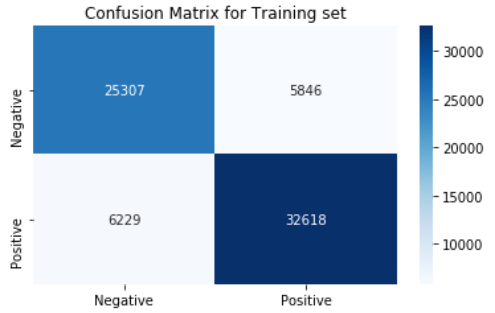
```
fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_
train, pos_label=1)
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test
, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Depth: {} with Min_Split: {} with AUC: {:.2f}%".format(o
ptimal_depth, optimal_min_split, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'Avg-W2V',
                                      'MAX-DEPTH(HYPERPARAMETER)': opti
mal_depth,
                                      'MIN_SPLIT(HYPERPARAMETER)': opti
mal_min_split,
                                      'DATASET-SIZE': '{0:,.0f}'.format
(int(min_final.shape[0])),
                                      'F1_SCORE': f1_sc,
                                      'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Decision Trees - AvgW2v
 - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}
'.format(float(auc_sc_train * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')
```

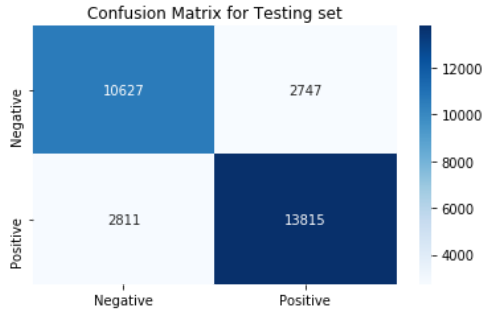
```
# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Decision Trees - AvgW2v
 - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.
format(float(auc_sc * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
plt.show()
```

```
Optimal Depth: 10 with Min_Split: 500 with AUC: 89.47%
```









[5.4] Applying Decision Trees on TFIDF W2V, SET 4

In [51]:

```
model = TfidfVectorizer()
model.fit(x_train)

#Creating the TFIDF W2V Training Set
# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))

# TF-IDF weighted Word2Vec
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidfw2v_train = [];
tfidfw2v_test = [];
```

```
for sent in tqdm(list_of_sent_train, ascii=True, desc='Training Set for
 TFIDF W2V'): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidfw2v_train.append(sent_vec)

for sent in tqdm(list_of_sent_test, ascii=True, desc='Testing Set for T
FIDF W2V'): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            vec = w2v_model.wv[word]
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidfw2v_test.append(sent_vec)
```

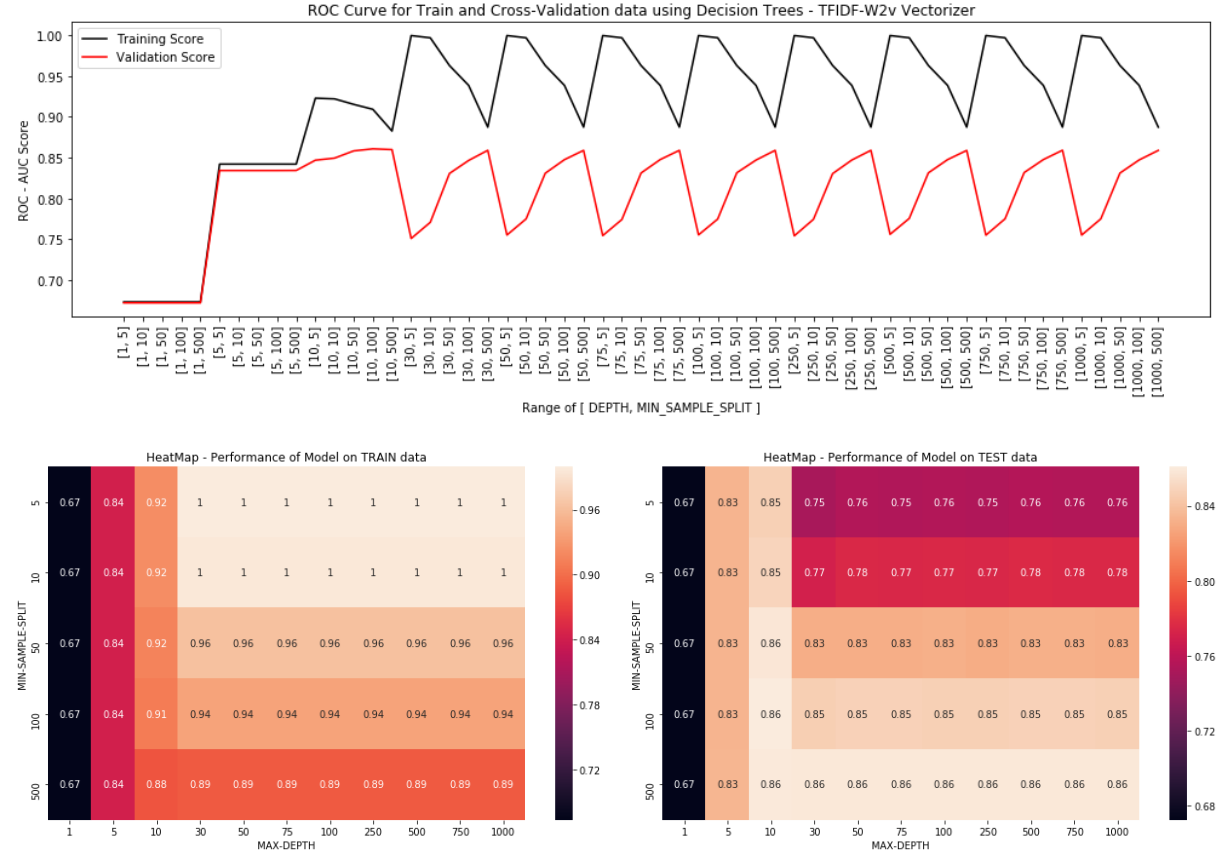
```
Training Set for TFIDF W2V: 100%|##########| 70000/70000 [51:42<00:00,
22.56it/s]
Testing Set for TFIDF W2V: 100%|##########| 30000/30000 [22:17<00:00, 2
2.43it/s]
```

In [52]:

```
# Applying DecisionTreeClassifier using GridSearch CV=10
dtc = DecisionTreeClassifier()
parameters = {'max_depth': depth_range, 'min_samples_split': min_split_
range}
```

```
clf = GridSearchCV(dtc, parameters, cv=10, scoring = 'roc_auc', return_
train_score=True)
clf.fit(tfidfw2v_train, y_train)

mean_train_score = clf.cv_results_['mean_train_score']
mean_test_score = clf.cv_results_['mean_test_score']

param_arr = list(map(lambda obj: list([obj['max_depth'], obj['min_sampl
es_split']]), clf.cv_results_['params']))

plt.figure(figsize=(14, 5))
#Plot mean accuracy for train and cv set scores
plt.plot(tot_hyp_length, mean_train_score, label='Training Score', colo
r='black')
plt.plot(tot_hyp_length, mean_test_score, label='Validation Score', col
or='red')
plt.xticks(tot_hyp_length, param_arr, rotation='vertical')

# Create plot
plt.title("ROC Curve for Train and Cross-Validation data using Decision
 Trees - TFIDF-W2v Vectorizer")
plt.xlabel("Range of [ DEPTH, MIN_SAMPLE_SPLIT ]")
plt.ylabel("ROC - AUC Score")
plt.tight_layout()
plt.legend(loc="best")

m_train_score = clf.cv_results_['mean_train_score'].reshape((len(depth_
range), len(min_split_range))).T
m_test_score = clf.cv_results_['mean_test_score'].reshape((len(depth_ra
nge), len(min_split_range))).T

plt.figure(figsize=(18,6))
plt.subplot(1, 2, 1)
plt.title('HeatMap - Performance of Model on TRAIN data')
ax1 = sns.heatmap(m_train_score, annot=True, xticklabels=depth_range, y
ticklabels=min_split_range)
ax1.set_xlabel('MAX-DEPTH')
ax1.set_ylabel('MIN-SAMPLE-SPLIT')
```

```
plt.subplot(1, 2, 2)
plt.title('HeatMap - Performance of Model on TEST data')
ax2 = sns.heatmap(m_test_score, annot=True, xticklabels=depth_range, yt
icklabels=min_split_range)
ax2.set_xlabel('MAX-DEPTH')
ax2.set_ylabel('MIN-SAMPLE-SPLIT')

plt.tight_layout()
plt.show()
```

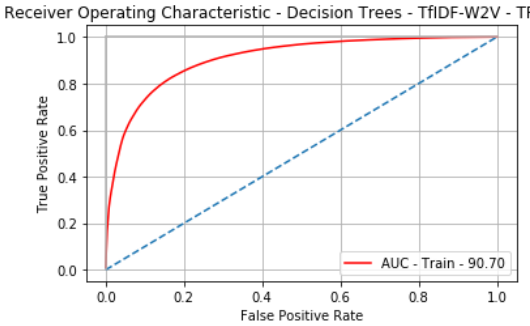


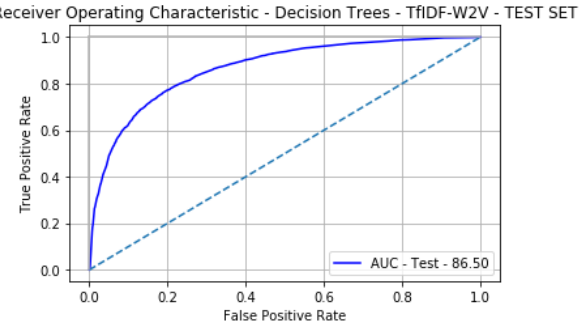
In [53]:
```
optimal_depth = clf.best_params_['max_depth']
optimal_min_split = clf.best_params_['min_samples_split']
```

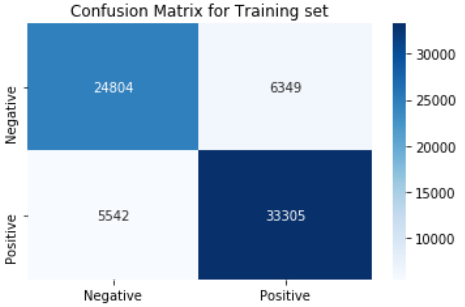
```
clf = DecisionTreeClassifier(max_depth = optimal_depth, min_samples_spl
it = optimal_min_split)
clf.fit(tfidfw2v_train, y_train)

# Get predicted values for test data
pred_train = clf.predict(tfidfw2v_train)
pred_test = clf.predict(tfidfw2v_test)
pred_proba_train = clf.predict_proba(tfidfw2v_train)[:,1]
pred_proba_test = clf.predict_proba(tfidfw2v_test)[:,1]

fpr_train, tpr_train, thresholds_train = roc_curve(y_train, pred_proba_
train, pos_label=1)
fpr_test, tpr_test, thresholds_test = roc_curve(y_test, pred_proba_test
, pos_label=1)
conf_mat_train = confusion_matrix(y_train, pred_train, labels=[0, 1])
conf_mat_test = confusion_matrix(y_test, pred_test, labels=[0, 1])
f1_sc = f1_score(y_test, pred_test, average='binary', pos_label=1)
auc_sc_train = auc(fpr_train, tpr_train)
auc_sc = auc(fpr_test, tpr_test)

print("Optimal Depth: {} with Min_Split: {} with AUC: {:.2f}%".format(o
ptimal_depth, optimal_min_split, float(auc_sc*100)))
#Saving the report in a global variable
result_report = result_report.append({'VECTORIZER': 'TFIDF-W2V',
                                      'MAX-DEPTH(HYPERPARAMETER)': opti
mal_depth,
                                      'MIN_SPLIT(HYPERPARAMETER)': opti
mal_min_split,
                                      'DATASET-SIZE': '{0:,.0f}'.format
(int(min_final.shape[0])),
                                      'F1_SCORE': f1_sc,
                                      'AUC': auc_sc
                                     }, ignore_index=True)


plt.figure(figsize=(13,7))
# Plot ROC curve for training set
plt.subplot(2, 2, 1)
plt.title('Receiver Operating Characteristic - Decision Trees - TfIDF-W
```

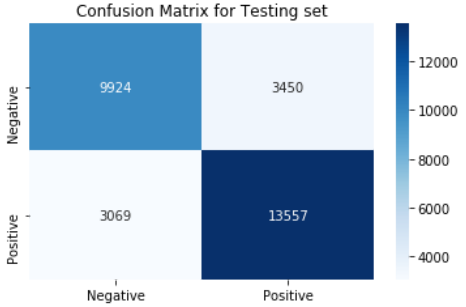
```
2V - TRAIN SET')
plt.plot(fpr_train, tpr_train, color='red', label='AUC - Train - {:.2f}
'.format(float(auc_sc_train * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

# Plot ROC curve for test set
plt.subplot(2, 2, 2)
plt.title('Receiver Operating Characteristic - Decision Trees - TfIDF-W
2V - TEST SET')
plt.plot(fpr_test, tpr_test, color='blue', label='AUC - Test - {:.2f}'.
format(float(auc_sc * 100)))
plt.plot([0, 1], ls="--")
plt.plot([0, 0], [1, 0] , c=".7"), plt.plot([1, 1] , c=".7")
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.grid()
plt.legend(loc='best')

#Plotting the confusion matrix for train
plt.subplot(2, 2, 3)
plt.title('Confusion Matrix for Training set')
df_cm = pd.DataFrame(conf_mat_train, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

#Plotting the confusion matrix for test
plt.subplot(2, 2, 4)
plt.title('Confusion Matrix for Testing set')
df_cm = pd.DataFrame(conf_mat_test, index = ["Negative", "Positive"],
                     columns = ["Negative", "Positive"])
sns.heatmap(df_cm, annot=True,cmap='Blues', fmt='g')

plt.tight_layout()
plt.show()
```

```
Optimal Depth: 10 with Min_Split: 100 with AUC: 86.50%
```









[6] Conclusions

In [54]:
```
result_report
```

Out[54]:

	VECTORIZER	DATASET-SIZE	MAX-DEPTH(HYPERPARAMETER)	MIN_SPLIT(HYPERPARAMETER)	F1_SCO
0	Bag of Words(BoW)	100,000	30	500	0.827
1	TF-IDF	100,000	30	500	0.825
2	Avg-W2V	100,000	10	500	0.832
3	TFIDF-W2V	100,000	10	100	0.806