DonorsChoose

DonorsChoose.org receives hundreds of thousands of project proposals each year for classroom projects in need of funding. Right now, a large number of volunteers is needed to manually screen each submission before it's approved to be posted on the DonorsChoose.org website.

Next year, DonorsChoose.org expects to receive close to 500,000 project proposals. As a result, there are three main problems they need to solve:

- How to scale current manual processes and resources to screen 500,000 projects so that they can be posted as quickly and as efficiently as possible
- How to increase the consistency of project vetting across different volunteers to improve the experience for teachers
- How to focus volunteer time on the applications that need the most assistance

The goal of the competition is to predict whether or not a DonorsChoose.org project proposal submitted by a teacher will be approved, using the text of project descriptions as well as additional metadata about the project, teacher, and school. DonorsChoose.org can then use this information to identify projects most likely to need further review before approval.

About the DonorsChoose Data Set

The `train.csv` data set provided by DonorsChoose contains the following features:

Feature	Description
`project_id`	A unique identifier for the proposed project. **Example:** `p036502`
`project_title`	Title of the project. **Examples:** • `Art Will Make You Happy!` • `First Grade Fun`
`project_grade_category`	Grade level of students for which the project is targeted. One of the following enumerated values: • `Grades PreK-2` • `Grades 3-5` • `Grades 6-8` • `Grades 9-12`
`project_subject_categories`	One or more (comma-separated) subject categories for the project from the following enumerated list of values: • `Applied Learning` • `Care & Hunger` • `Health & Sports` • `History & Civics` • `Literacy & Language` • `Math & Science` • `Music & The Arts`

Feature	Description
	• `Music & The Arts` • `Special Needs` • `Warmth` **Examples:** • `Music & The Arts` • `Literacy & Language, Math & Science`
`school_state`	State where school is located ([Two-letter U.S. postal code](#)). **Example:** `WY`
`project_subject_subcategories`	One or more (comma-separated) subject subcategories for the project. **Examples:** • `Literacy` • `Literature & Writing, Social Sciences`
`project_resource_summary`	An explanation of the resources needed for the project. **Example:** • `My students need hands on literacy materials to manage sensory needs!`
`project_essay_1`	First application essay[*]
`project_essay_2`	Second application essay[*]
`project_essay_3`	Third application essay[*]
`project_essay_4`	Fourth application essay[*]
`project_submitted_datetime`	Datetime when project application was submitted. **Example:** `2016-04-28 12:43:56.245`
`teacher_id`	A unique identifier for the teacher of the proposed project. **Example:** `bdf8baa8fedef6bfeec7ae4ff1c15c56`
`teacher_prefix`	Teacher's title. One of the following enumerated values: • `nan` • `Dr.` • `Mr.` • `Mrs.` • `Ms.` • `Teacher.`
`teacher_number_of_previously_posted_projects`	Number of project applications previously submitted by the same teacher. **Example:** `2`

[*] See the section **Notes on the Essay Data** for more details about these features.

Additionally, the `resources.csv` data set provides more data about the resources required for each project. Each line in this file represents a resource required by a project:

Feature	Description
`id`	A `project_id` value from the `train.csv` file. **Example:** `p036502`

Feature	Description
`description`	Description of the resource. **Example:** `Tenor Saxophone Reeds, Box of 25`
`quantity`	Quantity of the resource required. **Example:** `3`
`price`	Price of the resource required. **Example:** `9.95`

Note: Many projects require multiple resources. The `id` value corresponds to a `project_id` in train.csv, so you use it as a key to retrieve all resources needed for a project:

The data set contains the following label (the value you will attempt to predict):

Label	Description
`project_is_approved`	A binary flag indicating whether DonorsChoose approved the project. A value of `0` indicates the project was not approved, and a value of `1` indicates the project was approved.

Notes on the Essay Data

Prior to May 17, 2016, the prompts for the essays were as follows:

- __project_essay_1:__ "Introduce us to your classroom"
- __project_essay_2:__ "Tell us more about your students"
- __project_essay_3:__ "Describe how your students will use the materials you're requesting"
- __project_essay_3:__ "Close by sharing why your project will make a difference"

Starting on May 17, 2016, the number of essays was reduced from 4 to 2, and the prompts for the first 2 essays were changed to the following:

- __project_essay_1:__ "Describe your students: What makes your students special? Specific details about their background, your neighborhood, and your school are all helpful."
- __project_essay_2:__ "About your project: How will these materials make a difference in your students' learning and improve their school lives?"

For all projects with project_submitted_datetime of 2016-05-17 and later, the values of project_essay_3 and project_essay_4 will be NaN.

In [0]:

```
%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 TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer
```

```
import re
import scipy
# 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
import chart_studio.plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter
from scipy.sparse import hstack,vstack
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from sklearn import model_selection
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from prettytable import PrettyTable
from sklearn.preprocessing import Normalizer
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
nltk.download('vader_lexicon')
from sklearn.ensemble import RandomForestClassifier
from mpl_toolkits.mplot3d import Axes3D
from xgboost import XGBClassifier
from sklearn.ensemble import GradientBoostingClassifier
import pdb
```

1.1 Reading Data

In [0]:

```
Project_data = pd.read_csv('train_data_50K.csv')
Resource_data = pd.read_csv('resources.csv')
#Bk=Project_data
#print(Bk.shape)
print(Project_data.shape)
print(Resource_data.shape)
```

```
(50000, 17)
(1541272, 4)
```

In [0]:

```
# how to replace elements in list python: https://stackoverflow.com/a/2582163/4084039
cols = ['Date' if x=='project_submitted_datetime' else x for x in list(Project_data.columns)]
#sort dataframe based on time pandas python: https://stackoverflow.com/a/49702492/4084039
Project_data['Date'] = pd.to_datetime(Project_data['project_submitted_datetime'])
Project_data.drop('project_submitted_datetime', axis=1, inplace=True)
Project_data.sort_values(by=['Date'], inplace=True)
# how to reorder columns pandas python: https://stackoverflow.com/a/13148611/4084039
Project_data = Project_data[cols]
Project_data.head(2)
```

Out[0]:

	Unnamed: 0	id	teacher_id	teacher_prefix	school_state	Date	project_grade_category	project_subject_categories	project_subject_subcatego
31477	47750	p185738	3afe10b996b7646d8641985a4b4b570d	Mrs.	UT	2016-01-05 01:05:00	Grades PreK-2	Math & Science	Mathematics
40132	91045	p161351	40c9c33254a39827d6908ae9a6103c04	Teacher	CA	2016-01-05 01:59:00	Grades PreK-2	Special Needs	Special Needs

1.2 preprocessing of `project_subject_categories`

In [0]:

```
y = Project_data['project_is_approved'].values
# Project_data.drop(['project_is_approved'], axis=1, inplace=True)
lpd = len(Project_data)
ys = np.zeros(lpd, dtype=np.int32)
X = Project_data
```

In [0]:

```
#Spliting the Dataset into three Train and Test
X_Train, X_Test, Y_Train, Y_Test = train_test_split(X, y, test_size=0.33, random_state=0, stratify=ys)
print('Shape of the X_Train data is {0} and Y_Train data is: {1}'.format(X_Train.shape,Y_Train.shape[0]))
print('Shape of the X_Test data is  {0} and Y_Test data is : {1}'.format(X_Test.shape,Y_Test.shape[0]))
```

```
Shape of the X_Train data is (33500, 17) and Y_Train data is: 33500
Shape of the X_Test data is  (16500, 17) and Y_Test data is : 16500
```

In [0]:

```
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python

#*****************************************************************Train
Data*************************************************************************************
catogories = list(X_Train['project_subject_categories'].values)
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

X_Train['clean_categories'] = cat_list
X_Train.drop(['project_subject_categories'], axis=1, inplace=True)

from collections import Counter
my_counter = Counter()
for word in X_Train['clean_categories'].values:
    my_counter.update(word.split())

cat_dict = dict(my_counter)
sorted_cat_dict_Train = dict(sorted(cat_dict.items(), key=lambda kv: kv[1]))
print(len(sorted_cat_dict_Train))

#*****************************************************************Test
Data*************************************************************************************
catogories = list(X_Test['project_subject_categories'].values)
cat_list = []
for i in catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp+=j.strip()+" " #" abc ".strip() will return "abc", remove the trailing spaces
```

```
        temp = temp.replace('&','_') # we are replacing the & value into
    cat_list.append(temp.strip())

X_Test['clean_categories'] = cat_list
X_Test.drop(['project_subject_categories'], axis=1, inplace=True)
```

9

1.3 preprocessing of `project_subject_subcategories`

In [0]:

```
# remove special characters from list of strings python: https://stackoverflow.com/a/47301924/4084039

# https://www.geeksforgeeks.org/removing-stop-words-nltk-python/
# https://stackoverflow.com/questions/23669024/how-to-strip-a-specific-word-from-a-string
# https://stackoverflow.com/questions/8270092/remove-all-whitespace-in-a-string-in-python
#*****************************************************************Train
Data*************************************************************************************
sub_catogories = list(X_Train['project_subject_subcategories'].values)
sub_cat_list = []
for i in sub_catogories:
    temp = ""
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

X_Train['clean_subcategories'] = sub_cat_list
X_Train.drop(['project_subject_subcategories'], axis=1, inplace=True)

# count of all the words in corpus python: https://stackoverflow.com/a/22898595/4084039
my_counter = Counter()
for word in X_Train['clean_subcategories'].values:
    my_counter.update(word.split())

sub_cat_dict = dict(my_counter)
sorted_sub_cat_dict_Train = dict(sorted(sub_cat_dict.items(), key=lambda kv: kv[1]))
print(len(sorted_sub_cat_dict_Train))

#*****************************************************************Test
Data*************************************************************************************
sub_catogories = list(X_Test['project_subject_subcategories'].values)
sub_cat_list = []
for i in sub_catogories:
    temp = ""
```

```
    # consider we have text like this "Math & Science, Warmth, Care & Hunger"
    for j in i.split(','): # it will split it in three parts ["Math & Science", "Warmth", "Care & Hunger"]
        if 'The' in j.split(): # this will split each of the catogory based on space "Math & Science"=> "Math","&", "Science"
            j=j.replace('The','') # if we have the words "The" we are going to replace it with ''(i.e removing 'The')
        j = j.replace(' ','') # we are placeing all the ' '(space) with ''(empty) ex:"Math & Science"=>"Math&Science"
        temp +=j.strip()+" "#" abc ".strip() will return "abc", remove the trailing spaces
        temp = temp.replace('&','_')
    sub_cat_list.append(temp.strip())

X_Test['clean_subcategories'] = sub_cat_list
X_Test.drop(['project_subject_subcategories'], axis=1, inplace=True)
```

```
30
```

1.3 Text preprocessing

In [0]:

```
# merge two column text dataframe:
X_Train["essay"] = X_Train["project_essay_1"].map(str) +\
                        X_Train["project_essay_2"].map(str) + \
                        X_Train["project_essay_3"].map(str) + \
                        X_Train["project_essay_4"].map(str)


X_Test["essay"] = X_Test["project_essay_1"].map(str) +\
                        X_Test["project_essay_2"].map(str) + \
                        X_Test["project_essay_3"].map(str) + \
                        X_Test["project_essay_4"].map(str)
```

In [0]:

```
# 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 [0]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords = ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', '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', 'how', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', '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', "isn'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 [0]:

```
# Combining all the above stundents
# tqdm is for printing the status bar

#-----------------------------------PreProcessing of Essays in Train data set-----------------------------------------------
preprocessed_essays_Train = []
for sentance in tqdm(X_Train['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_Train.append(sent.lower().strip())
# pdb.set_trace()

#-----------------------------------PreProcessing of Essays in Test data set------------------------------------------------
preprocessed_essays_Test = []
for sentance in tqdm(X_Test['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
    preprocessed_essays_Test.append(sent.lower().strip())
```

```
# pdb.set_trace()
```

```
100%|██████████| 33500/33500 [00:18<00:00, 1848.60it/s]
100%|██████████| 16500/16500 [00:08<00:00, 1834.83it/s]
```

In [0]:

```
word_count_essay_Train = []
for a in tqdm(X_Train["essay"]) :
    b = len(a.split())
    word_count_essay_Train.append(b)

X_Train["word_count_essay_Train"] = word_count_essay_Train


word_count_essay_Test = []
for a in tqdm(X_Test["essay"]) :
    b = len(a.split())
    word_count_essay_Test.append(b)

X_Test["word_count_essay_Test"] = word_count_essay_Test
```

```
100%|██████████| 33500/33500 [00:00<00:00, 66475.46it/s]
100%|██████████| 16500/16500 [00:00<00:00, 65650.70it/s]
```

1.4 Preprocessing of `project_title`

In [0]:

```
# Combining all the above stundents
# tqdm is for printing the status bar

#-----------------------------------PreProcessing of Project Title in Train data set------------------------------------------
preprocessed_titles_Train = []
for sentance in tqdm(X_Train['project_title'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_Train.append(sent.lower().strip())
# pdb.set_trace()

#-----------------------------------PreProcessing of Project Title in Test data set-------------------------------------------
preprocessed_titles_Test = []
for sentance in tqdm(X_Test['project_title'].values):
```

```
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_titles_Test.append(sent.lower().strip())
# pdb.set_trace()
```

```
100%|██████████| 33500/33500 [00:00<00:00, 42123.97it/s]
100%|██████████| 16500/16500 [00:00<00:00, 42023.42it/s]
```

In [0]:

```
word_count_title_Train = []
for a in tqdm(X_Train["project_title"]) :
    b = len(a.split())
    word_count_title_Train.append(b)

X_Train["word_count_title_Train"] = word_count_title_Train

word_count_title_Test = []
for a in tqdm(X_Test["project_title"]) :
    b = len(a.split())
    word_count_title_Test.append(b)

X_Test["word_count_title_Test"] = word_count_title_Test
```

```
100%|██████████| 33500/33500 [00:00<00:00, 834164.58it/s]
100%|██████████| 16500/16500 [00:00<00:00, 835306.95it/s]
```

1.5 Preparing data for models

1.5.1 Vectorizing Categorical data

- https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/

In [0]:

```
def ResponseCoding(Train,Test,Column_Name):

  Unique_Category = Train[Column_Name].unique()
  Accept=[]
  Reject=[]
  Prob_Accept=[]
```

```
    Prob_Reject=[]
    Net=[]

    for i in Unique_Category:
      Accept.append((len(Train.loc[(Train[Column_Name] == i) & (Train['project_is_approved'] == 1)])))

    for i in Unique_Category:
      Reject.append((len(Train.loc[(Train[Column_Name] == i) & (Train['project_is_approved'] == 0)])))

    for i in range(len(Accept)):
      try:
        Prob_Accept.append(Accept[i]/(Accept[i]+Reject[i]))
      except ZeroDivisionError:
        Prob_Accept.append(0)

    for i in range(len(Reject)):
      try:
        Prob_Reject.append(Reject[i]/(Accept[i]+Reject[i]))
      except ZeroDivisionError:
        Prob_Reject.append(0)
    Prob_Accept_dict = dict(zip(Unique_Category, Prob_Accept))
    Prob_Reject_dict = dict(zip(Unique_Category, Prob_Reject))
    acc=Column_Name+'_accept'
    rej=Column_Name+'_reject'
    df = pd.DataFrame()
    df[acc] = Train[Column_Name].map(Prob_Accept_dict)
    df[rej] = Train[Column_Name].map(Prob_Reject_dict)
    acce_Train = df[acc].values.tolist()
    reje_Train = df[rej].values.tolist()
    Train_R = pd.DataFrame(list(zip(acce_Train, reje_Train)))
    #---------------------------------------------------------Test---------------------------------------------------------------------------------
    df1 = pd.DataFrame()
    df1[acc] = Test[Column_Name].map(Prob_Accept_dict)
    df1[rej] = Test[Column_Name].map(Prob_Reject_dict)
    acce_Test = df1[acc].values.tolist()
    reje_Test = df1[rej].values.tolist()
    Test_R = pd.DataFrame(list(zip(acce_Test, reje_Test)))
    Test_R.fillna(0.5, inplace = True)  #Filling the unseen values with 0.5 values.
    return Train_R,Test_R
```

project_subject_categories,project_subject_subcategories, School State, Prefix, project_grade_category

In [0]:

```
X_Train_clean_cat_raw,X_Test_clean_cat_raw=ResponseCoding(X_Train,X_Test,'clean_categories')
X_Train_clean_subcat_raw,X_Test_clean_subcat_raw=ResponseCoding(X_Train,X_Test,'clean_subcategories')
X_Train_grade_raw,X_Test_grade_raw=ResponseCoding(X_Train,X_Test,'school_state')
X_Train_state_raw,X_Test_state_raw=ResponseCoding(X_Train,X_Test,'teacher_prefix')
X_Train_teacher_raw,X_Test_teacher_raw=ResponseCoding(X_Train,X_Test,'project_grade_category')

X_Train_clean_cat= scipy.sparse.csr_matrix(X_Train_clean_cat_raw.values)
```

```
X_Train_clean_subcat= scipy.sparse.csr_matrix(X_Train_clean_subcat_raw.values)
X_Train_grade= scipy.sparse.csr_matrix(X_Train_grade_raw.values)
X_Train_state= scipy.sparse.csr_matrix(X_Train_state_raw.values)
X_Train_teacher= scipy.sparse.csr_matrix(X_Train_teacher_raw.values)
```

In [0]:

```
X_Test_clean_cat = scipy.sparse.csr_matrix(X_Test_clean_cat_raw.values)
X_Test_clean_subcat = scipy.sparse.csr_matrix(X_Test_clean_subcat_raw.values)
X_Test_grade = scipy.sparse.csr_matrix(X_Test_grade_raw.values)
X_Test_state = scipy.sparse.csr_matrix(X_Test_state_raw.values)
X_Test_teacher = scipy.sparse.csr_matrix(X_Test_teacher_raw.values)
```

1.5.2 Vectorizing Numerical features

In [0]:

```
price_data = Resource_data.groupby('id').agg({'price':'sum', 'quantity':'sum'}).reset_index()
X_Train = pd.merge(X_Train, price_data, on='id', how='left')
X_Test = pd.merge(X_Test, price_data, on='id', how='left')
```

In [0]:

```
price_norm = Normalizer(norm='l2', copy=False)
price_norm.fit(X_Train['price'].values.reshape(1,-1))

p=price_norm.transform(X_Train['price'].values.reshape(1,-1))
price_norm.transform(X_Test['price'].values.reshape(1,-1))
price_norm_Train = (X_Train['price'].values.reshape(-1,1))
price_norm_Test = (X_Test['price'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized price dataset matrix after one hot encoding is: {0}'.format(price_norm_Train.shape))
print('Shape of Test normalized price dataset matrix after one hot encoding is: {0}'.format(price_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized price dataset matrix after one hot encoding is: (33500, 1)
Shape of Test normalized price dataset matrix after one hot encoding is: (16500, 1)
```

In [0]:

```
quantity_norm = Normalizer(norm='l2', copy=False)
quantity_norm.fit(X_Train['quantity'].values.reshape(1,-1))

quantity_norm.transform(X_Train['quantity'].values.reshape(1,-1))
quantity_norm.transform(X_Test['quantity'].values.reshape(1,-1))
quantity_norm_Train = quantity_norm.transform(X_Train['quantity'].values.reshape(-1,1))
quantity_norm_Test = quantity_norm.transform(X_Test['quantity'].values.reshape(-1,1))
```

```
print("-"*120)
print('Shape of Train normalized quantity dataset matrix after one hot encoding is: {0}'.format(quantity_norm_Train.shape))
print('Shape of Test normalized quantity dataset matrix after one hot encoding is: {0}'.format(quantity_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized quantity dataset matrix after one hot encoding is: (33500, 1)
Shape of Test normalized quantity dataset matrix after one hot encoding is: (16500, 1)
```

In [0]:

```
teacher_prev_post_norm = Normalizer(norm='l2', copy=False)
teacher_prev_post_norm.fit(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

teacher_prev_post_norm.transform(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
teacher_prev_post_norm.transform(X_Test['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
teacher_prev_post_norm_Train = teacher_prev_post_norm.transform(X_Train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
teacher_prev_post_norm_Test = teacher_prev_post_norm.transform(X_Test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized previously posted project dataset matrix after one hot encoding is: {0}'.format(teacher_prev_post_norm_Train.shape
))
print('Shape of Test normalized previously posted project dataset matrix after one hot encoding is: {0}'.format(teacher_prev_post_norm_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized previously posted project dataset matrix after one hot encoding is: (33500, 1)
Shape of Test normalized previously posted project dataset matrix after one hot encoding is: (16500, 1)
```

In [0]:

```
title_norm = Normalizer(norm='l2', copy=False)
title_norm.fit(X_Train['word_count_title_Train'].values.reshape(1,-1))
title_norm.transform(X_Train['word_count_title_Train'].values.reshape(1,-1))
title_norm.transform(X_Test['word_count_title_Test'].values.reshape(1,-1))
word_count_title_Train = title_norm.transform(X_Train['word_count_title_Train'].values.reshape(-1,1))
word_count_title_Test = title_norm.transform(X_Test['word_count_title_Test'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_title_Train.shape))
print('Shape of Test normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_title_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized title dataset matrix after one hot encoding is: (33500, 1)
Shape of Test normalized title dataset matrix after one hot encoding is: (16500, 1)
```

In [0]:

```
essay_norm = Normalizer(norm='l2', copy=False)
essay_norm.fit(X_Train['word_count_essay_Train'].values.reshape(1,-1))
essay_norm.transform(X_Train['word_count_essay_Train'].values.reshape(1,-1))
essay_norm.transform(X_Test['word_count_essay_Test'].values.reshape(1,-1))
```

```
word_count_essay_Train = essay_norm.transform(X_Train['word_count_essay_Train'].values.reshape(-1,1))
word_count_essay_Test = essay_norm.transform(X_Test['word_count_essay_Test'].values.reshape(-1,1))
print("-"*120)
print('Shape of Train normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_essay_Train.shape))
print('Shape of Test normalized title dataset matrix after one hot encoding is: {0}'.format(word_count_essay_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Shape of Train normalized title dataset matrix after one hot encoding is: (33500, 1)
Shape of Test normalized title dataset matrix after one hot encoding is: (16500, 1)
```

1.5.3 Vectorizing Text data

1.5.3.1 Bag of words

In [0]:

```
# We are considering only the words which appeared in at least 10 documents(rows or projects).
vectorizer_essays_bow = CountVectorizer(min_df=10)
text_bow_Train = vectorizer_essays_bow.fit_transform(preprocessed_essays_Train)
text_bow_Test = vectorizer_essays_bow.transform(preprocessed_essays_Test)
print("-"*120)
print("Applying Bag Of Words for Text Data")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(text_bow_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(text_bow_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying Bag Of Words for Text Data
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (33500, 10323)
Shape of Test dataset matrix after one hot encoding is: (16500, 10323)
```

Bag of Words for Project Title

In [0]:

```
# you can vectorize the title also
# before you vectorize the title make sure you preprocess it
vectorizer_titles_bow = CountVectorizer(min_df=10)
title_bow_Train = vectorizer_titles_bow.fit_transform(preprocessed_titles_Train)
title_bow_Test = vectorizer_titles_bow.transform(preprocessed_titles_Test)
print("-"*120)
print("Applying Bag Of Words for Project Title Data")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(title_bow_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(title_bow_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying Bag Of Words for Project Title Data
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (33500, 1626)
Shape of Test dataset matrix after one hot encoding is: (16500, 1626)
```

1.5.2.2 TFIDF vectorizer

In [0]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer_essays_tfidf = TfidfVectorizer(min_df=10)
text_tfidf_Train = vectorizer_essays_tfidf.fit_transform(preprocessed_essays_Train)
text_tfidf_Test = vectorizer_essays_tfidf.transform(preprocessed_essays_Test)
print("-"*120)
print("Applying TFIDF for Text Data")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(text_tfidf_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(text_tfidf_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying TFIDF for Text Data
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (33500, 10323)
Shape of Test dataset matrix after one hot encoding is: (16500, 10323)
```

TFIDF vectorizer for Project Title

In [0]:

```
vectorizer_titles_tfidf = TfidfVectorizer(min_df=10)
title_tfidf_Train = vectorizer_titles_tfidf.fit_transform(preprocessed_titles_Train)
title_tfidf_Test = vectorizer_titles_tfidf.transform(preprocessed_titles_Test)
print("-"*120)
print("Applying TFIDF for Project Title")
print("-"*120)
print('Shape of Train dataset matrix after one hot encoding is: {0}'.format(title_tfidf_Train.shape))
print('Shape of Test dataset matrix after one hot encoding is: {0}'.format(title_tfidf_Test.shape))
```

```
------------------------------------------------------------------------------------------------------------------------
Applying TFIDF for Project Title
------------------------------------------------------------------------------------------------------------------------
Shape of Train dataset matrix after one hot encoding is: (33500, 1626)
Shape of Test dataset matrix after one hot encoding is: (16500, 1626)
```

1.5.2.3 Using Pretrained Models: Avg W2V

In [0]:

```
# stronging variables into pickle files python: http://www.jessicayung.com/how-to-use-pickle-to-save-and-load-variables-in-python/
# make sure you have the glove_vectors file
#with open('glove_vectors', 'rb') as f:
#    model = pickle.load(f)
#    glove_words =  set(model.keys())
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
avg_w2v_vectors_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_Train.append(vector)
#-------------------------------------------------------------------------------------

avg_w2v_vectors_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector += model[word]
            cnt_words += 1
    if cnt_words != 0:
        vector /= cnt_words
    avg_w2v_vectors_Test.append(vector)

print(len(avg_w2v_vectors_Test))
print(len(avg_w2v_vectors_Test[1]))
```

```
100%|██████████| 33500/33500 [00:10<00:00, 3320.55it/s]
100%|██████████| 16500/16500 [00:05<00:00, 3290.15it/s]
```

```
16500
300
```

AVG W2V on project_title

In [0]:

```
# Similarly you can vectorize for title also
# compute average word2vec for each title.
avg_w2v_vectors_title_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Train): # for each review/sentence
    vector_title = np.zeros(300) # as word vectors are of zero length
    cnt_title_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector_title += model[word]
            cnt_title_words += 1
    if cnt_title_words != 0:
        vector_title /= cnt_title_words
    avg_w2v_vectors_title_Train.append(vector_title)


#------------------------------------------------------------------------------------------

avg_w2v_vectors_title_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Test): # for each review/sentence
    vector_title = np.zeros(300) # as word vectors are of zero length
    cnt_title_words =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if word in glove_words:
            vector_title += model[word]
            cnt_title_words += 1
    if cnt_title_words != 0:
        vector_title /= cnt_title_words
    avg_w2v_vectors_title_Test.append(vector_title)

print(len(avg_w2v_vectors_title_Test))
print(len(avg_w2v_vectors_title_Test[0]))
```

```
100%|██████████| 33500/33500 [00:00<00:00, 63778.12it/s]
100%|██████████| 16500/16500 [00:00<00:00, 60001.70it/s]
```

```
16500
300
```

1.5.2.3 Using Pretrained Models: TFIDF weighted W2V

In [0]:

```
tfidf_model_essays = TfidfVectorizer()
tfidf_model_essays.fit(preprocessed_essays_Train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model_essays.get_feature_names(), list(tfidf_model_essays.idf_)))
tfidf_words_essays = set(tfidf_model_essays.get_feature_names())
```

In [0]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Train): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words_essays):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_Train.append(vector)

#-------------------------------------------------------------------------------------------
tfidf_w2v_vectors_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_essays_Test): # for each review/sentence
    vector = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words_essays):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector += (vec * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector /= tf_idf_weight
    tfidf_w2v_vectors_Test.append(vector)

print(len(tfidf_w2v_vectors_Test))
print(len(tfidf_w2v_vectors_Test[0]))
```

```
100%|██████████| 33500/33500 [00:58<00:00, 568.94it/s]
100%|██████████| 16500/16500 [00:29<00:00, 563.88it/s]
```

```
16500
300
```

Using Pretrained Models: TFIDF weighted W2V on project_title

In [0]:

```
# Similarly you can vectorize for title also
tfidf_model_title = TfidfVectorizer()
tfidf_model_title.fit(preprocessed_titles_Train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model_title.get_feature_names(), list(tfidf_model_title.idf_)))
tfidf_words_title = set(tfidf_model_title.get_feature_names())

# compute tfidf word2vec for each title.
tfidf_w2v_vectors_title_Train = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Train): # for each review/sentence
    vector_title = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector_title += (vector_title * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector_title /= tf_idf_weight
    tfidf_w2v_vectors_title_Train.append(vector_title)

#--------------------------------------------------------------------------------------------------------------------------------


tfidf_w2v_vectors_title_Test = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(preprocessed_titles_Test): # for each review/sentence
    vector_title = np.zeros(300) # as word vectors are of zero length
    tf_idf_weight =0; # num of words with a valid vector in the sentence/review
    for word in sentence.split(): # for each word in a review/sentence
        if (word in glove_words) and (word in tfidf_words_title):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tfidf value for each word
            vector_title += (vector_title * tf_idf) # calculating tfidf weighted w2v
            tf_idf_weight += tf_idf
    if tf_idf_weight != 0:
        vector_title /= tf_idf_weight
    tfidf_w2v_vectors_title_Test.append(vector_title)

print(len(tfidf_w2v_vectors_title_Test))
print(len(tfidf_w2v_vectors_title_Test[0]))
```

```
100%|██████████| 33500/33500 [00:01<00:00, 33090.71it/s]
100%|██████████| 16500/16500 [00:00<00:00, 33814.70it/s]
```

```
16500
300
```

Calculating the sentiment score's of each of the essay

In [0]:

```
sid = SentimentIntensityAnalyzer()

essays = X_Train['essay']
essays_sentiment_TR_P = []
essays_sentiment_TR_N = []
essays_sentiment_TR_NE = []
essays_sentiment_TR_C = []
for essay in tqdm(essays):
    res = sid.polarity_scores(essay)
    essays_sentiment_TR_P.append(res['pos'])
    essays_sentiment_TR_N.append(res['neg'])
    essays_sentiment_TR_NE.append(res['neu'])
    essays_sentiment_TR_C.append(res['compound'])
X_Train['sentiment_essay_TR_P'] = essays_sentiment_TR_P
X_Train['sentiment_essay_TR_N'] = essays_sentiment_TR_N
X_Train['sentiment_essay_TR_NE'] = essays_sentiment_TR_NE
X_Train['sentiment_essay_TR_C'] = essays_sentiment_TR_C


essays = X_Test['essay']
essays_sentiment_TS_P = []
essays_sentiment_TS_N = []
essays_sentiment_TS_NE = []
essays_sentiment_TS_C = []
for essay in tqdm(essays):
    res = sid.polarity_scores(essay)
    essays_sentiment_TS_P.append(res['pos'])
    essays_sentiment_TS_N.append(res['neg'])
    essays_sentiment_TS_NE.append(res['neu'])
    essays_sentiment_TS_C.append(res['compound'])
X_Test['sentiment_essay_TS_P'] = essays_sentiment_TS_P
X_Test['sentiment_essay_TS_N'] = essays_sentiment_TS_N
X_Test['sentiment_essay_TS_NE'] = essays_sentiment_TS_NE
X_Test['sentiment_essay_TS_C'] = essays_sentiment_TS_C

sentiment_norm_P = Normalizer(norm='l2', copy=False)
sentiment_norm_N = Normalizer(norm='l2', copy=False)
sentiment_norm_NE = Normalizer(norm='l2', copy=False)
sentiment_norm_C = Normalizer(norm='l2', copy=False)


sentiment_norm_P.fit(X_Train['sentiment_essay_TR_P'].values.reshape(1,-1))
sentiment_norm_N.fit(X_Train['sentiment_essay_TR_N'].values.reshape(1,-1))
```

```
sentiment_norm_N.fit(X_Train['sentiment_essay_TR_N'].values.reshape(1,-1))
sentiment_norm_NE.fit(X_Train['sentiment_essay_TR_NE'].values.reshape(1,-1))
sentiment_norm_C.fit(X_Train['sentiment_essay_TR_C'].values.reshape(1,-1))

sentiment_Train_P = sentiment_norm_P.transform(X_Train['sentiment_essay_TR_P'].values.reshape(1,-1))
sentiment_Test_P = sentiment_norm_P.transform(X_Test['sentiment_essay_TS_P'].values.reshape(1,-1))
sentiment_Train_N = sentiment_norm_N.transform(X_Train['sentiment_essay_TR_N'].values.reshape(1,-1))
sentiment_Test_N = sentiment_norm_N.transform(X_Test['sentiment_essay_TS_N'].values.reshape(1,-1))
sentiment_Train_NE = sentiment_norm_NE.transform(X_Train['sentiment_essay_TR_NE'].values.reshape(1,-1))
sentiment_Test_NE = sentiment_norm_NE.transform(X_Test['sentiment_essay_TS_NE'].values.reshape(1,-1))
sentiment_Train_C = sentiment_norm_C.transform(X_Train['sentiment_essay_TR_C'].values.reshape(1,-1))
sentiment_Test_C = sentiment_norm_C.transform(X_Test['sentiment_essay_TS_C'].values.reshape(1,-1))

sentiment_Train_P = (X_Train['sentiment_essay_TR_P'].values.reshape(-1,1))
sentiment_Test_P = (X_Test['sentiment_essay_TS_P'].values.reshape(-1,1))
sentiment_Train_N = (X_Train['sentiment_essay_TR_N'].values.reshape(-1,1))
sentiment_Test_N = (X_Test['sentiment_essay_TS_N'].values.reshape(-1,1))
sentiment_Train_NE = (X_Train['sentiment_essay_TR_NE'].values.reshape(-1,1))
sentiment_Test_NE = (X_Test['sentiment_essay_TS_NE'].values.reshape(-1,1))
sentiment_Train_C = (X_Train['sentiment_essay_TR_C'].values.reshape(-1,1))
sentiment_Test_C = (X_Test['sentiment_essay_TS_C'].values.reshape(-1,1))


print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_P.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_P.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_N.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_N.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_NE.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_NE.shape)
print("Shape of sentiment Train matrix after one hot encodig ",sentiment_Train_C.shape)
print("Shape of sentiment Test matrix after one hot encodig ",sentiment_Test_C.shape)
```

```
100%|██████████| 33500/33500 [01:28<00:00, 377.05it/s]
100%|██████████| 16500/16500 [00:44<00:00, 369.82it/s]
```

```
Shape of sentiment Train matrix after one hot encodig  (33500, 1)
Shape of sentiment Test matrix after one hot encodig  (16500, 1)
Shape of sentiment Train matrix after one hot encodig  (33500, 1)
Shape of sentiment Test matrix after one hot encodig  (16500, 1)
Shape of sentiment Train matrix after one hot encodig  (33500, 1)
Shape of sentiment Test matrix after one hot encodig  (16500, 1)
Shape of sentiment Train matrix after one hot encodig  (33500, 1)
Shape of sentiment Test matrix after one hot encodig  (16500, 1)
```

1.5.4 Merging all the above features

- we need to merge all the numerical vectors i.e catogorical, text, numerical vectors

In [0]:

```
BOW_Train = hstack((X_Train_clean_cat, X_Train_clean_subcat, X_Train_grade, X_Train_state, X_Train_teacher,text_bow_Train,title_bow_Train,price_norm
_Train,quantity_norm_Train,teacher_prev_post_norm_Train,word_count_title_Train,word_count_essay_Train,sentiment_Train_P,sentiment_Train_N,sentiment_
Train_NE,sentiment_Train_C))
BOW_Test = hstack((X_Test_clean_cat,X_Test_clean_subcat,X_Test_grade,X_Test_state,X_Test_teacher,text_bow_Test,title_bow_Test,price_norm_Test,quanti
ty_norm_Test,teacher_prev_post_norm_Test,word_count_title_Test,word_count_essay_Test,sentiment_Test_P,sentiment_Test_N,sentiment_Test_NE,sentiment_T
est_C))
print(BOW_Train.shape)
print(BOW_Test.shape)
```

```
(33500, 11968)
(16500, 11968)
```

In [0]:

```
TFIDF_Train = hstack((X_Train_clean_cat, X_Train_clean_subcat, X_Train_grade, X_Train_state, X_Train_teacher,text_tfidf_Train,title_tfidf_Train, pri
ce_norm_Train, quantity_norm_Train, teacher_prev_post_norm_Train, word_count_title_Train,
word_count_essay_Train,sentiment_Train_P,sentiment_Train_N,sentiment_Train_NE,sentiment_Train_C))
TFIDF_Test = hstack((X_Test_clean_cat,X_Test_clean_subcat,X_Test_grade,X_Test_state,X_Test_teacher,text_tfidf_Test,title_tfidf_Test, price_norm_Test
,quantity_norm_Test,teacher_prev_post_norm_Test,word_count_title_Test,word_count_essay_Test,sentiment_Test_P,sentiment_Test_N,sentiment_Test_NE,sent
iment_Test_C))
print(TFIDF_Train.shape)
print(TFIDF_Test.shape)
```

```
(33500, 11968)
(16500, 11968)
```

In [0]:

```
AVG_W2V_Train = hstack((X_Train_clean_cat, X_Train_clean_subcat, X_Train_grade, X_Train_state, X_Train_teacher,avg_w2v_vectors_Train,avg_w2v_vectors
_title_Train, price_norm_Train, quantity_norm_Train, teacher_prev_post_norm_Train, word_count_title_Train, word_count_essay_Train,sentiment_Train_P,
sentiment_Train_N,sentiment_Train_NE,sentiment_Train_C))
AVG_W2V_Test = hstack((X_Test_clean_cat,X_Test_clean_subcat,X_Test_grade,X_Test_state,X_Test_teacher,avg_w2v_vectors_Test,avg_w2v_vectors_title_Test
, price_norm_Test,quantity_norm_Test,teacher_prev_post_norm_Test,word_count_title_Test,word_count_essay_Test,sentiment_Test_P,sentiment_Test_N,senti
ment_Test_NE,sentiment_Test_C))
print(AVG_W2V_Train.shape)
print(AVG_W2V_Test.shape)
```

```
(33500, 619)
(16500, 619)
```

In [0]:

```
TFIDF_W2V_Train = hstack((X_Train_clean_cat, X_Train_clean_subcat, X_Train_grade, X_Train_state, X_Train_teacher,tfidf_w2v_vectors_Train,tfidf_w2v_v
ectors_title_Train, price_norm_Train, quantity_norm_Train, teacher_prev_post_norm_Train, word_count_title_Train, word_count_essay_Train,sentiment_Tr
ain_P,sentiment_Train_N,sentiment_Train_NE,sentiment_Train_C))
TFIDF_W2V_Test =
hstack((X_Test_clean_cat,X_Test_clean_subcat,X_Test_grade,X_Test_state,X_Test_teacher,tfidf_w2v_vectors_Test,tfidf_w2v_vectors_title_Test,
```

```
hstack((X_Test_clean_cat,X_Test_clean_subcat,X_Test_grade,X_Test_state,X_Test_teacher,tfidf_w2v_vectors_Test,tfidf_w2v_vectors_title_Test,
price_norm_Test,quantity_norm_Test,teacher_prev_post_norm_Test,word_count_title_Test,word_count_essay_Test,sentiment_Test_P,sentiment_Test_N,sentime
nt_Test_NE,sentiment_Test_C))
print(TFIDF_W2V_Train.shape)
print(TFIDF_W2V_Test.shape)
```

```
(33500, 619)
(16500, 619)
```

Assignment 9: RF and GBDT

Response Coding: Example

> The response tabel is built only on train dataset. For a category which is not there in train data and present in test data, we will encode them with default values Ex: in our test data if have State: D then we encode it as [0.5, 0.05]

1. **Apply both Random Forrest and GBDT on these feature sets**
    - Set 1: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(BOW) + preprocessed_eassay (BOW)
    - Set 2: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)
    - Set 3: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(AVG W2V)+ preprocessed_eassay (AVG W2V)
    - Set 4: categorical(instead of one hot encoding, try response coding: use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)

2. **The hyper paramter tuning (Consider any two hyper parameters preferably n_estimators, max_depth)**
    - Find the best hyper parameter which will give the maximum AUC value
    - find the best hyper paramter using k-fold cross validation/simple cross validation data
    - use gridsearch cv or randomsearch cv or you can write your own for loops to do this task

3. **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
      with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

      or

    - 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
      seaborn heat maps with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**
    - You can choose either of the plotting techniques: 3d plot or heat map

- 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

4. **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.

2. Random Forest and GBDT

In [0]:

```
n_estimators = [10, 50, 100, 150, 200, 300, 500, 1000]
max_depth = [2, 3, 4, 5, 6, 7, 8, 9, 10]
MD=[j for j in max_depth for i in n_estimators]
ES=[i for j in max_depth for i in n_estimators]

'''for i in max_depth:
  for j in n_estimators:
    MD.append(i)
    ES.append(j)

print(ES)
print(MD)'''
print(ES)
print(MD)
```

```
[10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 5
00, 1000, 10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 500, 1000, 10, 50, 100, 150, 20
0, 300, 500, 1000, 10, 50, 100, 150, 200, 300, 500, 1000]
[2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 5, 6, 6, 6, 6, 6, 6, 6, 6, 7, 7, 7, 7, 7, 7, 7, 7, 8,
8, 8, 8, 8, 8, 8, 8, 9, 9, 9, 9, 9, 9, 9, 9, 10, 10, 10, 10, 10, 10, 10, 10]
```

2.4 Applying Random Forest

Apply Random Forest on different kind of featurization as mentioned in the instructions

For Every model that you work on make sure you do the step 2 and step 3 of instrucations

2.4.1 Applying Random Forests on BOW, SET 1

In [0]:

```
%%time

RF_clf = RandomForestClassifier(class_weight='balanced',n_jobs=-1)
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
RFRan_clf = RandomizedSearchCV(RF_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
RFRan_clf.fit(BOW_Train, Y_Train)
print("-"*120)
print(RFRan_clf.best_estimator_)
print("-"*120)
BOW_Best_ES=RFRan_clf.best_params_['n_estimators']
BOW_Best_MD=RFRan_clf.best_params_['max_depth']
AUC_TR= RFRan_clf.cv_results_['mean_train_score']
AUC_CV = RFRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed:   32.5s
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed:  1.2min finished
```

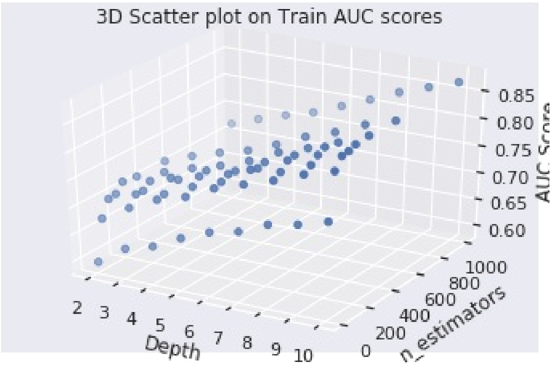
```
------------------------------------------------------------------------------------------------------------------------
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight='balanced',
                       criterion='gini', max_depth=10, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=1000,
                       n_jobs=-1, oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 39.1 s, sys: 2.9 s, total: 42 s
Wall time: 1min 18s
```

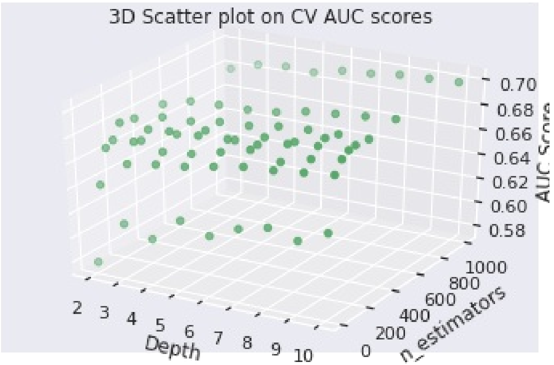
3D PLOT

In [0]:

```
#%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#------------------------------------------------------3D-Plot for Train Dataset--------------------------------------------------------------------
---
```

```
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset------------------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```

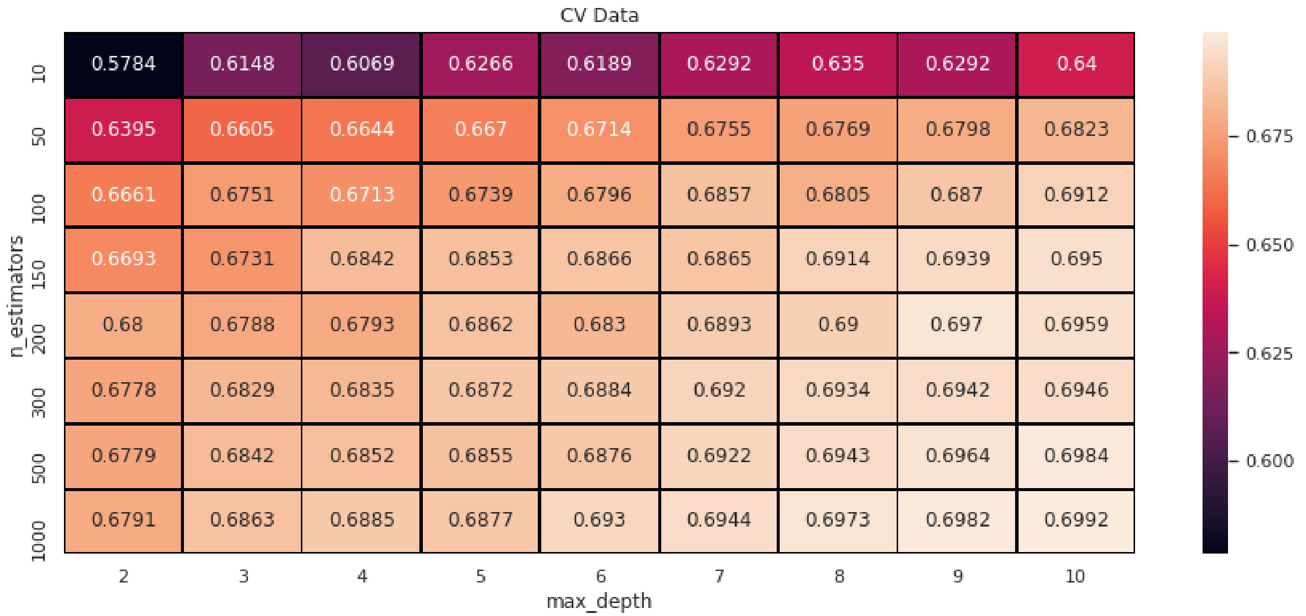




HEATMAP

In [0]:

```
%%time
#-----------------------------------------------Heat Map for Train data-----------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#-----------------------------------------------Heat Map for CV data--------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```




```
CPU times: user 1.18 s, sys: 437 ms, total: 1.61 s
Wall time: 1.14 s
```

In [0]:

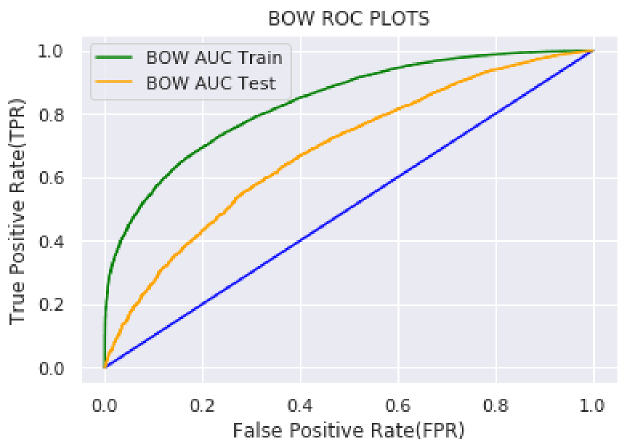
```
BOW_opt = RandomForestClassifier(n_estimators=BOW_Best_ES,max_depth=BOW_Best_MD,n_jobs=-1,class_weight='balanced')
#pdb.set_trace()
BOW_opt.fit(BOW_Train, Y_Train)
pred = BOW_opt.predict(BOW_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, BOW_opt.predict_proba(BOW_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, BOW_opt.predict_proba(BOW_Test)[:,1])
```

BOW ROC PLOT

In [0]:

```
%%time

#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci
```

```
plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="BOW AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="BOW AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("BOW ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
BOW_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred1 = BOW_opt.predict(BOW_Train)
pred2 = BOW_opt.predict(BOW_Test)
```




```
------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8357237027801431
AUC Test (for best estimator and depth) = 0.6830153857549816
CPU times: user 24.2 s, sys: 605 ms, total: 24.8 s
Wall time: 2.31 s
```

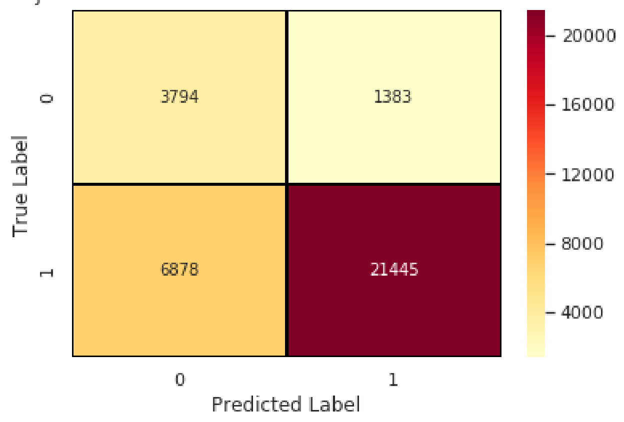
BOW CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
```

```
Train = confusion_matrix(Y_Train, pred1)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 88.2 ms, sys: 44.7 ms, total: 133 ms
Wall time: 82.9 ms
```



OBSERVATION:

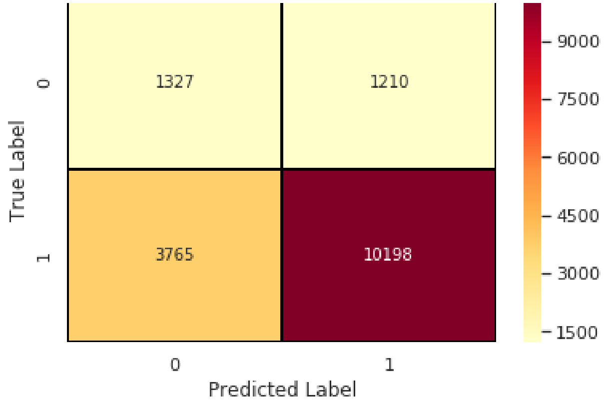
True Negative = 3794; False Negative = 6878; True Positive = 21445; False Positive = 1383
Accuracy (Overall, how often is the classifier correct) = 0.76
Precision(When it predicts yes, how often is it correct) =0.94
Misclassification (Overall, how often is it wrong) =0.25

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred2)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 74.2 ms, sys: 46.9 ms, total: 121 ms
Wall time: 69.3 ms
```

Project is APPROVED or NOT Confusion Matrix - Test Data



OBSERVATION:
True Negative = 1327; False Negative = 3765; True Positive = 10198; False Positive = 1210
Accuracy (Overall, how often is the classifier correct) = 0.70
Precision(When it predicts yes, how often is it correct) =0.90
Misclassification (Overall, how often is it wrong) =0.31

2.4.2 Applying Random Forests on TFIDF, SET 2

In [0]:

```
%%time

RF_clf = RandomForestClassifier(class_weight='balanced',n_jobs=-1)
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
RFRan_clf = RandomizedSearchCV(RF_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
RFRan_clf.fit(TFIDF_Train, Y_Train)
print("-"*120)
print(RFRan_clf.best_estimator_)
print("-"*120)
TFIDF_Best_ES=RFRan_clf.best_params_['n_estimators']
TFIDF_Best_MD=RFRan_clf.best_params_['max_depth']
AUC_TR= RFRan_clf.cv_results_['mean_train_score']
AUC_CV = RFRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed:   36.7s
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed:  1.5min finished
```

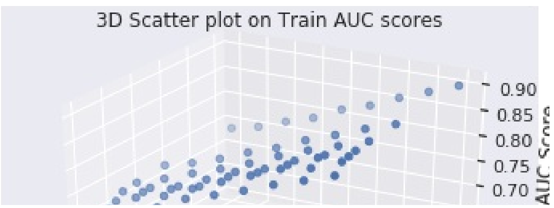
```
------------------------------------------------------------------------------------------------------------------------
```

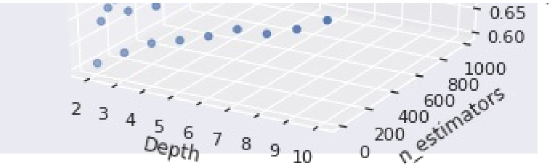
```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight='balanced',
                       criterion='gini', max_depth=10, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=1000,
                       n_jobs=-1, oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 1min 5s, sys: 2.16 s, total: 1min 7s
Wall time: 1min 34s
```

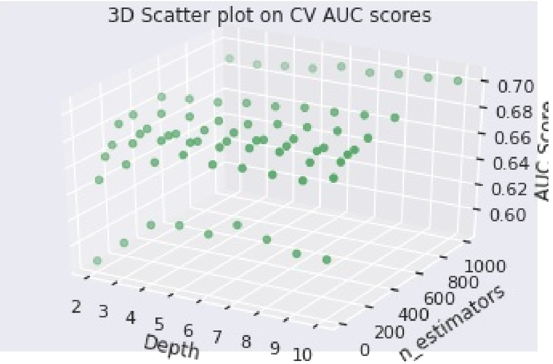
3D PLOT

In [0]:

```python
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset---------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```







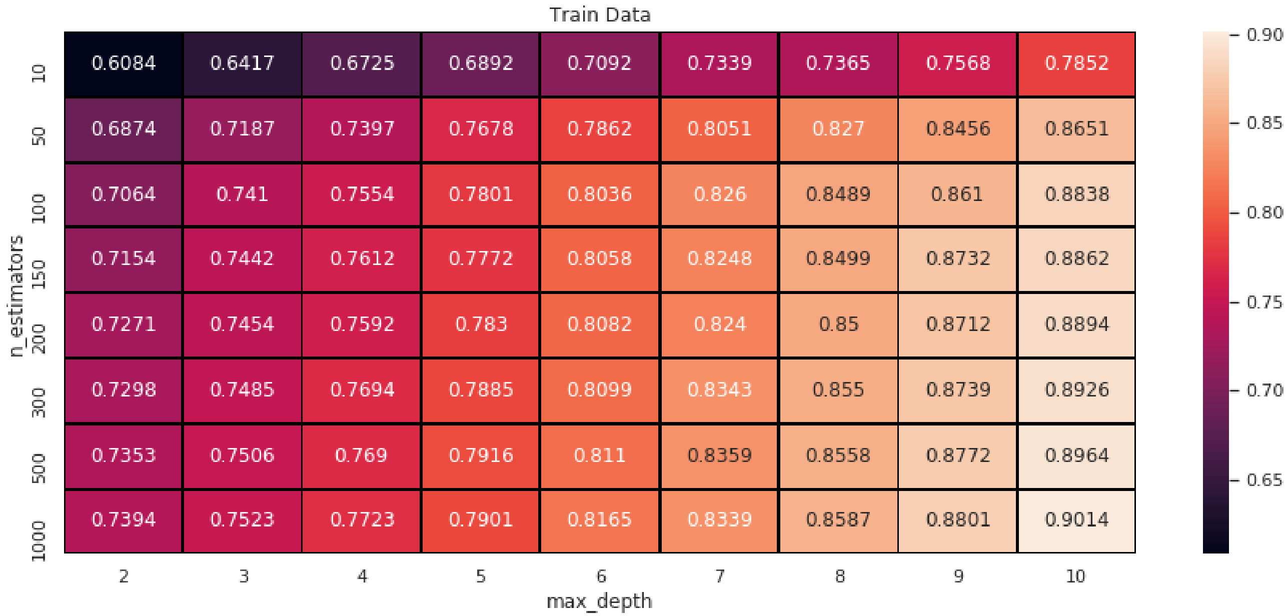

```
CPU times: user 428 ms, sys: 397 ms, total: 825 ms
Wall time: 348 ms
```

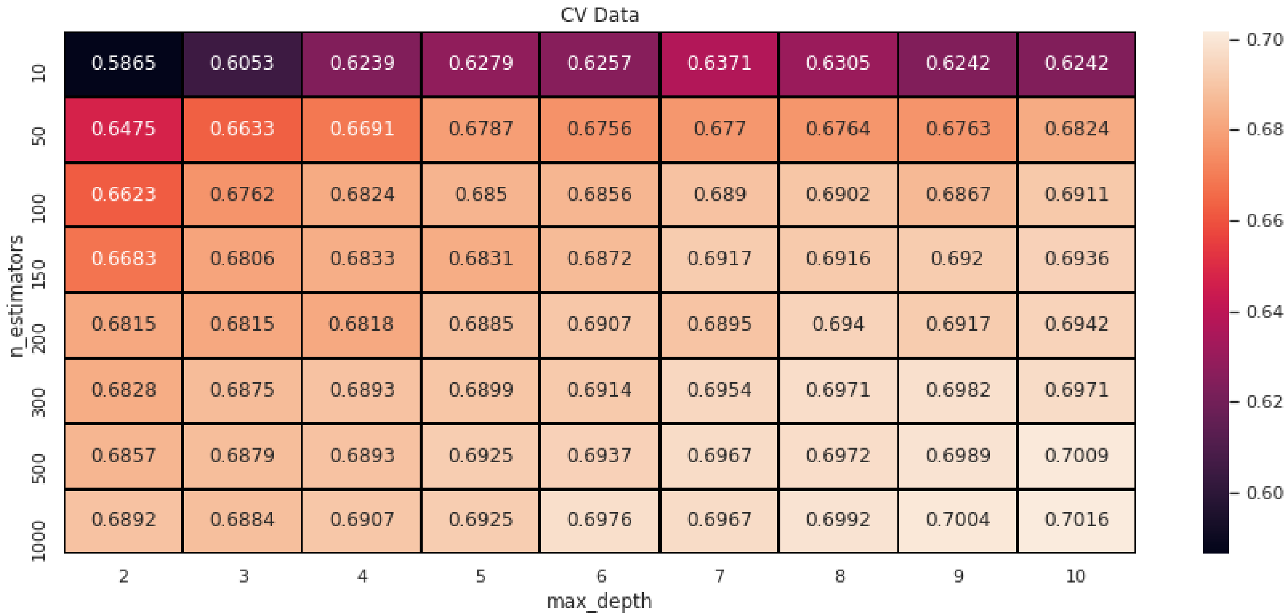
HEATMAP

In [0]:

```
%%time
#-------------------------------------------------Heat Map for Train data-------------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#-------------------------------------------------Heat Map for CV data----------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
```

```
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```





```
CPU times: user 1.2 s, sys: 448 ms, total: 1.65 s
Wall time: 1.17 s
```

In [0]:

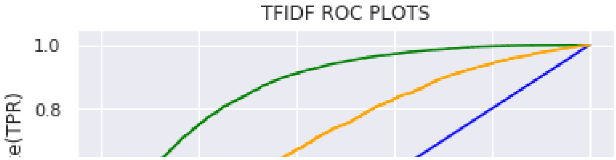
```
%%time
TFIDF_opt = RandomForestClassifier(n_estimators=TFIDF_Best_ES,max_depth=TFIDF_Best_MD,n_jobs=-1,class_weight='balanced')
#pdb.set_trace()
TFIDF_opt.fit(TFIDF_Train, Y_Train)
pred = TFIDF_opt.predict(TFIDF_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, TFIDF_opt.predict_proba(TFIDF_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, TFIDF_opt.predict_proba(TFIDF_Test)[:,1])
```

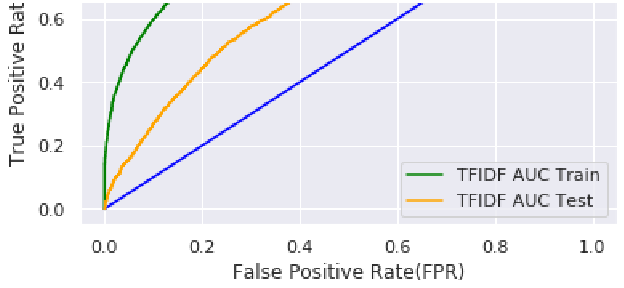
```
CPU times: user 1min 35s, sys: 2.93 s, total: 1min 38s
Wall time: 7.54 s
```

TFIDF ROC PLOT

In [0]:

```
%%time

#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci

plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="TFIDF AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="TFIDF AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("TFIDF ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
TFIDF_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred3 = TFIDF_opt.predict(TFIDF_Train)
pred4 = TFIDF_opt.predict(TFIDF_Test)
```





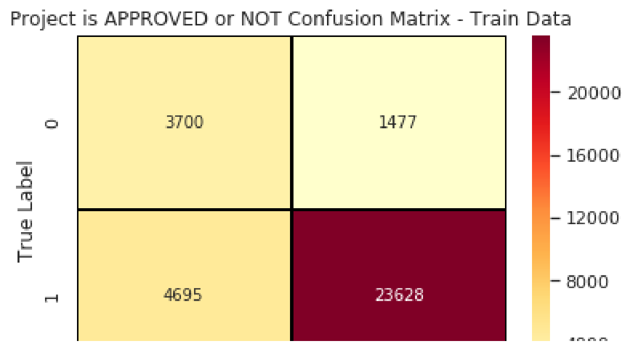

```
----------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8678407507381374
AUC Test (for best estimator and depth) = 0.6890352370252921
CPU times: user 24.2 s, sys: 582 ms, total: 24.8 s
Wall time: 2.17 s
```

TFIDF CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred3)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 88.5 ms, sys: 45.5 ms, total: 134 ms
Wall time: 83.5 ms
```

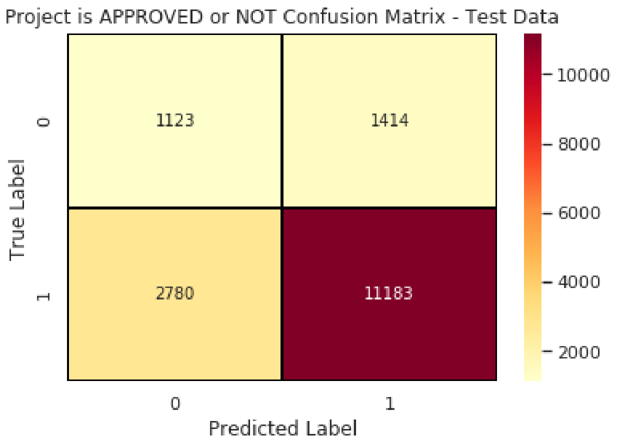


OBSERVATION:
True Negative = 3700; False Negative = 4695; True Positive = 23628; False Positive = 1477
Accuracy (Overall, how often is the classifier correct) = 0.82
Precision(When it predicts yes, how often is it correct) =0.95
Misclassification (Overall, how often is it wrong) =0.19

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred4)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 75.6 ms, sys: 41.7 ms, total: 117 ms
Wall time: 68.4 ms
```



OBSERVATION:
True Negative = 1123; False Negative = 2780; True Positive = 11183; False Positive = 1414
Accuracy (Overall, how often is the classifier correct) = 0.75
Precision(When it predicts yes, how often is it correct) =0.89

Misclassification (Overall, how often is it wrong) =0.26

2.4.3 Applying Random Forests on AVG_W2V SET 3

In [0]:

```
%%time

RF_clf = RandomForestClassifier(class_weight='balanced',n_jobs=-1)
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
RFRan_clf = RandomizedSearchCV(RF_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
RFRan_clf.fit(AVG_W2V_Train, Y_Train)
print("-"*120)
print(RFRan_clf.best_estimator_)
print("-"*120)
AVG_W2V_Best_ES=RFRan_clf.best_params_['n_estimators']
AVG_W2V_Best_MD=RFRan_clf.best_params_['max_depth']
AUC_TR= RFRan_clf.cv_results_['mean_train_score']
AUC_CV = RFRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 121 tasks      | elapsed:  2.3min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed:  6.8min finished
```

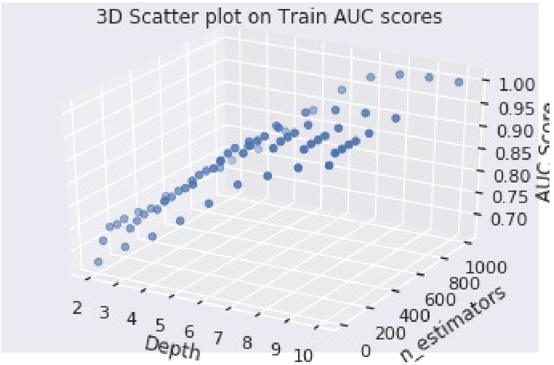
```
------------------------------------------------------------------------------------------------------------------------
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight='balanced',
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=1000,
                       n_jobs=-1, oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 4min 12s, sys: 2.49 s, total: 4min 15s
Wall time: 6min 53s
```

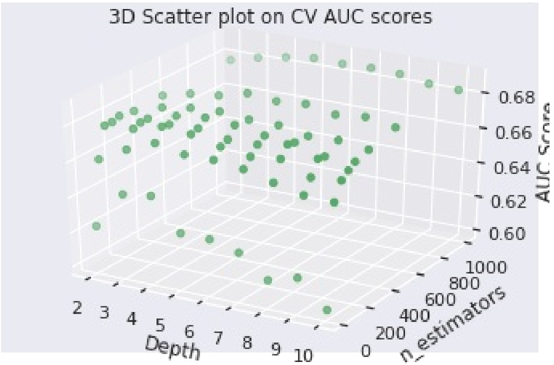
3D PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset-----------------------------------------------------------------
---
```

```
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#-------------------------------------------------------3D-Plot for CV Dataset---------------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```



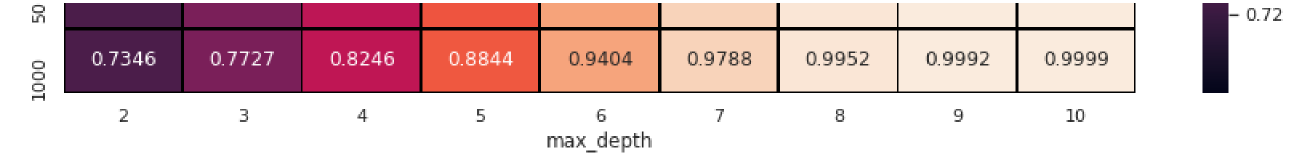


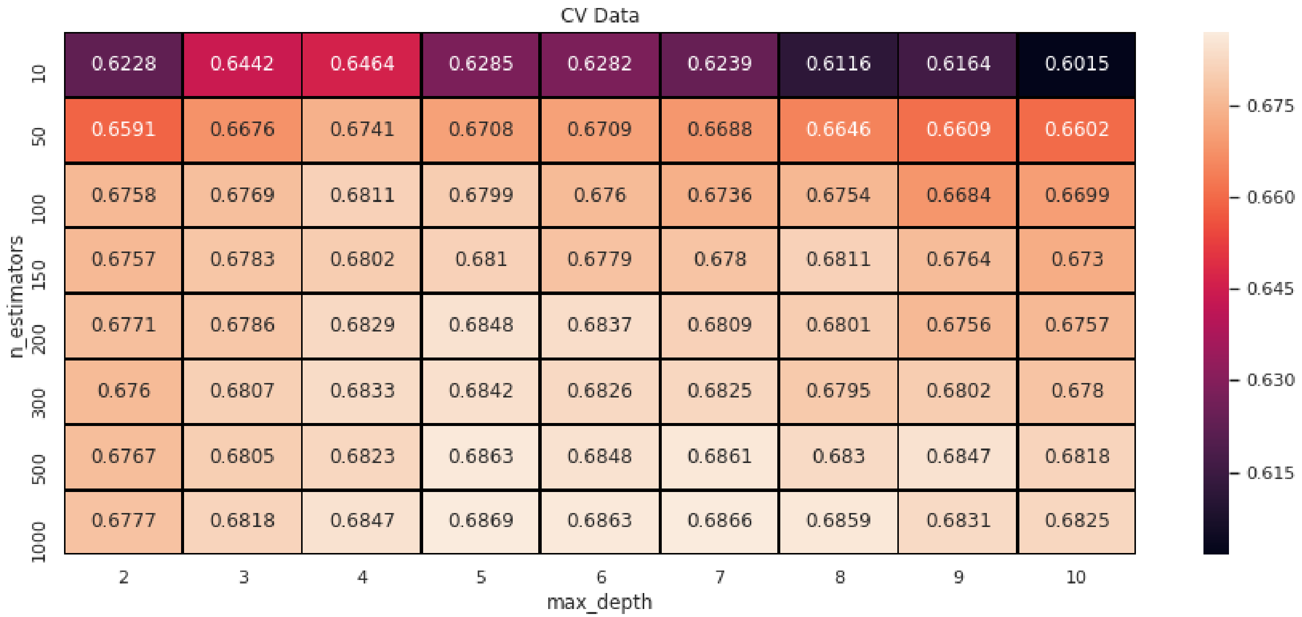
```
CPU times: user 1.02 s, sys: 4.06 s, total: 5.08 s
Wall time: 369 ms
```

HEATMAP

In [0]:

```
%%time
#--------------------------------------------------Heat Map for Train data-----------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#--------------------------------------------------Heat Map for CV data---------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```






```
CPU times: user 1.17 s, sys: 447 ms, total: 1.62 s
Wall time: 1.14 s
```

In [0]:

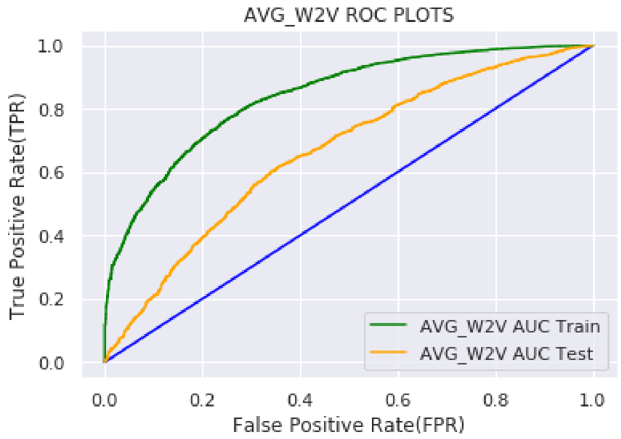
```
%%time
AVG_W2V_opt = RandomForestClassifier(n_estimators=AVG_W2V_Best_ES,max_depth=AVG_W2V_Best_MD,n_jobs=-1,class_weight='balanced')
#pdb.set_trace()
AVG_W2V_opt.fit(AVG_W2V_Train, Y_Train)
pred = AVG_W2V_opt.predict(AVG_W2V_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, AVG_W2V_opt.predict_proba(AVG_W2V_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, AVG_W2V_opt.predict_proba(AVG_W2V_Test)[:,1])
```

```
CPU times: user 4min 36s, sys: 1.85 s, total: 4min 38s
Wall time: 9.63 s
```

AVG_W2V ROC PLOT

In [0]:

```
%%time

#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci

plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="AVG_W2V AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="AVG_W2V AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AVG_W2V ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
AVG_W2V_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred5 = AVG_W2V_opt.predict(AVG_W2V_Train)
pred6 = AVG_W2V_opt.predict(AVG_W2V_Test)
```



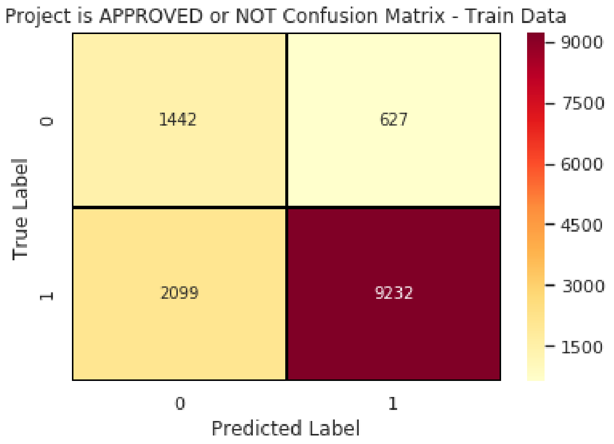

```
------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8408032063349351
AUC Test (for best estimator and depth) = 0.6638840874428062
CPU times: user 19.4 s, sys: 390 ms, total: 19.8 s
Wall time: 1.76 s
```

AVG_W2V CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred5)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 71.9 ms, sys: 49.2 ms, total: 121 ms
Wall time: 68.4 ms
```



OBSERVATION:

True Negative = 1442; False Negative = 2099; True Positive = 9232; False Positive = 627

Accuracy (Overall, how often is the classifier correct) = 0.80

Precision(When it predicts yes, how often is it correct) =0.94

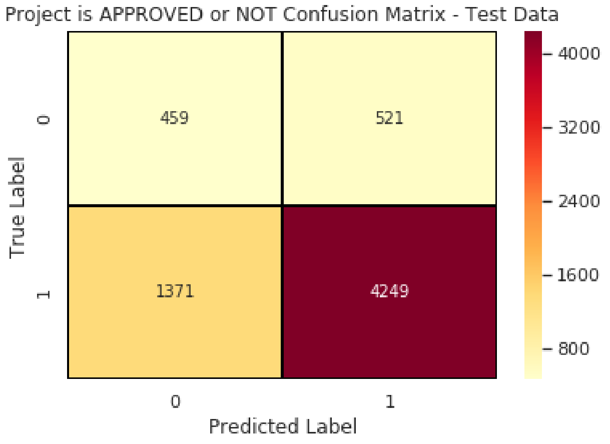
Misclassification (Overall, how often is it wrong) =0.21

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred6)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
```

```
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 71.4 ms, sys: 42.3 ms, total: 114 ms
Wall time: 62.1 ms
```



OBSERVATION:
True Negative = 459; False Negative = 1371; True Positive = 4249; False Positive = 521
Accuracy (Overall, how often is the classifier correct) = 0.72
Precision(When it predicts yes, how often is it correct) =0.90
Misclassification (Overall, how often is it wrong) =0.29

2.4.4 Applying Random Forests on TFIDF_W2V SET 4

In [0]:

```
%%time

RF_clf = RandomForestClassifier(class_weight='balanced',n_jobs=-1)
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
RFRan_clf = RandomizedSearchCV(RF_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
RFRan_clf.fit(TFIDF_W2V_Train, Y_Train)
print("-"*120)
print(RFRan_clf.best_estimator_)
print("-"*120)
TFIDF_W2V_Best_ES=RFRan_clf.best_params_['n_estimators']
TFIDF_W2V_Best_MD=RFRan_clf.best_params_['max_depth']
AUC_TR= RFRan_clf.cv_results_['mean_train_score']
AUC_CV = RFRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

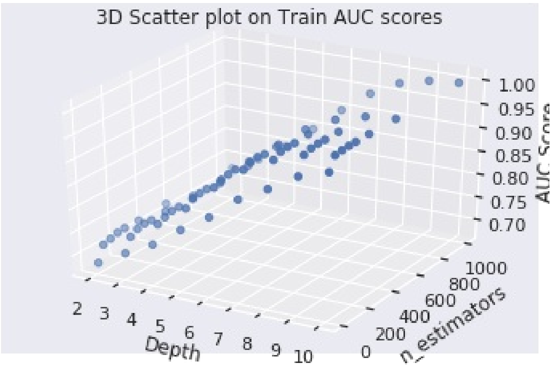
```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed:  1.2min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed:  3.5min finished
```

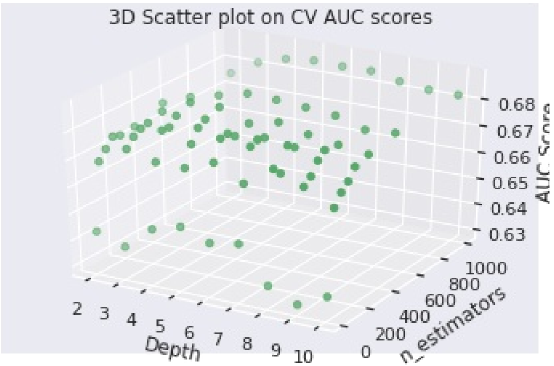
```
------------------------------------------------------------------------------------------------------------------------
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight='balanced',
                       criterion='gini', max_depth=5, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=300,
                       n_jobs=-1, oob_score=False, random_state=None, verbose=0,
                       warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 40.6 s, sys: 506 ms, total: 41.1 s
Wall time: 3min 29s
```

3D PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset---------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```





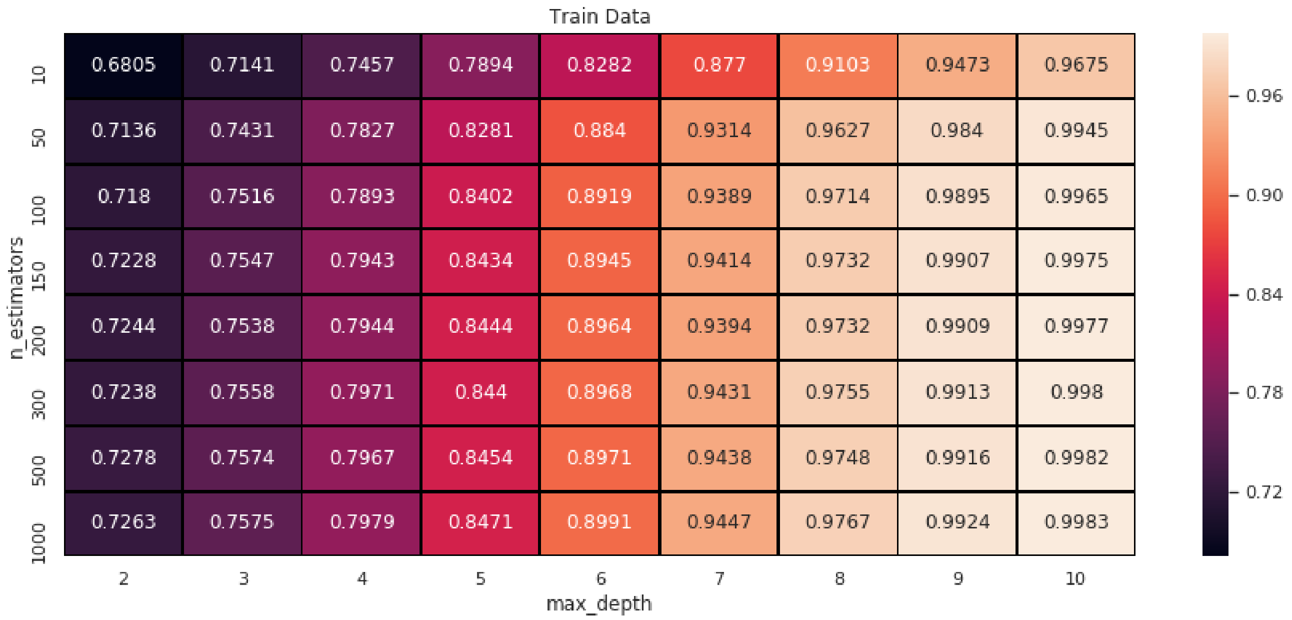

```
CPU times: user 407 ms, sys: 403 ms, total: 810 ms
Wall time: 332 ms
```

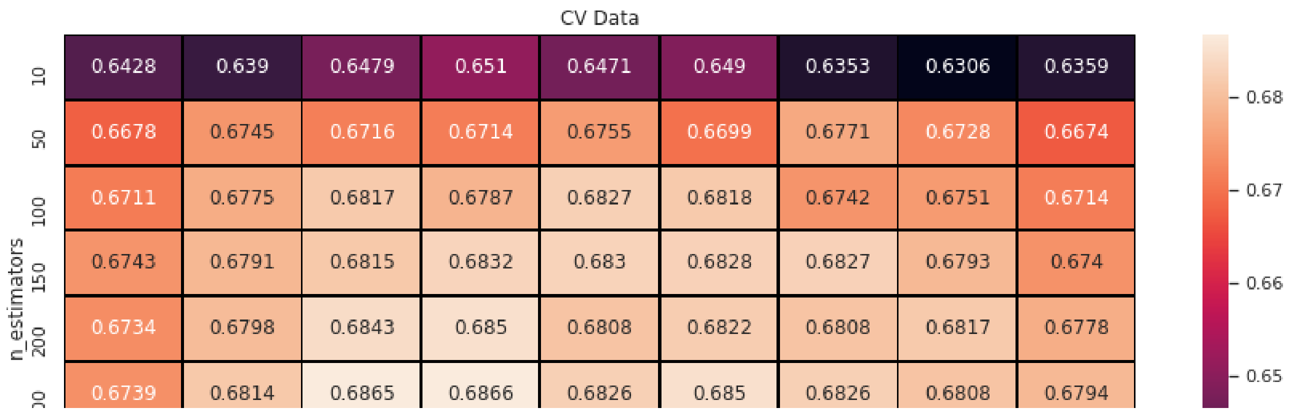
HEATMAP

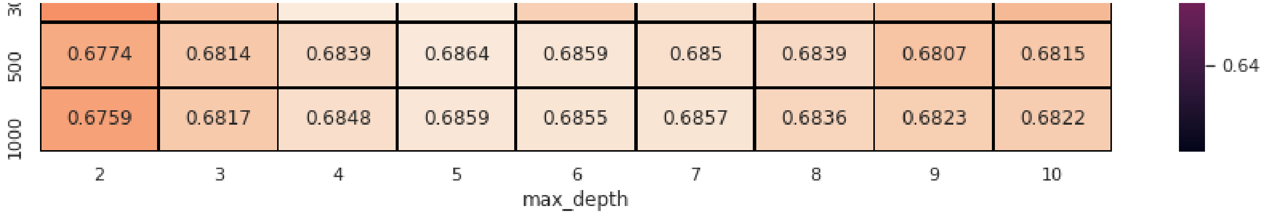
In [0]:

```
%%time
#------------------------------------------------Heat Map for Train data------------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()
```

```
#-----------------------------------------------Heat Map for CV data--------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```








```
CPU times: user 1.32 s, sys: 446 ms, total: 1.77 s
Wall time: 1.29 s
```

In [0]:

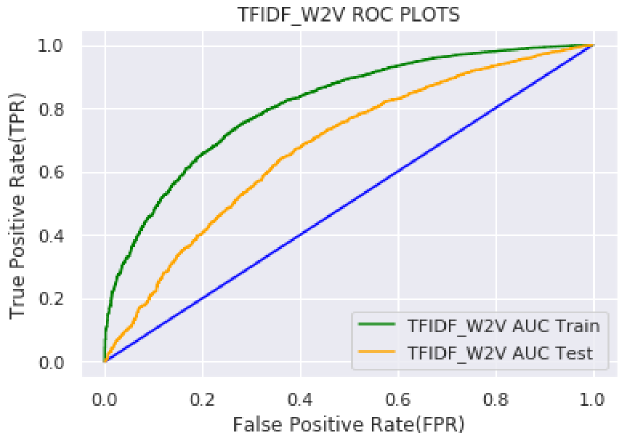
```
%%time
TFIDF_W2V_opt = RandomForestClassifier(n_estimators=TFIDF_W2V_Best_ES,max_depth=TFIDF_W2V_Best_MD,n_jobs=-1,class_weight='balanced')
#pdb.set_trace()
TFIDF_W2V_opt.fit(TFIDF_W2V_Train, Y_Train)
pred = TFIDF_W2V_opt.predict(TFIDF_W2V_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, TFIDF_W2V_opt.predict_proba(TFIDF_W2V_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, TFIDF_W2V_opt.predict_proba(TFIDF_W2V_Test)[:,1])
```

```
CPU times: user 43.6 s, sys: 640 ms, total: 44.3 s
Wall time: 2.57 s
```

TFIDF_W2V ROC PLOT

In [0]:

```
%%time

#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci

plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="TFIDF_W2V AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="TFIDF_W2V AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("TFIDF_W2V ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
TFIDF_W2V_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred7 = TFIDF_W2V_opt.predict(TFIDF_W2V_Train)
pred8 = TFIDF_W2V_opt.predict(TFIDF_W2V_Test)
```



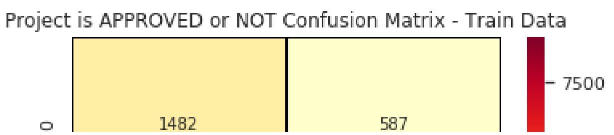

```
-----------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8106247445224307
AUC Test (for best estimator and depth) = 0.6773669111772823
CPU times: user 3.27 s, sys: 164 ms, total: 3.43 s
Wall time: 781 ms
```

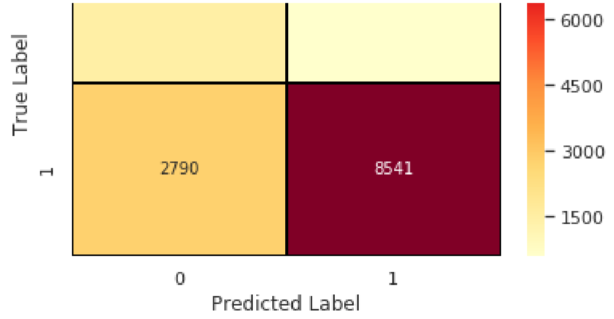
TFIDF_W2V CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred7)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 86.1 ms, sys: 61.3 ms, total: 147 ms
Wall time: 76.2 ms
```



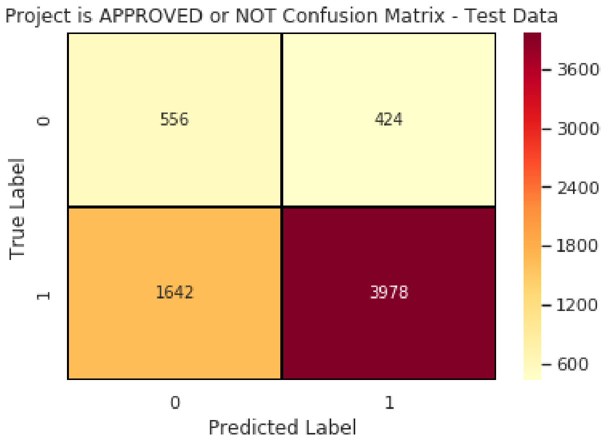


OBSERVATION:
True Negative = 1482; False Negative = 2790; True Positive = 8541; False Positive = 587
Accuracy (Overall, how often is the classifier correct) = 0.75
Precision(When it predicts yes, how often is it correct) =0.94
Misclassification (Overall, how often is it wrong) =0.26

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred8)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 65.3 ms, sys: 51.2 ms, total: 117 ms
Wall time: 62 ms
```



OBSERVATION:
True Negative = 556; False Negative = 1642; True Positive = 3978; False Positive = 424
Accuracy (Overall, how often is the classifier correct) = 0.69
Precision(When it predicts yes, how often is it correct) =0.91
Misclassification (Overall, how often is it wrong) =0.32

Gradient Boosting

2.4.5 Applying Gradient Boosting on BOW SET 1

In [0]:

```
%%time
GBDT_clf = GradientBoostingClassifier()
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
GBDTRan_clf = RandomizedSearchCV(GBDT_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
GBDTRan_clf.fit(BOW_Train, Y_Train)
print("-"*120)
print(GBDTRan_clf.best_estimator_)
print("-"*120)
BOWG_Best_ES=GBDTRan_clf.best_params_['n_estimators']
BOWG_Best_MD=GBDTRan_clf.best_params_['max_depth']
AUC_TR= GBDTRan_clf.cv_results_['mean_train_score']
AUC_CV = GBDTRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

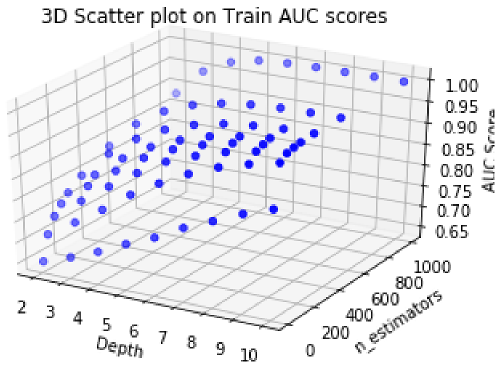
```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed:  8.8min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed: 33.6min finished
```

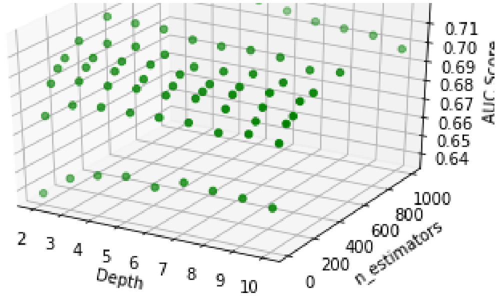
```
------------------------------------------------------------------------------------------------------------------------
GradientBoostingClassifier(ccp_alpha=0.0, criterion='friedman_mse', init=None,
                           learning_rate=0.1, loss='deviance', max_depth=2,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=1000,
                           n_iter_no_change=None, presort='deprecated',
                           random_state=None, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 4min 42s, sys: 1.4 s, total: 4min 44s
Wall time: 38min 15s
```

3D PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset---------------------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset------------------------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```



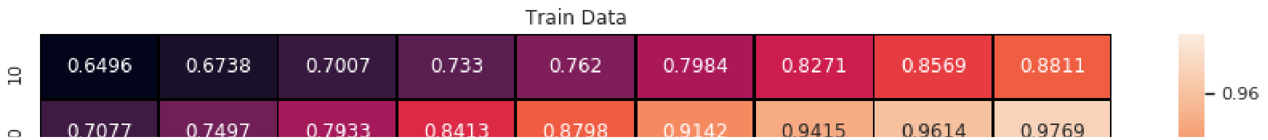


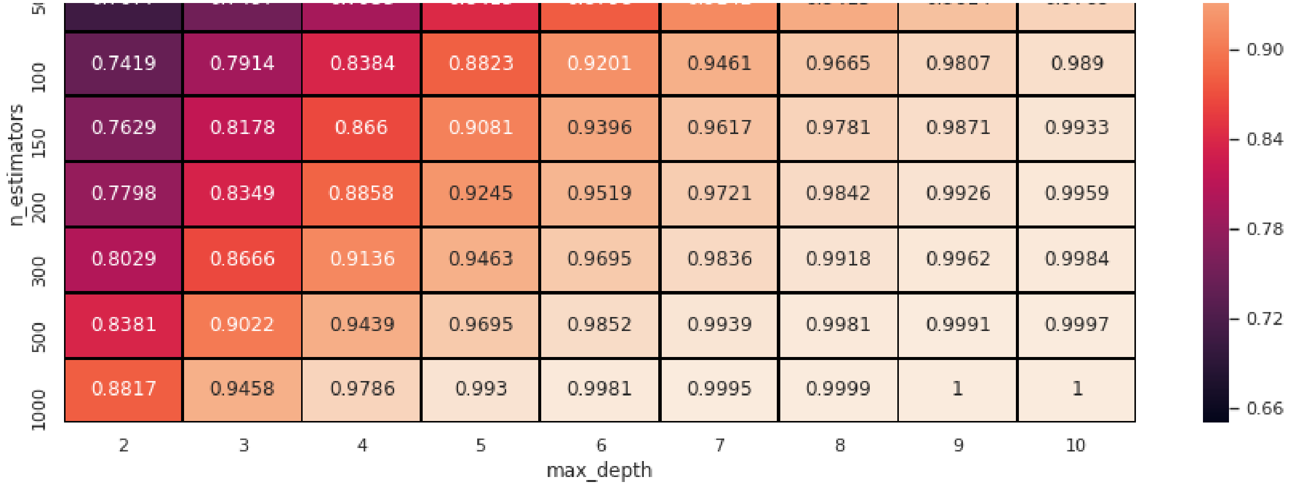

```
CPU times: user 1.34 s, sys: 3.56 s, total: 4.9 s
Wall time: 800 ms
```

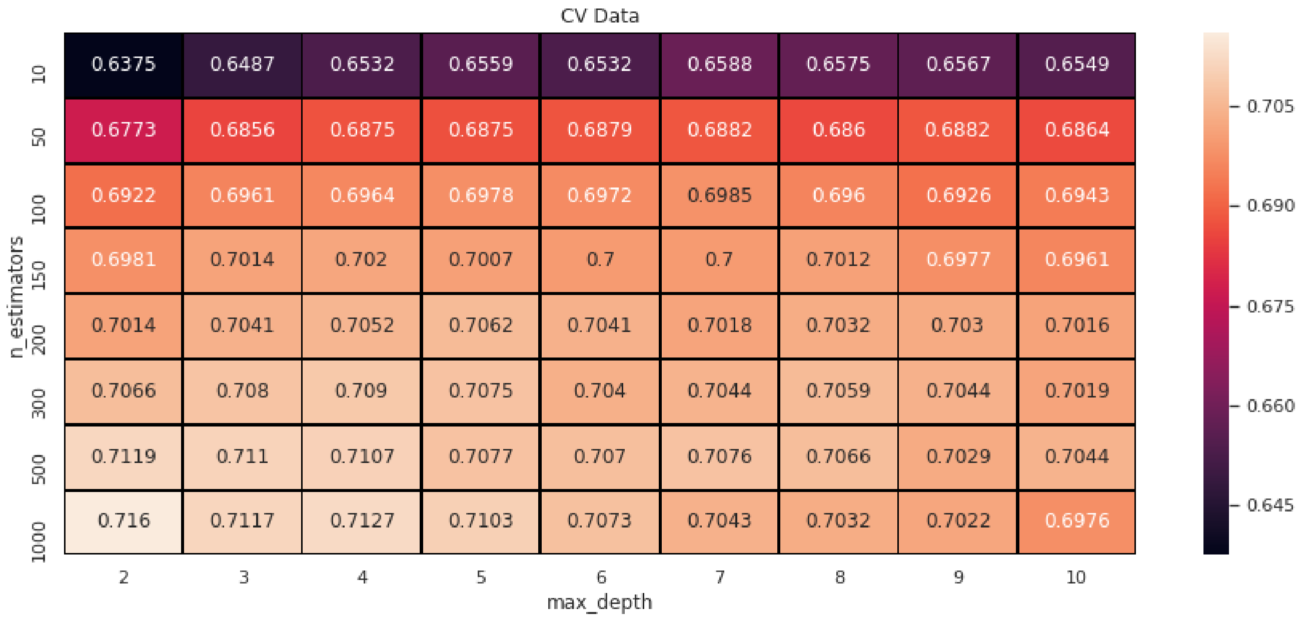
HEATMAP

In [0]:

```
%%time
#-----------------------------------------------Heat Map for Train data---------------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#-----------------------------------------------Heat Map for CV data------------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```








```
CPU times: user 1.2 s, sys: 446 ms, total: 1.65 s
Wall time: 1.18 s
```

In [0]:

```
%%time
BOW_opt = GradientBoostingClassifier(n_estimators=BOWG_Best_ES,max_depth=BOWG_Best_MD)
BOW_opt.fit(BOW_Train, Y_Train)
```

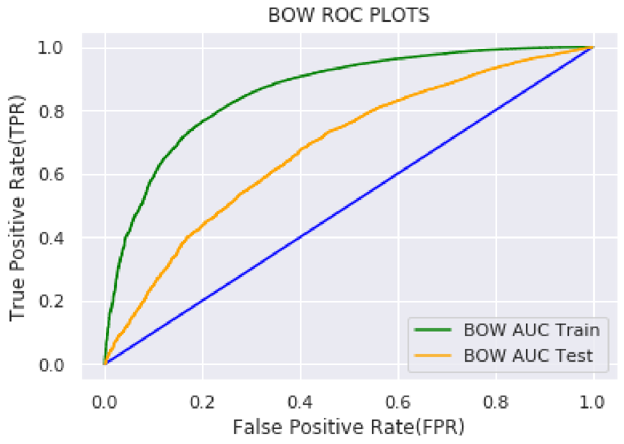
```
BOW_opt.fit(BOW_Train, Y_Train)
pred = BOW_opt.predict(BOW_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, BOW_opt.predict_proba(BOW_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, BOW_opt.predict_proba(BOW_Test)[:,1])
```

```
CPU times: user 4min 40s, sys: 376 ms, total: 4min 40s
Wall time: 4min 40s
```

BOW ROC PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci
plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="BOW AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="BOW AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("BOW ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
G_BOW_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred9 = BOW_opt.predict(BOW_Train)
pred10 = BOW_opt.predict(BOW_Test)
```




```
------------------------------------------------------------------------------------------------------------------------
```

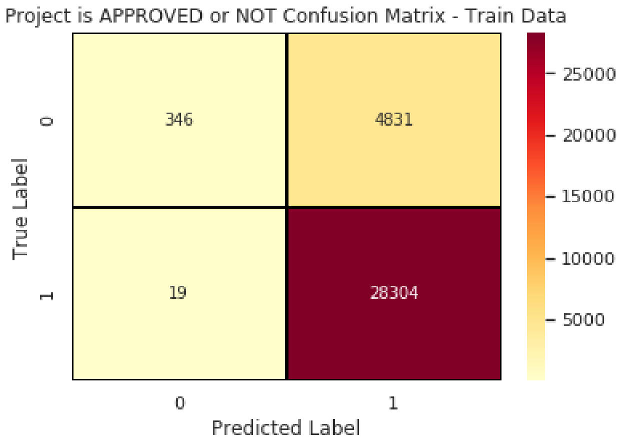
```
AUC Train (for best estimator and depth) = 0.8600601960724177
AUC Test (for best estimator and depth) = 0.6817789969216181
CPU times: user 1.14 s, sys: 7.04 ms, total: 1.15 s
Wall time: 1.14 s
```

BOW CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred9)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 90.4 ms, sys: 55.1 ms, total: 145 ms
Wall time: 88.4 ms
```

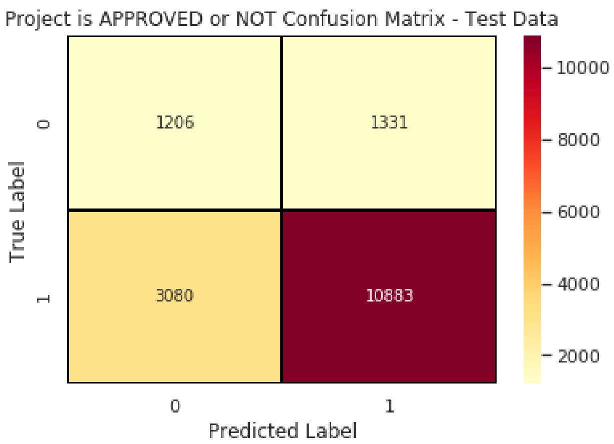


OBSERVATION:
True Negative = 346; False Negative = 19; True Positive = 28304; False Positive = 4831
Accuracy (Overall, how often is the classifier correct) = 0.86
Precision(When it predicts yes, how often is it correct) =0.856
Misclassification (Overall, how often is it wrong) =0.15

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred10)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 76.7 ms, sys: 44.1 ms, total: 121 ms
Wall time: 70.4 ms
```



OBSERVATION:
True Negative = 1206; False Negative = 3080; True Positive = 10883; False Positive = 1331
Accuracy (Overall, how often is the classifier correct) = 0.74
Precision(When it predicts yes, how often is it correct) =0.90
Misclassification (Overall, how often is it wrong) =0.27

2.4.6 Applying Gradient Boosting on TFIDF SET 2

In [0]:

```
%%time
GBDT_clf = GradientBoostingClassifier()
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
GBDTRan_clf = RandomizedSearchCV(GBDT_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
GBDTRan_clf.fit(TFIDF_Train, Y_Train)
print("-"*120)
```

```
print(GBDTRan_clf.best_estimator_)
print("-"*120)
TFIDFG_Best_ES=GBDTRan_clf.best_params_['n_estimators']
TFIDFG_Best_MD=GBDTRan_clf.best_params_['max_depth']
AUC_TR= GBDTRan_clf.cv_results_['mean_train_score']
AUC_CV = GBDTRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed: 25.2min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed: 104.3min finished
```

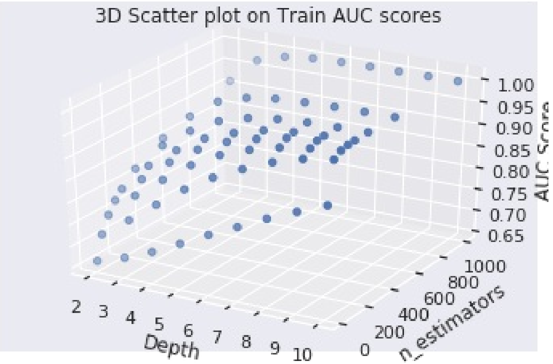
```
------------------------------------------------------------------------------------------------------------------------
GradientBoostingClassifier(ccp_alpha=0.0, criterion='friedman_mse', init=None,
                           learning_rate=0.1, loss='deviance', max_depth=2,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=500,
                           n_iter_no_change=None, presort='deprecated',
                           random_state=None, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 8min 12s, sys: 1.14 s, total: 8min 13s
Wall time: 1h 52min 26s
```

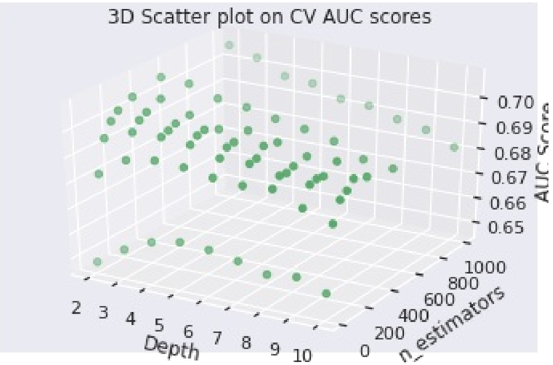
3D PLOT

In [0]:

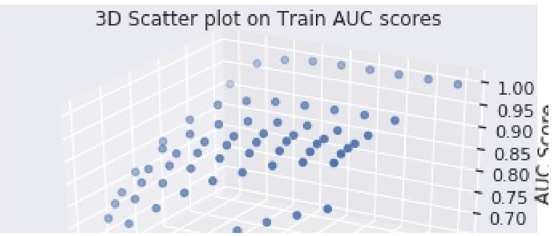
```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset-----------------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset--------------------------------------------------------------------------
figure = plt.figure()
```

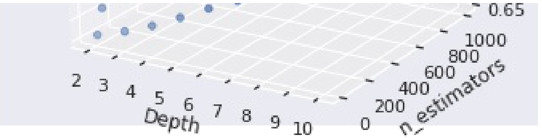
```
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```

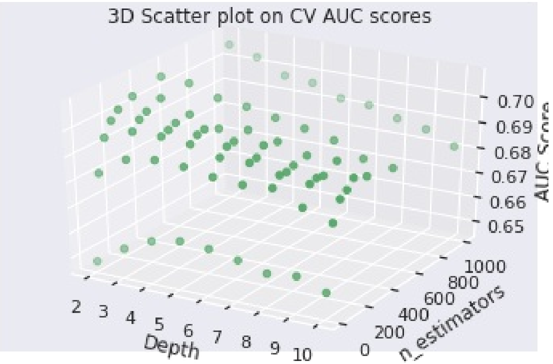





```
CPU times: user 1.07 s, sys: 4.05 s, total: 5.12 s
Wall time: 389 ms
```







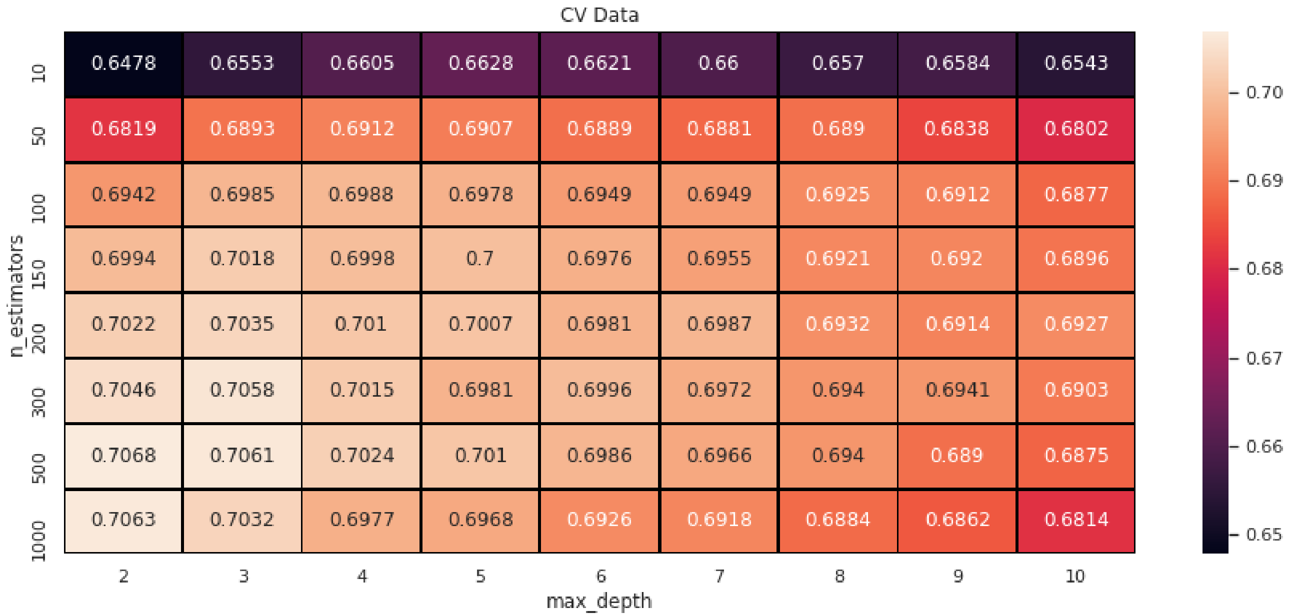

```
CPU times: user 1.07 s, sys: 4.05 s, total: 5.12 s
Wall time: 389 ms
```

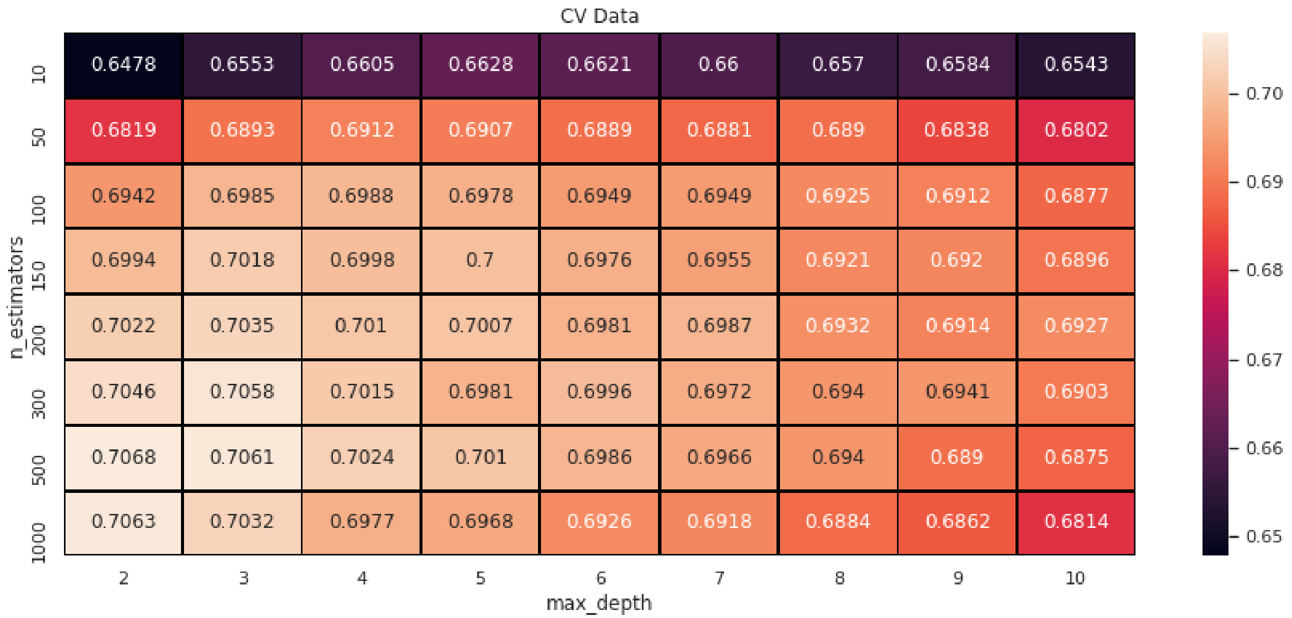
HEATMAP

In [0]:

```
%%time
#-----------------------------------------------Heat Map for Train data-----------------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#-----------------------------------------------Heat Map for CV data--------------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
```

```python
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```






```
CPU times: user 1.21 s, sys: 425 ms, total: 1.64 s
Wall time: 1.17 s
CPU times: user 1.21 s, sys: 425 ms, total: 1.64 s
```

```
Wall time: 1.17 s
```

In [0]:

```
%%time
TFIDF_opt = GradientBoostingClassifier(n_estimators=TFIDFG_Best_ES,max_depth=TFIDFG_Best_MD)
TFIDF_opt.fit(TFIDF_Train, Y_Train)
pred = TFIDF_opt.predict(TFIDF_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, TFIDF_opt.predict_proba(TFIDF_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, TFIDF_opt.predict_proba(TFIDF_Test)[:,1])
```

```
CPU times: user 8min 13s, sys: 146 ms, total: 8min 13s
Wall time: 8min 13s
CPU times: user 8min 13s, sys: 146 ms, total: 8min 13s
Wall time: 8min 13s
```

TFIDF ROC PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci
plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="TFIDF AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="TFIDF AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("TFIDF ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
G_TFIDF_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred11 = TFIDF_opt.predict(TFIDF_Train)
pred12 = TFIDF_opt.predict(TFIDF_Test)
```

```
------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.83113411064781
AUC Test (for best estimator and depth) = 0.6740369297979392
------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.83113411064781
AUC Test (for best estimator and depth) = 0.6740369297979392
CPU times: user 881 ms, sys: 12 ms, total: 893 ms
Wall time: 888 ms
CPU times: user 881 ms, sys: 12 ms, total: 893 ms
Wall time: 888 ms
```

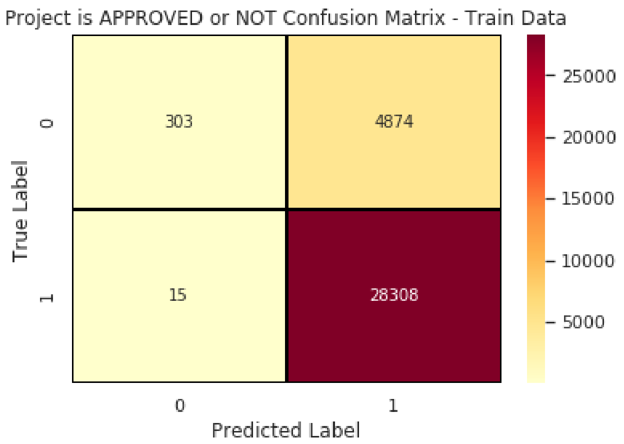
Wall time: 888 ms

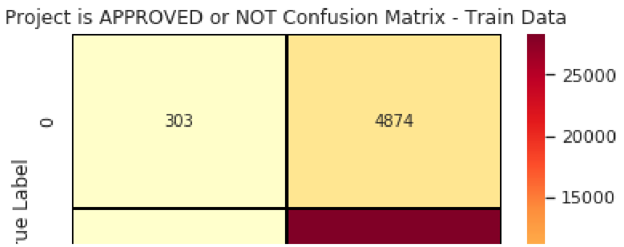
TFIDF CONFUSION MATRIX

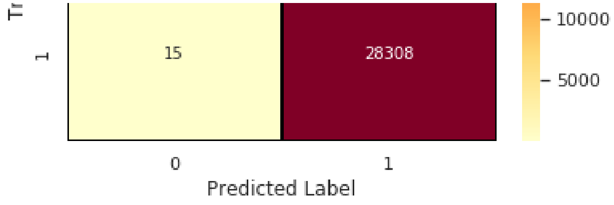
In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred11)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 334 ms, sys: 55 ms, total: 389 ms
Wall time: 335 ms
CPU times: user 334 ms, sys: 55 ms, total: 389 ms
Wall time: 335 ms
```





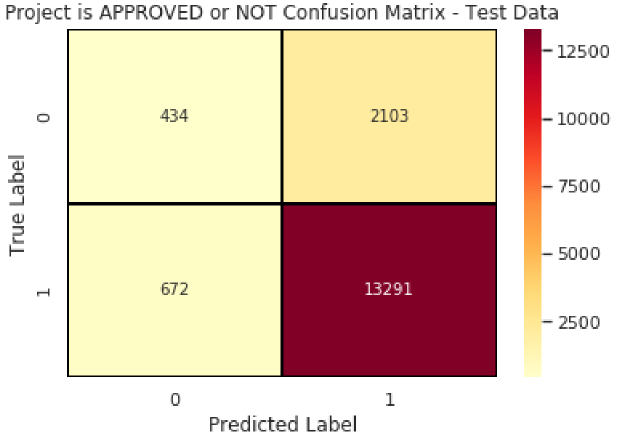


OBSERVATION:
True Negative = 303; False Negative = 15; True Positive = 28308; False Positive = 4874
Accuracy (Overall, how often is the classifier correct) = 0.86
Precision(When it predicts yes, how often is it correct) =0.86
Misclassification (Overall, how often is it wrong) =0.15

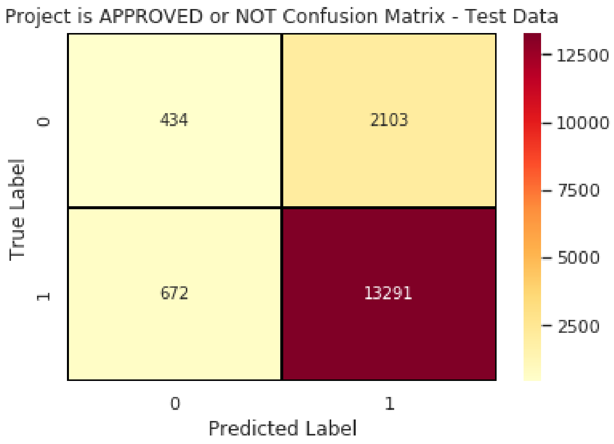
In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred12)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 76 ms, sys: 45 ms, total: 121 ms
Wall time: 69.5 ms
```




```
CPU times: user 76 ms, sys: 45 ms, total: 121 ms
Wall time: 69.5 ms
```



OBSERVATION:
True Negative = 434; False Negative = 672; True Positive = 13291; False Positive = 2103
Accuracy (Overall, how often is the classifier correct) = 0.84
Precision(When it predicts yes, how often is it correct) =0.87
Misclassification (Overall, how often is it wrong) =0.17

2.4.7 Applying Gradient Boosting on AVG_W2V SET 3

In [0]:

```
%%time
GBDT_clf = GradientBoostingClassifier()
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
GBDTRan_clf = RandomizedSearchCV(GBDT_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
GBDTRan_clf.fit(AVG_W2V_Train, Y_Train)
print("-"*120)
print(GBDTRan_clf.best_estimator_)
print("-"*120)
AVG_W2VG_Best_ES=GBDTRan_clf.best_params_['n_estimators']
AVG_W2VG_Best_MD=GBDTRan_clf.best_params_['max_depth']
AUC_TR= GBDTRan_clf.cv_results_['mean_train_score']
AUC_CV = GBDTRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

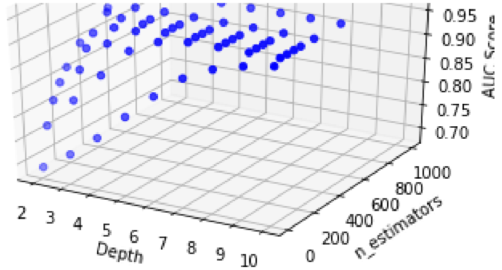
```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed: 58.5min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed: 200.1min finished
```

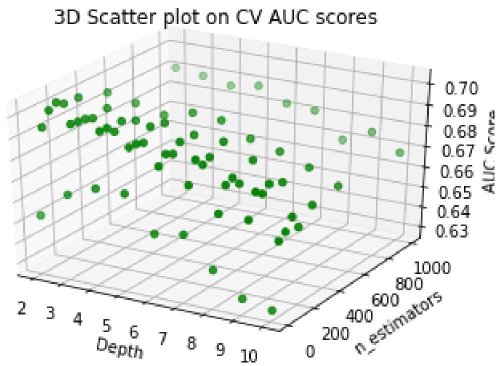
```
------------------------------------------------------------------------------------------------------------------------
GradientBoostingClassifier(ccp_alpha=0.0, criterion='friedman_mse', init=None,
                           learning_rate=0.1, loss='deviance', max_depth=2,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=150,
                           n_iter_no_change=None, presort='deprecated',
                           random_state=None, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 5min 44s, sys: 1.35 s, total: 5min 45s
Wall time: 3h 25min 46s
```

3D PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
#--------------------------------------------------------3D-Plot for Train Dataset-------------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#--------------------------------------------------------3D-Plot for CV Dataset----------------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```





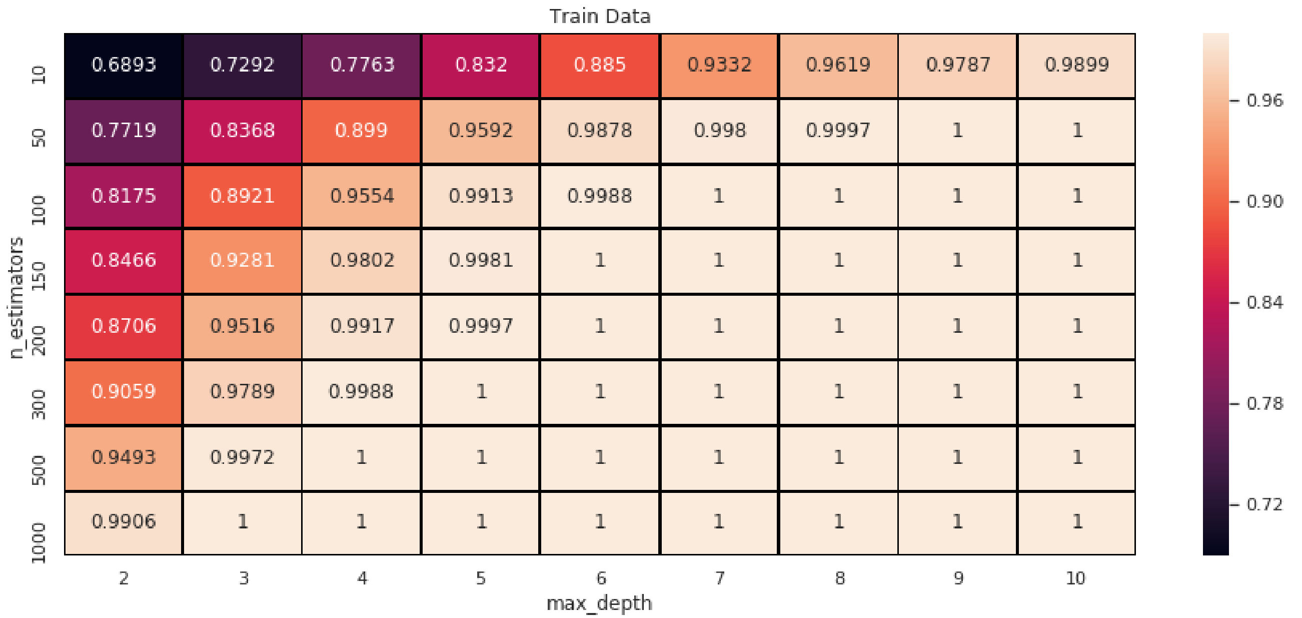

```
CPU times: user 1.15 s, sys: 4 s, total: 5.15 s
Wall time: 469 ms
```

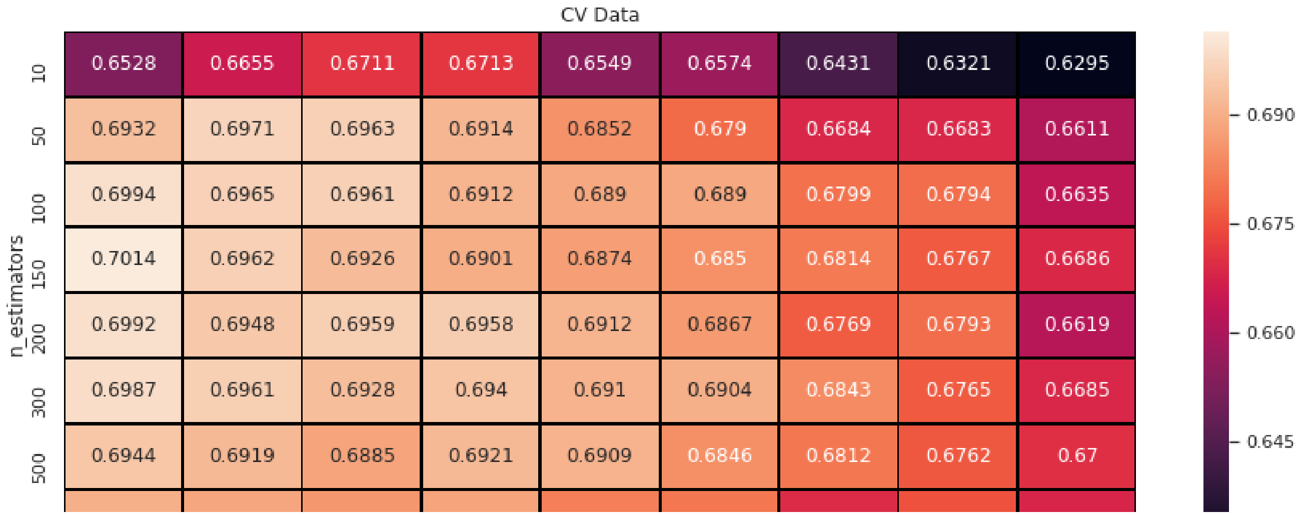
HEATMAP

In [0]:

```
%%time
#-----------------------------------------------Heat Map for Train data-----------------------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#-----------------------------------------------Heat Map for CV data--------------------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
```

```python
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```






```
CPU times: user 1.3 s, sys: 428 ms, total: 1.73 s
Wall time: 1.25 s
```

In [0]:

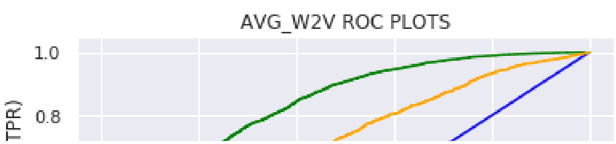
```
%%time
AVG_W2V_opt = GradientBoostingClassifier(n_estimators=AVG_W2VG_Best_ES,max_depth=AVG_W2VG_Best_MD)
AVG_W2V_opt.fit(AVG_W2V_Train, Y_Train)
pred = AVG_W2V_opt.predict(AVG_W2V_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, AVG_W2V_opt.predict_proba(AVG_W2V_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, AVG_W2V_opt.predict_proba(AVG_W2V_Test)[:,1])
```

```
CPU times: user 5min 44s, sys: 132 ms, total: 5min 44s
Wall time: 5min 44s
```

AVG_W2V ROC PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci
plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="AVG_W2V AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="AVG_W2V AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("AVG_W2V ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
G_AVG_W2V_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred13 = AVG_W2V_opt.predict(AVG_W2V_Train)
pred14 = AVG_W2V_opt.predict(AVG_W2V_Test)
```



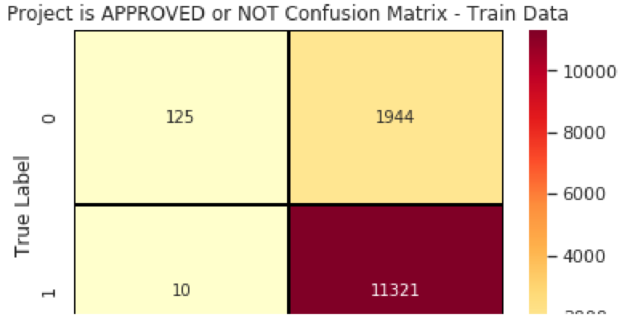

```
----------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8160369127257701
AUC Test (for best estimator and depth) = 0.6618643329217808
CPU times: user 724 ms, sys: 4.03 ms, total: 728 ms
Wall time: 723 ms
```

AVG_W2V CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred13)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 91.7 ms, sys: 69 ms, total: 161 ms
Wall time: 84.8 ms
```

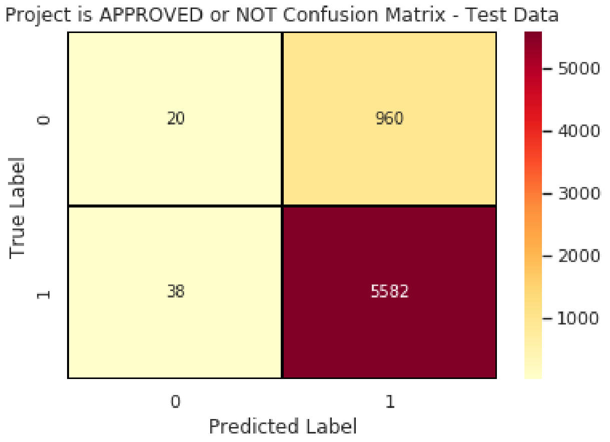


OBSERVATION:
True Negative = 125; False Negative = 10; True Positive = 11321; False Positive = 1944
Accuracy (Overall, how often is the classifier correct) = 0.86
Precision(When it predicts yes, how often is it correct) =0.86
Misclassification (Overall, how often is it wrong) =0.15

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred14)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 85.8 ms, sys: 64.1 ms, total: 150 ms
Wall time: 75.3 ms
```



OBSERVATION:
True Negative = 20; False Negative = 38; True Positive = 5582; False Positive = 960
Accuracy (Overall, how often is the classifier correct) = 0.85
Precision(When it predicts yes, how often is it correct) =0.86

Precision(When it predicts yes, how often is it correct) =0.[illegible]
Misclassification (Overall, how often is it wrong) =0.16

2.4.8 Applying Gradient Boosting on TFIDF_W2V SET 4

In [0]:

```
%%time
GBDT_clf = GradientBoostingClassifier()
parameters = {'n_estimators': [10, 50, 100, 150, 200, 300, 500, 1000], 'max_depth':[2, 3, 4, 5, 6, 7, 8, 9, 10]}
GBDTRan_clf = RandomizedSearchCV(GBDT_clf, parameters, cv=3, scoring='roc_auc',n_jobs=-1,return_train_score=True,verbose=1,n_iter=100)
GBDTRan_clf.fit(TFIDF_W2V_Train, Y_Train)
print("-"*120)
print(GBDTRan_clf.best_estimator_)
print("-"*120)
TFIDF_W2VG_Best_ES=GBDTRan_clf.best_params_['n_estimators']
TFIDF_W2VG_Best_MD=GBDTRan_clf.best_params_['max_depth']
AUC_TR= GBDTRan_clf.cv_results_['mean_train_score']
AUC_CV = GBDTRan_clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 72 candidates, totalling 216 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=-1)]: Done 120 tasks      | elapsed: 29.4min
[Parallel(n_jobs=-1)]: Done 216 out of 216 | elapsed: 82.8min finished
```

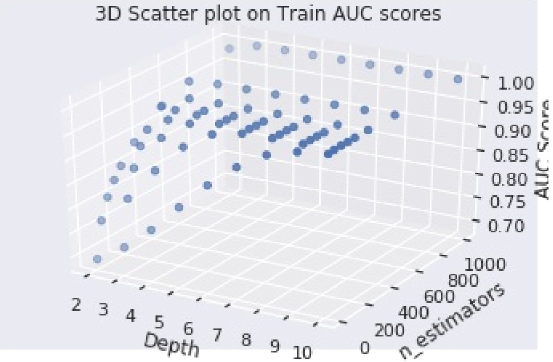
```
------------------------------------------------------------------------------------------------------------------------
GradientBoostingClassifier(ccp_alpha=0.0, criterion='friedman_mse', init=None,
                           learning_rate=0.1, loss='deviance', max_depth=2,
                           max_features=None, max_leaf_nodes=None,
                           min_impurity_decrease=0.0, min_impurity_split=None,
                           min_samples_leaf=1, min_samples_split=2,
                           min_weight_fraction_leaf=0.0, n_estimators=300,
                           n_iter_no_change=None, presort='deprecated',
                           random_state=None, subsample=1.0, tol=0.0001,
                           validation_fraction=0.1, verbose=0,
                           warm_start=False)
------------------------------------------------------------------------------------------------------------------------
CPU times: user 5min 46s, sys: 1.29 s, total: 5min 47s
Wall time: 1h 28min 35s
```

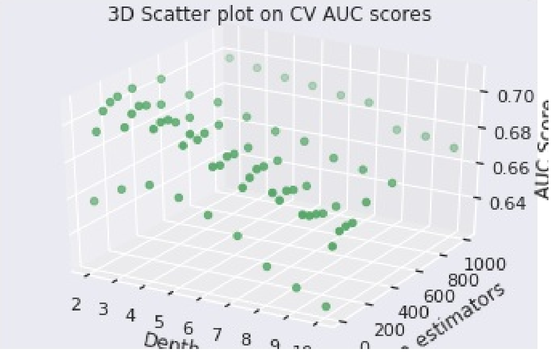
3D PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/53311685/difference-between-ax-set-xlabel-and-ax-xaxis-set-label-in-matplotlib-3-0-1
```

```
#-------------------------------------------------------3D-Plot for Train Dataset-------------------------------------------------------------------
---
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')
ax.scatter(MD, ES,AUC_TR, c='b', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on Train AUC scores')
plt.show()
plt.close()

#-------------------------------------------------------3D-Plot for CV Dataset-------------------------------------------------------------------
figure = plt.figure()
ax = figure.add_subplot(111, projection='3d')

ax.scatter(MD, ES, AUC_CV, c='g', marker='o')
ax.set_xlabel('Depth')
ax.yaxis.set_label_text('n_estimators')
ax.zaxis.set_label_text('AUC Score')
plt.title('3D Scatter plot on CV AUC scores')
plt.show()
plt.close()
```



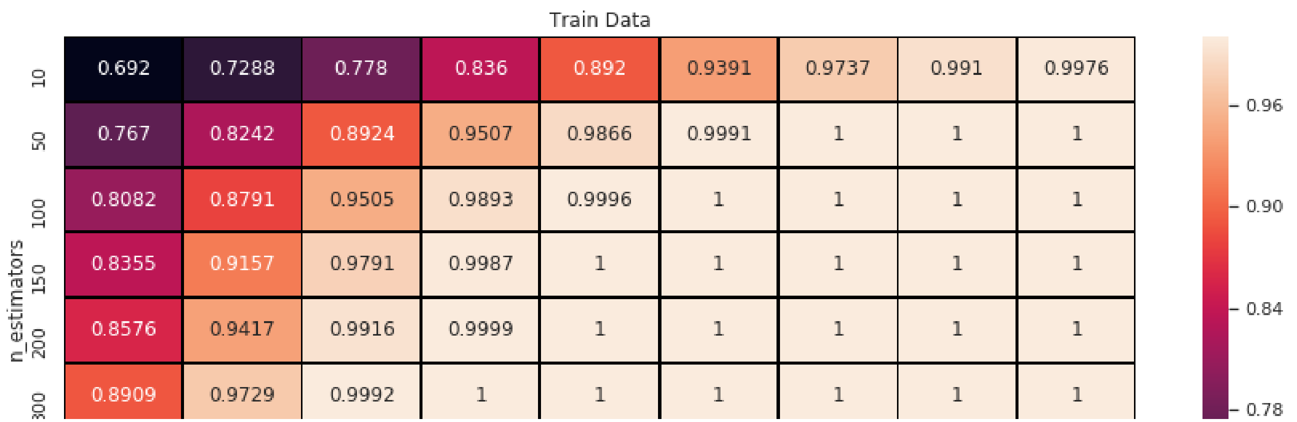


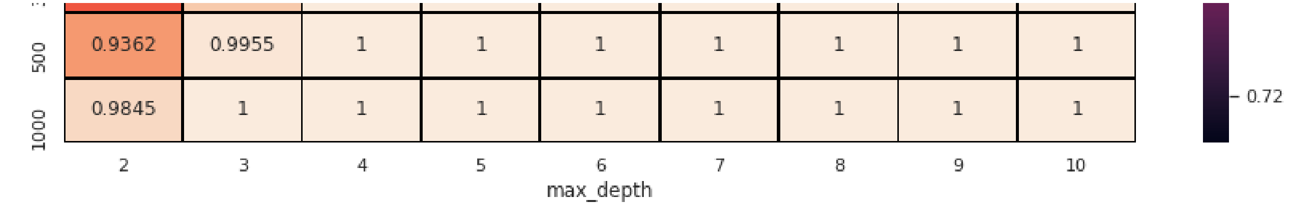
```
CPU times: user 1.08 s, sys: 4.03 s, total: 5.12 s
Wall time: 381 ms
```

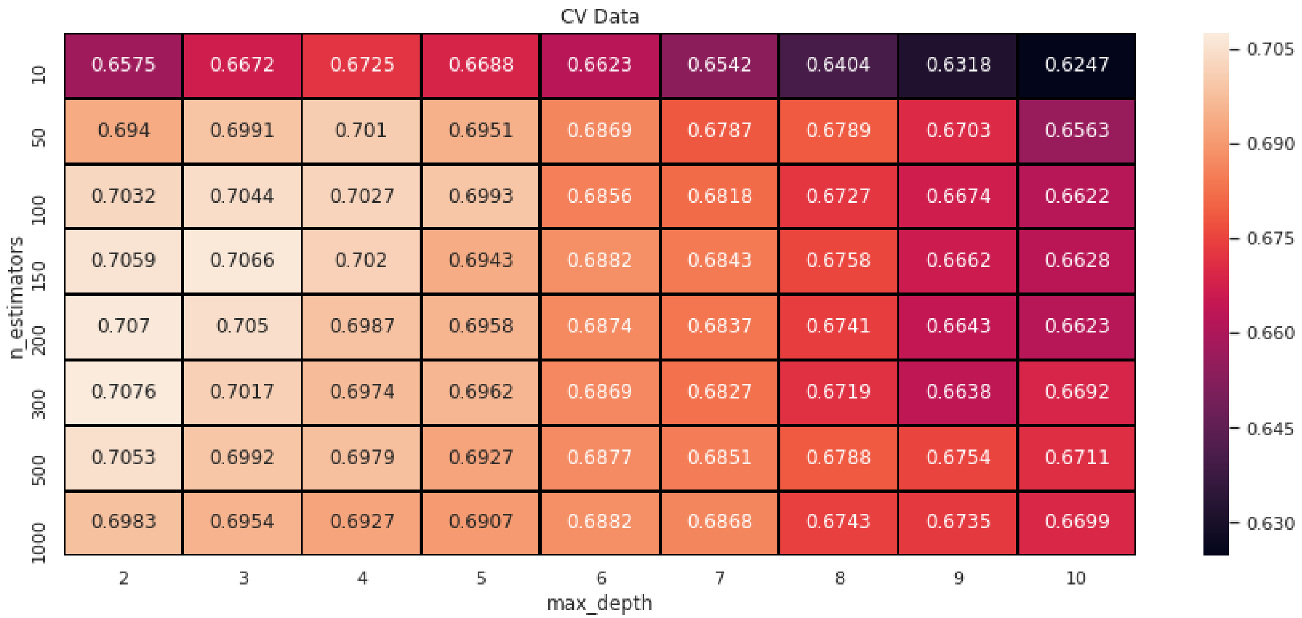
HEATMAP

In [0]:

```
%%time
#----------------------------------------------Heat Map for Train data---------------------------------------------------------------
----
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_TR':AUC_TR}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_TR')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('Train Data')
plt.show()

#----------------------------------------------Heat Map for CV data------------------------------------------------------------------
-
plt.close()
d={'n_estimators':ES,'max_depth':MD,'AUC_CV':AUC_CV}
df=pd.DataFrame(d)
result = df.pivot(index='n_estimators',columns='max_depth',values='AUC_CV')
sns.set()
plt.figure(figsize=(15,6))
sns.heatmap(result,annot = True, fmt='.4g',linewidths=1,linecolor='black')
plt.title('CV Data')
plt.show()
```








```
CPU times: user 1.18 s, sys: 417 ms, total: 1.6 s
Wall time: 1.13 s
```

In [0]:

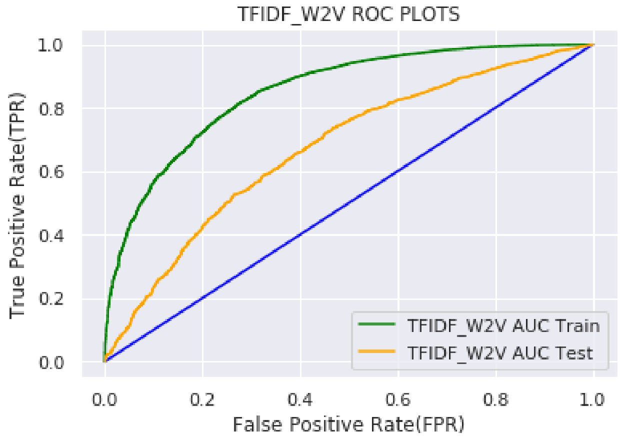
```
%%time
TFIDF_W2V_opt = GradientBoostingClassifier(n_estimators=TFIDF_W2VG_Best_ES,max_depth=TFIDF_W2VG_Best_MD)
TFIDF_W2V_opt.fit(TFIDF_W2V_Train, Y_Train)
pred = TFIDF_W2V_opt.predict(TFIDF_W2V_Test)

a_fpr_train, a_tpr_train, thresholds = roc_curve(Y_Train, TFIDF_W2V_opt.predict_proba(TFIDF_W2V_Train)[:,1])
a_fpr_Test, a_tpr_Test, thresholds = roc_curve(Y_Test, TFIDF_W2V_opt.predict_proba(TFIDF_W2V_Test)[:,1])
```

```
CPU times: user 5min 46s, sys: 198 ms, total: 5min 46s
Wall time: 5min 46s
```

TFIDF_W2V ROC PLOT

In [0]:

```
%%time
#https://stackoverflow.com/questions/52910061/implementing-roc-curves-for-k-nn-machine-learning-algorithm-using-python-and-sci

plt.plot([0,1],[0,1],'k-', color='blue')
plt.plot(a_fpr_train, a_tpr_train, label="TFIDF_W2V AUC Train", color='green')
plt.plot(a_fpr_Test, a_tpr_Test, label="TFIDF_W2V AUC Test", color='orange')
plt.legend()
plt.ylabel("True Positive Rate(TPR)")
plt.xlabel("False Positive Rate(FPR)")
plt.title("TFIDF_W2V ROC PLOTS")
plt.show()
print("-"*120)
print("AUC Train (for best estimator and depth) =", auc(a_fpr_train, a_tpr_train))
print("AUC Test (for best estimator and depth) =", auc(a_fpr_Test, a_tpr_Test))
G_TFIDF_W2V_AUC=round(auc(a_fpr_Test, a_tpr_Test)*100)
pred15 = TFIDF_W2V_opt.predict(TFIDF_W2V_Train)
pred16 = TFIDF_W2V_opt.predict(TFIDF_W2V_Test)
```



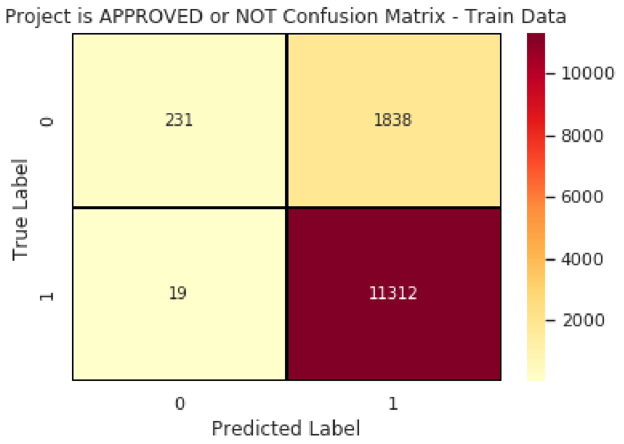

```
------------------------------------------------------------------------------------------------------------------------
AUC Train (for best estimator and depth) = 0.8523021762775286
AUC Test (for best estimator and depth) = 0.6735076984530467
CPU times: user 629 ms, sys: 7.03 ms, total: 636 ms
Wall time: 631 ms
```

TFIDF_W2V CONFUSION MATRIX

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
%matplotlib inline
from sklearn.metrics import confusion_matrix
Train = confusion_matrix(Y_Train, pred15)
sns.heatmap(Train,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
plt.title('Project is APPROVED or NOT Confusion Matrix - Train Data')
```

```
CPU times: user 77.5 ms, sys: 45.1 ms, total: 123 ms
Wall time: 69.7 ms
```



OBSERVATION:

True Negative = 231; False Negative = 19; True Positive = 11312; False Positive = 1838

Accuracy (Overall, how often is the classifier correct) = 0.87

Precision(When it predicts yes, how often is it correct) =0.87

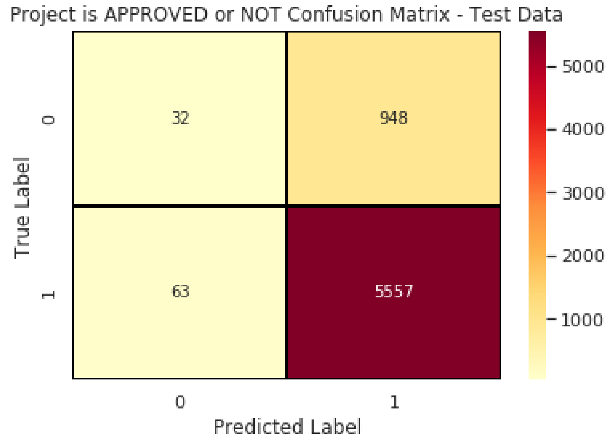
Misclassification (Overall, how often is it wrong) =0.14

In [0]:

```
%%time
#https://seaborn.pydata.org/generated/seaborn.heatmap.html
#https://getaravind.com/blog/confusion-matrix-seaborn-heatmap/
Test = confusion_matrix(Y_Test, pred16)
sns.heatmap(Test,annot=True,cbar=True,fmt='d',cmap='YlOrRd',linewidths=1,linecolor='black')
plt.ylabel('True Label')
plt.xlabel('Predicted Label')
```

```
plt.title('Project is APPROVED or NOT Confusion Matrix - Test Data')
```

```
CPU times: user 75.3 ms, sys: 46 ms, total: 121 ms
Wall time: 65.5 ms
```



OBSERVATION:
True Negative = 32; False Negative = 63; True Positive = 5557; False Positive = 948
Accuracy (Overall, how often is the classifier correct) = 0.85
Precision(When it predicts yes, how often is it correct) =0.86
Misclassification (Overall, how often is it wrong) =0.16

Conclusion

In [0]:

```
%%time
# Please compare all your models using Prettytable library

pt = PrettyTable()
pt.field_names= ("S.No","Vectorizer", "Model", "n_estimators","max_depth", "AUC")
pt.add_row(["1","BOW", "RandomForest",BOW_Best_ES, BOW_Best_MD, BOW_AUC])
pt.add_row(["2","TFIDF", "RandomForest", TFIDF_Best_ES, TFIDF_Best_MD, TFIDF_AUC])
pt.add_row(["3","AVG_W2V", "RandomForest",AVG_W2V_Best_ES, AVG_W2V_Best_MD, AVG_W2V_AUC])
pt.add_row(["4","TFIDF_W2V", "RandomForest", TFIDF_W2V_Best_ES, TFIDF_W2V_Best_MD, TFIDF_W2V_AUC])
pt.add_row(["5","BOW", "GradientBoosting",BOWG_Best_ES, BOWG_Best_MD, G_BOW_AUC])
pt.add_row(["6","TFIDF", "GradientBoosting", TFIDFG_Best_ES, TFIDFG_Best_MD, G_TFIDF_AUC])
pt.add_row(["7","AVG_W2V", "GradientBoosting", AVG_W2VG_Best_ES, AVG_W2VG_Best_MD, G_AVG_W2V_AUC])
pt.add_row(["8","TFIDF_W2V", "GradientBoosting", TFIDF_W2VG_Best_ES, TFIDF_W2VG_Best_MD, G_TFIDF_W2V_AUC])
print(pt)
```

S.No	Vectorizer	Model	n_estimators	max_depth	AUC
1	BOW	RandomForest	1000	10	0.68
2	TFIDF	RandomForest	1000	10	0.69
3	AVG_W2V	RandomForest	1000	5	0.66
4	TFIDF_W2V	RandomForest	300	5	0.68
5	BOW	GradientBoosting	1000	2	0.68
6	TFIDF	GradientBoosting	500	2	0.67
7	AVG_W2V	GradientBoosting	150	2	0.66
8	TFIDF_W2V	GradientBoosting	300	2	0.67

```
CPU times: user 1.43 ms, sys: 0 ns, total: 1.43 ms
Wall time: 1.37 ms
```

SUMMARY:

1. After applying the Gradient Boosting over the Random Forest, we can see **"Accuracy,Precision were improved"** for the TFIDF,AVG_W2V and TFIDF_W2V.
2. Also we can see the **"Misclassfication is dropped around 10%"** approx.After applying the Gradient Boosting over the Random Forest.
3. Comparatively after applying the Gradient Boost**" TFIDF,AVG_W2V and TFIDF_W2V"** vectorizer are performing very well.
4. Both Random Forest and Gradient Boosting are giving more or less same AUC score.
5. Gradient Boosting take more time and space complexity when compare to the Random Forest.
6. Compare to the Random Forest the Gradient Boosting is taking small value of the Estimators and Depth.
7. Due to memory constraints issue only 50K data points were used for BOW/TFIDF and 20K points were used for AVG_W2V/TFIDF_W2V.