Assignment 9: GBDT

In [2]:

```
from google.colab import drive
drive.mount('/content/drive')
```

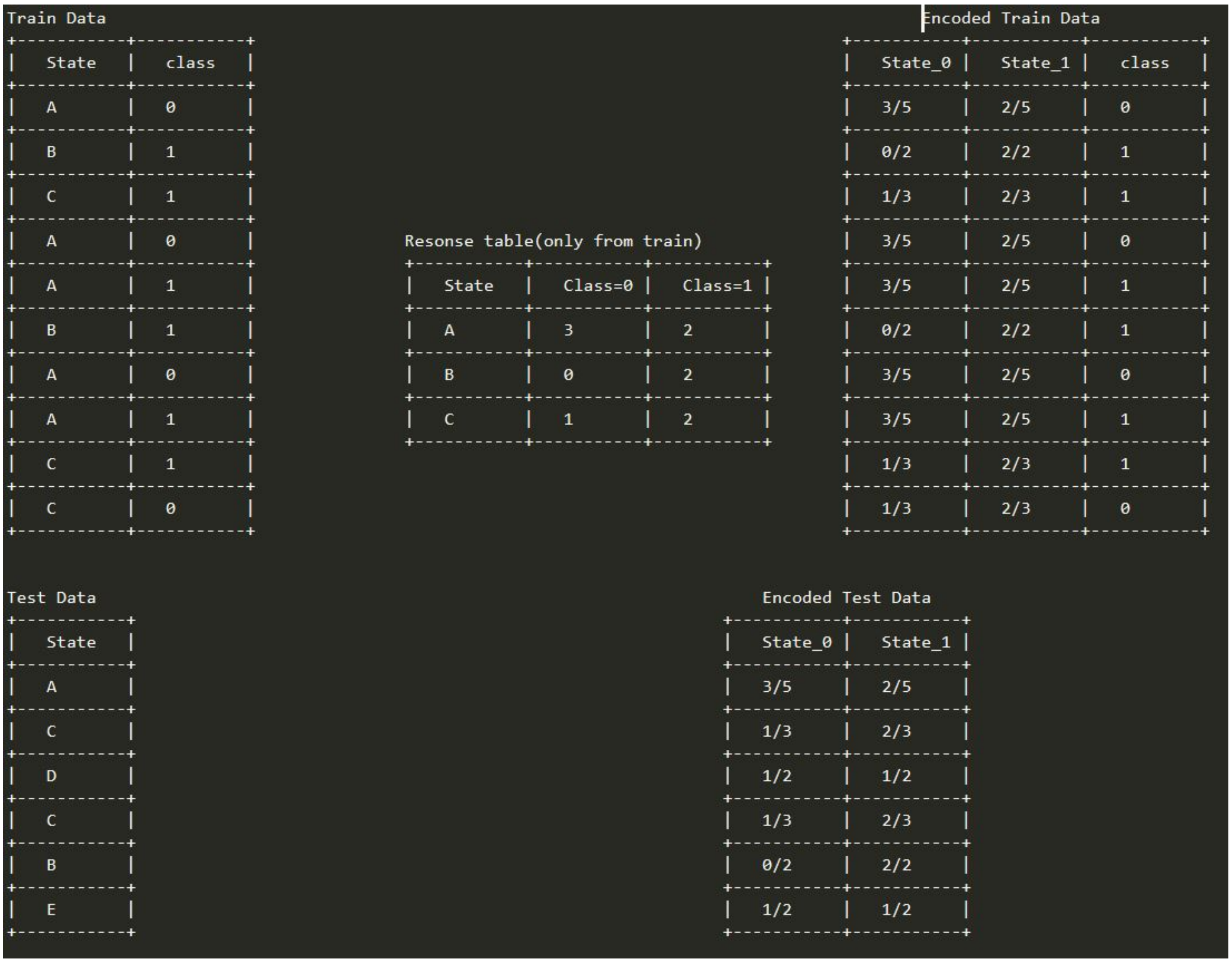
```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?cli
ent_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent
t.com&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&
scope=email%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%
3a%2f%2fwww.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.c
om%2fauth%2fdrive.photos.readonly%20https%3a%2f%2fwww.googleapis.com%2faut
h%2fpeopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/drive
```

In [3]:

```
cd /content/drive/My Drive/9_Donors_choose_DT
```

```
/content/drive/My Drive/9_Donors_choose_DT
```

Response Coding: Example



```
Train Data
+-----------+-----------+
|   State   |   class   |
+-----------+-----------+
|   A       |   0       |
+-----------+-----------+
|   B       |   1       |
+-----------+-----------+
|   C       |   1       |
+-----------+-----------+
|   A       |   0       |
+-----------+-----------+
|   A       |   1       |
+-----------+-----------+
|   B       |   1       |
+-----------+-----------+
|   A       |   0       |
+-----------+-----------+
|   A       |   1       |
+-----------+-----------+
|   C       |   1       |
+-----------+-----------+
|   C       |   0       |
+-----------+-----------+
```

```
Resonse table(only from train)
+-----------+-----------+-----------+
|   State   |   Class=0 |   Class=1 |
+-----------+-----------+-----------+
|   A       |   3       |   2       |
+-----------+-----------+-----------+
|   B       |   0       |   2       |
+-----------+-----------+-----------+
|   C       |   1       |   2       |
+-----------+-----------+-----------+
```

```
       Encoded Train Data
+-----------+-----------+-----------+
|   State_0 |   State_1 |   class   |
+-----------+-----------+-----------+
|   3/5     |   2/5     |   0       |
+-----------+-----------+-----------+
|   0/2     |   2/2     |   1       |
+-----------+-----------+-----------+
|   1/3     |   2/3     |   1       |
+-----------+-----------+-----------+
|   3/5     |   2/5     |   0       |
+-----------+-----------+-----------+
|   3/5     |   2/5     |   1       |
+-----------+-----------+-----------+
|   0/2     |   2/2     |   1       |
+-----------+-----------+-----------+
|   3/5     |   2/5     |   0       |
+-----------+-----------+-----------+
|   3/5     |   2/5     |   1       |
+-----------+-----------+-----------+
|   1/3     |   2/3     |   1       |
+-----------+-----------+-----------+
|   1/3     |   2/3     |   0       |
+-----------+-----------+-----------+
```

```
Test Data
+-----------+
|   State   |
+-----------+
|   A       |
+-----------+
|   C       |
+-----------+
|   D       |
+-----------+
|   C       |
+-----------+
|   B       |
+-----------+
|   E       |
+-----------+
```

```
   Encoded Test Data
+-----------+-----------+
|   State_0 |   State_1 |
+-----------+-----------+
|   3/5     |   2/5     |
+-----------+-----------+
|   1/3     |   2/3     |
+-----------+-----------+
|   1/2     |   1/2     |
+-----------+-----------+
|   1/3     |   2/3     |
+-----------+-----------+
|   0/2     |   2/2     |
+-----------+-----------+
|   1/2     |   1/2     |
+-----------+-----------+
```

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]

In [4]:

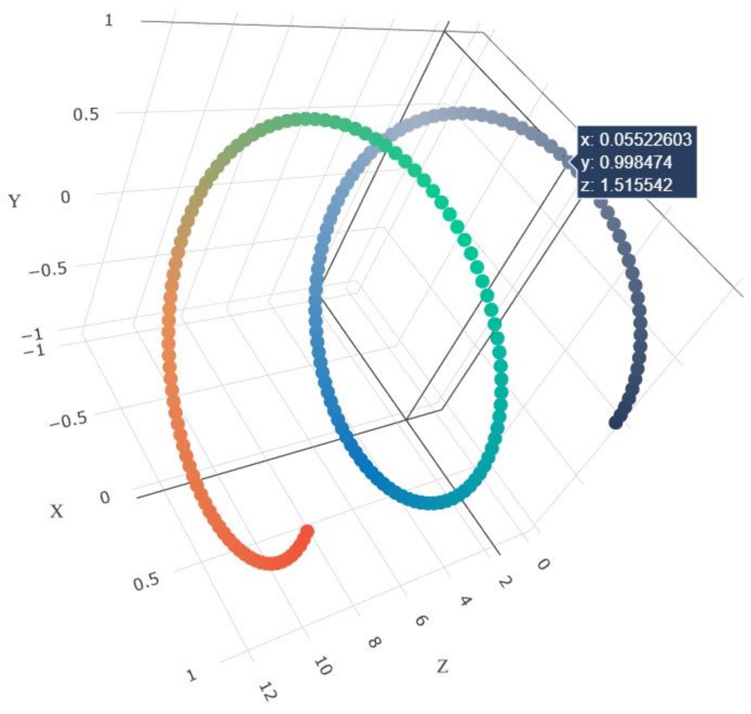
```
import nltk
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
```

Out[4]:

```
True
```

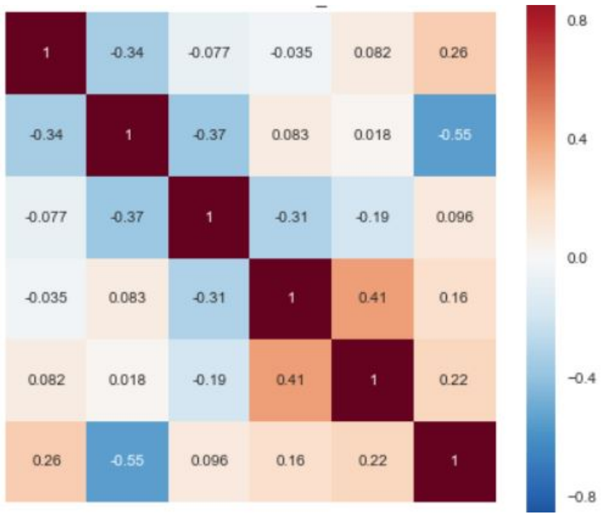
1. **Apply GBDT on these feature sets**
    - Set 1: categorical(instead of one hot encoding, try [response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF)+ preprocessed_eassay (TFIDF)+sentiment Score of eassay(check the bellow example, include all 4 values as 4 features)
    - Set 2: categorical(instead of one hot encoding, try [response coding (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/handling-categorical-and-numerical-features/): use probability values), numerical features + project_title(TFIDF W2V)+ preprocessed_eassay (TFIDF W2V)
2. **The hyper paramter tuning (Consider any two hyper parameters)**
    - Find the best hyper parameter which will give the maximum [AUC (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/)](https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/receiver-operating-characteristic-curve-roc-curve-and-auc-1/) 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*

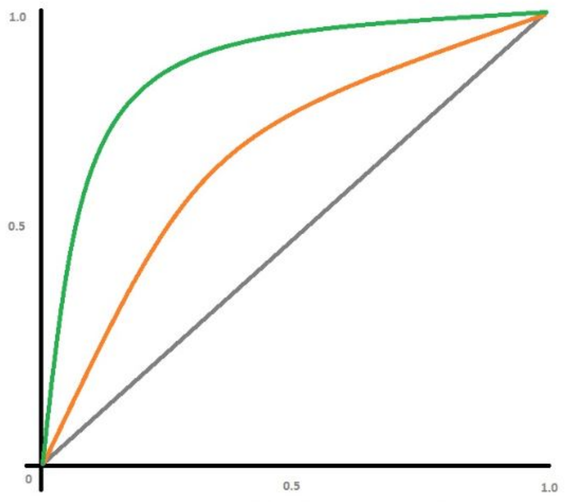
or

- 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

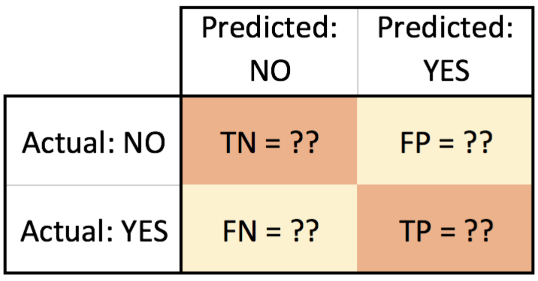


seaborn heat maps (https://seaborn.pydata.org/generated/seaborn.heatmap.html) with rows as **n_estimators**, columns as **max_depth**, and values inside the cell representing **AUC Score**

- You choose either of the plotting techniques out of 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.

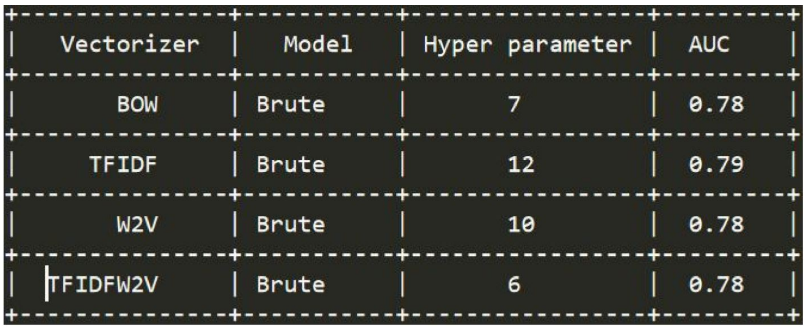


- Along with plotting ROC curve, you need to print the confusion matrix (https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/confusion-matrix-tpr-fpr-fnr-tnr-1/) with predicted and original labels of test data points



	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

4. You need to summarize the results at the end of the notebook, summarize it in the table format



```
+---------------+------------+------------------+----------+
|   Vectorizer  |   Model    | Hyper parameter  |  AUC     |
+---------------+------------+------------------+----------+
|      BOW      | Brute      |        7         |  0.78    |
+---------------+------------+------------------+----------+
|     TFIDF     | Brute      |       12         |  0.79    |
+---------------+------------+------------------+----------+
|      W2V      | Brute      |       10         |  0.78    |
+---------------+------------+------------------+----------+
|   TFIDFW2V    | Brute      |        6         |  0.78    |
+---------------+------------+------------------+----------+
```

In [5]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer

# import nltk
# nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

for_sentiment = 'a person is a person no matter how small dr seuss i teach the smallest
students with the biggest enthusiasm \
for learning my students learn in many different ways using all of our senses and multi
ple intelligences i use a wide range\
of techniques to help all my students succeed students in my class come from a variety
 of different backgrounds which makes\
for wonderful sharing of experiences and cultures including native americans our school
is a caring community of successful \
learners which can be seen through collaborative student project based learning in and
 out of the classroom kindergarteners \
in my class love to work with hands on materials and have many different opportunities
 to practice a skill before it is\
mastered having the social skills to work cooperatively with friends is a crucial aspec
t of the kindergarten curriculum\
montana is the perfect place to learn about agriculture and nutrition my students love
 to role play in our pretend kitchen\
in the early childhood classroom i have had several kids ask me can we try cooking with
real food i will take their idea \
and create common core cooking lessons where we learn important math and writing concep
ts while cooking delicious healthy \
food for snack time my students will have a grounded appreciation for the work that wen
t into making the food and knowledge \
of where the ingredients came from as well as how it is healthy for their bodies this p
roject would expand our learning of \
nutrition and agricultural cooking recipes by having us peel our own apples to make hom
emade applesauce make our own bread \
and mix up healthy plants from our classroom garden in the spring we will also create o
ur own cookbooks to be printed and \
shared with families students will gain math and literature skills as well as a life lo
ng enjoyment for healthy cooking \
nannan'
ss = sid.polarity_scores(for_sentiment)

for k in ss:
    print('{0}: {1}, '.format(k, ss[k]), end='')

# we can use these 4 things as features/attributes (neg, neu, pos, compound)
# neg: 0.0, neu: 0.753, pos: 0.247, compound: 0.93
```

```
neg: 0.01, neu: 0.745, pos: 0.245, compound: 0.9975,

/usr/local/lib/python3.6/dist-packages/nltk/twitter/__init__.py:20: UserWa
rning: The twython library has not been installed. Some functionality from
the twitter package will not be available.
  warnings.warn("The twython library has not been installed. "
```

1. GBDT (xgboost/lightgbm)

1.1 Loading Data

In [6]:

```
import pandas
data = pandas.read_csv('preprocessed_data.csv')
```

1.2 Splitting data into Train and cross validation(or test): Stratified Sampling

In [7]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
import numpy as np
data.head()
```

Out[7]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	
2	ca	mrs	grades_prek_2	
3	ga	mrs	grades_prek_2	
4	wa	mrs	grades_3_5	

1.3 Make Data Model Ready: encoding eassay, and project_title

In [8]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# make sure you featurize train and test data separatly

# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
# train test split
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)

from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, stratify=y,ra
ndom_state=1)
```

In [9]:

```
def code_train(name):
    d=dict()
    p=0
    n=0
    t=0
    l=X_train[name].unique()
    f=[]
    for j in range(len(l)):
        for i in range(X_train.shape[0]):
            if X_train[name].values[i]==l[j] and y_train[i]==1:
               p+=1
            if X_train[name].values[i]==l[j] and y_train[i]==0:
               n+=1
        t=n+p
        d[l[j]]=[n/t,p/t]
        p=n=t=0


    for i in range(X_train.shape[0]):
        f.append(d[X_train[name].values[i]])
    return np.array(f),l,d
```

In [10]:

```
new_school_state,l_sc,d_sc=code_train('school_state')
new_teacher_prefix,l_t,d_t=code_train('teacher_prefix')
new_project_grade_category,l_p,d_p=code_train('project_grade_category')
new_clean_categories,l_c,d_c=code_train('clean_categories')
new_clean_subcategories,l_cs,d_cs=code_train('clean_subcategories')
```

In [11]:

```
def code_test(name,l,d):
    f=[]



    for i in range(X_test.shape[0]):
        if X_test[name].values[i] in l:
           f.append(d[X_test[name].values[i]])
        else:
           f.append([0.5,0.5])
    return np.array(f)
```

In [12]:

```
new_school_state_test=code_test('school_state',l_sc,d_sc)
new_teacher_prefix_test=code_test('teacher_prefix',l_t,d_t)
new_project_grade_category_test=code_test('project_grade_category',l_p,d_p)
new_clean_categories_test=code_test('clean_categories',l_c,d_c)
new_clean_subcategories_test=code_test('clean_subcategories',l_cs,d_cs)
```

In [13]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['price'].values.reshape(1,-1))


X_train_price_norm = normalizer.transform(X_train['price'].values.reshape(1,-1))
X_test_price_norm = normalizer.transform(X_test['price'].values.reshape(1,-1))
X_train_price_norm=X_train_price_norm.reshape(-1,1)
X_test_price_norm=X_test_price_norm.reshape(-1,1)
```

In [14]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
# normalizer.fit(X_train['price'].values)
# this will rise an error Expected 2D array, got 1D array instead:
# array=[105.22 215.96  96.01 ... 368.98  80.53 709.67].
# Reshape your data either using
# array.reshape(-1, 1) if your data has a single feature
# array.reshape(1, -1)  if it contains a single sample.
normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(1
,-1))

X_train_teacher_number_of_previously_posted_projects_norm= normalizer.transform(X_train
['teacher_number_of_previously_posted_projects'].values.reshape(1,-1))
X_test_teacher_number_of_previously_posted_projects_norm = normalizer.transform(X_test[
'teacher_number_of_previously_posted_projects'].values.reshape(1,-1))

X_train_teacher_number_of_previously_posted_projects_norm=X_train_teacher_number_of_pre
viously_posted_projects_norm.reshape(-1,1)

X_test_teacher_number_of_previously_posted_projects_norm=X_test_teacher_number_of_previ
ously_posted_projects_norm.reshape(-1,1)
print("After vectorizations")
print(X_train_teacher_number_of_previously_posted_projects_norm.shape, y_train.shape)
#print(X_cv_teacher_number_of_previously_posted_projects_norm.shape, y_cv.shape)
print(X_test_teacher_number_of_previously_posted_projects_norm.shape, y_test.shape)
print("="*100)
```

```
After vectorizations
(73196, 1) (73196,)
(36052, 1) (36052,)
==========================================================================
==========================
```

In [15]:

```
 import pickle
#please use below code to load glove vectors
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [16]:

```



from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer = TfidfVectorizer(min_df=10,max_features=8000)
vectorizer.fit(X_train['essay'].values)
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf_ra= vectorizer.transform(X_train['essay'].values)
#X_cv_essay_tfidf= vectorizer.transform(X_cv['essay'].values)
X_test_essay_tfidf_ra = vectorizer.transform(X_test['essay'].values)

print(X_train_essay_tfidf_ra.shape)
```

```
(73196, 8000)
```

In [17]:

```

import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
sid = SentimentIntensityAnalyzer()
sent_score_train=[]
sent_score_test=[]
temp_l=[]
temp_l1=[]
for i in X_train['essay'].values:
    temp_l=sid.polarity_scores(i).values()
    sent_score_train.append(list(temp_l))

for i in X_test['essay'].values:
    temp_l1=sid.polarity_scores(i).values()
    sent_score_test.append(list(temp_l1))
print(len(sent_score_train))
```

```
73196
```

In [18]:

```

# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_train['essay'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(tfidf_model.get_feature_names(), list(tfidf_model.idf_)))
tfidf_words = set(tfidf_model.get_feature_names())
```

In [19]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_tr = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in (X_train['essay'].values): # 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):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting 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_tr.append(vector)

print(len(tfidf_w2v_vectors_tr))
print(len(tfidf_w2v_vectors_tr[0]))
```

```
73196
300
```

In [20]:

```
# average Word2Vec
# compute average word2vec for each review.
tfidf_w2v_vectors_te = []; # the avg-w2v for each sentence/review is stored in this lis
t
for sentence in (X_test['essay'].values): # 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):
            vec = model[word] # getting the vector for each word
            # here we are multiplying idf value(dictionary[word]) and the tf value((sen
tence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # ge
tting 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_te.append(vector)

print(len(tfidf_w2v_vectors_te))
print(len(tfidf_w2v_vectors_te[0]))
```

```
36052
300
```

In [21]:

```
sent_score_train_np=np.array(sent_score_train)
sent_score_test_np=np.array(sent_score_test)
print(sent_score_train_np.shape)
print(sent_score_train_np[0])
```

```
(73196, 4)
[0.062  0.618  0.32   0.9914]
```

In [22]:

```
tfidf_w2v_vectors_te_np=np.array(tfidf_w2v_vectors_te)
tfidf_w2v_vectors_tr_np=np.array(tfidf_w2v_vectors_tr)
print(tfidf_w2v_vectors_te_np.shape)
print(tfidf_w2v_vectors_tr_np.shape)
```

```
(36052, 300)
(73196, 300)
```

In [23]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_= np.hstack((new_school_state, new_teacher_prefix, new_project_grade_category,new_
clean_categories, new_clean_subcategories,X_train_price_norm,X_train_teacher_number_of_
previously_posted_projects_norm,tfidf_w2v_vectors_tr_np))
X_te_= np.hstack((new_school_state_test, new_teacher_prefix_test, new_project_grade_cat
egory_test,new_clean_categories_test, new_clean_subcategories_test,X_test_price_norm,X_
test_teacher_number_of_previously_posted_projects_norm,tfidf_w2v_vectors_te_np))

print("Final Data matrix")
print(X_tr_.shape, y_train.shape)

print(X_te_.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(73196, 312) (73196,)
(36052, 312) (36052,)
===========================================================================
==========================
```

In [24]:

```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_ra = hstack((new_school_state, new_teacher_prefix, new_project_grade_category,new_
clean_categories, new_clean_subcategories,X_train_price_norm,X_train_teacher_number_of_
previously_posted_projects_norm,X_train_essay_tfidf_ra,sent_score_train_np)).tocsr()
X_te_ra=hstack((new_school_state_test, new_teacher_prefix_test, new_project_grade_categ
ory_test,new_clean_categories_test, new_clean_subcategories_test,X_test_price_norm,X_te
st_teacher_number_of_previously_posted_projects_norm,X_test_essay_tfidf_ra,sent_score_t
est_np)).tocsr()

print("Final Data matrix")
print(X_tr_ra.shape, y_train.shape)

print(X_te_ra.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(73196, 8016) (73196,)
(36052, 8016) (36052,)
==========================================================================
==========================
```

1.5 Appling Models on different kind of featurization as mentioned in the instructions

In [25]:

```
%%time
from xgboost import XGBClassifier


# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchC
V.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier

dtree = XGBClassifier(tree_method='gpu_hist', gpu_id=0)
parameters = {'learning_rate' :[0.0001, 0.001, 0.01, 0.1, 0.2, 0.3] ,'n_estimators':[5,
10,50,75,100]}
clf = RandomizedSearchCV(dtree, parameters, cv=3, scoring='roc_auc',return_train_score=
True,n_jobs=-1)
clf.fit(X_tr_ra, y_train)
```

```
/usr/local/lib/python3.6/dist-packages/joblib/externals/loky/process_execu
tor.py:691: UserWarning: A worker stopped while some jobs were given to th
e executor. This can be caused by a too short worker timeout or by a memor
y leak.
  "timeout or by a memory leak.", UserWarning

CPU times: user 13.1 s, sys: 13.9 s, total: 27 s
Wall time: 7min 32s
```

In [26]:

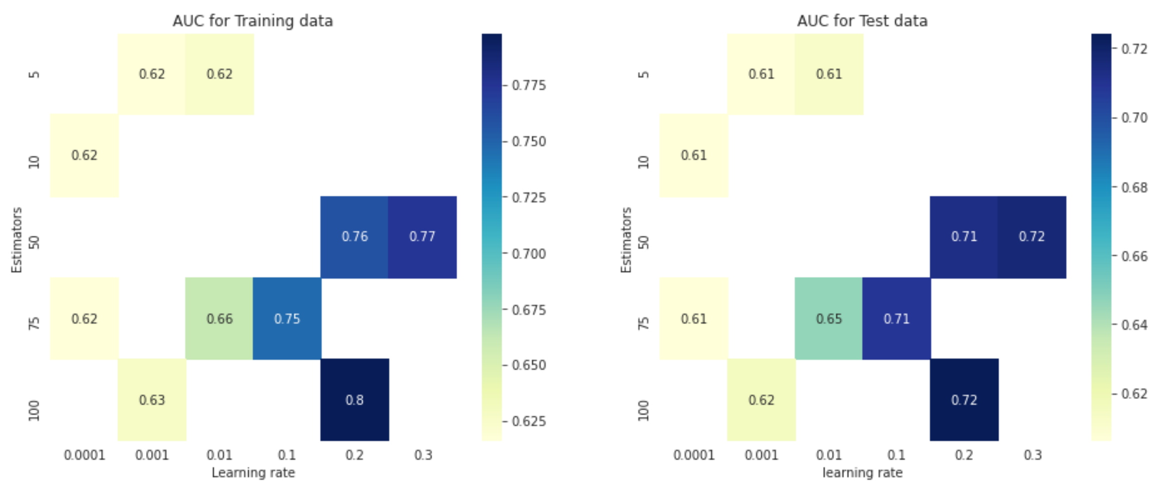
```
import pandas as pd
results = pd.DataFrame.from_dict(clf.cv_results_)


train_auc= results['mean_train_score']
train_auc_std= results['std_train_score']
cv_auc = results['mean_test_score']
cv_auc_std= results['std_test_score']
results.head()
```

Out[26]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_n_estimators	param_
0	25.557605	0.823871	1.979051	0.053493	50	
1	20.616565	1.816967	1.929717	0.038062	10	
2	25.013358	0.733841	2.007719	0.056965	75	
3	21.534328	1.055336	1.896257	0.034025	50	
4	23.555114	0.400442	1.974423	0.060700	75	

In [28]:

```
#Took this code from https://www.kaggle.com/arindambanerjee/grid-search-simplified
import seaborn as sns
import matplotlib.pyplot as plt

learning_rate_list = list(clf.cv_results_['param_learning_rate'].data)
estimators_list = list(clf.cv_results_['param_n_estimators'].data)

sns.set_style("whitegrid")
plt.figure(figsize=(16,6))
plt.subplot(1,2,1)
data = pd.DataFrame(data={'Estimators':estimators_list, 'Learning rate':learning_rate_l
ist, 'AUC':clf.cv_results_['mean_train_score']})
data = data.pivot(index='Estimators', columns='Learning rate', values='AUC')
sns.heatmap(data, annot=True, cmap="YlGnBu").set_title('AUC for Training data')
plt.subplot(1,2,2)
data = pd.DataFrame(data={'Estimators':estimators_list, 'learning rate':learning_rate_l
ist, 'AUC':clf.cv_results_['mean_test_score']})
data = data.pivot(index='Estimators', columns='learning rate', values='AUC')
sns.heatmap(data, annot=True, cmap="YlGnBu").set_title('AUC for Test data')
plt.show()
```



In [29]:

```
clf.best_params_
```

Out[29]:

```
{'learning_rate': 0.2, 'n_estimators': 100}
```

In [30]:

```
dtree_final= XGBClassifier(n_jobs=-1,learning_rate=0.3,n_estimators=50,tree_method='gpu
_hist', gpu_id=0)
dtree_final.fit(X_tr_ra, y_train)
```

Out[30]:

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=0,
              learning_rate=0.3, max_delta_step=0, max_depth=3,
              min_child_weight=1, missing=None, n_estimators=50, n_jobs=-
1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, tree_method='gpu_hist', verbosity=
1)
```

In [31]:

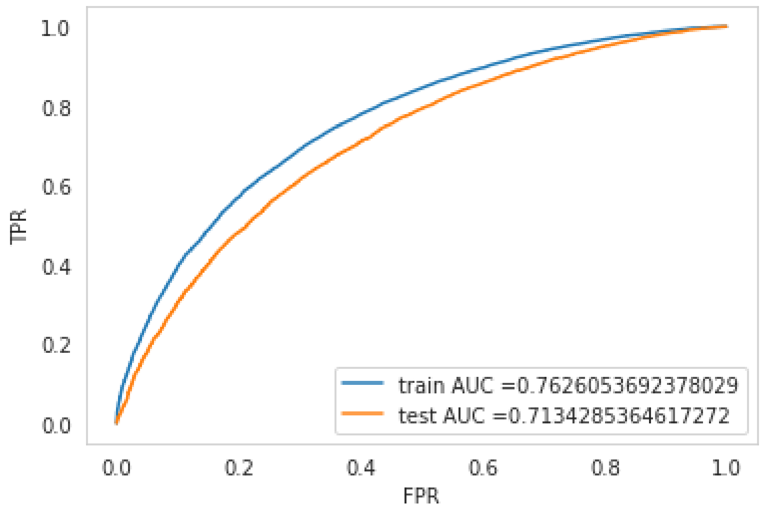
```

# we are writing our own function for predict, with defined thresould
# we will pick a threshold that will give the least fpr
def find_best_threshold(threshould, fpr, tpr):
    t = threshould[np.argmax(tpr*(1-fpr))]
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.rou
nd(t,3))
    return t

def predict_with_best_t(proba, threshould):
    predictions = []
    for i in proba:
        if i>=threshould:
            predictions.append(1)
        else:
            predictions.append(0)
    return predictions
```

In [32]:

```
import matplotlib.pyplot as plt
```

In [33]:

```
from sklearn.metrics import roc_curve, auc
y_train_pred = dtree_final.predict_proba(X_tr_ra)[:,1]
y_test_pred = dtree_final.predict_proba(X_te_ra)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.grid()
plt.show()
a=auc(test_fpr,test_tpr)
```



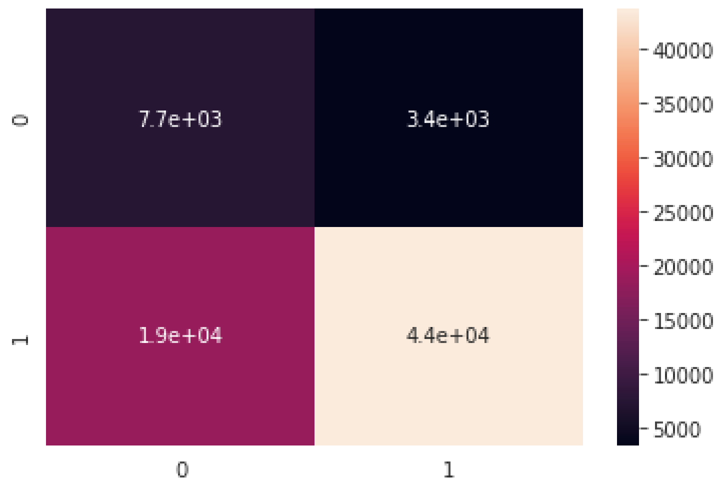
In [34]:

```
import seaborn as sns
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")

sns.heatmap(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)),annot=
True)
```

```
==========================================================================
==========================
the maximum value of tpr*(1-fpr) 0.48449559757025523 for threshold 0.838
Train confusion matrix
```

Out[34]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3f1f35bf98>
```



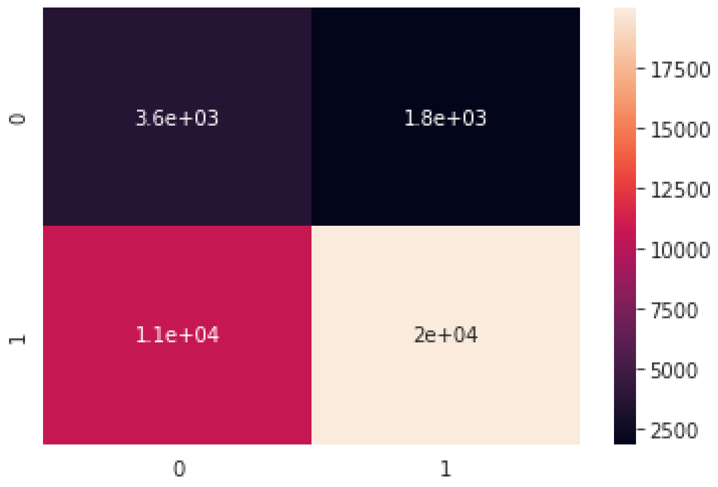
In [35]:

```
print("Test confusion matrix")
sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)),annot=Tr
ue)
```

```
Test confusion matrix
```

Out[35]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3f1f35b7b8>
```



1.4 Make Data Model Ready: encoding numerical, categorical features

In [36]:

```
%%time
from xgboost import XGBClassifier


# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchC
V.html
from sklearn.model_selection import GridSearchCV
from scipy.stats import randint as sp_randint
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier

dtree = XGBClassifier(tree_method='gpu_hist', gpu_id=0)
parameters = {'learning_rate' :[0.0001, 0.001, 0.01, 0.1, 0.2, 0.3] ,'n_estimators':[5,
10,50,75,100]}
clf = RandomizedSearchCV(dtree, parameters, cv=3, scoring='roc_auc',return_train_score=
True,n_jobs=-1)
clf.fit(X_tr_, y_train)
```

```
CPU times: user 3.24 s, sys: 2.51 s, total: 5.75 s
Wall time: 1min 14s
```

In [37]:

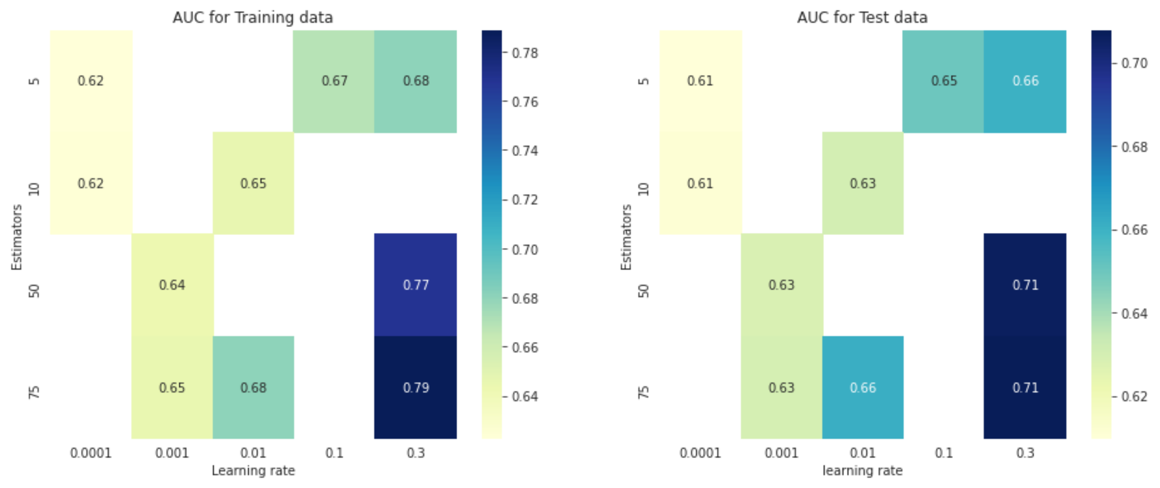
```
import pandas as pd
results = pd.DataFrame.from_dict(clf.cv_results_)


train_auc= results['mean_train_score']
train_auc_std= results['std_train_score']
cv_auc = results['mean_test_score']
cv_auc_std= results['std_test_score']
results.head()
```

Out[37]:

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_n_estimators	param_
0	1.807911	0.295590	0.126292	0.014376	5	
1	1.475820	0.135400	0.133450	0.011994	10	
2	7.574486	0.420583	0.174255	0.017043	75	
3	5.406503	0.372415	0.139446	0.002164	50	
4	5.478174	0.620881	0.133609	0.001465	50	

In [38]:

```
#Took this code from https://www.kaggle.com/arindambanerjee/grid-search-simplified
import seaborn as sns
import matplotlib.pyplot as plt

learning_rate_list = list(clf.cv_results_['param_learning_rate'].data)
estimators_list = list(clf.cv_results_['param_n_estimators'].data)

sns.set_style("whitegrid")
plt.figure(figsize=(16,6))
plt.subplot(1,2,1)
data = pd.DataFrame(data={'Estimators':estimators_list, 'Learning rate':learning_rate_l
ist, 'AUC':clf.cv_results_['mean_train_score']})
data = data.pivot(index='Estimators', columns='Learning rate', values='AUC')
sns.heatmap(data, annot=True, cmap="YlGnBu").set_title('AUC for Training data')
plt.subplot(1,2,2)
data = pd.DataFrame(data={'Estimators':estimators_list, 'learning rate':learning_rate_l
ist, 'AUC':clf.cv_results_['mean_test_score']})
data = data.pivot(index='Estimators', columns='learning rate', values='AUC')
sns.heatmap(data, annot=True, cmap="YlGnBu").set_title('AUC for Test data')
plt.show()
```



In [39]:

```
clf.best_params_
```

Out[39]:

```
{'learning_rate': 0.3, 'n_estimators': 75}
```

In [40]:

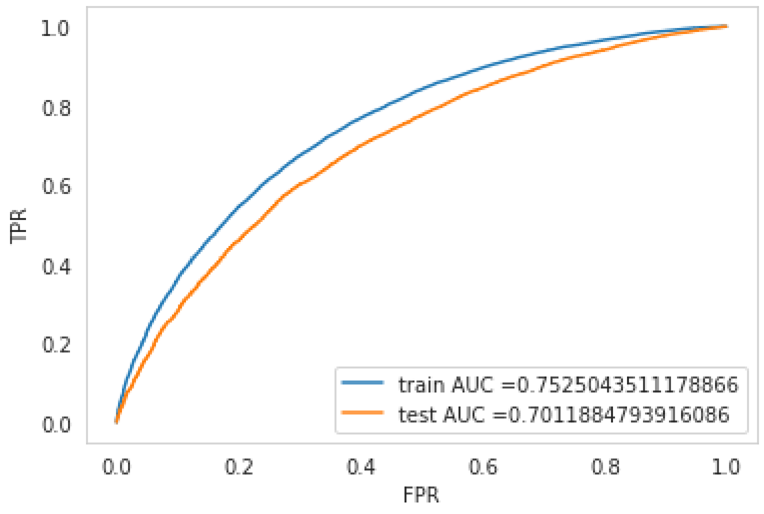
```
dtree_final= XGBClassifier(n_jobs=-1,learning_rate=0.3,n_estimators=50,tree_method='gpu
_hist', gpu_id=0)
dtree_final.fit(X_tr_, y_train)
```

Out[40]:

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=0,
              learning_rate=0.3, max_delta_step=0, max_depth=3,
              min_child_weight=1, missing=None, n_estimators=50, n_jobs=-
1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, tree_method='gpu_hist', verbosity=
1)
```

In [41]:

```
from sklearn.metrics import roc_curve, auc
y_train_pred = dtree_final.predict_proba(X_tr_)[:,1]
y_test_pred = dtree_final.predict_proba(X_te_)[:,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("FPR")
plt.ylabel("TPR")
plt.grid()
plt.show()
b=auc(test_fpr,test_tpr)
```



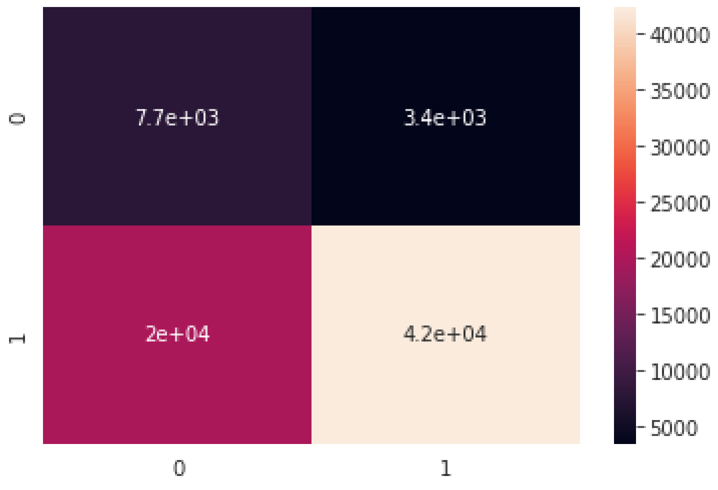
In [42]:

```
import seaborn as sns
print("="*100)
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")

sns.heatmap(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)),annot=
True)
```

```
==========================================================================
==========================
the maximum value of tpr*(1-fpr) 0.4719287347421252 for threshold 0.845
Train confusion matrix
```

Out[42]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3f1d0e6550>
```



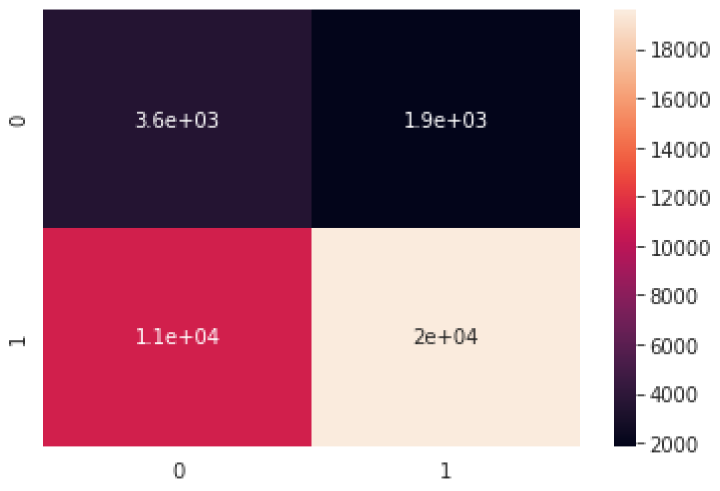
In [43]:

```
print("Test confusion matrix")
sns.heatmap(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)),annot=Tr
ue)
```

```
Test confusion matrix
```

Out[43]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3f1d073908>
```



Apply GBDT 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

In [ ]:

```
# please write all the code with proper documentation, and proper titles for each subse
ction
# go through documentations and blogs before you start coding
# first figure out what to do, and then think about how to do.
# reading and understanding error messages will be very much helpfull in debugging your
code
# when you plot any graph make sure you use
    # a. Title, that describes your plot, this will be very helpful to the reader
    # b. Legends if needed
    # c. X-axis label
    # d. Y-axis label
```

3. Summary

as mentioned in the step 4 of instructions

In [44]:

```
#https://stackoverflow.com/questions/9535954/printing-lists-as-tabular-data
from tabulate import tabulate
print(tabulate([['TFIDF', "Xgboost",0.3,50,a], ['TFidf_w2v',"Xgboost",0.3,50,b]], heade
rs=['Vectorizer', 'Model',"Hyperparameter_learning_rate","Hyperparameter_n_estimators",
"AUC"], tablefmt='orgtbl'))
```

```
| Vectorizer   | Model   |   Hyperparameter_learning_rate |   Hyperparamet
er_n_estimators |      AUC |
|--------------+---------+--------------------------------+---------------
----------------+----------|
| TFIDF        | Xgboost |                            0.3 |
50 | 0.713429 |
| TFidf_w2v    | Xgboost |                            0.3 |
50 | 0.701188 |
```

In [ ]: