Assignment 9: GBDT

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

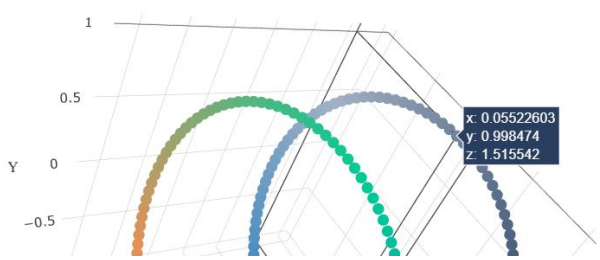
State
A
C
D
C
B
E

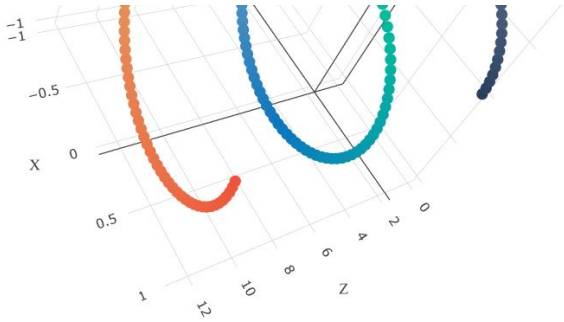
Encoded Test Data

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]

1. **Apply GBDT on these feature sets**
   - Set 1: categorical(instead of one hot encoding, try response coding: 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: 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 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

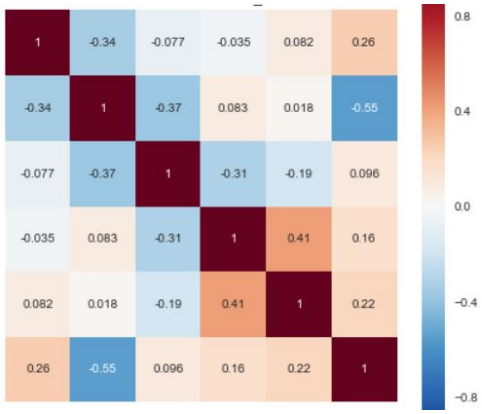




with X-axis as **n_estimators**, Y-axis as **max_depth**, and Z-axis as **AUC Score** , we have given the notebook which explains how to plot this 3d plot, you can find it in the same drive *3d_scatter_plot.ipynb*

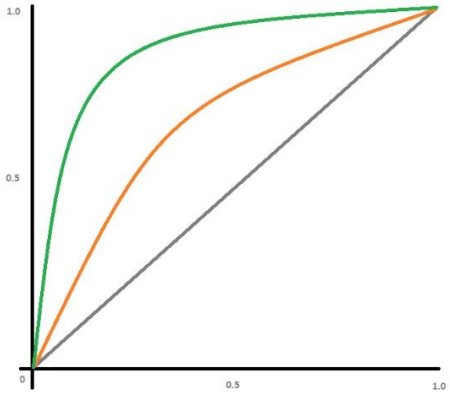
or

- 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 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 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]:

```
!wget --header="Host: doc-10-bk-docs.googleusercontent.com" --header="User-Agent: Mozilla/5.0
(Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/86.0.4240.111
Safari/537.36" --header="Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,ap
ation/signed-exchange;v=b3;q=0.9" --header="Accept-Language: en-GB,en;q=0.9,en-US;q=0.8,hi;q=0.7"
--header="Cookie: AUTH_ts1f1mr2obfc7q038mk41gveuq7r19la_nonce=0r49keuqinic6" --header="Connection:
keep-alive" "https://doc-10-bk-
docs.googleusercontent.com/docs/securesc/d1v6i1q2tfr1n0oukfsvi9flul411o5k/vkj44ahf3lu89b0q42k3qbql7
8eh/1603988475000/00997051694618726929/00997051694618726929/1F27ImX-SjdgLVVqN43-OOtRmmk2tRReE?e=do
wnload&authuser=1&nonce=0r49keuqinic6&user=00997051694618726929&hash=fmsb7o7ujkereh6veknage7ktabgol
-c -O 'preprocessed_data.csv'
```

```
--2020-10-29 16:23:27--  https://doc-10-bk-
docs.googleusercontent.com/docs/securesc/d1v6i1q2tfr1n0oukfsvi9flul411o5k/vkj44ahf3lu89b0q42k3qbql7
8eh/1603988475000/00997051694618726929/00997051694618726929/1F27ImX-SjdgLVVqN43-OOtRmmk2tRReE?e=do
wnload&authuser=1&nonce=0r49keuqinic6&user=00997051694618726929&hash=fmsb7o7ujkereh6veknage7ktabgol

Resolving doc-10-bk-docs.googleusercontent.com (doc-10-bk-docs.googleusercontent.com)...
173.194.216.132, 2607:f8b0:400c:c12::84
Connecting to doc-10-bk-docs.googleusercontent.com (doc-10-bk-
docs.googleusercontent.com)|173.194.216.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [text/csv]
Saving to: 'preprocessed_data.csv'

preprocessed_data.c     [      <=>           ] 118.69M  69.1MB/s    in 1.7s

2020-10-29 16:23:30 (69.1 MB/s) - 'preprocessed_data.csv' saved [124454659]
```

In [6]:

```
!wget --header="Host: doc-0c-bk-docs.googleusercontent.com" --header="User-Agent: Mozilla/5.0
(Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/86.0.4240.111
Safari/537.36" --header="Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,ap
ation/signed-exchange;v=b3;q=0.9" --header="Accept-Language: en-GB,en;q=0.9,en-US;q=0.8,hi;q=0.7"
--header="Cookie:
AUTH_ts1f1mr2obfc7q038mk41gveuq7r19la=00997051694618726929|1603988475000|j7q2cek3s5uhpt0t81kmjsbh38
54" --header="Connection: keep-alive" "https://doc-0c-bk-
docs.googleusercontent.com/docs/securesc/d1v6i1q2tfr1n0oukfsvi9flul411o5k/50ejgkegeca7it2ck9ks0jih3
249/1603988550000/00997051694618726929/00997051694618726929/1ZIR9symHyFeJr7zizEdW9RauHBWiHfbQ?e=do
wnload&authuser=1" -c -O 'glove_vectors'
```

```
--2020-10-29 16:23:34--  https://doc-0c-bk-
docs.googleusercontent.com/docs/securesc/d1v6i1q2tfr1n0oukfsvi9flul411o5k/50ejgkegeca7it2ck9ks0jih3
249/1603988550000/00997051694618726929/00997051694618726929/1ZIR9symHyFeJr7zizEdW9RauHBWiHfbQ?e=do
wnload&authuser=1
Resolving doc-0c-bk-docs.googleusercontent.com (doc-0c-bk-docs.googleusercontent.com)...
173.194.216.132, 2607:f8b0:400c:c12::84
Connecting to doc-0c-bk-docs.googleusercontent.com (doc-0c-bk-
docs.googleusercontent.com)|173.194.216.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [application/octet-stream]
Saving to: 'glove_vectors'

glove_vectors           [      <=>           ] 121.60M  35.7MB/s    in 3.4s

2020-10-29 16:23:37 (35.7 MB/s) - 'glove_vectors' saved [127506004]
```

In [7]:

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

# import nltk
```

```
# 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 w
ith the biggest enthusiasm \
for learning my students learn in many different ways using all of our senses and multiple intelli
gences i use a wide range\
of techniques to help all my students succeed students in my class come from a variety of differen
t backgrounds which makes\
for wonderful sharing of experiences and cultures including native americans our school is a carin
g 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 aspect of the ki
ndergarten curriculum\
montana is the perfect place to learn about agriculture and nutrition my students love to role pla
y 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 concepts while co
oking delicious healthy \
food for snack time my students will have a grounded appreciation for the work that went into maki
ng the food and knowledge \
of where the ingredients came from as well as how it is healthy for their bodies this project woul
d expand our learning of \
nutrition and agricultural cooking recipes by having us peel our own apples to make homemade apple
sauce make our own bread \
and mix up healthy plants from our classroom garden in the spring we will also create our own cook
books to be printed and \
shared with families students will gain math and literature skills as well as a life long enjoymen
t for healthy cooking \
nannan'
ss = sid.polarity_scores(for_sentiment)
print(ss['neg'])

# 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
```

```
/usr/local/lib/python3.6/dist-packages/nltk/twitter/__init__.py:20: UserWarning: 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. "
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
0.01
```

1. GBDT (xgboost/lightgbm)

1.1 Loading Data

In [8]:

```
import pandas as pd
ppcsd_df = pd.read_csv('preprocessed_data.csv')
ppcsd_df.head()
```

Out[8]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ca	mrs	grades_prek_2	53	1	math_s
1	ut	ms	grades_3_5	4	1	special

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
2	ca	mrs	grades_prek_2	10	1	literacy_lan
3	ga	mrs	grades_prek_2	2	1	appliedle
4	wa	mrs	grades_3_5	2	1	literacy_lan

In [9]:

```
ppcsd_df.shape
```

Out[9]:

```
(109248, 9)
```

In [10]:

```
import nltk
from nltk.sentiment.vader import SentimentIntensityAnalyzer
from tqdm.notebook import tqdm
## ************************************************
sid = SentimentIntensityAnalyzer()
essay_neg = [0 for i in range(109248)]
essay_neu = [0 for i in range(109248)]
essay_pos = [0 for i in range(109248)]
essay_compound = [0 for i in range(109248)]
i=0
for sentence in tqdm(ppcsd_df['essay']):
    ss = sid.polarity_scores(sentence)
    essay_neg[i] = ss['neg']
    essay_neu[i] = ss['neu']
    essay_pos[i] = ss['pos']
    essay_compound[i] = ss['compound']
    i+=1
```

In [11]:

```
ppcsd_df['essay_neg'] = essay_neg
ppcsd_df['essay_neu'] = essay_neu
ppcsd_df['essay_pos'] = essay_pos
ppcsd_df['essay_compound'] = essay_compound
```

In [12]:

```
ppcsd_df.head()
```

Out[12]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ca	mrs	grades_prek_2	53	1	math_s

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
1	ut	ms	grades_3_5	4	1	special
2	ca	mrs	grades_prek_2	10	1	literacy_lan
3	ga	mrs	grades_prek_2	2	1	appliedle
4	wa	mrs	grades_3_5	2	1	literacy_lan

In [13]:

```
### Essay Preprocessing
import nltk
nltk.download('punkt')
nltk.download('wordnet')
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer

def lem_stop_word(essay_str):

    lemmatizer = WordNetLemmatizer()
    tokens = word_tokenize(essay_str)
    new_token = []
    for word in tokens:
          new_token.append(lemmatizer.lemmatize(word,pos='v'))
    return(" ".join(new_token))
    new_token.clear()


ppcsd_df['essay'] = ppcsd_df['essay'].apply(lem_stop_word)
```

```
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Unzipping corpora/wordnet.zip.
```

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

In [14]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

In [15]:

```
## Import required library
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
```

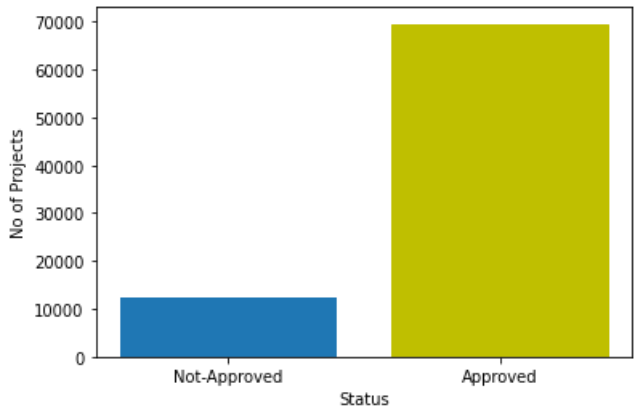
```
from sklearn.model_selection import train_test_split

## create train,test split
X_tr,X_test = train_test_split(ppcsd_df, test_size=0.25, random_state=42,stratify=ppcsd_df['project
_is_approved'])

### check number of approved and not approved data in train file
print("counts of label 'Approved': {}".format(sum(X_tr['project_is_approved'] == 1)))
print("counts of label 'Not Approved': {} \n".format(sum(X_tr['project_is_approved'] == 0)))
print("Ratio of Aprroved to Not Approved :{}".format((sum(X_tr['project_is_approved'] ==
1)/sum(X_tr['project_is_approved'] == 0))))
##
print("-"*100)
temp=np.unique(X_tr['project_is_approved'] ,return_counts=True)
temp = pd.Series(temp[1],index=temp[0])
ind = np.arange(len(temp))
fig, ax = plt.subplots()
ax.bar(ind, temp)
ax.set_ylabel('No of Projects')
ax.set_xlabel('Status')
ax.set_xticks(ind)
ax.set_xticklabels(['Not-Approved','Approved'])
ax.get_children()[1].set_color('y')
```

```
counts of label 'Approved': 69530
counts of label 'Not Approved': 12406

Ratio of Aprroved to Not Approved :5.604546187328712
----------------------------------------------------------------------------------------------------
```



In [16]:

```
print("Total number of unique states is {}".format(X_tr['school_state'].nunique()))
print("Total number of unique prefix is {}".format(X_tr['teacher_prefix'].nunique()))
print("Total number of unique project_grade_category is {}".format(X_tr['project_grade_category'].
nunique()))
print("Total number of unique clean_categories is {}".format(X_tr['clean_categories'].nunique()))
print("Total number of unique clean_categories is {}".format(X_tr['clean_subcategories'].nunique()
))
```

```
Total number of unique states is 51
Total number of unique prefix is 5
Total number of unique project_grade_category is 4
Total number of unique clean_categories is 51
Total number of unique clean_categories is 397
```

1.3 Make Data Model Ready: encoding eassay, and project_title

In [17]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

In [18]:

```
## reference "https://towardsdatascience.com/all-about-categorical-variable-encoding-305f3361fd02
### Response Coding of the features
def
response_coding_for_feature(X_tr_func,X_test_func,col_name='school_state',new_col='Res_Code_State'
):

    ### laplace smoothing
    k = X_tr_func[col_name].nunique()
    alpha = 0.01
    x_pos_cnt = X_tr_func.groupby(col_name)['project_is_approved'].sum()
    x_pos_cnt = x_pos_cnt.to_dict()
    total_cnt = X_tr_func.groupby(col_name)['project_is_approved'].count()
    total_cnt = total_cnt.to_dict()
    ### lpalace smoothing for all the variables
    for uniq_val in x_pos_cnt.keys():
      x = x_pos_cnt.get(uniq_val)
      n = total_cnt.get(uniq_val)
      x = (x+alpha)/(n+(k*alpha))
      x_pos_cnt[uniq_val] = x
    ## get train features variables.
    pr_df = pd.DataFrame.from_dict(x_pos_cnt,orient ='index')
    pr_df.reset_index(inplace=True,drop=False)
    pr_df['project_not_approved'] = 1 - pr_df[0]
    pos_col = new_col + '_pos'
    neg_col = new_col + '_neg'
    pr_df = pr_df.rename(columns = {'index' : col_name,
                                    0:pos_col,
                                   'project_not_approved':neg_col})
    X_tr_func = X_tr_func.merge(pr_df,left_on=col_name,right_on=col_name,how='inner')
    X_test_func = X_test_func.merge(pr_df,left_on=col_name,right_on=col_name,how='inner')
    ### fill not found state with 0.5 as the inner join will return NAN value
    X_test_func[[pos_col, neg_col]].fillna(value=0.5,inplace=True)
    return X_tr_func, X_test_func
```

In [19]:

```
X_tr,X_test =
response_coding_for_feature(X_tr,X_test,col_name='school_state',new_col='Res_Code_State')
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:4323: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  downcast=downcast,
```

In [20]:

```
X_tr,X_test =
response_coding_for_feature(X_tr,X_test,col_name='teacher_prefix',new_col='Res_Code_tpr')
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:4323: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  downcast=downcast,
```

In [21]:

```
X_tr,X_test =
response_coding_for_feature(X_tr,X_test,col_name='project_grade_category',new_col='Res_Code_pgc')
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:4323: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  downcast=downcast,
```

In [22]:

```
X_tr,X_test =
response_coding_for_feature(X_tr,X_test,col_name='clean_categories',new_col='Res_Code_cc')
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:4323: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  downcast=downcast,
```

In [23]:

```
X_tr,X_test =
response_coding_for_feature(X_tr,X_test,col_name='clean_subcategories',new_col='Res_Code_csc')
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:4323: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  downcast=downcast,
```

In [24]:

```
X_tr.head()
```

Out[24]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_projects	project_is_approved	clean_cate
0	ok	mr	grades_6_8	0	1	appliedle
1	tx	mr	grades_6_8	1	1	appliedle
2	or	mr	grades_6_8	0	0	appliedle
3	md	mrs	grades_6_8	0	1	appliedle
4	nh	mrs	grades_6_8	4	1	appliedle

In [25]:

```
y_tr = X_tr['project_is_approved']
X_tr = X_tr.drop('project_is_approved',axis=1)
y_test = X_test['project_is_approved']
X_test = X_test.drop('project_is_approved',axis=1)
```

1.4 Make Data Model Ready: encoding numerical, categorical features

In [26]:

```
# please write all the code with proper documentation, and proper titles for each subsection
# 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
```

In [27]:

```
### Normalize your data
def norm_data(X_tr, y_tr, X_test, y_test, col_name = 'price'):

    from sklearn.preprocessing import Normalizer
    normalizer = Normalizer()

    normalizer.fit(X_tr['price'].values.reshape(1,-1))

    X_tr_norm = normalizer.transform(X_tr['price'].values.reshape(-1,1))
    X_test_norm = normalizer.transform(X_test['price'].values.reshape(-1,1))


    print("After vectorizations")
    print(X_tr_norm.shape, y_tr.shape)
    print(X_test_norm.shape, y_test.shape)
    print("="*100)
    return X_tr_norm,X_test_norm
```

In [28]:

```
X_tr_price_norm, X_test_price_norm = norm_data(X_tr, y_tr, X_test, y_test, 'price')
```

```
After vectorizations
(81936, 1) (81936,)
(27306, 1) (27306,)
====================================================================================================
```

In [29]:

```
X_tr_nopp_norm, X_test_nopp_norm = norm_data(X_tr, y_tr, X_test, y_test,
'teacher_number_of_previously_posted_project')
```

```
After vectorizations
(81936, 1) (81936,)
(27306, 1) (27306,)
====================================================================================================
```

TF-IDF Implementation

In [30]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
```

```
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
```

In [31]:

```
def TFIDF_essays_sub(X_tr, y_tr, X_test, y_test, col_name = 'essay'):

    vectorizer = TfidfVectorizer(min_df=10,ngram_range=(1,2),max_features=5000)
    vectorizer.fit(X_tr[col_name].values) # fit has to happen only on train data

    # we use the fitted CountVectorizer to convert the text to vector
    X_tr_ohe = vectorizer.transform(X_tr[col_name].values)
    X_test_ohe = vectorizer.transform(X_test[col_name].values)

    print("After vectorizations {}".format(col_name))
    print(X_tr_ohe.shape, y_tr.shape)
    print(X_test_ohe.shape, y_test.shape)
    #print(vectorizer.get_feature_names())
    print("="*100)

    return X_tr_ohe, X_test_ohe, vectorizer.get_feature_names()
```

In [32]:

```
X_tr_essay_tfidf, X_test_essay_tfidf, TFIDF_feature_name = TFIDF_essays_sub(X_tr, y_tr, X_test, y_t
est, col_name = 'essay')
```

```
After vectorizations essay
(81936, 5000) (81936,)
(27306, 5000) (27306,)
====================================================================================================
```

In [33]:

```
## prepare your data set to train your model
from scipy.sparse import hstack
X_tr_tfidf_csr = hstack((X_tr_essay_tfidf,X_tr_nopp_norm, X_tr_price_norm,X_tr['essay_neg'].values.
reshape(-1,1),
                         X_tr['essay_neu'].values.reshape(-1,1),X_tr['essay_pos'].values.reshape(-1,
),
                         X_tr['essay_compound'].values.reshape(-1,1),X_tr['Res_Code_State_pos'].valu
s.reshape(-1,1),
                         X_tr['Res_Code_State_neg'].values.reshape(-1,1),X_tr['Res_Code_tpr_pos'].va
ues.reshape(-1,1),
                         X_tr['Res_Code_tpr_neg'].values.reshape(-1,1),X_tr['Res_Code_pgc_pos'].valu
s.reshape(-1,1),
                         X_tr['Res_Code_pgc_neg'].values.reshape(-1,1),X_tr['Res_Code_cc_pos'].value
.reshape(-1,1),
                         X_tr['Res_Code_cc_neg'].values.reshape(-1,1),X_tr['Res_Code_csc_pos'].value
.reshape(-1,1),
                         X_tr['Res_Code_csc_neg'].values.reshape(-1,1)))
##
X_test_tfidf_csr = hstack((X_test_essay_tfidf,X_test_nopp_norm,
X_test_price_norm,X_test['essay_neg'].values.reshape(-1,1),
                         X_test['essay_neu'].values.reshape(-1,1),X_test['essay_pos'].values.reshape
-1,1),
                         X_test['essay_compound'].values.reshape(-1,1),X_test['Res_Code_State_pos'].
alues.reshape(-1,1),
                         X_test['Res_Code_State_neg'].values.reshape(-1,1),X_test['Res_Code_tpr_pos'
.values.reshape(-1,1),
                         X_test['Res_Code_tpr_neg'].values.reshape(-1,1),X_test['Res_Code_pgc_pos'].
alues.reshape(-1,1),
                         X_test['Res_Code_pgc_neg'].values.reshape(-1,1),X_test['Res_Code_cc_pos'].v
lues.reshape(-1,1),
                         X_test['Res_Code_cc_neg'].values.reshape(-1,1),X_test['Res_Code_csc_pos'].v
lues.reshape(-1,1),
                         X_test['Res_Code_csc_neg'].values.reshape(-1,1)))
##
print("Final Data matrix")
print(X_tr_tfidf_csr.shape, y_tr.shape)
print(X_test_tfidf_csr.shape, y_test.shape)
```

```
print("="*100)
```

```
Final Data matrix
(81936, 5016) (81936,)
(27306, 5016) (27306,)
====================================================================================================
```

In [34]:

```
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier
from scipy.stats import randint
```

In [88]:

```
%%time
### Train XGBoost Classifier
model_params = {
                'n_estimators': [500,750,1000,1250] ,
                'max_depth' :  [1, 3, 5, 7 ]
               }
#
xgbdt_clf = XGBClassifier(learning_rate =0.1,
                    min_child_weight=1,
                    reg_lambda = 1.5,
                    subsample=0.6,
                    colsample_bytree=0.6,
                    colsample_bylevel=0.8,
                    objective= 'binary:logistic',
                    nthread=4
                    )
#
clf = GridSearchCV(xgbdt_clf, model_params, cv=5, scoring='roc_auc', return_train_score=True, n_jobs=-1,
                           verbose=40)
clf.fit(X_tr_tfidf_csr,y_tr,
        verbose=15)
```

```
Fitting 5 folds for each of 16 candidates, totalling 80 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  2.9min
[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:  2.9min
[Parallel(n_jobs=-1)]: Done   3 tasks      | elapsed:  5.7min
[Parallel(n_jobs=-1)]: Done   4 tasks      | elapsed:  5.7min
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:  8.5min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed:  9.6min
[Parallel(n_jobs=-1)]: Done   7 tasks      | elapsed: 12.6min
[Parallel(n_jobs=-1)]: Done   8 tasks      | elapsed: 13.7min
[Parallel(n_jobs=-1)]: Done   9 tasks      | elapsed: 16.6min
[Parallel(n_jobs=-1)]: Done  10 tasks      | elapsed: 17.7min
[Parallel(n_jobs=-1)]: Done  11 tasks      | elapsed: 21.9min
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed: 23.1min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 27.3min
[Parallel(n_jobs=-1)]: Done  14 tasks      | elapsed: 28.4min
[Parallel(n_jobs=-1)]: Done  15 tasks      | elapsed: 32.7min
[Parallel(n_jobs=-1)]: Done  16 tasks      | elapsed: 35.1min
[Parallel(n_jobs=-1)]: Done  17 tasks      | elapsed: 39.3min
[Parallel(n_jobs=-1)]: Done  18 tasks      | elapsed: 41.7min
[Parallel(n_jobs=-1)]: Done  19 tasks      | elapsed: 46.0min
[Parallel(n_jobs=-1)]: Done  20 tasks      | elapsed: 48.5min
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed: 53.1min
[Parallel(n_jobs=-1)]: Done  22 tasks      | elapsed: 55.6min
[Parallel(n_jobs=-1)]: Done  23 tasks      | elapsed: 60.1min
[Parallel(n_jobs=-1)]: Done  24 tasks      | elapsed: 62.5min
[Parallel(n_jobs=-1)]: Done  25 tasks      | elapsed: 67.1min
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed: 72.9min
[Parallel(n_jobs=-1)]: Done  27 tasks      | elapsed: 77.4min
[Parallel(n_jobs=-1)]: Done  28 tasks      | elapsed: 83.3min
[Parallel(n_jobs=-1)]: Done  29 tasks      | elapsed: 87.7min
```

```
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed: 93.8min
[Parallel(n_jobs=-1)]: Done  31 tasks      | elapsed: 101.4min
[Parallel(n_jobs=-1)]: Done  32 tasks      | elapsed: 107.5min
[Parallel(n_jobs=-1)]: Done  33 tasks      | elapsed: 115.3min
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed: 121.3min
[Parallel(n_jobs=-1)]: Done  35 tasks      | elapsed: 128.9min
[Parallel(n_jobs=-1)]: Done  36 tasks      | elapsed: 138.6min
[Parallel(n_jobs=-1)]: Done  37 tasks      | elapsed: 146.4min
[Parallel(n_jobs=-1)]: Done  38 tasks      | elapsed: 156.1min
[Parallel(n_jobs=-1)]: Done  39 tasks      | elapsed: 163.4min
[Parallel(n_jobs=-1)]: Done  40 tasks      | elapsed: 173.1min
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed: 174.6min
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed: 184.3min
[Parallel(n_jobs=-1)]: Done  43 tasks      | elapsed: 186.1min
[Parallel(n_jobs=-1)]: Done  44 tasks      | elapsed: 195.5min
[Parallel(n_jobs=-1)]: Done  45 tasks      | elapsed: 197.2min
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed: 211.9min
[Parallel(n_jobs=-1)]: Done  47 tasks      | elapsed: 213.9min
[Parallel(n_jobs=-1)]: Done  48 tasks      | elapsed: 228.7min
[Parallel(n_jobs=-1)]: Done  49 tasks      | elapsed: 230.5min
[Parallel(n_jobs=-1)]: Done  50 tasks      | elapsed: 245.6min
[Parallel(n_jobs=-1)]: Done  51 tasks      | elapsed: 253.3min
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed: 268.7min
[Parallel(n_jobs=-1)]: Done  53 tasks      | elapsed: 276.4min
[Parallel(n_jobs=-1)]: Done  54 tasks      | elapsed: 291.3min
[Parallel(n_jobs=-1)]: Done  55 tasks      | elapsed: 299.1min
[Parallel(n_jobs=-1)]: Done  56 tasks      | elapsed: 319.1min
[Parallel(n_jobs=-1)]: Done  57 tasks      | elapsed: 326.9min
[Parallel(n_jobs=-1)]: Done  58 tasks      | elapsed: 346.8min
[Parallel(n_jobs=-1)]: Done  59 tasks      | elapsed: 354.3min
[Parallel(n_jobs=-1)]: Done  60 tasks      | elapsed: 369.9min
[Parallel(n_jobs=-1)]: Done  61 tasks      | elapsed: 373.8min
[Parallel(n_jobs=-1)]: Done  62 tasks      | elapsed: 385.3min
[Parallel(n_jobs=-1)]: Done  63 tasks      | elapsed: 389.2min
[Parallel(n_jobs=-1)]: Done  64 tasks      | elapsed: 400.7min
[Parallel(n_jobs=-1)]: Done  65 tasks      | elapsed: 404.7min
[Parallel(n_jobs=-1)]: Done  66 tasks      | elapsed: 424.1min
[Parallel(n_jobs=-1)]: Done  67 tasks      | elapsed: 428.3min
[Parallel(n_jobs=-1)]: Done  68 tasks      | elapsed: 447.6min
[Parallel(n_jobs=-1)]: Done  69 tasks      | elapsed: 451.3min
[Parallel(n_jobs=-1)]: Done  70 tasks      | elapsed: 471.0min
[Parallel(n_jobs=-1)]: Done  71 tasks      | elapsed: 482.2min
[Parallel(n_jobs=-1)]: Done  72 tasks      | elapsed: 501.8min
[Parallel(n_jobs=-1)]: Done  73 tasks      | elapsed: 512.5min
[Parallel(n_jobs=-1)]: Done  74 tasks      | elapsed: 531.7min
[Parallel(n_jobs=-1)]: Done  75 tasks      | elapsed: 542.5min
[Parallel(n_jobs=-1)]: Done  76 tasks      | elapsed: 568.9min
[Parallel(n_jobs=-1)]: Done  77 tasks      | elapsed: 579.9min
[Parallel(n_jobs=-1)]: Done  80 out of  80 | elapsed: 629.9min remaining:    0.0s
[Parallel(n_jobs=-1)]: Done  80 out of  80 | elapsed: 629.9min finished

CPU times: user 7min 49s, sys: 1.31 s, total: 7min 50s
Wall time: 10h 33min 59s
```

In [89]:

```
train_auc= clf.cv_results_['mean_train_score']
train_auc_std = clf.cv_results_['std_train_score']
test_auc = clf.cv_results_['mean_test_score']
test_auc_std = clf.cv_results_['std_test_score']

#Output of GridSearchCV
print('Best score: ',clf.best_score_)
print('Best Hyper parameters: ',clf.best_params_)
print('='*75)
print('Train AUC scores')
print(clf.cv_results_['mean_train_score'])
print('CV AUC scores')
print(clf.cv_results_['mean_test_score'])
```

```
Best score:  0.6526207037918785
Best Hyper parameters:  {'max_depth': 1, 'n_estimators': 1250}
===========================================================================
Train AUC scores
[0.73332033 0.75181519 0.76605276 0.77789603 0.8517532  0.88655417
```

```
 0.9119096  0.93048882 0.94613544 0.9730147  0.98663968 0.99326684
 0.98826787 0.99705505 0.99927462 0.99979901]
CV AUC scores
[0.64503882 0.6488506  0.65143128 0.6526207  0.62822379 0.63091631
 0.62950553 0.62896355 0.61965915 0.62115954 0.62102054 0.61964313
 0.61546911 0.61619335 0.61483068 0.61394219]
```

In [90]:

```
'''%%time
### Train XGBoost Classifier
model_params = {
                'n_estimators': randint(50,1050),
                'max_depth' :  randint(1,12)
               }
#
eval_set = [(X_test_tfidf_csr, y_test)]
xgbdt_clf = XGBClassifier(learning_rate =0.1,
                    min_child_weight=1,
                    n_estimators = 10000,
                    reg_lambda = 0.2,
                    subsample=0.6,
                    colsample_bytree=0.6,
                    colsample_bylevel=0.8,
                    objective= 'binary:logistic',
                    nthread=4
                    )
#
clf = RandomizedSearchCV(xgbdt_clf, model_params, cv=5, scoring='roc_auc',
return_train_score=True, n_jobs=-1,
                         n_iter = 10, verbose=1, random_state = 42)
xgbdt_clf.fit(X_tr_tfidf_csr,y_tr,
        verbose=True,eval_metric="auc", eval_set=eval_set,early_stopping_rounds=100)'''
```

Out[90]:

```
'%%time\n### Train XGBoost Classifier\nmodel_params = {\n                \'n_estimators\': randint(
50,1050),\n                \'max_depth\' :  randint(1,12)\n               }\n#\neval_set = [(X_test
tfidf_csr, y_test)]\nxgbdt_clf = XGBClassifier(learning_rate =0.1,\n
min_child_weight=1,\n                    n_estimators = 10000,\n                    reg_lambda = 0.
,                    \n                    subsample=0.6,\n
colsample_bytree=0.6,\n                    colsample_bylevel=0.8,\n                    objective= \
binary:logistic\',\n                    nthread=4\n                    )\n#\nclf =
RandomizedSearchCV(xgbdt_clf, model_params, cv=5, scoring=\'roc_auc\', return_train_score=True,
n_jobs=-1,\n                         n_iter = 10, verbose=1, random_state =
42)\nxgbdt_clf.fit(X_tr_tfidf_csr,y_tr,\n        verbose=True,eval_metric="auc", eval_set=eval_set,
early_stopping_rounds=100)'
```

In [91]:

```
from itertools import repeat
x1 = []
y1 = []
max_depth = [1, 3, 5, 7 ]
n_estimators =  [500,750,1000,1250]
train_auc_scores = clf.cv_results_['mean_train_score']
cv_auc_scores = clf.cv_results_['mean_test_score']

x1 = [x for item in max_depth for x in repeat(item, 4)]
for _ in max_depth:
    for item in n_estimators:
        y1.append(item)
```

In [92]:

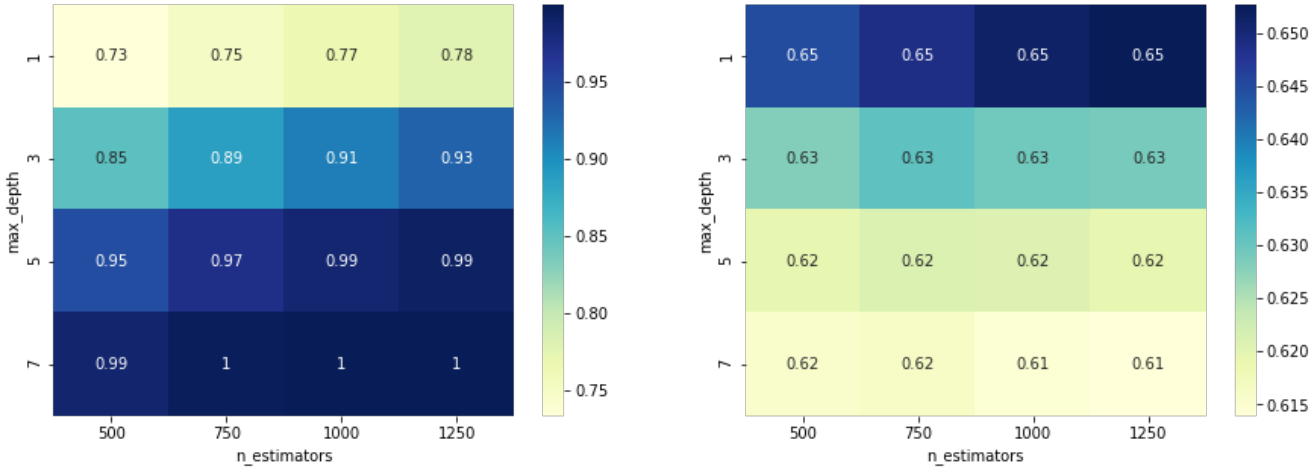
```
import seaborn as sns
df1 = pd.DataFrame(list(zip(x1,y1,train_auc))).rename(columns = {0 : 'max_depth', 1: 'n_estimators'
, 2: 'mean_train_score'}).pivot('max_depth','n_estimators','mean_train_score')
df2 = pd.DataFrame(list(zip(x1,y1,test_auc))).rename(columns = {0 : 'max_depth', 1: 'n_estimators',
2: 'mean_CV_score'}).pivot('max_depth','n_estimators','mean_CV_score')
plt.figure(figsize=(50,20))
f, axes = plt.subplots(1, 2,figsize=(15,5))
sns.heatmap(df1,annot=True,ax=axes[0],cbar = True ,cmap= "YlGnBu")
sns.heatmap(df2,annot=True,ax=axes[1],cbar = True ,cmap= "YlGnBu")
```

```
sns.heatmap(df2,annot=True,ax=axes[1],cbar = True ,cmap= 'YlGnBu' )
```

Out[92]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f2e0f129588>

<Figure size 3600x1440 with 0 Axes>
```



In [35]:

```
%%time
### Train XGBoost Classifier
#
xgbdt_clf = XGBClassifier(learning_rate =0.1,
                      min_child_weight=1,
                      n_estimators = 1250,
                      max_depth = 1,
                      reg_lambda = 1.5,
                      subsample=0.6,
                      colsample_bytree=0.6,
                      colsample_bylevel=0.8,
                      objective= 'binary:logistic',
                      verbose = 4,
                      nthread=4
                      )
xgbdt_clf.fit(X_tr_tfidf_csr,y_tr,
        verbose=True)
```

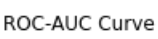
```
CPU times: user 7min 53s, sys: 1.01 s, total: 7min 54s
Wall time: 4min 11s
```

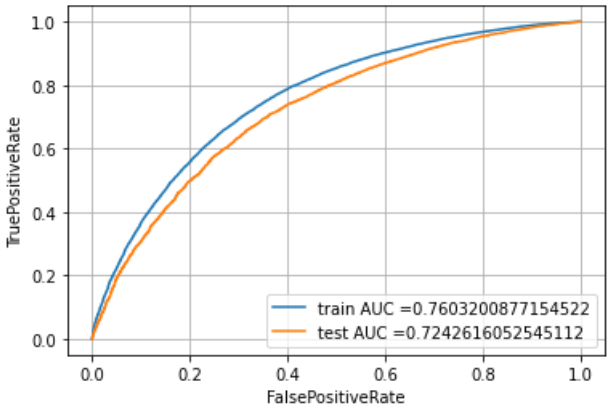
In [36]:

```
from sklearn.metrics import roc_curve, auc
y_train_pred = xgbdt_clf.predict_proba(X_tr_tfidf_csr)[::,1]
y_test_pred =  xgbdt_clf.predict_proba(X_test_tfidf_csr)[::,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_tr, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
auc_tfidf_train = auc(train_fpr, train_tpr)
auc_tfidf_test = auc(test_fpr, test_tpr)
### feature importance


plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc_tfidf_train))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc_tfidf_test))
plt.legend()
plt.xlabel("FalsePositiveRate")
plt.ylabel("TruePositiveRate")
plt.title("ROC-AUC Curve")
plt.grid()
plt.show()
```





In [37]:

```
### find best threshold
def find_best_threshold(threshold, fpr, tpr):
    t = threshold[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.round(t,3))
    return t

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

In [39]:

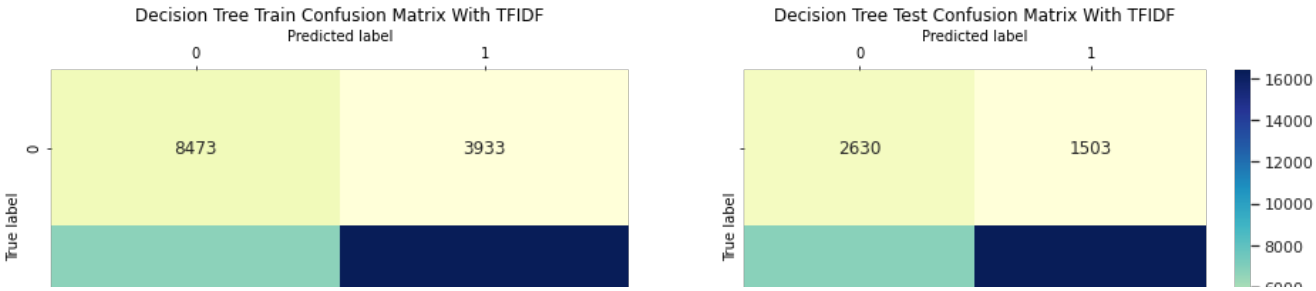
```
from sklearn.metrics import confusion_matrix
import seaborn as sns
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
y_train_pred_class = predict_with_best_t(y_train_pred, best_t)
y_test_pred_class = predict_with_best_t(y_test_pred, best_t)
train_conf_mat = pd.DataFrame(confusion_matrix(y_tr, y_train_pred_class))
test_conf_mat = pd.DataFrame(confusion_matrix(y_test, y_test_pred_class))

fig, axs = plt.subplots(1,2,figsize=(16, 4),sharey=True)
sns.set(font_scale=1)
f1 = sns.heatmap(train_conf_mat, annot=True,fmt="d", ax=axs[0], cbar = False ,cmap= "YlGnBu")

f1.set_title('Decision Tree Train Confusion Matrix With TFIDF')
f1.set_ylabel('True label')
f1.set_xlabel('Predicted label')
f1.xaxis.set_ticks_position('top')
f1.xaxis.set_label_position('top')

f2 = sns.heatmap(test_conf_mat, annot=True, fmt = 'd', ax=axs[1] , cmap = "YlGnBu")
f2.set_title('Decision Tree Test Confusion Matrix With TFIDF')
f2.set_ylabel('True label')
f2.set_xlabel('Predicted label')
f2.xaxis.set_ticks_position('top')
f2.xaxis.set_label_position('top')
```

```
the maximum value of tpr*(1-fpr) 0.4857056414734996 for threshold 0.834
```



TFIDF Word2Vec Implementation

Weighted TFIDF Word2Vec Implementation

In [40]:

```
tfidf_model = TfidfVectorizer()
tfidf_model.fit(X_tr['essay'])
# 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 [41]:

```
import pickle
with open('glove_vectors', 'rb') as f:
    model = pickle.load(f)
    glove_words =  set(model.keys())
```

In [42]:

```
tfidf_w2v_tr_vector = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_tr['essay']): # 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((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_tr_vector.append(vector)

print(len(tfidf_w2v_tr_vector))
print(len(tfidf_w2v_tr_vector[0]))
```

```
81936
300
```

In [43]:

```
tfidf_w2v_test_vector = []; # the avg-w2v for each sentence/review is stored in this list
for sentence in tqdm(X_test['essay']): # 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((sentence.count(word)/len(sentence.split())))
            tf_idf = dictionary[word]*(sentence.count(word)/len(sentence.split())) # getting the tf
idf 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_test_vector.append(vector)

print(len(tfidf_w2v_test_vector))
print(len(tfidf_w2v_test_vector[0]))
```

```
27306
300
```

In [44]:

```
tfidf_w2v_tr_vector = np.array(tfidf_w2v_tr_vector)
tfidf_w2v_test_vector = np.array(tfidf_w2v_test_vector)
tfidf_w2v_test_vector.shape
```

Out[44]:

```
(27306, 300)
```

In [46]:

```
## prepare your data set to train your model
from scipy.sparse import hstack
tfidf_w2v_tr_vector = np.array(tfidf_w2v_tr_vector)
tfidf_w2v_test_vector = np.array(tfidf_w2v_test_vector)
X_tr_tfidf_csr = np.concatenate((tfidf_w2v_tr_vector,X_tr_nopp_norm,
X_tr_price_norm,X_tr['essay_neg'].values.reshape(-1,1),
                         X_tr['essay_neu'].values.reshape(-1,1),X_tr['essay_pos'].values.reshape(-1,
),
                         X_tr['essay_compound'].values.reshape(-1,1),X_tr['Res_Code_State_pos'].valu
s.reshape(-1,1),
                         X_tr['Res_Code_State_neg'].values.reshape(-1,1),X_tr['Res_Code_tpr_pos'].va
ues.reshape(-1,1),
                         X_tr['Res_Code_tpr_neg'].values.reshape(-1,1),X_tr['Res_Code_pgc_pos'].valu
s.reshape(-1,1),
                         X_tr['Res_Code_pgc_neg'].values.reshape(-1,1),X_tr['Res_Code_cc_pos'].value
.reshape(-1,1),
                         X_tr['Res_Code_cc_neg'].values.reshape(-1,1),X_tr['Res_Code_csc_pos'].value
.reshape(-1,1),
                         X_tr['Res_Code_csc_neg'].values.reshape(-1,1)),axis=1)
##
X_test_tfidf_csr = np.concatenate((tfidf_w2v_test_vector,X_test_nopp_norm,
X_test_price_norm,X_test['essay_neg'].values.reshape(-1,1),
                         X_test['essay_neu'].values.reshape(-1,1),X_test['essay_pos'].values.reshape
-1,1),
                         X_test['essay_compound'].values.reshape(-1,1),X_test['Res_Code_State_pos'].
alues.reshape(-1,1),
                         X_test['Res_Code_State_neg'].values.reshape(-1,1),X_test['Res_Code_tpr_pos'
.values.reshape(-1,1),
                         X_test['Res_Code_tpr_neg'].values.reshape(-1,1),X_test['Res_Code_pgc_pos'].
alues.reshape(-1,1),
                         X_test['Res_Code_pgc_neg'].values.reshape(-1,1),X_test['Res_Code_cc_pos'].v
lues.reshape(-1,1),
                         X_test['Res_Code_cc_neg'].values.reshape(-1,1),X_test['Res_Code_csc_pos'].v
lues.reshape(-1,1),
                         X_test['Res_Code_csc_neg'].values.reshape(-1,1)),axis=1)
##
print("Final Data matrix")
print(X_tr_tfidf_csr.shape, y_tr.shape)
print(X_test_tfidf_csr.shape, y_test.shape)
print("="*100)
```

```
Final Data matrix
(81936, 316) (81936,)
(27306, 316) (27306,)
====================================================================================================
```

In [47]:

```
from sklearn.metrics import roc_auc_score
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import GridSearchCV
from xgboost import XGBClassifier
from scipy.stats import randint
```

In [48]:

```
%%time
### Train XGBoost Classifier
model_params = {
                'n_estimators': [500,750,1000,1250] ,
                'max_depth' :  [1, 3, 5, 7 ]
               }
#
xgbdt_clf = XGBClassifier(learning_rate =0.1,
                    min_child_weight=1,
                    reg_lambda = 1.5,
                    subsample=0.6,
                    colsample_bytree=0.6,
                    colsample_bylevel=0.8,
                    objective= 'binary:logistic',
                    nthread=4
                    )
#
clf = GridSearchCV(xgbdt_clf, model_params, cv=4, scoring='roc_auc', return_train_score=True, n_jobs=-1,
                           verbose=40)
clf.fit(X_tr_tfidf_csr,y_tr,
        verbose=15)
```

```
Fitting 4 folds for each of 16 candidates, totalling 64 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  3.2min
[Parallel(n_jobs=-1)]: Done   2 tasks      | elapsed:  3.2min
[Parallel(n_jobs=-1)]: Done   3 tasks      | elapsed:  6.3min
[Parallel(n_jobs=-1)]: Done   4 tasks      | elapsed:  6.3min
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed: 10.9min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 11.0min
[Parallel(n_jobs=-1)]: Done   7 tasks      | elapsed: 15.6min
[Parallel(n_jobs=-1)]: Done   8 tasks      | elapsed: 15.6min
[Parallel(n_jobs=-1)]: Done   9 tasks      | elapsed: 21.7min
[Parallel(n_jobs=-1)]: Done  10 tasks      | elapsed: 21.7min
[Parallel(n_jobs=-1)]: Done  11 tasks      | elapsed: 27.9min
[Parallel(n_jobs=-1)]: Done  12 tasks      | elapsed: 27.9min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 35.6min
[Parallel(n_jobs=-1)]: Done  14 tasks      | elapsed: 35.6min
[Parallel(n_jobs=-1)]: Done  15 tasks      | elapsed: 43.3min
[Parallel(n_jobs=-1)]: Done  16 tasks      | elapsed: 43.3min
[Parallel(n_jobs=-1)]: Done  17 tasks      | elapsed: 51.1min
[Parallel(n_jobs=-1)]: Done  18 tasks      | elapsed: 51.1min
[Parallel(n_jobs=-1)]: Done  19 tasks      | elapsed: 59.0min
[Parallel(n_jobs=-1)]: Done  20 tasks      | elapsed: 59.0min
[Parallel(n_jobs=-1)]: Done  21 tasks      | elapsed: 70.8min
[Parallel(n_jobs=-1)]: Done  22 tasks      | elapsed: 70.8min
[Parallel(n_jobs=-1)]: Done  23 tasks      | elapsed: 82.5min
[Parallel(n_jobs=-1)]: Done  24 tasks      | elapsed: 82.6min
[Parallel(n_jobs=-1)]: Done  25 tasks      | elapsed: 98.2min
[Parallel(n_jobs=-1)]: Done  26 tasks      | elapsed: 98.2min
[Parallel(n_jobs=-1)]: Done  27 tasks      | elapsed: 113.8min
[Parallel(n_jobs=-1)]: Done  28 tasks      | elapsed: 113.9min
[Parallel(n_jobs=-1)]: Done  29 tasks      | elapsed: 133.3min
[Parallel(n_jobs=-1)]: Done  30 tasks      | elapsed: 133.3min
[Parallel(n_jobs=-1)]: Done  31 tasks      | elapsed: 152.9min
[Parallel(n_jobs=-1)]: Done  32 tasks      | elapsed: 153.1min
[Parallel(n_jobs=-1)]: Done  33 tasks      | elapsed: 166.0min
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed: 166.1min
[Parallel(n_jobs=-1)]: Done  35 tasks      | elapsed: 179.1min
[Parallel(n_jobs=-1)]: Done  36 tasks      | elapsed: 179.1min
[Parallel(n_jobs=-1)]: Done  37 tasks      | elapsed: 198.5min
[Parallel(n_jobs=-1)]: Done  38 tasks      | elapsed: 198.5min
[Parallel(n_jobs=-1)]: Done  39 tasks      | elapsed: 218.3min
[Parallel(n_jobs=-1)]: Done  40 tasks      | elapsed: 218.3min
[Parallel(n_jobs=-1)]: Done  41 tasks      | elapsed: 244.6min
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed: 244.8min
[Parallel(n_jobs=-1)]: Done  43 tasks      | elapsed: 271.0min
[Parallel(n_jobs=-1)]: Done  44 tasks      | elapsed: 271.2min
[Parallel(n_jobs=-1)]: Done  45 tasks      | elapsed: 303.8min
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed: 304.0min
[Parallel(n_jobs=-1)]: Done  47 tasks      | elapsed: 337.1min
[Parallel(n_jobs=-1)]: Done  48 tasks      | elapsed: 337.3min
```

```
[Parallel(n_jobs=-1)]: Done  49 tasks      | elapsed: 356.1min
[Parallel(n_jobs=-1)]: Done  50 tasks      | elapsed: 356.3min
[Parallel(n_jobs=-1)]: Done  51 tasks      | elapsed: 374.7min
[Parallel(n_jobs=-1)]: Done  52 tasks      | elapsed: 374.9min
[Parallel(n_jobs=-1)]: Done  53 tasks      | elapsed: 402.9min
[Parallel(n_jobs=-1)]: Done  54 tasks      | elapsed: 403.1min
[Parallel(n_jobs=-1)]: Done  55 tasks      | elapsed: 431.0min
[Parallel(n_jobs=-1)]: Done  56 tasks      | elapsed: 431.1min
[Parallel(n_jobs=-1)]: Done  57 tasks      | elapsed: 468.7min
[Parallel(n_jobs=-1)]: Done  58 tasks      | elapsed: 468.7min
[Parallel(n_jobs=-1)]: Done  59 tasks      | elapsed: 506.0min
[Parallel(n_jobs=-1)]: Done  60 tasks      | elapsed: 506.0min
[Parallel(n_jobs=-1)]: Done  61 tasks      | elapsed: 552.5min
[Parallel(n_jobs=-1)]: Done  64 out of  64 | elapsed: 599.0min finished
```

```
CPU times: user 4min 12s, sys: 1.64 s, total: 4min 13s
Wall time: 10h 1min 11s
```

In [49]:

```
train_auc= clf.cv_results_['mean_train_score']
train_auc_std = clf.cv_results_['std_train_score']
test_auc = clf.cv_results_['mean_test_score']
test_auc_std = clf.cv_results_['std_test_score']

#Output of GridSearchCV
print('Best score: ',clf.best_score_)
print('Best Hyper parameters: ',clf.best_params_)
print('='*75)
print('Train AUC scores')
print(clf.cv_results_['mean_train_score'])
print('CV AUC scores')
print(clf.cv_results_['mean_test_score'])
```

```
Best score:  0.6595321051912355
Best Hyper parameters:  {'max_depth': 1, 'n_estimators': 500}
===========================================================================
Train AUC scores
[0.71808331 0.72901735 0.73786103 0.74487395 0.83175945 0.86648936
 0.8936044  0.9148107  0.97425734 0.99407334 0.9990021  0.99987501
 0.99998869 0.9999986  0.99999897 0.99999921]
CV AUC scores
[0.65953211 0.65787609 0.65742014 0.65611589 0.62980352 0.62508153
 0.62360175 0.62074369 0.61552483 0.61274121 0.61208374 0.61204082
 0.61513557 0.61513565 0.61655365 0.6167116 ]
```

In [50]:

```
from itertools import repeat
x1 = []
y1 = []
max_depth = [1, 3, 5, 7 ]
n_estimators =  [500,750,1000,1250]
train_auc_scores = clf.cv_results_['mean_train_score']
cv_auc_scores = clf.cv_results_['mean_test_score']

x1 = [x for item in max_depth for x in repeat(item, 4)]
for _ in max_depth:
    for item in n_estimators:
        y1.append(item)
```

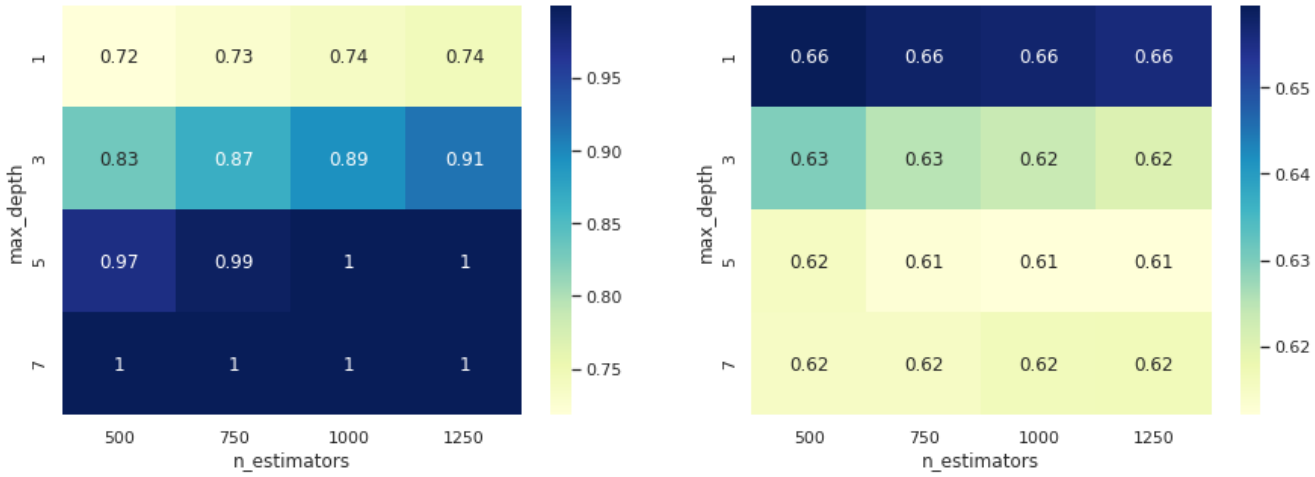
In [51]:

```
import seaborn as sns
df1 = pd.DataFrame(list(zip(x1,y1,train_auc))).rename(columns = {0 : 'max_depth', 1: 'n_estimators'
, 2: 'mean_train_score'}).pivot('max_depth','n_estimators','mean_train_score')
df2 = pd.DataFrame(list(zip(x1,y1,test_auc))).rename(columns = {0 : 'max_depth', 1: 'n_estimators',
2: 'mean_CV_score'}).pivot('max_depth','n_estimators','mean_CV_score')
plt.figure(figsize=(50,20))
f, axes = plt.subplots(1, 2,figsize=(15,5))
sns.heatmap(df1,annot=True,ax=axes[0],cbar = True ,cmap= "YlGnBu")
sns.heatmap(df2,annot=True,ax=axes[1],cbar = True ,cmap= "YlGnBu")
```

Out[51]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3d6d230c50>

<Figure size 3600x1440 with 0 Axes>
```



In [52]:

```
%%time
### Train XGBoost Classifier
#
xgbdt_clf = XGBClassifier(learning_rate =0.1,
                    min_child_weight=1,
                    n_estimators = 500,
                    max_depth = 1,
                    reg_lambda = 1.5,
                    subsample=0.6,
                    colsample_bytree=0.6,
                    colsample_bylevel=0.8,
                    objective= 'binary:logistic',
                    verbose = 4,
                    nthread=4
                    )
xgbdt_clf.fit(X_tr_tfidf_csr,y_tr,
        verbose=True)
```

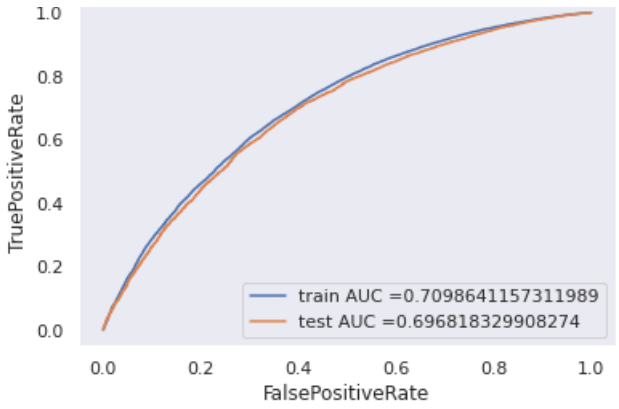
```
CPU times: user 4min 7s, sys: 921 ms, total: 4min 8s
Wall time: 2min 11s
```

In [53]:

```
from sklearn.metrics import roc_curve, auc
y_train_pred = xgbdt_clf.predict_proba(X_tr_tfidf_csr)[::,1]
y_test_pred =  xgbdt_clf.predict_proba(X_test_tfidf_csr)[::,1]

train_fpr, train_tpr, tr_thresholds = roc_curve(y_tr, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test, y_test_pred)
auc_tfidf_train = auc(train_fpr, train_tpr)
auc_tfidf_test = auc(test_fpr, test_tpr)
### feature importance


plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc_tfidf_train))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc_tfidf_test))
plt.legend()
plt.xlabel("FalsePositiveRate")
plt.ylabel("TruePositiveRate")
plt.title("ROC-AUC Curve")
plt.grid()
plt.show()
```



In [54]:

```
### find best threshold
def find_best_threshold(threshold, fpr, tpr):
    t = threshold[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.round(t,3))
    return t

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

In [55]:

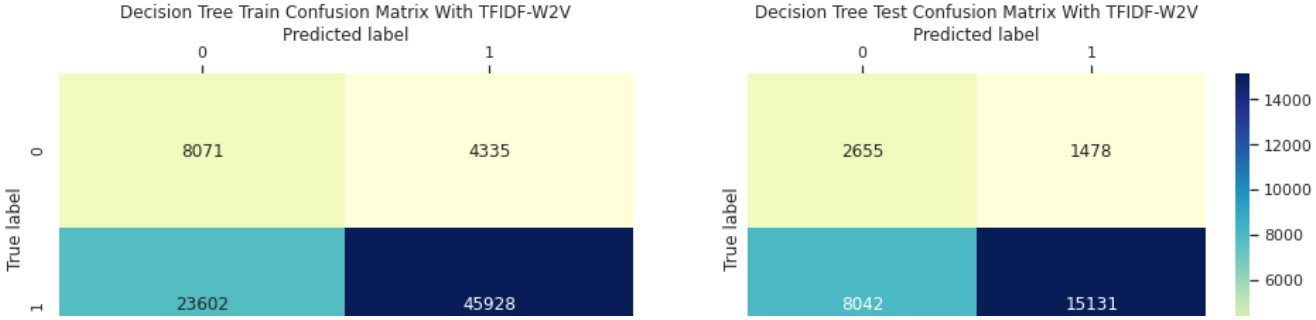
```
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
y_train_pred_class = predict_with_best_t(y_train_pred, best_t)
y_test_pred_class = predict_with_best_t(y_test_pred, best_t)
train_conf_mat = pd.DataFrame(confusion_matrix(y_tr, y_train_pred_class))
test_conf_mat = pd.DataFrame(confusion_matrix(y_test, y_test_pred_class))

fig, axs = plt.subplots(1,2,figsize=(16, 4),sharey=True)
sns.set(font_scale=1)
f1 = sns.heatmap(train_conf_mat, annot=True,fmt="d", ax=axs[0], cbar = False ,cmap= "YlGnBu")

f1.set_title('Decision Tree Train Confusion Matrix With TFIDF-W2V')
f1.set_ylabel('True label')
f1.set_xlabel('Predicted label')
f1.xaxis.set_ticks_position('top')
f1.xaxis.set_label_position('top')

f2 = sns.heatmap(test_conf_mat, annot=True, fmt = 'd', ax=axs[1] , cmap = "YlGnBu")
f2.set_title('Decision Tree Test Confusion Matrix With TFIDF-W2V')
f2.set_ylabel('True label')
f2.set_xlabel('Predicted label')
f2.xaxis.set_ticks_position('top')
f2.xaxis.set_label_position('top')
```

```
the maximum value of tpr*(1-fpr) 0.42973514692127257 for threshold 0.841
```



3. Summary

as mentioned in the step 4 of instructions

In [57]:

```
from prettytable import PrettyTable
model = ['TFIDF','TFIDFWord2Vec']
max_depth = [1,1]
n_estimators = [1250,500]
train_auc = [0.76,0.724]
test_auc = [0.71,0.696]
x = PrettyTable()
x.field_names = ['Model','Max_Depth','n_estimators','Train_AUC',"Test_AUC"]
for i in range(2):
  x.add_row([model[i],max_depth[i],n_estimators[i],train_auc[i],test_auc[i]])
print(x)
```

```
+---------------+-----------+--------------+-----------+----------+
|     Model     | Max_Depth | n_estimators | Train_AUC | Test_AUC |
+---------------+-----------+--------------+-----------+----------+
|     TFIDF     |     1     |     1250     |    0.76   |   0.71   |
| TFIDFWord2Vec |     1     |     500      |   0.724   |  0.696   |
+---------------+-----------+--------------+-----------+----------+
```

In [ ]:

```
```