In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pandas as pd
import numpy as np
import nltk
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/

import pickle
from tqdm import tqdm
import os
'''from plotly import plotly
import plotly.offline as offline
import plotly.graph_objs as go
offline.init_notebook_mode()
from collections import Counter'''
```

Out[1]:

```
'from plotly import plotly\nimport plotly.offline as offline\nimport plotly.g
raph_objs as go\noffline.init_notebook_mode()\nfrom collections import Counte
r'
```

1.1 Loading Data

In [2]:

```
import pandas
data = pandas.read_csv('preprocessed_data.csv')
data.head(5)
```

Out[2]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pro
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	

1.2 Splitting data into train and cross validation (or test) : stratified sampling

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) X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)

1.3 Make Data Model Ready: encoding eassay

In [3]:

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

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

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

In [4]:

```
sent = decontracted(data['essay'].values[20000])
# \r \n \t remove from string python: http://texthandler.com/info/remove-line-
breaks-python/
sent = sent.replace('\\r', ' ')
sent = sent.replace('\\"', ' ')
sent = sent.replace('\\n', ' ')
print(sent)
```

```
a person person no matter small dr seuss i teach smallest students biggest en
thusiasm learning my students learn many different ways using senses multiple
intelligences i use wide range techniques help students succeed students clas
s come variety different backgrounds makes wonderful sharing experiences cult
ures including native americans our school caring community successful learne
rs seen collaborative student project based learning classroom kindergartener
s class love work hands materials many different opportunities practice skill
mastered having social skills work cooperatively friends crucial aspect kinde
rgarten curriculum montana perfect place learn agriculture nutrition my stude
nts love role play pretend kitchen early childhood classroom i several kids a
sk can try cooking real food i take idea create common core cooking lessons l
earn important math writing concepts cooking delicious healthy food snack tim
e my students grounded appreciation work went making food knowledge ingredien
ts came well healthy bodies this project would expand learning nutrition agri
cultural cooking recipes us peel apples make homemade applesauce make bread m
ix healthy plants classroom garden spring we also create cookbooks printed sh
ared families students gain math literature skills well life long enjoyment h
ealthy cooking nannan
```

In [5]:

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

```
a person person no matter small dr seuss i teach smallest students biggest en
thusiasm learning my students learn many different ways using senses multiple
intelligences i use wide range techniques help students succeed students clas
s come variety different backgrounds makes wonderful sharing experiences cult
ures including native americans our school caring community successful learne
rs seen collaborative student project based learning classroom kindergartener
s class love work hands materials many different opportunities practice skill
mastered having social skills work cooperatively friends crucial aspect kinde
rgarten curriculum montana perfect place learn agriculture nutrition my stude
nts love role play pretend kitchen early childhood classroom i several kids a
sk can try cooking real food i take idea create common core cooking lessons l
earn important math writing concepts cooking delicious healthy food snack tim
e my students grounded appreciation work went making food knowledge ingredien
ts came well healthy bodies this project would expand learning nutrition agri
cultural cooking recipes us peel apples make homemade applesauce make bread m
ix healthy plants classroom garden spring we also create cookbooks printed sh
ared families students gain math literature skills well life long enjoyment h
ealthy cooking nannan
```

In [6]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you'
, "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he'
, 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'it
self', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 't
hat', "that'll", 'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have',
'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'becau
se', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into',
'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on',
'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'a
ll', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'tha
n', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "shoul
d've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn',
"didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'm
a', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shoul
dn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"]
```

In [7]:
```
# Combining all the above statemennts
from tqdm import tqdm
preprocessed_essays = []
# tqdm is for printing the status bar
for sentance in tqdm(data['essay'].values):
    sent = decontracted(sentance)
    sent = sent.replace('\\r', ' ')
    sent = sent.replace('\\"', ' ')
    sent = sent.replace('\\n', ' ')
    sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
    # https://gist.github.com/sebleier/554280
    sent = ' '.join(e for e in sent.split() if e not in stopwords)
    preprocessed_essays.append(sent.lower().strip())

data['preprocessed_essays'] = preprocessed_essays

print(data.shape)
#print(project_data.head(2))
```

```
100%|████████████████████████████████████████████████████████████
| 109248/109248 [01:31<00:00, 1194.92it/s]

(109248, 10)
```

In [8]:
```
data.head(2)
```

Out[8]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pro
0	ca	mrs	grades_prek_2	
1	ut	ms	grades_3_5	

In [9]:
```
y = data['project_is_approved'].values
X = data.drop(['project_is_approved'], axis=1)
X.head(1)
```

Out[9]:

	school_state	teacher_prefix	project_grade_category	teacher_number_of_previously_posted_pro
0	ca	mrs	grades_prek_2	

In [10]:

```
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)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33, stratify=y_train)
```

In [11]:

```
#Vectorization of feature - essay(Text) with BOW
all_feature_names_bow=[]
print('Before')
print(X_train.shape, y_train.shape)
print(X_cv.shape, y_cv.shape)
print(X_test.shape, y_test.shape)

print("***************************************************************************************************************")

vectorizer = CountVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer.fit(X_train['preprocessed_essays'].values) # fit should be donw only on train data
count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in essay:', count)
print('size: ', len(all_feature_names_bow))
# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_bow = vectorizer.transform(X_train['preprocessed_essays'].values)
X_cv_essay_bow = vectorizer.transform(X_cv['preprocessed_essays'].values)
X_test_essay_bow = vectorizer.transform(X_test['preprocessed_essays'].values)

print("After")
print(X_train_essay_bow.shape, y_train.shape)
print(X_cv_essay_bow.shape, y_cv.shape)
print(X_test_essay_bow.shape, y_test.shape)
```

```
Before
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
***************************************************************************************************************
no of features in essay: 5000
size:  5000
After
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
```

1.4 Make Data Model Ready: encoding numerical, categorical features

In [12]:

```
#Vectorizion of clean_categories (categorical feature)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_categories'].values) # fit should be done on tra
in data only

# we use the fitted CountVectorizer to convert the text to vector
X_train_cleancate = vectorizer.transform(X_train['clean_categories'].values)
X_cv_cleancate = vectorizer.transform(X_cv['clean_categories'].values)
X_test_cleancate = vectorizer.transform(X_test['clean_categories'].values)

count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in clean_categories:', count)
print('size: ', len(all_feature_names_bow))

print('feature vector is')
print(vectorizer.get_feature_names())
print("After vectorization")
print(X_train_cleancate.shape, y_train.shape)
print(X_cv_cleancate.shape, y_cv.shape)
print(X_test_cleancate.shape, y_test.shape)
```

```
no of features in clean_categories: 9
size:  5009
feature vector is
['appliedlearning', 'care_hunger', 'health_sports', 'history_civics', 'litera
cy_language', 'math_science', 'music_arts', 'specialneeds', 'warmth']
After vectorization
(49041, 9) (49041,)
(24155, 9) (24155,)
(36052, 9) (36052,)
```

In [13]:

```python
#Vectorizion of clean_subcategories (categorical feature)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['clean_subcategories'].values) # fit should be done on train data only

# we use the fitted CountVectorizer to convert the text to vector
X_train_cleansubcate = vectorizer.transform(X_train['clean_subcategories'].values)
X_cv_cleansubcate = vectorizer.transform(X_cv['clean_subcategories'].values)
X_test_cleansubcate = vectorizer.transform(X_test['clean_subcategories'].values)

count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in clean_subcategories:', count)
print('size: ', len(all_feature_names_bow))

print('feature vector is')
print(vectorizer.get_feature_names())
print("After vectorization")
print(X_train_cleansubcate.shape, y_train.shape)
print(X_cv_cleansubcate.shape, y_cv.shape)
print(X_test_cleansubcate.shape, y_test.shape)
```

```
no of features in clean_subcategories: 30
size:  5039
feature vector is
['appliedsciences', 'care_hunger', 'charactereducation', 'civics_government', 'college_careerprep', 'communityservice', 'earlydevelopment', 'economics', 'environmentalscience', 'esl', 'extracurricular', 'financialliteracy', 'foreignlanguages', 'gym_fitness', 'health_lifescience', 'health_wellness', 'history_geography', 'literacy', 'literature_writing', 'mathematics', 'music', 'nutritioneducation', 'other', 'parentinvolvement', 'performingarts', 'socialsciences', 'specialneeds', 'teamsports', 'visualarts', 'warmth']
After vectorization
(49041, 30) (49041,)
(24155, 30) (24155,)
(36052, 30) (36052,)
```

In [14]:

```
#Vectorizion of school_state (categorical feature)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['school_state'].values) # fit should be done on train data only
# we use the fitted CountVectorizer to convert the text to vector
X_train_state = vectorizer.transform(X_train['school_state'].values)
X_cv_state = vectorizer.transform(X_cv['school_state'].values)
X_test_state = vectorizer.transform(X_test['school_state'].values)

count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in school_state:', count)
print('size: ', len(all_feature_names_bow))

print("After vectorizations")
print(X_train_state.shape, y_train.shape)
print(X_cv_state.shape, y_cv.shape)
print(X_test_state.shape, y_test.shape)
print(vectorizer.get_feature_names())
```

```
no of features in school_state: 51
size:  5090
After vectorizations
(49041, 51) (49041,)
(24155, 51) (24155,)
(36052, 51) (36052,)
['ak', 'al', 'ar', 'az', 'ca', 'co', 'ct', 'dc', 'de', 'fl', 'ga', 'hi', 'i
a', 'id', 'il', 'in', 'ks', 'ky', 'la', 'ma', 'md', 'me', 'mi', 'mn', 'mo',
'ms', 'mt', 'nc', 'nd', 'ne', 'nh', 'nj', 'nm', 'nv', 'ny', 'oh', 'ok', 'or',
'pa', 'ri', 'sc', 'sd', 'tn', 'tx', 'ut', 'va', 'vt', 'wa', 'wi', 'wv', 'wy']
```

In [15]:

```
#Vectorizion of teacher_prefix (categorical feature)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['teacher_prefix'].values) # fit should be done on train
data only
# we use the fitted CountVectorizer to convert the text to vector
X_train_teacher_prefix = vectorizer.transform(X_train['teacher_prefix'].values
)
X_cv_teacher_prefix = vectorizer.transform(X_cv['teacher_prefix'].values)
X_test_teacher_prefix = vectorizer.transform(X_test['teacher_prefix'].values)

count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in teacher_prefix:', count)
print('size: ', len(all_feature_names_bow))

print("After vectorizations")
print(X_train_teacher_prefix.shape, y_train.shape)
print(X_cv_teacher_prefix.shape, y_cv.shape)
print(X_test_teacher_prefix.shape, y_test.shape)
print(vectorizer.get_feature_names())
```

```
no of features in teacher_prefix: 5
size:  5095
After vectorizations
(49041, 5) (49041,)
(24155, 5) (24155,)
(36052, 5) (36052,)
['dr', 'mr', 'mrs', 'ms', 'teacher']
```

In [16]:

```
#Vectorizion of project_grade_category (categorical feature)
vectorizer = CountVectorizer()
vectorizer.fit(X_train['project_grade_category'].values) # fit should be done on train data only
# we use the fitted CountVectorizer to convert the text to vector
X_train_project_grade_category = vectorizer.transform(X_train['project_grade_category'].values)
X_cv_project_grade_category = vectorizer.transform(X_cv['project_grade_category'].values)
X_test_project_grade_category = vectorizer.transform(X_test['project_grade_category'].values)

count = 0
for i in vectorizer.get_feature_names():
    all_feature_names_bow.append(i)
    count+=1
print('no of features in project_grade_category:', count)
print('size: ', len(all_feature_names_bow))

print("After vectorizations")
print(X_train_project_grade_category.shape, y_train.shape)
print(X_cv_project_grade_category.shape, y_cv.shape)
print(X_test_project_grade_category.shape, y_test.shape)
print(vectorizer.get_feature_names())
```

```
no of features in project_grade_category: 4
size:  5099
After vectorizations
(49041, 4) (49041,)
(24155, 4) (24155,)
(36052, 4) (36052,)
['grades_3_5', 'grades_6_8', 'grades_9_12', 'grades_prek_2']
```

In [17]:

```
#Vectorizion of price (numerical feature)
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
#reshape is used to convert row vector to coulmn vector
normalizer.fit(X_train['price'].values.reshape(-1,1))

X_train_price = normalizer.transform(X_train['price'].values.reshape(-1,1))
X_cv_price = normalizer.transform(X_cv['price'].values.reshape(-1,1))
X_test_price = normalizer.transform(X_test['price'].values.reshape(-1,1))

all_feature_names_bow.append("price")
print('size: ', len(all_feature_names_bow))

print("After vectorizations")
print(X_train_price.shape, y_train.shape)
print(X_cv_price.shape, y_cv.shape)
print(X_test_price.shape, y_test.shape)
```

```
size:  5100
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

In [18]:
```
#Vectorization of teacher_number_of_previously_posted_projects (numerical data)
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()

normalizer.fit(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

X_train_previously_posted_proj = normalizer.transform(X_train['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_cv_previously_posted_proj = normalizer.transform(X_cv['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))
X_test_previously_posted_proj = normalizer.transform(X_test['teacher_number_of_previously_posted_projects'].values.reshape(-1,1))

all_feature_names_bow.append("teacher_number_of_previously_posted_projects")
print('size: ', len(all_feature_names_bow))

print("After vectorizations")
print(X_train_previously_posted_proj.shape, y_train.shape)
print(X_cv_previously_posted_proj.shape, y_cv.shape)
print(X_test_previously_posted_proj.shape, y_test.shape)
```

```
size:  5101
After vectorizations
(49041, 1) (49041,)
(24155, 1) (24155,)
(36052, 1) (36052,)
```

Concatinating all the features

In [19]:
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr = hstack((X_train_essay_bow, X_train_cleancate, X_train_cleansubcate, X_train_state, X_train_teacher_prefix,X_train_project_grade_category,X_train_price,X_train_previously_posted_proj)).tocsr().toarray()
X_cr = hstack((X_cv_essay_bow, X_cv_cleancate, X_cv_cleansubcate, X_cv_state, X_cv_teacher_prefix,X_cv_project_grade_category,X_cv_price,X_cv_previously_posted_proj)).tocsr().toarray()
X_te = hstack((X_test_essay_bow, X_test_cleancate, X_test_cleansubcate, X_test_state, X_test_teacher_prefix,X_test_project_grade_category,X_test_price,X_test_previously_posted_proj)).tocsr().toarray()

print("Final Data matrix")
print(X_tr.shape, y_train.shape)
print(X_cr.shape, y_cv.shape)
print(X_te.shape, y_test.shape)
```

```
Final Data matrix
(49041, 5101) (49041,)
(24155, 5101) (24155,)
(36052, 5101) (36052,)
```

In [20]:

```
def batch_predict(clf, data):
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
    # not the predicted outputs

    y_data_pred = []
    tr_loop = data.shape[0] - data.shape[0]%1000
    # consider you X_tr shape is 49041, then your tr_loop will be 49041 - 49041%1000 = 49000
    # in this for loop we will iterate unti the last 1000 multiplier
    for i in range(0, tr_loop, 1000):
        y_data_pred.extend(clf.predict_proba(data[i:i+1000])[:,1])
    # we will be predicting for the last data points
    if data.shape[0]%1000 !=0:
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

    return y_data_pred
```

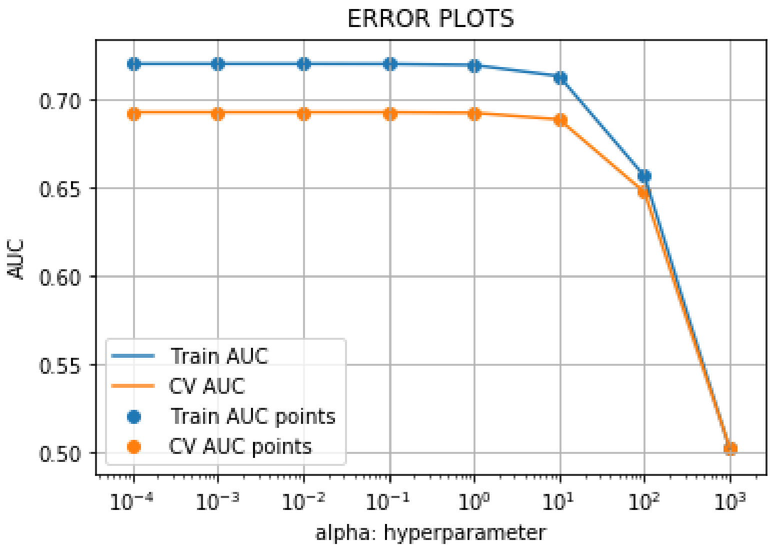
Finding best parameter which will give maximum AUC Value

In [27]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import BernoulliNB
from sklearn.metrics import roc_auc_score
from tqdm import tqdm
from sklearn.naive_bayes import MultinomialNB
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, conf
idence values, or non-thresholded measure of
decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with great
er label.

"""


train_auc = []
cv_auc = []
a = [0.0001,0.001,0.01,0.1,1,10,100,1000]
for i in tqdm(a):
    #neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    #model = GaussianNB()
    #model = BernoulliNB(alpha=i, binarize=0.0, class_prior=None, fit_prior=Tr
ue)
    model = MultinomialNB(alpha=i,class_prior=[0.5,0.5])
    model.fit(X_tr, y_train)

    y_train_pred = batch_predict(model, X_tr)
    y_cv_pred = batch_predict(model, X_cr)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability e
stimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

#plt.plot(a, train_auc, label='Train AUC')
#plt.plot(a, cv_auc, label='CV AUC')

plt.semilogx(a, train_auc, label='Train AUC')
plt.semilogx(a, cv_auc, label='CV AUC')




plt.scatter(a, train_auc, label='Train AUC points')
plt.scatter(a, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
print(cv_auc)
print(a)
```

```
100%|██████████████████████████████████████████████████████████████
██████████| 8/8 [00:19<00:00,  2.42s/it]
```



```
[0.6924795920384719, 0.6924793585843212, 0.6924759168031307, 0.69244253285960
56, 0.6921105343770841, 0.6883782695220431, 0.6470963252902643, 0.50234643432
66928]
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000]
```

AUC at alpha = 0.0001,0.001 is almost same lets try with both alpha = 0.0001, alpha = 0.001 AUC is maximum at alpha = 0.1 hence lets go with alpha=0.1

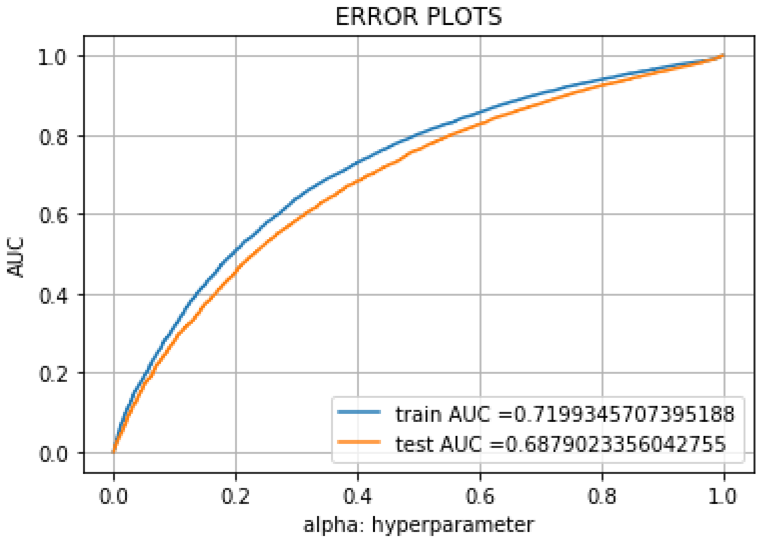
Finding Best hyper parameter using GridsearchCV:

In [ ]:

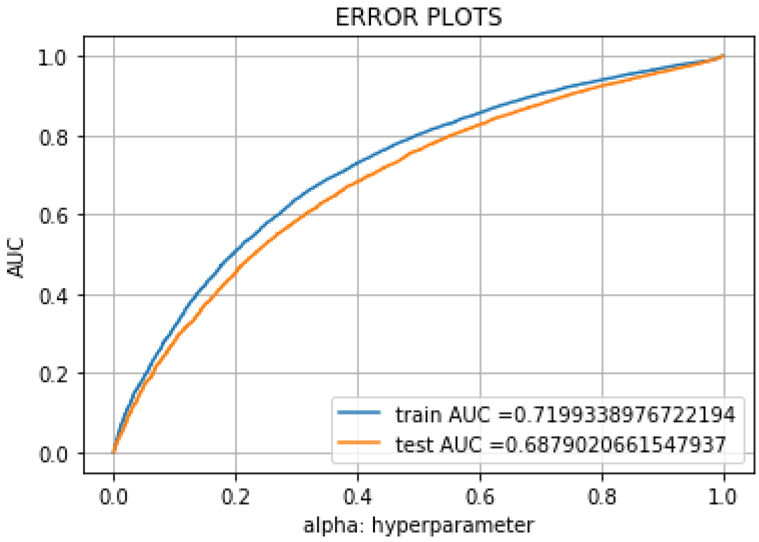
```
#gridsearchcv taking so much time to execute
'''from sklearn.model_selection import GridSearchCV
#mnb_bow = MultinomialNB(class_prior=[0.5, 0.5])
model = BernoulliNB(binarize=0.0, class_prior=None, fit_prior=True)
parameters = {'alpha':[3, 15, 25, 51, 101]}
clf = GridSearchCV(model, parameters, cv= 10, scoring='roc_auc',verbose=1,retu
rn_train_score=True)
# clf.fit(x_cv_onehot_bow, y_cv)
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']
bestAlpha_1=clf.best_params_['alpha']
bestScore_1=clf.best_score_
print("BEST ALPHA: ",clf.best_params_['alpha']," BEST SCORE: ",clf.best_score
_) #clf.best_estimator_.alpha'''
```

In [29]:

```
# first we will try with alpha = 0.0001
#Training model on using best k.
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.
html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = MultinomialNB(alpha=0.0001,class_prior=[0.5,0.5])
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estim
ates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, X_te)

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_tp
r)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [30]:
```
# Now take alpha = 0.001
#Training model on using best k.
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.
html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = MultinomialNB(alpha=0.001,class_prior=[0.5,0.5])
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estim
ates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr)
y_test_pred = batch_predict(model, X_te)

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_tp
r)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



error plots for both the aplhas are almost same. we will go for aplha = 0.001 due to very small difference of AUC.

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(threshold, fpr, tpr):
    t = threshold[np.argmax(tpr*(1-fpr))]
    #print(t)
    # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very hi
gh
    print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshol
d", np.round(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]:

```
from sklearn.metrics import confusion_matrix
best_t = find_best_threshold(tr_thresholds, train_fpr, train_tpr)
print("Train confusion matrix")
print(confusion_matrix(y_train, predict_with_best_t(y_train_pred, best_t)))
print("Test confusion matrix")
print(confusion_matrix(y_test, predict_with_best_t(y_test_pred, best_t)))
```

```
the maximum value of tpr*(1-fpr) 0.44942563251903944 for threshold 0.526
Train confusion matrix
[[ 5051  2375]
 [14118 27497]]
Test confusion matrix
[[ 3457  2002]
 [10681 19912]]
```

Finding TOP 20 features refered from https://www.kaggle.com/nikhilparmar9/naive-bayes-donorschoose-dataset/comments#620511 (https://www.kaggle.com/nikhilparmar9/naive-bayes-donorschoose-dataset/comments#620511)

In [33]:

```
print(len(all_feature_names_bow))
totalFeatureNamesBow=len(all_feature_names_bow)
X_tr.shape
```

```
5101
```

Out[33]:

```
(49041, 5101)
```

In [34]:

```
from sklearn.naive_bayes import MultinomialNB
nb_bow=MultinomialNB(alpha=0.001,class_prior=[0.5,0.5])
nb_bow.fit(X_tr, y_train)
```

Out[34]:

```
MultinomialNB(alpha=0.001, class_prior=[0.5, 0.5], fit_prior=True)
```

In [35]:

```
bow_features_probs_neg = {}

for a in range (totalFeatureNamesBow):
# for a in range(101) :
    bow_features_probs_neg[a] = nb_bow.feature_log_prob_[0,a]
```

In [36]:

```
final_bow_features_neg = pd.DataFrame({'feature_prob_estimates' : list(bow_features_probs_neg.values()),
'feature_names' : list(all_feature_names_bow)})
```

In [37]:

```
result = final_bow_features_neg.sort_values(by = ['feature_prob_estimates'], ascending = False)
```

In [38]:

```
print("TOP 20 Negative features - BOW")
result.head(20)
```

```
TOP 20 Negative features - BOW
```

Out[38]:

	feature_prob_estimates	feature_names
4114	-3.150351	students
3673	-4.259519	school
2377	-4.551729	learning
690	-4.725637	classroom
2324	-4.918292	learn
2979	-4.928059	not
1940	-4.965950	help
5099	-5.081786	price
2880	-5.125272	nannan
2668	-5.168822	many
2895	-5.262870	need
4892	-5.299022	work
783	-5.462841	come
5100	-5.466792	teacher_number_of_previously_posted_projects
3482	-5.485973	reading
2556	-5.508001	love
3909	-5.524847	skills
2713	-5.552275	materials
95	-5.554649	able
1017	-5.572086	day

In [39]:

```
result2 = final_bow_features_neg.sort_values(by = ['feature_prob_estimates'],
ascending = True)
print("TOP 20 Negative features - BOW")
result2.head(20)
```

```
TOP 20 Negative features - BOW
```

Out[39]:

	feature_prob_estimates	feature_names
5090	-13.993530	dr
5089	-12.607985	wy
5067	-11.914963	nd
4882	-11.914963	wobble cushions
5085	-11.914963	vt
1850	-11.691844	graphing
660	-11.596543	chromebooks allow
5016	-11.509539	economics
5047	-11.429503	de
4726	-11.286412	using ipads
4404	-11.286412	subscription
605	-11.286412	chairs help
4769	-11.286412	volleyball
4069	-11.286412	stools allow
3571	-11.221878	reluctant readers
5065	-11.221878	mt
1177	-11.221878	docs
1603	-11.104102	fires
4708	-11.104102	use google
751	-11.104102	clipboards

TASK 2 : with Set 2: categorical, numerical features + preprocessed_eassay (TFIDF)

In [40]:

```
#Preprocessing using tfidf, code copied from sample solution
from sklearn.feature_extraction.text import TfidfVectorizer
vectorizer2 = TfidfVectorizer(min_df=10,ngram_range=(1,4), max_features=5000)
vectorizer2.fit(X_train['essay'].values) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_essay_tfidf = vectorizer2.transform(X_train['preprocessed_essays'].values)
X_cv_essay_tfidf = vectorizer2.transform(X_cv['preprocessed_essays'].values)
X_test_essay_tfidf = vectorizer2.transform(X_test['preprocessed_essays'].values)

print("After vectorizations")
print(X_train_essay_tfidf.shape, y_train.shape)
print(X_cv_essay_tfidf.shape, y_cv.shape)
print(X_test_essay_tfidf.shape, y_test.shape)
```

```
After vectorizations
(49041, 5000) (49041,)
(24155, 5000) (24155,)
(36052, 5000) (36052,)
```

Concatinate all the features

In [41]:

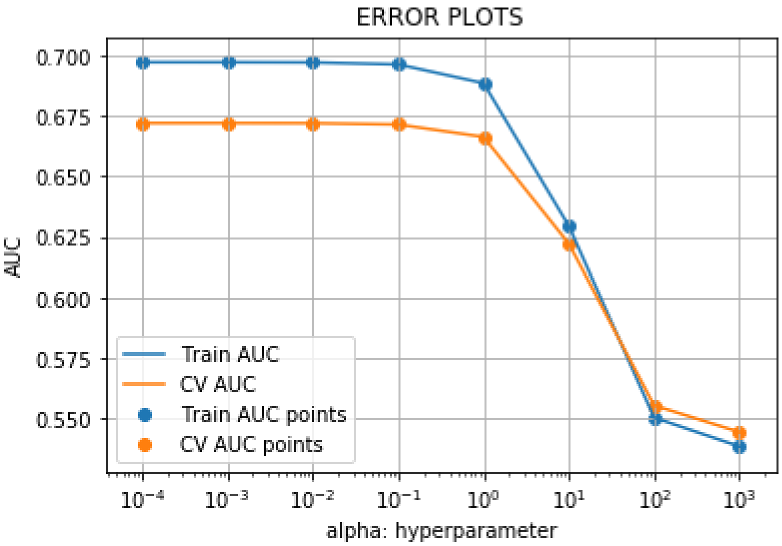
```
# merge two sparse matrices: https://stackoverflow.com/a/19710648/4084039
from scipy.sparse import hstack
X_tr_TFIDF = hstack((X_train_essay_tfidf, X_train_cleancate, X_train_cleansubcate, X_train_state, X_train_teacher_prefix,X_train_project_grade_category,X_train_price,X_train_previously_posted_proj)).tocsr().toarray()
X_cr_TFIDF = hstack((X_cv_essay_tfidf, X_cv_cleancate, X_cv_cleansubcate, X_cv_state, X_cv_teacher_prefix,X_cv_project_grade_category,X_cv_price,X_cv_previously_posted_proj)).tocsr().toarray()
X_te_TFIDF = hstack((X_test_essay_tfidf, X_test_cleancate, X_test_cleansubcate, X_test_state, X_test_teacher_prefix,X_test_project_grade_category,X_test_price,X_test_previously_posted_proj)).tocsr().toarray()

print("Final Data matrix")
print(X_tr_TFIDF.shape, y_train.shape)
print(X_cr_TFIDF.shape, y_cv.shape)
print(X_te_TFIDF.shape, y_test.shape)
```

```
Final Data matrix
(49041, 5101) (49041,)
(24155, 5101) (24155,)
(36052, 5101) (36052,)
```

In [43]:

```
import matplotlib.pyplot as plt
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import BernoulliNB
from sklearn.metrics import roc_auc_score
from tqdm import tqdm
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, conf
idence values, or non-thresholded measure of
decisions (as returned by “decision_function” on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with great
er label.

"""


train_auc = []
cv_auc = []
a = [0.0001,0.001,0.01,0.1,1,10,100,1000]
for i in tqdm(a):
    #neigh = KNeighborsClassifier(n_neighbors=i, n_jobs=-1)
    #model = GaussianNB()
    #model = BernoulliNB(alpha=i, binarize=0.0, class_prior=None, fit_prior=Tr
ue)
    model = MultinomialNB(alpha=i,class_prior=[0.5,0.5])
    model.fit(X_tr_TFIDF, y_train)

    y_train_pred = batch_predict(model, X_tr_TFIDF)
    y_cv_pred = batch_predict(model, X_cr_TFIDF)

    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability e
stimates of the positive class
    # not the predicted outputs
    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

plt.semilogx(a, train_auc, label='Train AUC')
plt.semilogx(a, cv_auc, label='CV AUC')

plt.scatter(a, train_auc, label='Train AUC points')
plt.scatter(a, cv_auc, label='CV AUC points')

plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
print(cv_auc)
print(a)
```

```
100%|████████████████████████████████████████████████████████████████████
████████████| 8/8 [00:20<00:00,  2.49s/it]
```

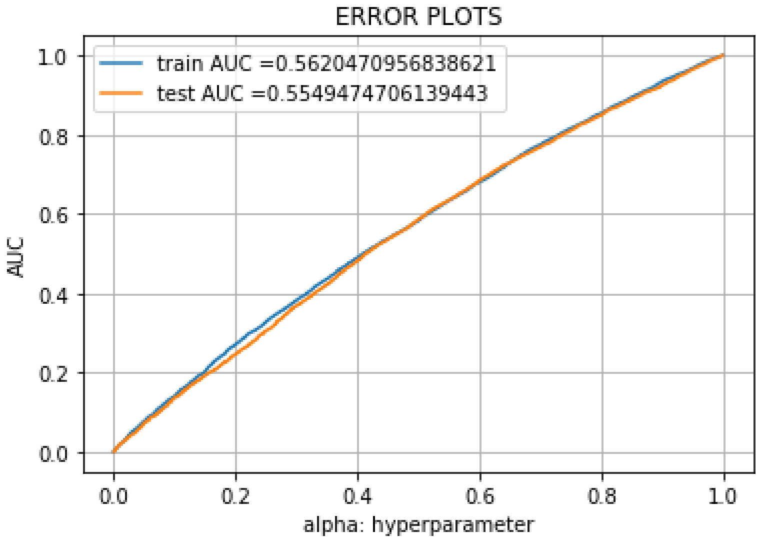


```
[0.6721141525162102, 0.6721093633710651, 0.6720576966324946, 0.67152993016946
13, 0.6663802784550393, 0.6222417025258912, 0.5554526044985467, 0.54440619442
70733]
[0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000]
```

```
In [ ]: AUC is maximum at alpha=0.0001
```

In [44]:

```
#Training model on using best k.
# https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

model = MultinomialNB(alpha=0.0001,class_prior=[0.5,0.5])
model.fit(X_tr, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive class
# not the predicted outputs

y_train_pred = batch_predict(model, X_tr_TFIDF)
y_test_pred = batch_predict(model, X_te_TFIDF)

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("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [45]:

```
#http://zetcode.com/python/prettytable/
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Model", "HyperParameter", "AUC"]

x.add_row(["BOW", "Brute", 0.001, 0.6879])
x.add_row(["TFIDF", "Brute", 0.0001, 0.55494])

x.align["Vectorizer"] = "l"
print(x)
```

```
+------------+-------+----------------+---------+
| Vectorizer | Model | HyperParameter |   AUC   |
+------------+-------+----------------+---------+
| BOW        | Brute |     0.001      |  0.6879 |
| TFIDF      | Brute |     0.0001     | 0.55494 |
+------------+-------+----------------+---------+
```

In [ ]: