Naive Bayes Assignment

In [1]:

```
import warnings
warnings.filterwarnings("ignore")

import sqlite3
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import pickle

from sklearn.metrics import accuracy_score
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.naive_bayes import MultinomialNB

from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
from sklearn.metrics import f1_score
from sklearn.metrics import log_loss
from sklearn.preprocessing import label_binarize
import seaborn as sns
```

In [2]:

```
# function to load the pickle data
def loadPickleData(filename):
    pickle_off = open(filename,"rb")
    final = pickle.load(pickle_off)
    return final
```

In [3]:

```
# load the y values because they are common across all feature engineering
y_train = loadPickleData('y_train.pickle')
y_test = loadPickleData('y_test.pickle')
y_cv = loadPickleData('y_cv.pickle')
```

In [4]:

```
encoded_column_vector = label_binarize(y_train, classes=['negative','positive'])

y_train = np.ravel(encoded_column_vector)

encoded_column_vector = label_binarize(y_test, classes=['negative','positive'])
y_test = np.ravel(encoded_column_vector)

encoded_column = label_binarize(y_cv, classes=['negative','positive'])
y_cv = np.ravel(encoded_column)
```

In [5]:

```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are
 predicted class j

    A =(((C.T)/(C.sum(axis=1))).T)
    #divid each element of the confusion matrix with the sum of elements in that
 column

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #        [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to columns and axis=1 corresponds to ro
ws in two diamensional array
    # C.sum(axix =1) = [[3, 7]]
    # ((C.T)/(C.sum(axis=1))) = [[1/3, 3/7]
    #                            [2/3, 4/7]]

    # ((C.T)/(C.sum(axis=1))).T = [[1/3, 2/3]
    #                            [3/7, 4/7]]
    # sum of row elements = 1

    B =(C/C.sum(axis=0))
    #divid each element of the confusion matrix with the sum of elements in that
 row
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to ro
ws in two diamensional array
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                      [3/4, 4/6]]

    labels = [0,1]
    # representing A in heatmap format
    print("-"*20, "Confusion matrix", "-"*20)
    plt.figure(figsize=(20,7))
    sns.heatmap(C, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yti
cklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()
```

In [6]:

```
def calculateMetric(X,y,alpha,train,y_train):
    fpr_array =[]
    for i in alpha:
            print("for alpha =", i)
            clf = MultinomialNB(alpha=i)
            clf.fit(train, y_train)
            pred = clf.predict(X)
            tn, fp, fn, tp = confusion_matrix(y, pred,labels=[0,1]).ravel()
            if fp == 0 and tp ==0:
                fpr = np.inf
            else:
                fpr = fp/(fp+tn)
            fpr_array.append(fpr)
            # to avoid rounding error while multiplying probabilites we use log-
probability estimates
            print("FPR :",fpr)
    return fpr_array
```

In [7]:

```
# function to perform cross validation
def performCrossValidation(train,cv,test):
    alpha = [10**x for x in range(-8,3)]
#     fpr_array = []
#     fpr_array_train = []
#     for i in alpha:
#         print("for alpha =", i)
#         clf = MultinomialNB(alpha=i)
#         clf.fit(train, y_train)
#         pred = clf.predict(cv)
#         tn, fp, fn, tp = confusion_matrix(y_cv, pred,labels=[0,1]).ravel()
#         if fp == 0 and tp ==0:
#             fpr = np.inf
#         else:
#             fpr = fp/(fp+tn)
#         fpr_array.append(fpr)
#         # to avoid rounding error while multiplying probabilites we use log-pr
obability estimates
#         print("FPR :",fpr)
    fpr_array = calculateMetric(cv,y_cv,alpha,train,y_train)
    fpr_array_train = calculateMetric(train,y_train,alpha,train,y_train)
#     for i in alpha:
#         print("for alpha =", i)
#         clf = MultinomialNB(alpha=i)
#         clf.fit(train, y_train)
#         pred = clf.predict(train)
#         tn, fp, fn, tp = confusion_matrix(y_train, pred,labels=[0,1]).ravel()
#         if fp == 0 and tp ==0:
#             fpr = np.inf
#         else:
#             fpr = fp/(fp+tn)
#         fpr_array_train.append(fpr)
#         # to avoid rounding error while multiplying probabilites we use log-pr
obability estimates
#         print("FPR :",fpr)
    a = np.arange(len(alpha))
    fig, ax = plt.subplots(figsize=(15,15))
    ax.plot(a, fpr_array,c='g',label = 'cross validation')
    for i, txt in enumerate(np.round(fpr_array,3)):
        ax.annotate((a[i],str(txt)), (a[i],fpr_array[i]))
    ax.plot(a, fpr_array_train,c='r',label ='train')
    for i, txt in enumerate(np.round(fpr_array_train,5)):
        ax.annotate((a[i],np.round(txt,5)), (a[i],fpr_array_train[i]))
    ax.set_xticks(a)
    ax.set_xticklabels(alpha)
    plt.grid()
    plt.title("Cross Validation Error for each alpha")
    plt.xlabel("Alpha i's")
    plt.ylabel("Error measure")
    plt.legend(loc= 4)
    plt.show()

    best_alpha = np.argmin(fpr_array)
    clf = MultinomialNB(alpha=alpha[best_alpha])
    clf.fit(train, y_train)


    predict_y = clf.predict(train)
    tn, fp, fn, tp = confusion_matrix(y_train, predict_y).ravel()
```

```
    print('For values of best alpha = ', alpha[best_alpha], "The train fpr is:",
fp/(fp+tn))
    plot_confusion_matrix(y_train,predict_y)
    predict_y = clf.predict(cv)
    tn, fp, fn, tp = confusion_matrix(y_cv, predict_y).ravel()
    print('For values of best alpha = ', alpha[best_alpha], "The cross validatio
n fpr is:",fp/(fp+tn))
    print(confusion_matrix(y_cv,predict_y))
    predict_y = clf.predict(test)
    tn, fp, fn, tp = confusion_matrix(y_test, predict_y).ravel()
    print('For values of best alpha = ', alpha[best_alpha], "The test fpr is:",f
p/(fp+tn))
    plot_confusion_matrix(y_test,predict_y)
    return alpha[best_alpha]
```

In [8]:

```
def performNB(train,test,al):
    clf = MultinomialNB(alpha=al)
    clf.fit(train, y_train)
    pred = clf.predict(test)
    return pred,clf
```

In [9]:

```
def printNegativeWords(negative_words_arg,index_word_dict):
    negative_words= []
    for x in negative_words_arg[:20]:
        negative_words.append(index_word_dict[x])
    print(negative_words)
```

In [10]:

```
def printPositiveWords(postive_words_arg,index_word_dict):
    positive_words = []
    for x in positive_words_arg[:20]:
        positive_words.append(index_word_dict[x])
    print(positive_words)
```

BOW

In [11]:

```
count_vect = loadPickleData('count_vect.pickle')
```

In [12]:

```
train = loadPickleData("bow_train.pickle")
test = loadPickleData('bow_test.pickle')
cv = loadPickleData('bow_cv.pickle')
```

In [13]:

```
train.shape
```

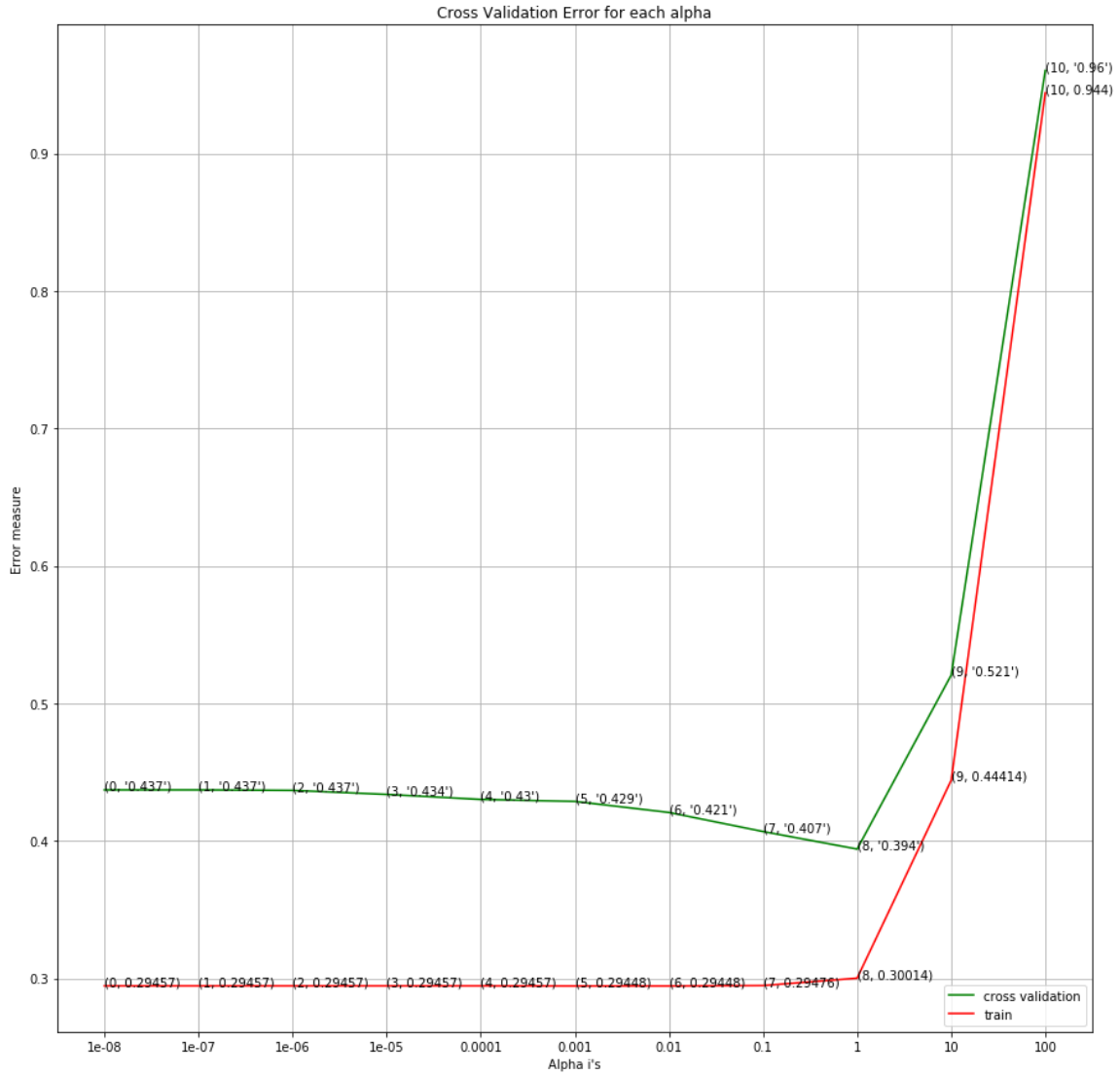
Out[13]:

```
(69920, 15548)
```

In [14]:

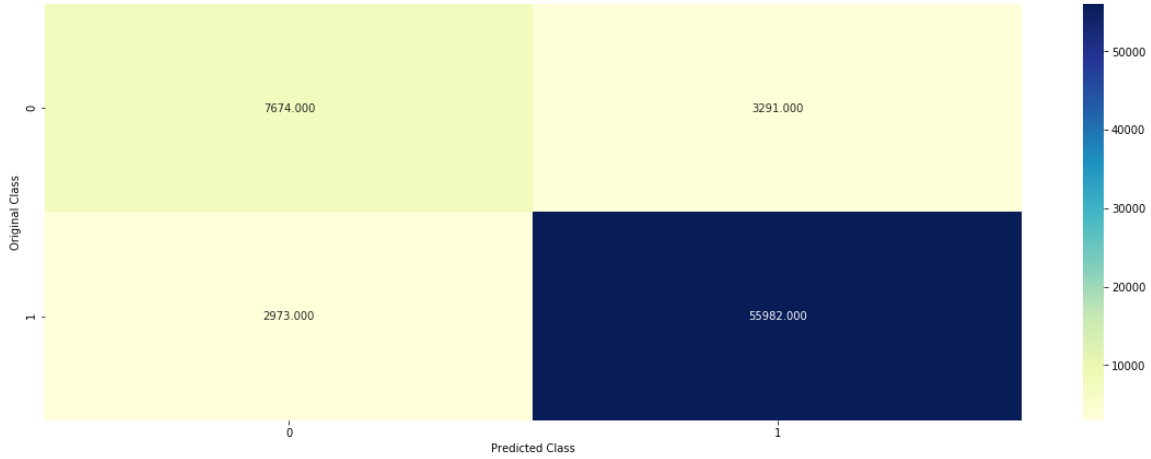
```
alpha = performCrossValidation(train,cv,test)
```

```
for alpha = 1e-08
FPR : 0.437066763954761
for alpha = 1e-07
FPR : 0.437066763954761
for alpha = 1e-06
FPR : 0.4367019336008756
for alpha = 1e-05
FPR : 0.43378329076979205
for alpha = 0.0001
FPR : 0.4301349872309376
for alpha = 0.001
FPR : 0.42867566581539585
for alpha = 0.01
FPR : 0.4206493980299161
for alpha = 0.1
FPR : 0.40678584458226924
for alpha = 1
FPR : 0.3940167821962787
for alpha = 10
FPR : 0.5206129149945276
for alpha = 100
FPR : 0.9602334914264867
for alpha = 1e-08
FPR : 0.29457364341085274
for alpha = 1e-07
FPR : 0.29457364341085274
for alpha = 1e-06
FPR : 0.29457364341085274
for alpha = 1e-05
FPR : 0.29457364341085274
for alpha = 0.0001
FPR : 0.29457364341085274
for alpha = 0.001
FPR : 0.2944824441404469
for alpha = 0.01
FPR : 0.2944824441404469
for alpha = 0.1
FPR : 0.2947560419516644
for alpha = 1
FPR : 0.30013679890560874
for alpha = 10
FPR : 0.444140446876425
for alpha = 100
FPR : 0.9440036479708163
```

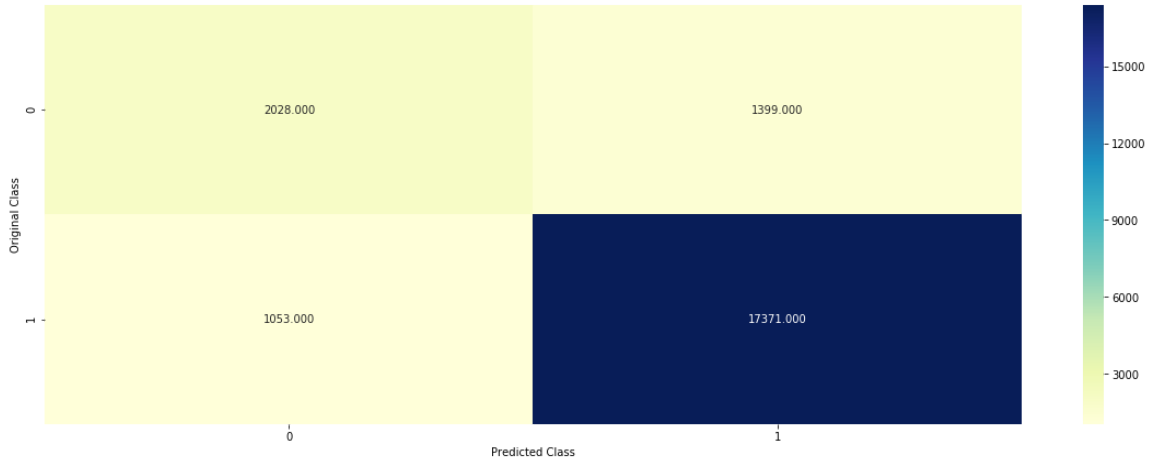


For values of best alpha = 1 The train fpr is: 0.30013679890560874

---------- Confusion matrix ----------



```
For values of best alpha =  1 The cross validation fpr is: 0.3940167
821962787
[[ 1661  1080]
 [  827 13912]]
For values of best alpha =  1 The test fpr is: 0.40822877152028014
-------------------- Confusion matrix --------------------
```



In [15]:

```
pred,clf = performNB(train,test,alpha)
```

In [16]:

```
print(y_test[:10])
print(pred[:10])
```

```
[0 1 1 1 1 1 1 0 1 1]
[1 1 0 1 1 1 1 1 1 1]
```

In [17]:

```
confusion_matrix(y_test,pred,labels=[0,1])
```

Out[17]:

```
array([[ 2028,  1399],
       [ 1053, 17371]])
```

In [18]:

```
#precision-score
precision_score(y_test, pred, average='binary')
```

Out[18]:

```
0.925466169419286
```

In [19]:

```
#recall-score
recall_score(y_test, pred, average='binary')
```

Out[19]:

```
0.9428462874511506
```

In [20]:

```
#f1-score
f1_score(y_test, pred, average='binary')
```

Out[20]:

```
0.9340753885035221
```

In [21]:

```
#find most commom positive and negative works
index_word_dict = {y:x for x,y in count_vect.vocabulary_.items()}
negative_words_arg = clf.feature_log_prob_[0, :].argsort()[::-1]
positive_words_arg = clf.feature_log_prob_[1, :].argsort()[::-1]
printNegativeWords(negative_words_arg,index_word_dict)
printPositiveWords(positive_words_arg,index_word_dict)
```

```
['wast money', 'custom servic', 'expir date', 'wont buy', 'ingredi l
ist', 'never buy', 'smell like', 'read review', 'save money', 'buy p
roduct', 'noth like', 'corn syrup', 'purchas product', 'coconut wate
r', 'made china', 'dont wast', 'didnt like', 'doesnt tast', 'one sta
r', 'throw away']
['coconut oil', 'ice tea', 'hot sauc', 'ice cream', 'love love', 'bl
ack tea', 'work great', 'best tast', 'find local', 'kid love', 'suga
r free', 'well worth', 'easi make', 'last long', 'pleasant surpris',
'everi time', 'use make', 'also use', 'far best', 'good product']
```

Tfidf

In [95]:

```
train = loadPickleData("tfidf_train.pickle")
test = loadPickleData('tfidf_test.pickle')
cv = loadPickleData('tfidf_cv.pickle')
```

In [96]:

```
train.shape
```

Out[96]:

```
(69920, 46189)
```

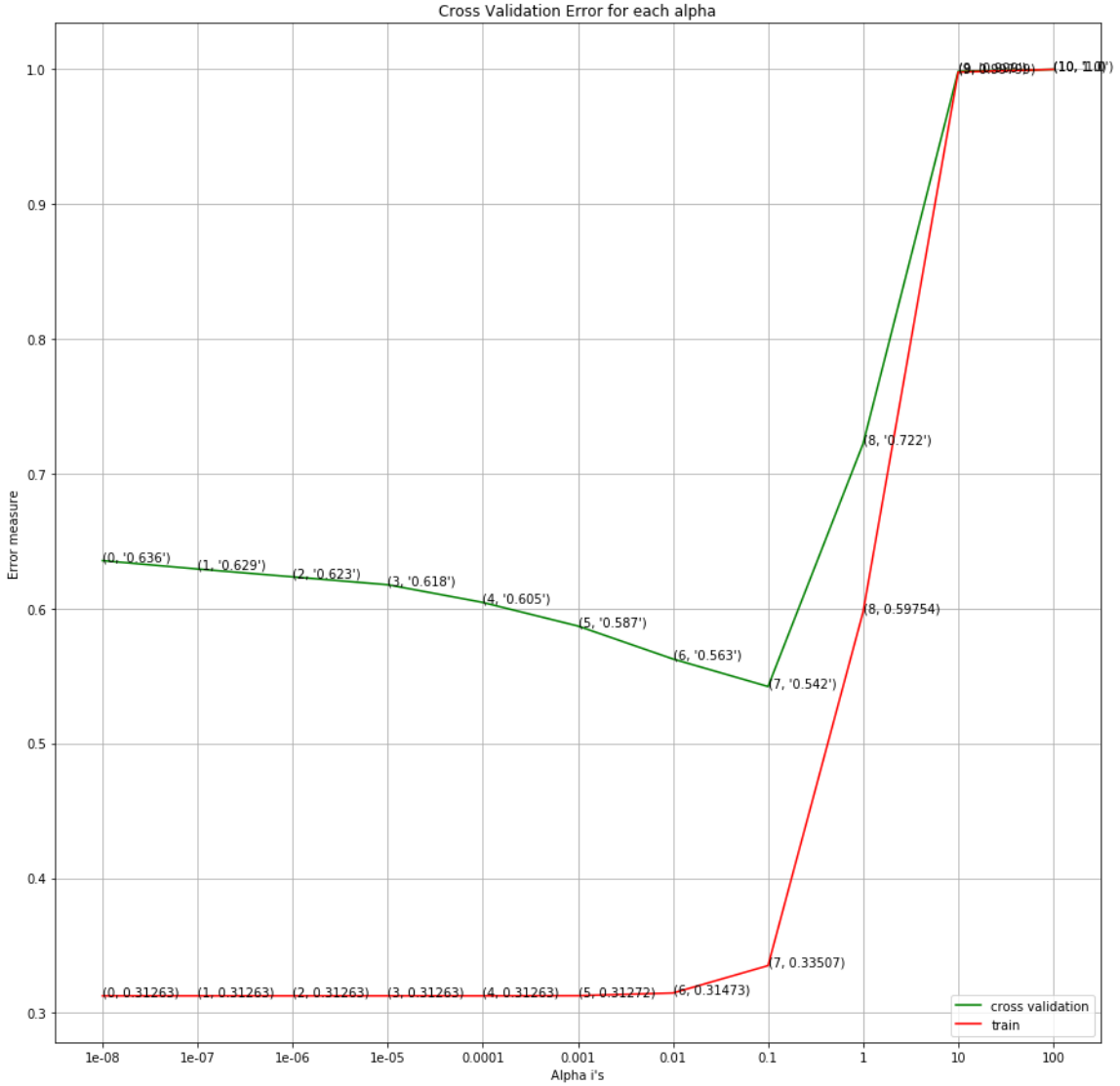
In [97]:

```
tfidf_vect = loadPickleData('tf_idf_vect.pickle')
```

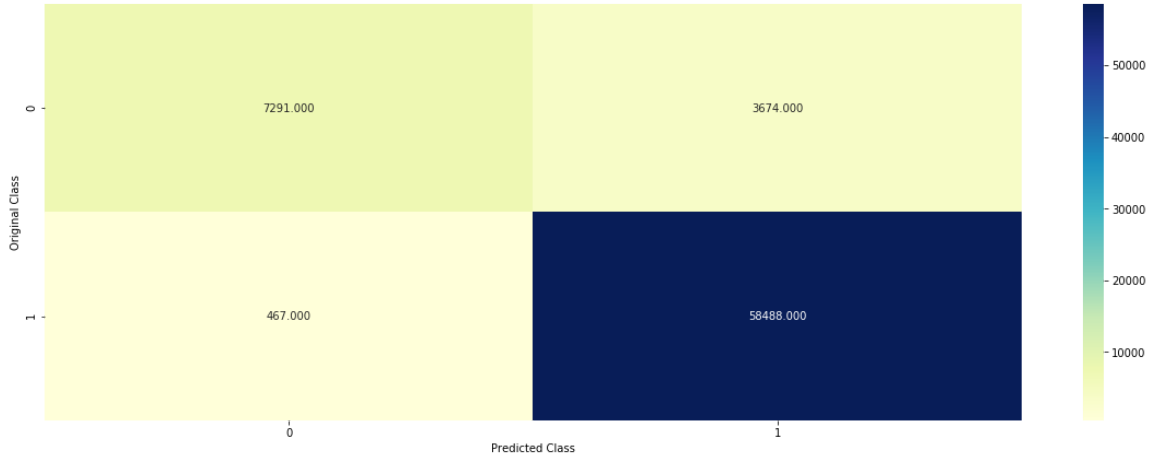
In [98]:

```
alpha = performCrossValidation(train,cv,test)
```

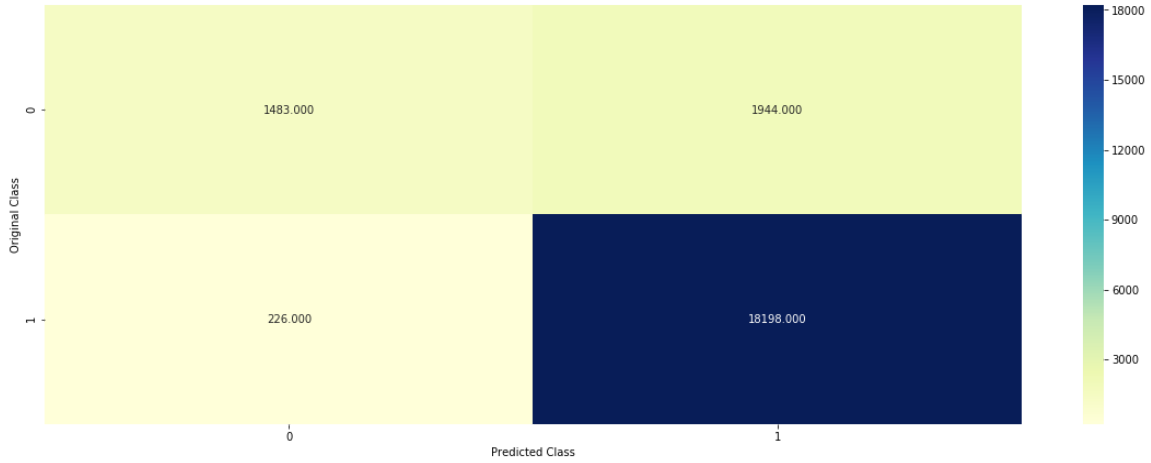
```
for alpha = 1e-08
FPR : 0.6355344764684422
for alpha = 1e-07
FPR : 0.6293323604523896
for alpha = 1e-06
FPR : 0.6234950747902226
for alpha = 1e-05
FPR : 0.6176577891280555
for alpha = 0.0001
FPR : 0.6045238963881795
for alpha = 0.001
FPR : 0.5870120394016782
for alpha = 0.01
FPR : 0.5625684056913535
for alpha = 0.1
FPR : 0.5421379058737686
for alpha = 1
FPR : 0.7223641006931777
for alpha = 10
FPR : 0.9985406785844583
for alpha = 100
FPR : 1.0
for alpha = 1e-08
FPR : 0.3126310989512084
for alpha = 1e-07
FPR : 0.3126310989512084
for alpha = 1e-06
FPR : 0.3126310989512084
for alpha = 1e-05
FPR : 0.3126310989512084
for alpha = 0.0001
FPR : 0.3126310989512084
for alpha = 0.001
FPR : 0.31272229822161424
for alpha = 0.01
FPR : 0.3147286821705426
for alpha = 0.1
FPR : 0.33506611947104425
for alpha = 1
FPR : 0.5975376196990424
for alpha = 10
FPR : 0.9979936160510716
for alpha = 100
FPR : 1.0
```




```
For values of best alpha =  0.1 The train fpr is: 0.3350661194710442
5
-------------------- Confusion matrix --------------------
```




```
For values of best alpha =  0.1 The cross validation fpr is: 0.54213
79058737686
[[ 1255  1486]
 [  161 14578]]
For values of best alpha =  0.1 The test fpr is: 0.5672599941639919
-------------------- Confusion matrix --------------------
```



In [99]:

```
pred,clf = performNB(train,test,alpha)
```

In [100]:

```
#confusion-matrix
confusion_matrix(y_test,pred)
```

Out[100]:

```
array([[ 1483,  1944],
       [  226, 18198]])
```

In [101]:

```
tn, fp, fn, tp = confusion_matrix(y_test, pred).ravel()
(tn, fp, fn, tp)
```

Out[101]:

```
(1483, 1944, 226, 18198)
```

In [102]:

```
#precision-score
precision_score(y_test, pred, average='binary')
```

Out[102]:

0.903485254691689

In [103]:

```
#recall-score
recall_score(y_test, pred, average='binary')
```

Out[103]:

0.987733391228832

In [104]:

```
#f1-score
f1_score(y_test, pred, average='binary')
```

Out[104]:

0.9437328216563814

In [105]:

```
#find most commom positive and negative works
index_word_dict = {y:x for x,y in tfidf_vect.vocabulary_.items()}
negative_words_arg = clf.feature_log_prob_[0, :].argsort()[::-1]
positive_words_arg = clf.feature_log_prob_[1, :].argsort()[::-1]
printNegativeWords(negative_words_arg,index_word_dict)
printPositiveWords(positive_words_arg,index_word_dict)
```

```
['wast money', 'terribl', 'aw', 'horribl', 'stale', 'worst', 'pictu
r', 'descript', 'expir', 'threw', 'refund', 'broken', 'weak', 'poo
r', 'china', 'nasti', 'send', 'sorri', 'bland', 'pod']
['hair', 'espresso', 'pod', 'cherri', 'granola', 'mint', 'cocoa', 't
omato', 'chai', 'one best', 'great flavor', 'pancak', 'love produc
t', 'hook', 'formula', 'make great', 'skin', 'absolut love', 'fun',
'veggi']
```

Summary

Vectorizer	Alpha	FPR
BOW	1	0.40
TFIDF	0.1	0.56