In [0]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&scope=email%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.photos.readonly%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fpeopleapi.readonly&response_type=code (https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&scope=email%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.photos.readonly%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fpeopleapi.readonly&response_type=code)

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

In [0]:
```
%cd drive/My Drive
```

```
/content/drive/My Drive
```

In [0]:
```
import warnings
warnings.filterwarnings("ignore")
import shutil
import os
import pandas as pd
import matplotlib
matplotlib.use(u'nbAgg')
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import pickle
from sklearn.manifold import TSNE
from sklearn import preprocessing
import pandas as pd
from multiprocessing import Process# this is used for multithreading
import multiprocessing
import codecs# this is used for file operations
import random as r
from xgboost import XGBClassifier
from sklearn.model_selection import RandomizedSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.calibration import CalibratedClassifierCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import log_loss
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
import pickle
```

In [0]:
```
data_size_byte = pd.read_pickle('data_size_byte')
```

In [0]:
```
byte_features=pd.read_csv("results(1).csv")
print (byte_features.head())
```

```
                     ID       0     1     2     3     4     5     6     7  \
0  01azqd4InC7m9JpocGv5  601905  3905  2816  3832  3345  3242  3650  3201
1  01IsoiSMh5gxyDYTl4CB   39755  8337  7249  7186  8663  6844  8420  7589
2  01jsnpXSAlgw6aPeDxrU   93506  9542  2568  2438  8925  9330  9007  2342
3  01kcPWA9K2BOxQeS5Rju   21091  1213   726   817  1257   625   550   523
4  01SuzwMJEIXsK7A8dQbl   19764   710   302   433   559   410   262   249

      8  ...    f7    f8    f9    fa    fb    fc    fd     fe     ff     ??
0  2965  ...  2804  3687  3101  3211  3097  2758  3099   2759   5753   1824
1  9291  ...   451  6536   439   281   302  7639   518  17001  54902   8588
2  9107  ...  2325  2358  2242  2885  2863  2471  2786   2680  49144    468
3  1078  ...   478   873   485   462   516  1133   471    761   7998  13940
4   422  ...   847   947   350   209   239   653   221    242   2199   9008

[5 rows x 258 columns]
```

In [0]:
```
df = byte_features
import math
for column in df.loc[:, '0':'ff']:
   p = (df[column]/df[column].sum())
   h = p.apply(lambda x: np.log(x))
   df[column+'ent'] = - p * h
```

In [0]:
```
df.columns.get_loc("0ent")
```

Out[7]:
```
258
```

In [0]:
```
# https://stackoverflow.com/a/29651514
def normalize(df):
    result1 = df.copy()
    for feature_name in df.columns[:258]:
        if (str(feature_name) != str('ID') and str(feature_name)!=str('Class')):
            max_value = df[feature_name].max()
            min_value = df[feature_name].min()
            result1[feature_name] = (df[feature_name] - min_value) / (max_value -
    return result1
result = normalize(df)
```

In [0]:
```
result = pd.merge(result, data_size_byte,on='ID', how='left')
#result.head()
```

In [0]:
```
max_value = result['size'].max()
min_value = result['size'].min()
result['size'] = (result['size'] - min_value) / (max_value - min_value)
```

In [0]:
```
result.head()
```

Out[75]:

	ID	0	1	2	3	4	5	6
0	01azqd4InC7m9JpocGv5	0.262786	0.005425	0.001558	0.002056	0.002038	0.001828	0.002057
1	01IsoiSMh5gxyDYTl4CB	0.017332	0.011665	0.004024	0.003866	0.005294	0.003867	0.004746
2	01jsnpXSAlgw6aPeDxrU	0.040801	0.013361	0.001420	0.001304	0.005454	0.005274	0.005077
3	01kcPWA9K2BOxQeS5Rju	0.009182	0.001635	0.000395	0.000430	0.000760	0.000347	0.000309
4	01SuzwMJEIXsK7A8dQbl	0.008603	0.000926	0.000159	0.000223	0.000332	0.000225	0.000147

5 rows × 516 columns

In [0]:
```
max_value = result['size'].max()
min_value = result['size'].min()
result['size'] = (result['size'] - min_value) / (max_value - min_value)
```

In [0]:
```
asm_features=pd.read_csv("try_results.csv")
print(asm_features.head())
```

```
                    ID  .BSS:  .CODE  .Pav:  .bss:   .data:  .dll  .edata:  \
0  01azqd4InC7m9JpocGv5      0      0      0      0  1366755     0        0
1  01IsoiSMh5gxyDYTl4CB      0      0      0      0    24618     0        0
2  01jsnpXSAlgw6aPeDxrU      0      0      0      0      662     0        0
3  01kcPWA9K2BOxQeS5Rju      0      0      0      0       58     0        0
4  01SuzwMJEIXsK7A8dQbl      0      0      0     96     4686     0        0

   .idata:  .rdata:  ...  retn  rol  ror  rtn  shl  shr  std::  sub  xchg  xor

0     1158     2263  ...   290    0    0    0  158    2      0  648     0  418

1      616    26760  ...   252    0    0    0   23   14      0  216     0  106

2      304     1236  ...    27    0    0    0    0    0      0   91     0  199

3      127      381  ...    16    0    0    0    1    0      0    5     0   18

4      206        0  ...    33    0    2    0   32    0      0  363     9   19


[5 rows x 52 columns]
```

In [0]:
```
result2 = pd.merge(asm_features, data_size_byte,on='ID', how='left')
result2.head()
```

Out[13]:

	ID	.BSS:	.CODE	.Pav:	.bss:	.data:	.dll	.edata:	.idata:	.rdata:	...
0	01azqd4InC7m9JpocGv5	0	0	0	0	1366755	0	0	1158	2263	...
1	01IsoiSMh5gxyDYTl4CB	0	0	0	0	24618	0	0	616	26760	...
2	01jsnpXSAlgw6aPeDxrU	0	0	0	0	662	0	0	304	1236	...
3	01kcPWA9K2BOxQeS5Rju	0	0	0	0	58	0	0	127	381	...
4	01SuzwMJEIXsK7A8dQbl	0	0	0	96	4686	0	0	206	0	...

5 rows × 54 columns

In [0]:
```
result2 = result2.loc[:, (result2 != 0).any(axis=0)]
```

In [0]:
```
df = result2.copy()
import math
for column in df.loc[:, '.Pav:':'xor']:
   p = (df[column]/df[column].sum())
   h = p.apply(lambda x: np.log(x))
   df[column+'ent'] = - p * h
```

In [0]:
```
df = df.fillna(0)
```

In [0]:
```
# https://stackoverflow.com/a/29651514
def normalize(df):
    result1 = df.copy()
    for feature_name in df.columns[:92]:
        if (str(feature_name) != str('ID') and str(feature_name)!=str('Class')):
            max_value = df[feature_name].max()
            min_value = df[feature_name].min()
            result1[feature_name] = (df[feature_name] - min_value) / (max_value -
    return result1
result2 = normalize(df)
```

In [0]:
```
result2.head()
```

Out[18]:

	ID	.Pav:	.bss:	.data:	.edata:	.idata:	.rdata:	.reloc:	.r
0	01azqd4InC7m9JpocGv5	0.0	0.000000	0.542821	0.0	0.006936	0.000589	0.000000	0.000
1	01IsoiSMh5gxyDYTl4CB	0.0	0.000000	0.009777	0.0	0.003689	0.006969	0.000000	0.000
2	01jsnpXSAlgw6aPeDxrU	0.0	0.000000	0.000263	0.0	0.001821	0.000322	0.000000	0.000
3	01kcPWA9K2BOxQeS5Rju	0.0	0.000000	0.000023	0.0	0.000761	0.000099	0.001001	0.000
4	01SuzwMJEIXsK7A8dQbl	0.0	0.013393	0.001861	0.0	0.001234	0.000000	0.000000	0.000

5 rows × 93 columns

In [0]:
```
res = pd.merge(result2, result, on='ID', how='left')
res.head()
```

Out[19]:

	ID	.Pav:	.bss:	.data:	.edata:	.idata:	.rdata:	.reloc:	.r
0	01azqd4InC7m9JpocGv5	0.0	0.000000	0.542821	0.0	0.006936	0.000589	0.000000	0.000
1	01IsoiSMh5gxyDYTl4CB	0.0	0.000000	0.009777	0.0	0.003689	0.006969	0.000000	0.000
2	01jsnpXSAlgw6aPeDxrU	0.0	0.000000	0.000263	0.0	0.001821	0.000322	0.000000	0.000
3	01kcPWA9K2BOxQeS5Rju	0.0	0.000000	0.000023	0.0	0.000761	0.000099	0.001001	0.000
4	01SuzwMJEIXsK7A8dQbl	0.0	0.013393	0.001861	0.0	0.001234	0.000000	0.000000	0.000

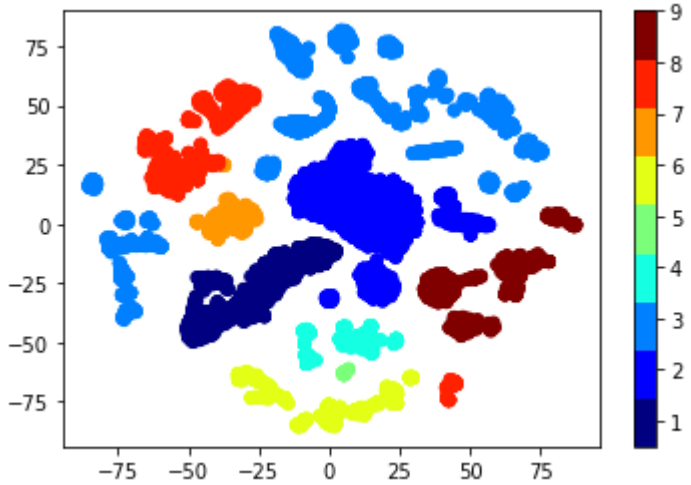
5 rows × 608 columns

In [0]:
```
data_y = res['Class_y']
res.drop('Class_y',axis =1 , inplace=True)
res.drop('ID',axis =1 , inplace=True)
```

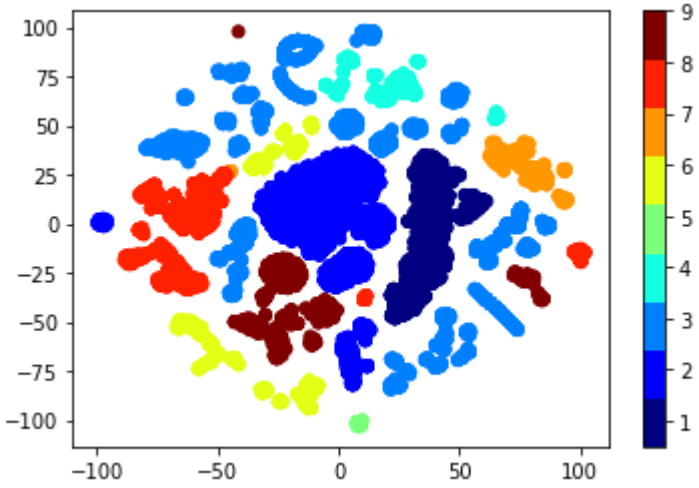
In [0]:
```
results = res.copy()
result = res.copy()
```

3.2.4 Multivariate Analysis

In [0]:
```
%matplotlib inline
#multivariate analysis on byte files
#this is with perplexity 50
xtsne=TSNE(perplexity=50)
results=xtsne.fit_transform(result)
vis_x = results[:, 0]
vis_y = results[:, 1]
plt.scatter(vis_x, vis_y, c=data_y, cmap=plt.cm.get_cmap("jet", 9))
plt.colorbar(ticks=range(10))
plt.clim(0.5, 9)
plt.show()
```



In [0]:
```
%matplotlib inline
#this is with perplexity 30
xtsne=TSNE(perplexity=30)
results=xtsne.fit_transform(result)
vis_x = results[:, 0]
vis_y = results[:, 1]
plt.scatter(vis_x, vis_y, c=data_y, cmap=plt.cm.get_cmap("jet", 9))
plt.colorbar(ticks=range(10))
plt.clim(0.5, 9)
plt.show()
```



Train Test split

In [0]:
```
#data_y = result['Class']
# split the data into test and train by maintaining same distribution of output v
X_train, X_test, y_train, y_test = train_test_split(result, data_y,stratify=data_
# split the train data into train and cross validation by maintaining same distri
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train,stratify=y_train
```

In [0]:
```
print('Number of data points in train data:', X_train.shape[0])
print('Number of data points in test data:', X_test.shape[0])
print('Number of data points in cross validation data:', X_cv.shape[0])
```

```
Number of data points in train data: 6955
Number of data points in test data: 2174
Number of data points in cross validation data: 1739
```

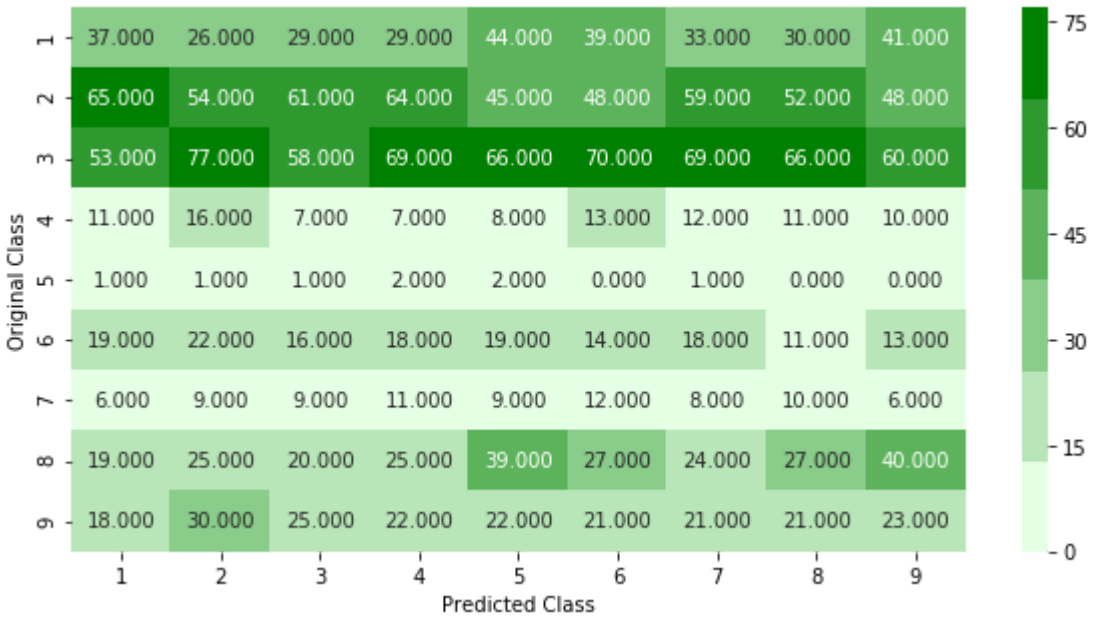
In [0]:
```
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    print("Number of misclassified points ",(len(test_y)-np.trace(C))/len(test_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are p

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

    # 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 rows
    # 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 c
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to rows
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                      [3/4, 4/6]]

    labels = [1,2,3,4,5,6,7,8,9]
    cmap=sns.light_palette("green")
    # representing A in heatmap format
    print("-"*50, "Confusion matrix", "-"*50)
    plt.figure(figsize=(10,5))
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()

    print("-"*50, "Precision matrix", "-"*50)
    plt.figure(figsize=(10,5))
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()
    print("Sum of columns in precision matrix",B.sum(axis=0))

    # representing B in heatmap format
    print("-"*50, "Recall matrix"    , "-"*50)
    plt.figure(figsize=(10,5))
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()
    print("Sum of rows in precision matrix",A.sum(axis=1))
```

4. Machine Learning Models

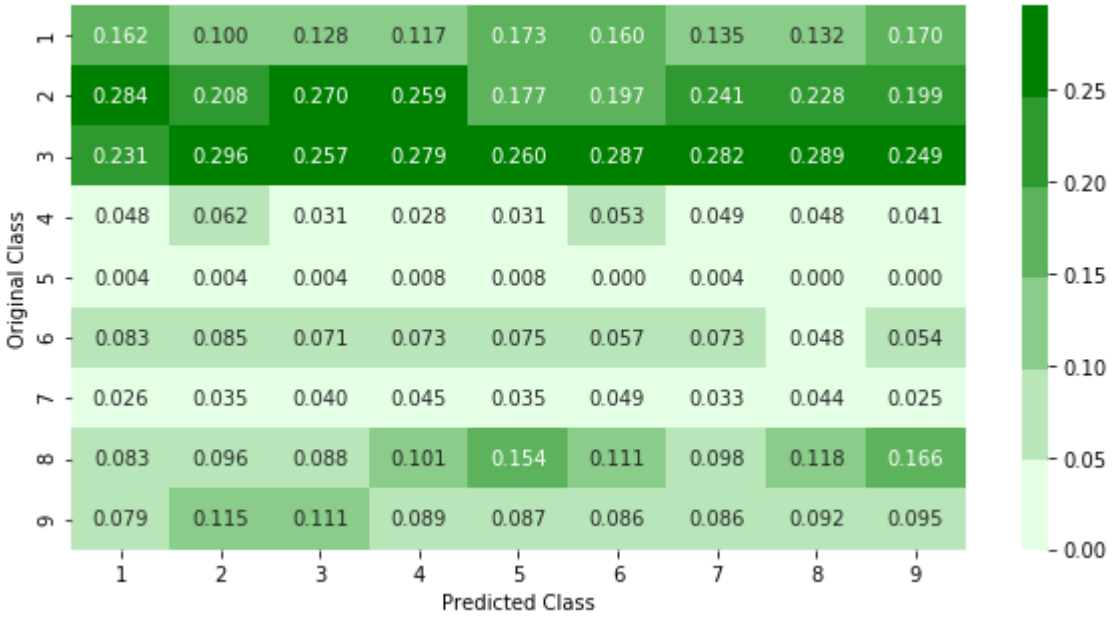
4.1.1. Random Model

In [0]:
```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their s
# ref: https://stackoverflow.com/a/18662466/4084039

test_data_len = X_test.shape[0]
cv_data_len = X_cv.shape[0]

# we create a output array that has exactly same size as the CV data
cv_predicted_y = np.zeros((cv_data_len,9))
for i in range(cv_data_len):
    rand_probs = np.random.rand(1,9)
    cv_predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Cross Validation Data using Random Model",log_loss(y_cv,cv_pre


# Test-Set error.
#we create a output array that has exactly same as the test data
test_predicted_y = np.zeros((test_data_len,9))
for i in range(test_data_len):
    rand_probs = np.random.rand(1,9)
    test_predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test,test_predicted_y

predicted_y =np.argmax(test_predicted_y, axis=1)
plot_confusion_matrix(y_test, predicted_y+1)
```

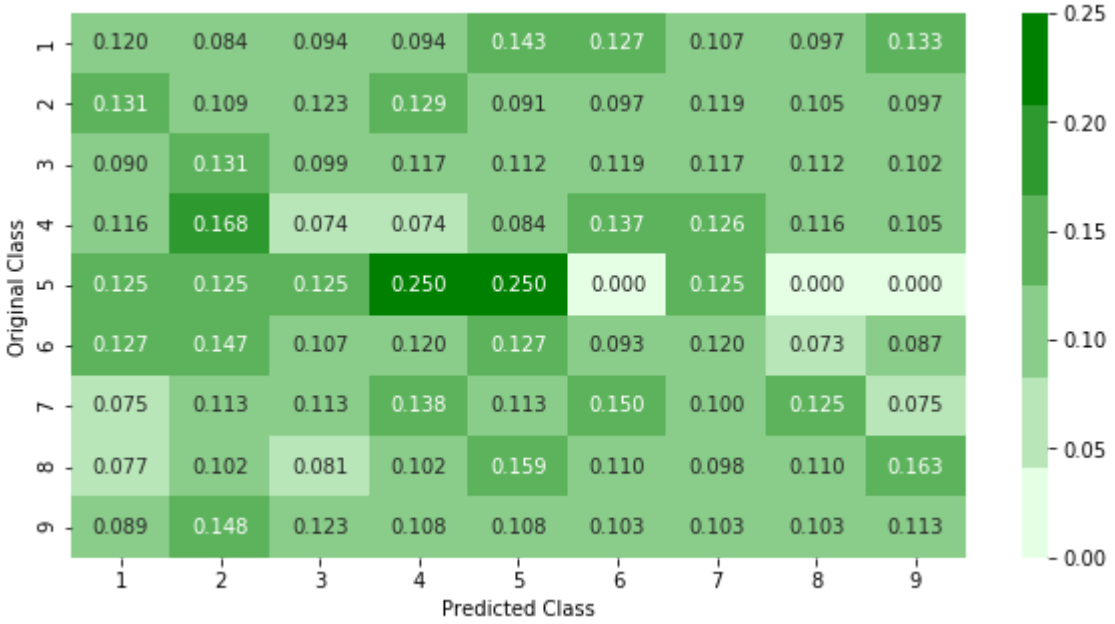
```
Log loss on Cross Validation Data using Random Model 2.4722724250890247
Log loss on Test Data using Random Model 2.4881624758360954
Number of misclassified points  89.42042318307267
---------------------------------------------------- Confusion matrix -----------
----------------------------------------
```




```
---------------------------------------------------- Precision matrix -----------
----------------------------------------
```




```
Sum of columns in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
---------------------------------------------------- Recall matrix --------------
-----------------------------------
```



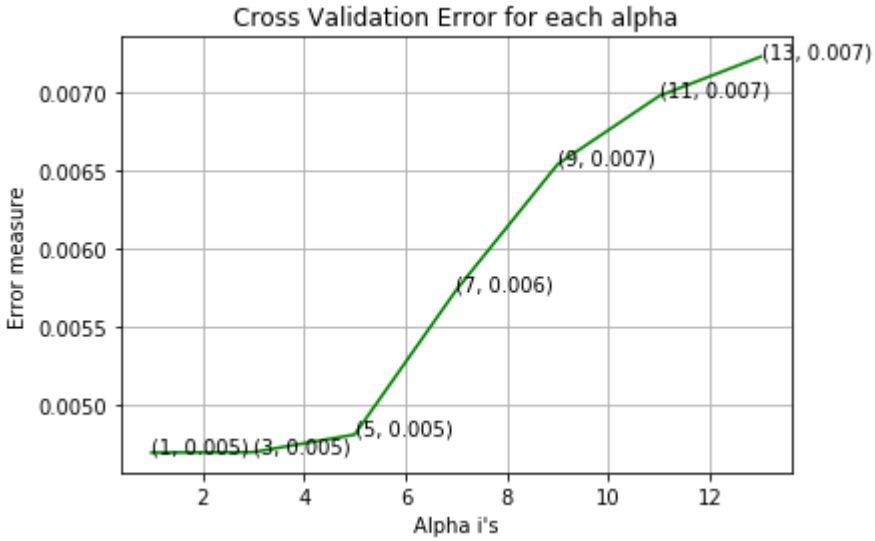

```
Sum of rows in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

4.1.2. K Nearest Neighbour Classification

In [0]:
```
%matplotlib inline
# find more about KNeighborsClassifier() here http://scikit-learn.org/stable/modu
# ------------------------
# default parameter
# KNeighborsClassifier(n_neighbors=5, weights='uniform', algorithm='auto', leaf_s
# metric='minkowski', metric_params=None, n_jobs=1, **kwargs)

# methods of
# fit(X, y) : Fit the model using X as training data and y as target values
# predict(X):Predict the class labels for the provided data
# predict_proba(X):Return probability estimates for the test data X.
#-----------------------------------
# video link: https://www.appliedaicourse.com/course/applied-ai-course-online/les
#-----------------------------------


# find more about CalibratedClassifierCV here at http://scikit-learn.org/stable/m
# ----------------------------
# default paramters
# sklearn.calibration.CalibratedClassifierCV(base_estimator=None, method='sigmoid
#
# some of the methods of CalibratedClassifierCV()
# fit(X, y[, sample_weight])    Fit the calibrated model
# get_params([deep])    Get parameters for this estimator.
# predict(X)    Predict the target of new samples.
# predict_proba(X)  Posterior probabilities of classification
#-----------------------------------
# video link:
#-----------------------------------

alpha = [x for x in range(1, 15, 2)]
cv_log_error_array=[]
for i in alpha:
    k_cfl=KNeighborsClassifier(n_neighbors=i)
    k_cfl.fit(X_train,y_train)
    sig_clf = CalibratedClassifierCV(k_cfl, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    cv_log_error_array.append(log_loss(y_cv, predict_y, labels=k_cfl.classes_, ep

for i in range(len(cv_log_error_array)):
    print ('log_loss for k = ',alpha[i],'is',cv_log_error_array[i])

best_alpha = np.argmin(cv_log_error_array)

fig, ax = plt.subplots()
ax.plot(alpha, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],cv_log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()

k_cfl=KNeighborsClassifier(n_neighbors=alpha[best_alpha])
```

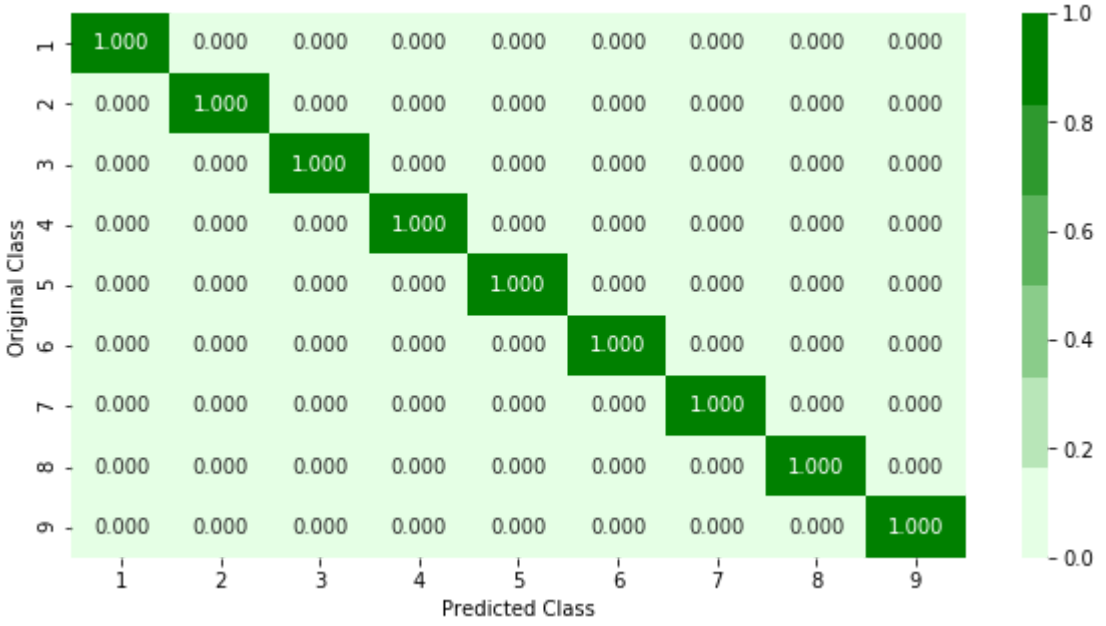
```
k_cfl.fit(X_train,y_train)
sig_clf = CalibratedClassifierCV(k_cfl, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print ('For values of best alpha = ', alpha[best_alpha], "The train log loss is:"
predict_y = sig_clf.predict_proba(X_cv)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation log
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",l
plot_confusion_matrix(y_test, sig_clf.predict(X_test))
```

```
log_loss for k =  1 is 0.00468998682255479
log_loss for k =  3 is 0.0046929679530416085
log_loss for k =  5 is 0.004805547082328919
log_loss for k =  7 is 0.005730846477819891
log_loss for k =  9 is 0.006537565306376415
log_loss for k =  11 is 0.006974389928988957
log_loss for k =  13 is 0.007226098217296325
```



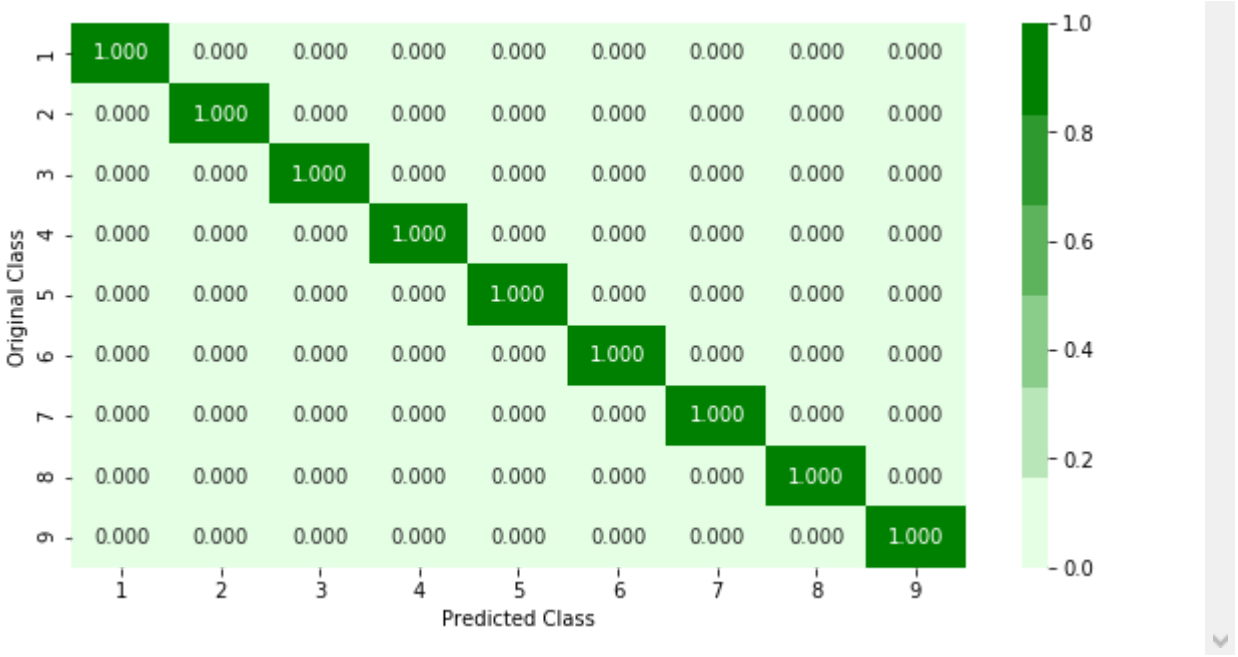

```
For values of best alpha =  1 The train log loss is: 0.004690064861750737
For values of best alpha =  1 The cross validation log loss is: 0.0046899868225
5479
For values of best alpha =  1 The test log loss is: 0.004457068078296095
Number of misclassified points  0.0
---------------------------------------------------- Confusion matrix -----------
----------------------------------------
```

---------- Precision matrix ----------



Sum of columns in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]

---------- Recall matrix ----------



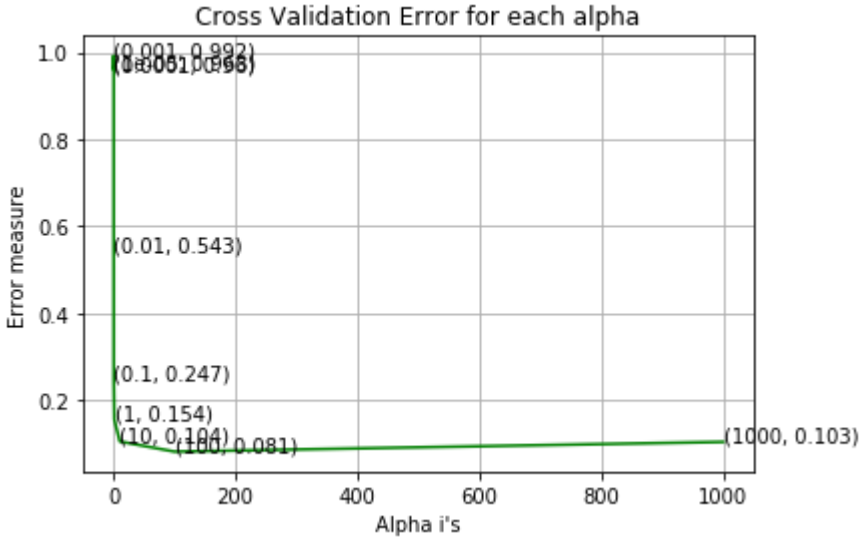

```
Sum of rows in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

4.1.3. Logistic Regression

In [0]:
```
% matplotlib inline
# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/genera
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_inte
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rat
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, ...]) Fit linear model with Stochastic Grad
# predict(X)    Predict class labels for samples in X.

#-------------------------------
# video link: https://www.appliedaicourse.com/course/applied-ai-course-online/les
#-------------------------------

alpha = [10 ** x for x in range(-5, 4)]
cv_log_error_array=[]
for i in alpha:
    logisticR=LogisticRegression(penalty='l2',C=i,class_weight='balanced')
    logisticR.fit(X_train,y_train)
    sig_clf = CalibratedClassifierCV(logisticR, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    cv_log_error_array.append(log_loss(y_cv, predict_y, labels=logisticR.classes_

for i in range(len(cv_log_error_array)):
    print ('log_loss for c = ',alpha[i],'is',cv_log_error_array[i])

best_alpha = np.argmin(cv_log_error_array)

fig, ax = plt.subplots()
ax.plot(alpha, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],cv_log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()

logisticR=LogisticRegression(penalty='l2',C=alpha[best_alpha],class_weight='balan
logisticR.fit(X_train,y_train)
sig_clf = CalibratedClassifierCV(logisticR, method="sigmoid")
sig_clf.fit(X_train, y_train)
pred_y=sig_clf.predict(X_test)

predict_y = sig_clf.predict_proba(X_train)
print ('log loss for train data',log_loss(y_train, predict_y, labels=logisticR.cl
predict_y = sig_clf.predict_proba(X_cv)
print ('log loss for cv data',log_loss(y_cv, predict_y, labels=logisticR.classes_
predict_y = sig_clf.predict_proba(X_test)
print ('log loss for test data',log_loss(y_test, predict_y, labels=logisticR.clas
plot_confusion_matrix(y_test, sig_clf.predict(X_test))
```

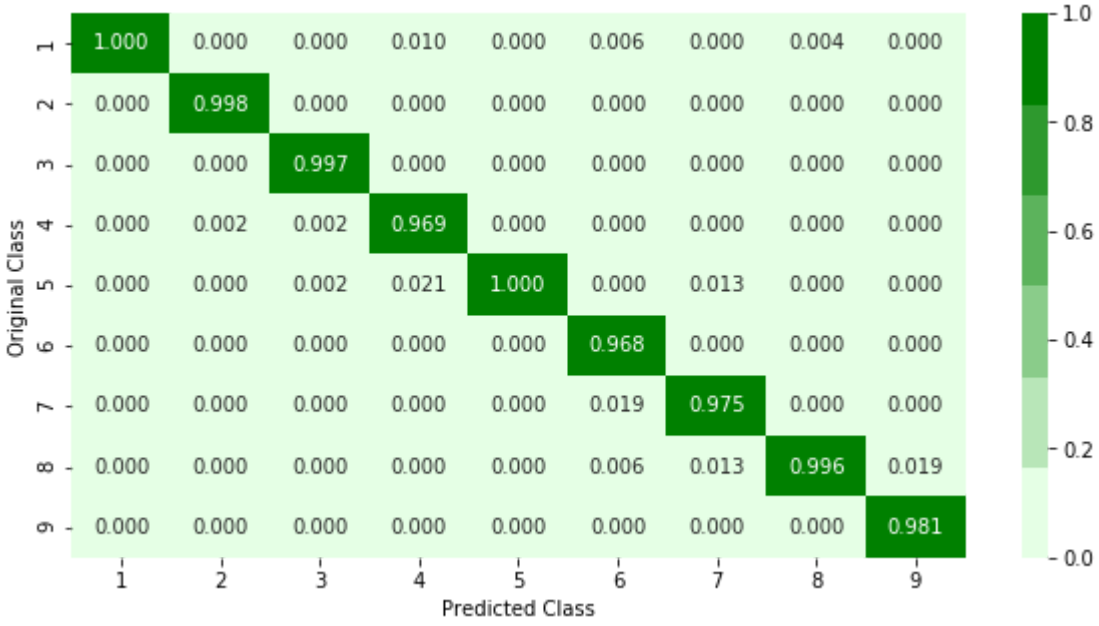
```
log_loss for c =  1e-05 is 0.9625389047670373
log_loss for c =  0.0001 is 0.9601632287777145
```

```
log_loss for c =  0.001 is 0.9920569575873288
log_loss for c =  0.01 is 0.5426182303710824
log_loss for c =  0.1 is 0.24705584406637587
log_loss for c =  1 is 0.15436203509238586
log_loss for c =  10 is 0.10430217321982718
log_loss for c =  100 is 0.08085153457154395
log_loss for c =  1000 is 0.10322979610181114
```

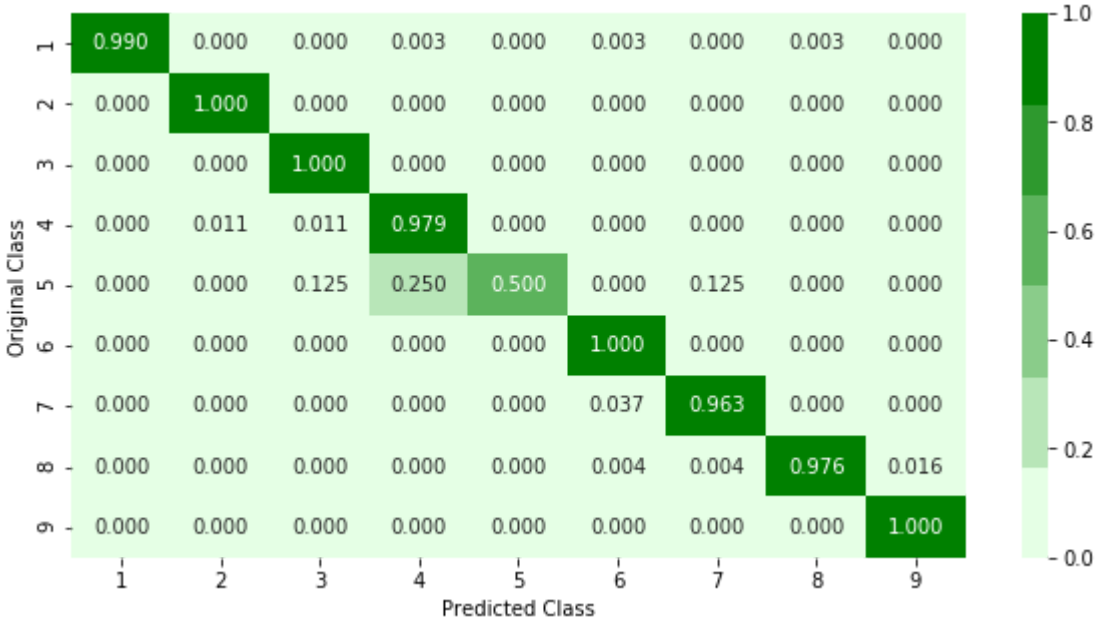



```
log loss for train data 0.06998436061921276
log loss for cv data 0.08085153457154395
log loss for test data 0.07922021738297313
Number of misclassified points  0.8279668813247469
---------------------------------------------------- Confusion matrix -----------
----------------------------------------
```


```
---------------------------------------------------- Precision matrix -----------
----------------------------------------
```




```
Sum of columns in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
---------------------------------------------------- Recall matrix --------------
-----------------------------------
```



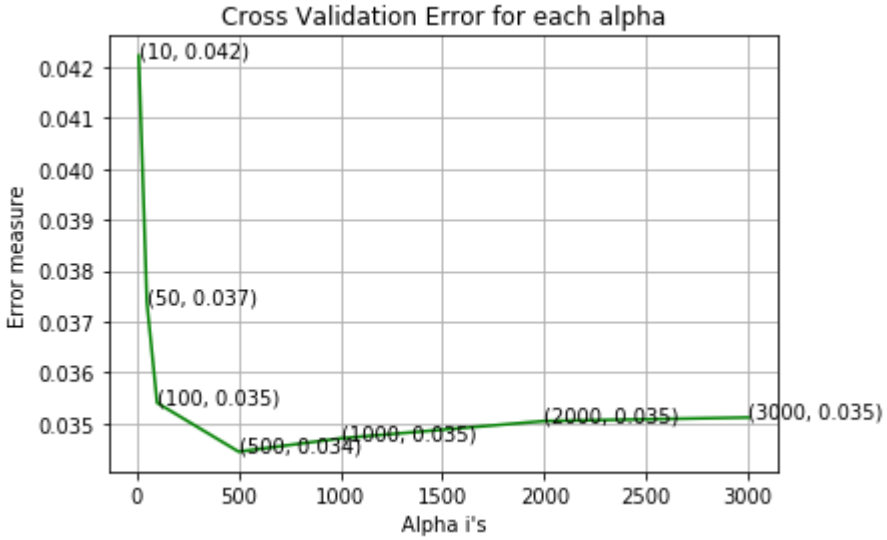

```
Sum of rows in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

4.1.4. Random Forest Classifier

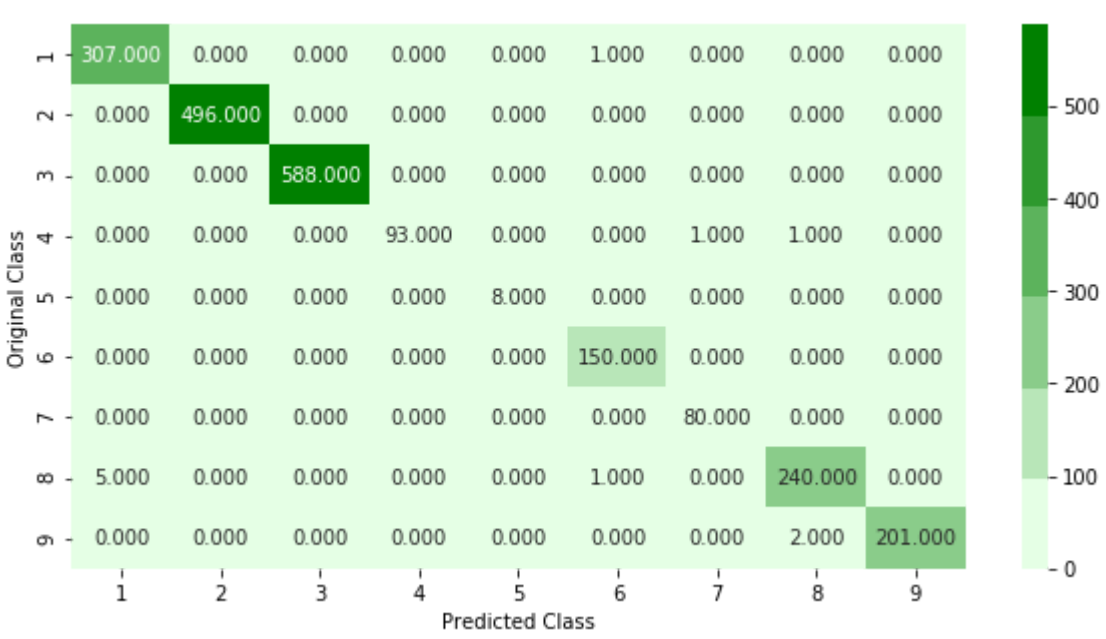
In [0]:
```
%matplotlib inline
# ------------------------------
# default parameters
# sklearn.ensemble.RandomForestClassifier(n_estimators=10, criterion='gini', max_
# min_samples_leaf=1, min_weight_fraction_leaf=0.0, max_features='auto', max_leaf_
# min_impurity_split=None, bootstrap=True, oob_score=False, n_jobs=1, random_stat
# class_weight=None)

# Some of methods of RandomForestClassifier()
# fit(X, y, [sample_weight])    Fit the SVM model according to the given training
# predict(X)    Perform classification on samples in X.
# predict_proba (X) Perform classification on samples in X.

# some of attributes of  RandomForestClassifier()
# feature_importances_ : array of shape = [n_features]
# The feature importances (the higher, the more important the feature).

# ------------------------------
# video link: https://www.appliedaicourse.com/course/applied-ai-course-online/les
# ------------------------------

alpha=[10,50,100,500,1000,2000,3000]
cv_log_error_array=[]
train_log_error_array=[]
from sklearn.ensemble import RandomForestClassifier
for i in alpha:
    r_cfl=RandomForestClassifier(n_estimators=i,random_state=42,n_jobs=-1)
    r_cfl.fit(X_train,y_train)
    sig_clf = CalibratedClassifierCV(r_cfl, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    cv_log_error_array.append(log_loss(y_cv, predict_y, labels=r_cfl.classes_, ep

for i in range(len(cv_log_error_array)):
    print ('log_loss for c = ',alpha[i],'is',cv_log_error_array[i])


best_alpha = np.argmin(cv_log_error_array)

fig, ax = plt.subplots()
ax.plot(alpha, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],cv_log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


r_cfl=RandomForestClassifier(n_estimators=alpha[best_alpha],random_state=42,n_job
r_cfl.fit(X_train,y_train)
sig_clf = CalibratedClassifierCV(r_cfl, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
```

```
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",
predict_y = sig_clf.predict_proba(X_cv)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation log
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",l
plot_confusion_matrix(y_test, sig_clf.predict(X_test))
```

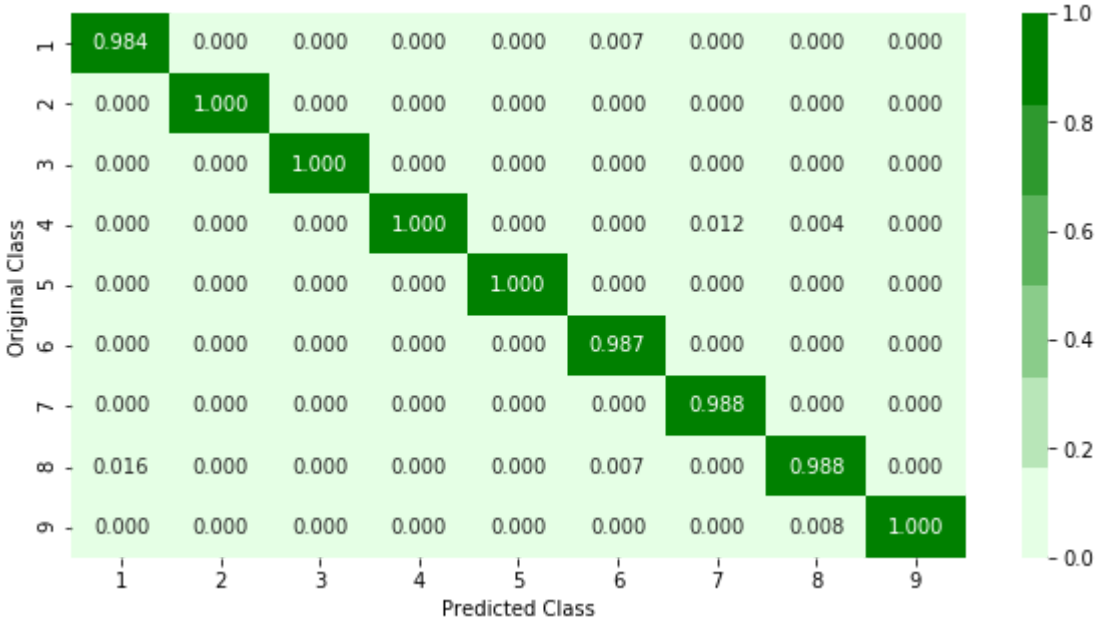
```
log_loss for c =  10 is 0.042231980761280326
log_loss for c =  50 is 0.03737767399742709
log_loss for c =  100 is 0.035400078549594836
log_loss for c =  500 is 0.0344390613268972
log_loss for c =  1000 is 0.03470007249433358
log_loss for c =  2000 is 0.03504116590622085
log_loss for c =  3000 is 0.035110932773390335
```




```
For values of best alpha =  500 The train log loss is: 0.015320721288463691
For values of best alpha =  500 The cross validation log loss is: 0.03443906132
68972
For values of best alpha =  500 The test log loss is: 0.02938321670815787
Number of misclassified points  0.5059797608095675
---------------------------------------------------- Confusion matrix -----------
---------------------------------------
```

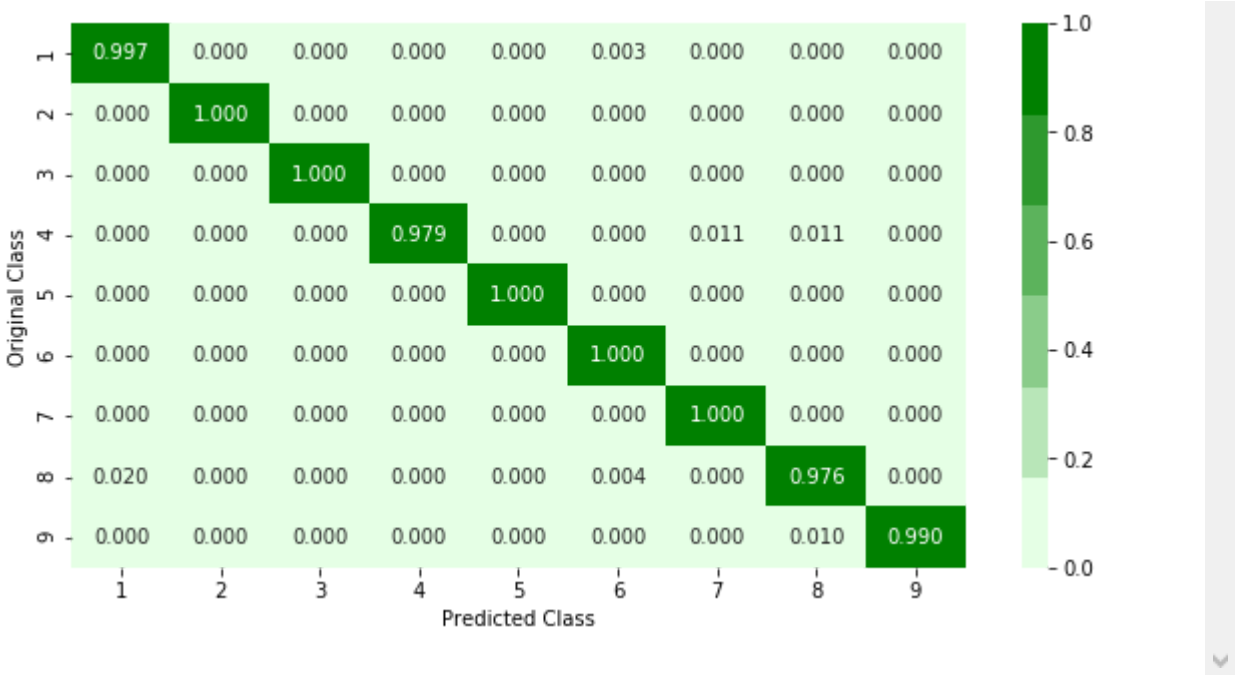


---------- Precision matrix -----------



Sum of columns in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]

---------- Recall matrix --------------



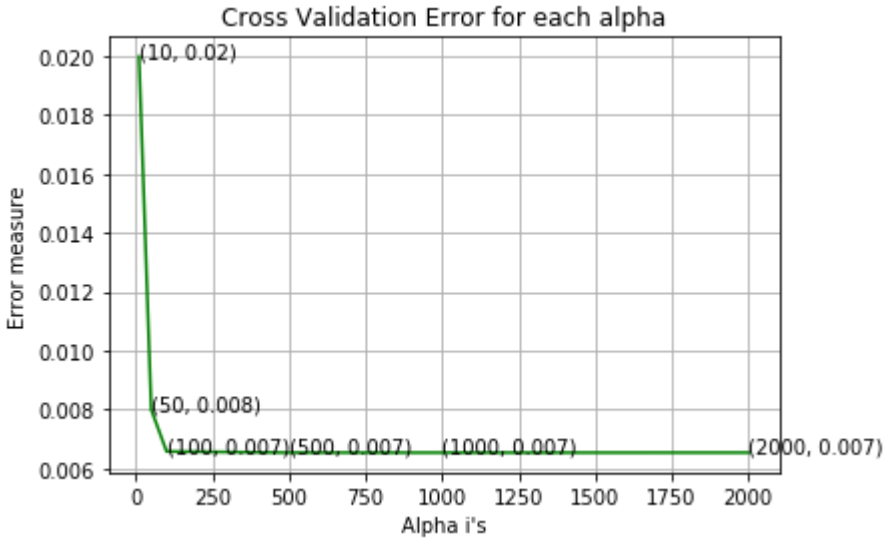

```
Sum of rows in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

4.1.5. XgBoost Classification

In [0]:
```
# Training a hyper-parameter tuned Xg-Boost regressor on our train data

# find more about XGBClassifier function here http://xgboost.readthedocs.io/en/la
# ------------------------
# default paramters
# class xgboost.XGBClassifier(max_depth=3, learning_rate=0.1, n_estimators=100, s
# objective='binary:logistic', booster='gbtree', n_jobs=1, nthread=None, gamma=0,
# max_delta_step=0, subsample=1, colsample_bytree=1, colsample_bylevel=1, reg_alp
# scale_pos_weight=1, base_score=0.5, random_state=0, seed=None, missing=None, **

# some of methods of RandomForestRegressor()
# fit(X, y, sample_weight=None, eval_set=None, eval_metric=None, early_stopping_r
# get_params([deep])    Get parameters for this estimator.
# predict(data, output_margin=False, ntree_limit=0) : Predict with data. NOTE: Th
# get_score(importance_type='weight') -> get the feature importance
# -----------------------
# video link1: https://www.appliedaicourse.com/course/applied-ai-course-online/les
# video link2: https://www.appliedaicourse.com/course/applied-ai-course-online/les
# -----------------------

alpha=[10,50,100,500,1000,2000]
cv_log_error_array=[]
for i in alpha:
    x_cfl=XGBClassifier(n_estimators=i,nthread=-1)
    x_cfl.fit(X_train,y_train)
    sig_clf = CalibratedClassifierCV(x_cfl, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    cv_log_error_array.append(log_loss(y_cv, predict_y, labels=x_cfl.classes_, ep

for i in range(len(cv_log_error_array)):
    print ('log_loss for c = ',alpha[i],'is',cv_log_error_array[i])


best_alpha = np.argmin(cv_log_error_array)

fig, ax = plt.subplots()
ax.plot(alpha, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],cv_log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()

x_cfl=XGBClassifier(n_estimators=alpha[best_alpha],nthread=-1)
x_cfl.fit(X_train,y_train)
sig_clf = CalibratedClassifierCV(x_cfl, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print ('For values of best alpha = ', alpha[best_alpha], "The train log loss is:"
predict_y = sig_clf.predict_proba(X_cv)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation log
predict_y = sig_clf.predict_proba(X_test)
```

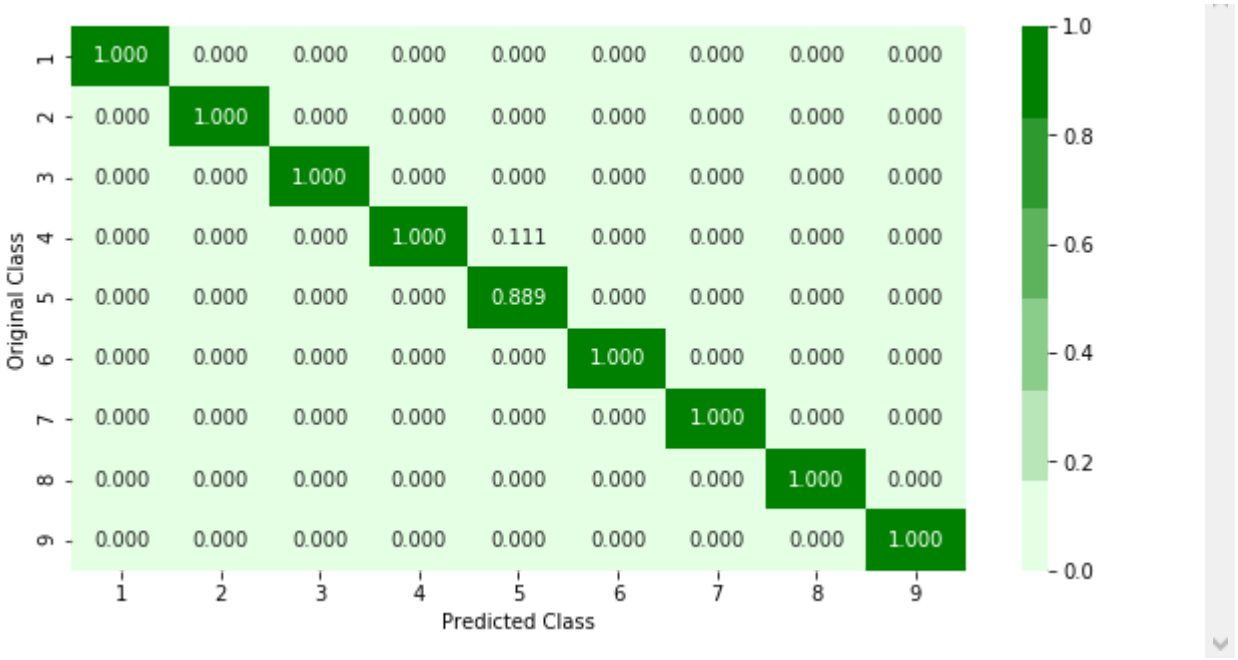
```
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",l
plot_confusion_matrix(y_test, sig_clf.predict(X_test))
```

```
log_loss for c =  10 is 0.01997742337030902
log_loss for c =  50 is 0.008003836283608134
log_loss for c =  100 is 0.006583674805485681
log_loss for c =  500 is 0.006543262494328588
log_loss for c =  1000 is 0.006542903033794922
log_loss for c =  2000 is 0.006543560204869673
```

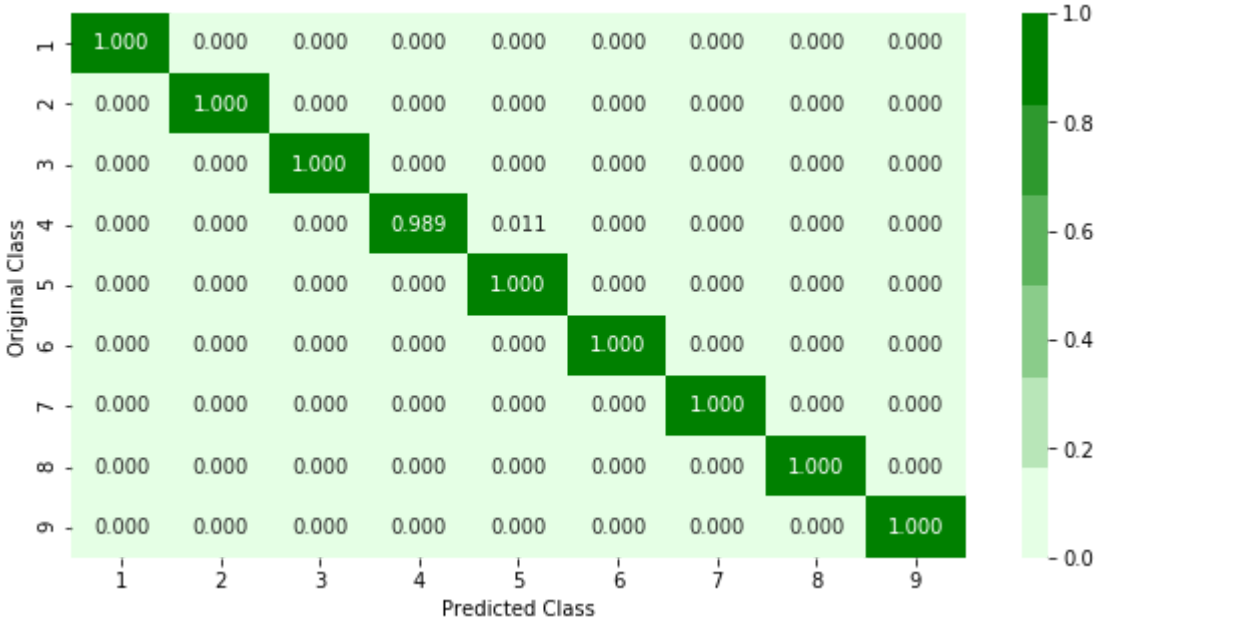



```
For values of best alpha =  1000 The train log loss is: 0.005785584154058571
For values of best alpha =  1000 The cross validation log loss is: 0.0065429030
33794922
For values of best alpha =  1000 The test log loss is: 0.006308327689794849
Number of misclassified points  0.045998160073597055
---------------------------------------------------- Confusion matrix -----------
--------------------------------------
```


```
---------------------------------------------------- Precision matrix -----------
--------------------------------------
```




```
Sum of columns in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
---------------------------------------------------- Recall matrix --------------
-------------------------------------
```




```
Sum of rows in precision matrix [1. 1. 1. 1. 1. 1. 1. 1. 1.]
```

4.1.5. XgBoost Classification with best hyper parameters using RandomSearch

In [0]:
```
# https://www.analyticsvidhya.com/blog/2016/03/complete-guide-parameter-tuning-xgl
x_cfl=XGBClassifier()

prams={
    'learning_rate':[0.01,0.03,0.05,0.1,0.15,0.2],
     'n_estimators':[100,200,500,1000,2000],
     'max_depth':[3,5,10],
    'colsample_bytree':[0.1,0.3,0.5,1],
    'subsample':[0.1,0.3,0.5,1]
}
random_cfl1=RandomizedSearchCV(x_cfl,param_distributions=prams,verbose=10,n_jobs=
random_cfl1.fit(X_train,y_train)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=10)]: Using backend LokyBackend with 10 concurrent workers.
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
[Parallel(n_jobs=10)]: Done   5 tasks      | elapsed: 21.1min
/usr/local/lib/python3.6/dist-packages/sklearn/externals/joblib/externals/loky/
process_executor.py:706: UserWarning: A worker stopped while some jobs were giv
en to the executor. This can be caused by a too short worker timeout or by a me
mory leak.
  "timeout or by a memory leak.", UserWarning
[Parallel(n_jobs=10)]: Done  15 out of  30 | elapsed: 49.7min remaining: 49.7mi
n
[Parallel(n_jobs=10)]: Done  19 out of  30 | elapsed: 53.1min remaining: 30.7mi
n
[Parallel(n_jobs=10)]: Done  23 out of  30 | elapsed: 59.8min remaining: 18.2mi
n
[Parallel(n_jobs=10)]: Done  27 out of  30 | elapsed: 61.4min remaining:  6.8mi
n
[Parallel(n_jobs=10)]: Done  30 out of  30 | elapsed: 62.4min finished
```

Out[24]:
```
RandomizedSearchCV(cv='warn', error_score='raise-deprecating',
          estimator=XGBClassifier(base_score=0.5, booster='gbtree', colsample_b
ylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
       max_depth=3, min_child_weight=1, missing=None, n_estimators=100,
       n_jobs=1, nthread=None, objective='binary:logistic', random_state=0,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1),
          fit_params=None, iid='warn', n_iter=10, n_jobs=10,
          param_distributions={'learning_rate': [0.01, 0.03, 0.05, 0.1, 0.15,
0.2], 'n_estimators': [100, 200, 500, 1000, 2000], 'max_depth': [3, 5, 10], 'co
lsample_bytree': [0.1, 0.3, 0.5, 1], 'subsample': [0.1, 0.3, 0.5, 1]},
          pre_dispatch='2*n_jobs', random_state=None, refit=True,
          return_train_score='warn', scoring=None, verbose=10)
```

In [0]:
```
print (random_cfl1.best_params_)
```

```
{'subsample': 0.3, 'n_estimators': 500, 'max_depth': 3, 'learning_rate': 0.01,
'colsample_bytree': 1}
```

In [0]:
```
best_param = random_cfl1.best_params_
n_est =  best_param['n_estimators']
max_depth = best_param['max_depth']
lr = best_param['learning_rate']
ctree = best_param['colsample_bytree']
```

In [0]:
```
# Training a hyper-parameter tuned Xg-Boost regressor on our train data

# find more about XGBClassifier function here http://xgboost.readthedocs.io/en/la
# ------------------------
# default paramters
# class xgboost.XGBClassifier(max_depth=3, learning_rate=0.1, n_estimators=100, s
# objective='binary:logistic', booster='gbtree', n_jobs=1, nthread=None, gamma=0,
# max_delta_step=0, subsample=1, colsample_bytree=1, colsample_bylevel=1, reg_alp
# scale_pos_weight=1, base_score=0.5, random_state=0, seed=None, missing=None, **

# some of methods of RandomForestRegressor()
# fit(X, y, sample_weight=None, eval_set=None, eval_metric=None, early_stopping_r
# get_params([deep])    Get parameters for this estimator.
# predict(data, output_margin=False, ntree_limit=0) : Predict with data. NOTE: Th
# get_score(importance_type='weight') -> get the feature importance
# -----------------------
# video link2: https://www.appliedaicourse.com/course/applied-ai-course-online/les
# -----------------------

x_cfl=XGBClassifier(n_estimators=n_est, learning_rate=lr, colsample_bytree=ctree,
x_cfl.fit(X_train,y_train)
c_cfl=CalibratedClassifierCV(x_cfl,method='sigmoid')
c_cfl.fit(X_train,y_train)

predict_y = c_cfl.predict_proba(X_train)
print ('train loss',log_loss(y_train, predict_y))
predict_y = c_cfl.predict_proba(X_cv)
print ('cv loss',log_loss(y_cv, predict_y))
predict_y = c_cfl.predict_proba(X_test)
print ('test loss',log_loss(y_test, predict_y))
```

```
train loss 0.005635756651314513
cv loss 0.009256384440519657
test loss 0.006213312130558958
```

In [1]:
```
from prettytable import PrettyTable
import sys
sys.stdout.write("\033[1;30m")

x = PrettyTable()
x.field_names = ["Model", "Train Loss","CV Loss", "Test Loss"]

x.add_row(["Random Model", '-', 2.4722, 2.4881])
x.add_row(["KNN", 0.0046, 0.0046, 0.0044])
x.add_row(["LR", 0.0699, 0.0808, 0.0792])
x.add_row(["RF", 0.0153, 0.0344, 0.0293])
x.add_row(["XGBoost", 0.0057, 0.0065, 0.0063])
x.add_row(["XGBoost(Random Search)", 0.0056, 0.0092, 0.0062])
print(x)
```

```
+-----------------------+------------+---------+-----------+
|         Model         | Train Loss | CV Loss | Test Loss |
+-----------------------+------------+---------+-----------+
|      Random Model     |     -      |  2.4722 |   2.4881  |
|          KNN          |   0.0046   |  0.0046 |   0.0044  |
|           LR          |   0.0699   |  0.0808 |   0.0792  |
|           RF          |   0.0153   |  0.0344 |   0.0293  |
|        XGBoost        |   0.0057   |  0.0065 |   0.0063  |
| XGBoost(Random Search) |   0.0056   |  0.0092 |   0.0062  |
+-----------------------+------------+---------+-----------+
```

Steps Taken

1) combined the asm and bytes file data.

2) Normalize the columns but before that calculated the entropy for each columns.

3) Applied various model on the data.