Importing the required packages

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.utils import resample
import seaborn as sns
from urllib.parse import urlparse
import tldextract
from sklearn.model_selection import train_test_split
from sklearn import tree
from sklearn.model_selection import cross_val_score
from sklearn.metrics import confusion_matrix,classification_report
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import AdaBoostClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
from sklearn.model_selection import learning_curve
```

Loading the Train Dataset

In [2]:

```
df=pd.read_csv("url train dataset.csv",delimiter = ',',encoding = 'unicode_escape', low
_memory = False)
```

In [102]:

```
df.head()
```

Out[102]:

	domain	label
0	00000kx.rcomhost.com/??SignIn&errmsg=8&pUserId...	1
1	0012091312642.web44.net/cieloquedapremios.com/	1
2	00wwebhost.tk/	1
3	02d34321.linkbucks.com/	1
4	0de0ee94.yyv.co	1

In [103]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13749 entries, 0 to 13748
Data columns (total 2 columns):
domain    13749 non-null object
label     13749 non-null int64
dtypes: int64(1), object(1)
memory usage: 214.9+ KB
```

In [104]:

```
df.describe()
```

Out[104]:

	label
count	13749.000000
mean	0.545349
std	0.497957
min	0.000000
25%	0.000000
50%	1.000000
75%	1.000000
max	1.000000

Checking dataset distribution

In [105]:

```
df['label'].value_counts()
```

Out[105]:

```
1    7498
0    6251
Name: label, dtype: int64
```

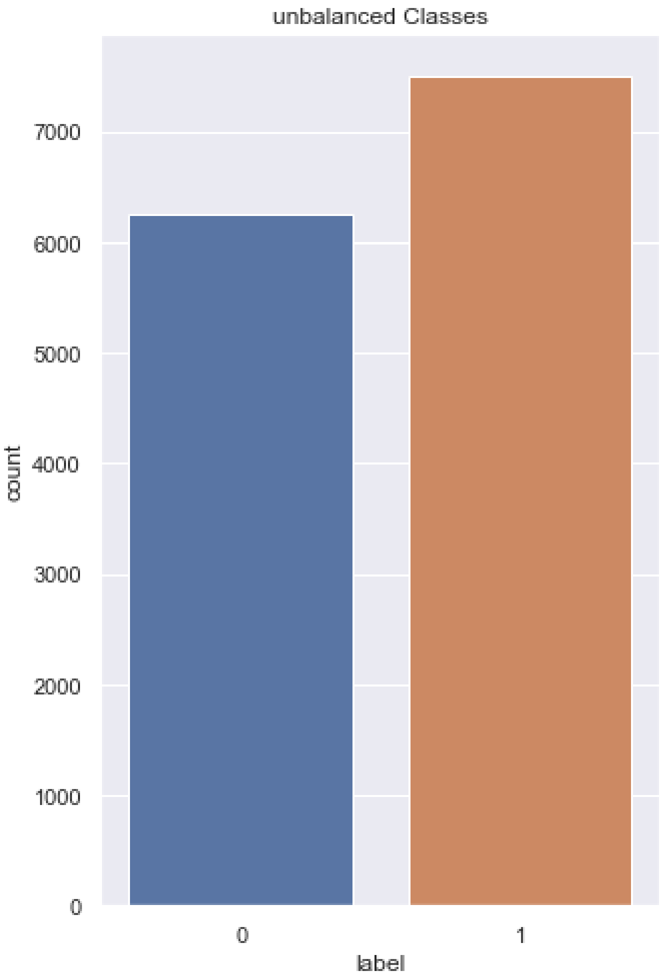
Plot of unbalanced distribution

In [106]:

```
df_ublabel0 = df[df.label==0]
df_ublabel1 = df[df.label==1]
df_ubclass = pd.concat([df_ublabel0,df_ublabel1])
```

In [107]:

```
plt.figure(figsize=(5, 8))
sns.countplot('label', data=df_ubclass)
plt.title('unbalanced Classes')
plt.show()
```



Resampling and balancing dataset

In [108]:

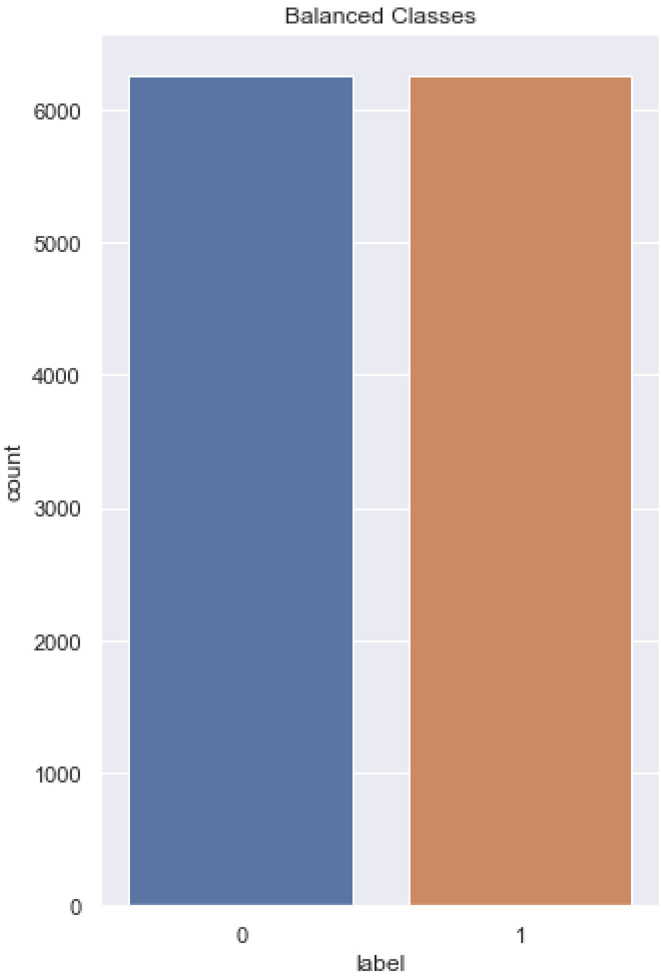
```
df_blabel1_resampled = resample(df_ublabel1, replace= False, n_samples=6251)
df_bsampled = pd.concat([df_blabel1_resampled,df_ublabel0])
df_bsampled.label.value_counts()
```

Out[108]:

```
1    6251
0    6251
Name: label, dtype: int64
```

In [109]:

```
plt.figure(figsize=(5,8))
sns.countplot('label', data=df_bsampled)
plt.title('Balanced Classes')
plt.show()
```



Creating Features from train data

In [3]:

```
# Method to count number of dots
def countdots(url):
    return url.count('.')
```

In [4]:

```
# Method to count number of delimeters
def countdelim(url):
    count = 0
    delim=[';','_','?','=','&']
    for each in url:
        if each in delim:
            count = count + 1

    return count
```

In [5]:

```
# Is IP addr present as the hostname, let's validate

import ipaddress as ip #works only in python 3

def isip(url):
    try:
        if ip.ip_address(url):
            return 1
    except:
        return 0
```

In [6]:

```
#method to check the presence of hyphens

def isPresentHyphen(url):
    return url.count('-')
```

In [7]:

```
#method to check the presence of @

def isPresentAt(url):
    return url.count('@')
```

In [8]:

```
def isPresentDSlash(url):
    return url.count('//')
```

In [9]:

```
def countSubDir(url):
    return url.count('/')
```

In [10]:

```
def get_ext(url):

    root, ext = splitext(url)
    return ext
```

In [11]:

```
def countSubDomain(subdomain):
    if not subdomain:
        return 0
    else:
        return len(subdomain.split('.'))
```

In [12]:

```
def countQueries(query):
    if not query:
        return 0
    else:
        return len(query.split('&'))
```

In [13]:

```
featureSet = pd.DataFrame(columns=('url','no of dots','presence of hyphen','len of url'
,'presence of at',\
'presence of double slash','no of subdir','no of subdomain','len of domain','no of quer
ies','is IP','label'))
```

In [22]:

```
!pip install tldextract
```

```
Requirement already satisfied: tldextract in c:\programdata\anaconda3\lib
\site-packages (2.2.2)
Requirement already satisfied: setuptools in c:\programdata\anaconda3\lib
\site-packages (from tldextract) (41.0.1)
Requirement already satisfied: requests>=2.1.0 in c:\programdata\anaconda3
\lib\site-packages (from tldextract) (2.22.0)
Requirement already satisfied: idna in c:\programdata\anaconda3\lib\site-p
ackages (from tldextract) (2.8)
Requirement already satisfied: requests-file>=1.4 in c:\programdata\anacon
da3\lib\site-packages (from tldextract) (1.4.3)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in
c:\programdata\anaconda3\lib\site-packages (from requests>=2.1.0->tldextra
ct) (1.24.2)
Requirement already satisfied: certifi>=2017.4.17 in c:\programdata\anacon
da3\lib\site-packages (from requests>=2.1.0->tldextract) (2019.6.16)
Requirement already satisfied: chardet<3.1.0,>=3.0.2 in c:\programdata\ana
conda3\lib\site-packages (from requests>=2.1.0->tldextract) (3.0.4)
Requirement already satisfied: six in c:\programdata\anaconda3\lib\site-pa
ckages (from requests-file>=1.4->tldextract) (1.12.0)
```

In [14]:

```python
def getFeatures(url, label):
    result = []
    url = str(url)

    #add the url to feature set
    result.append(url)

    #parse the URL and extract the domain information
    path = urlparse(url)
    ext = tldextract.extract(url)

    #counting number of dots in subdomain
    result.append(countdots(ext.subdomain))

    #checking hyphen in domain
    result.append(isPresentHyphen(path.netloc))

    #length of URL
    result.append(len(url))

    #checking @ in the url
    result.append(isPresentAt(path.netloc))

    #checking presence of double slash
    result.append(isPresentDSlash(path.path))
    #Count number of subdir
    result.append(countSubDir(path.path))

    #number of sub domain
    result.append(countSubDomain(ext.subdomain))

    #length of domain name
    result.append(len(path.netloc))

    #count number of queries
    result.append(len(path.query))

    #Adding domain information

    #if IP address is being used as a URL
    result.append(isip(ext.domain))
    #result.append(get_ext(path.path))
    result.append(str(label))
    return result
```

In [15]:

```python
for i in range(len(df)):
    features = getFeatures(df["domain"].loc[i],df["label"].loc[i])
    featureSet.loc[i] = features
```

In [123]:

```
featureSet.head()
```

Out[123]:

	url	no of dots	presence of hyphen	len of url	presence of at	presence of double slash
0	00000kx.rcomhost.com/??SignIn&errmsg=8&pUserId...	0	0	164	0	0
1	0012091312642.web44.net/cieloquedapremios.com/	0	0	46	0	0
2	00wwebhost.tk/	0	0	14	0	0
3	02d34321.linkbucks.com/	0	0	23	0	0
4	0de0ee94.yyv.co	0	0	15	0	0

In [124]:

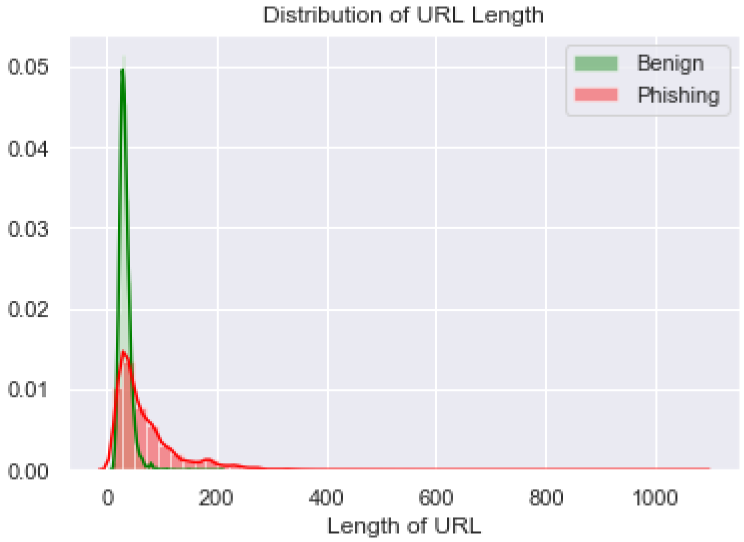
```
featureSet.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 13749 entries, 0 to 13748
Data columns (total 12 columns):
url                         13749 non-null object
no of dots                  13749 non-null object
presence of hyphen          13749 non-null object
len of url                  13749 non-null object
presence of at              13749 non-null object
presence of double slash    13749 non-null object
no of subdir                13749 non-null object
no of subdomain             13749 non-null object
len of domain               13749 non-null object
no of queries               13749 non-null object
is IP                       13749 non-null object
label                       13749 non-null object
dtypes: object(12)
memory usage: 1.4+ MB
```

Visualizing of Features

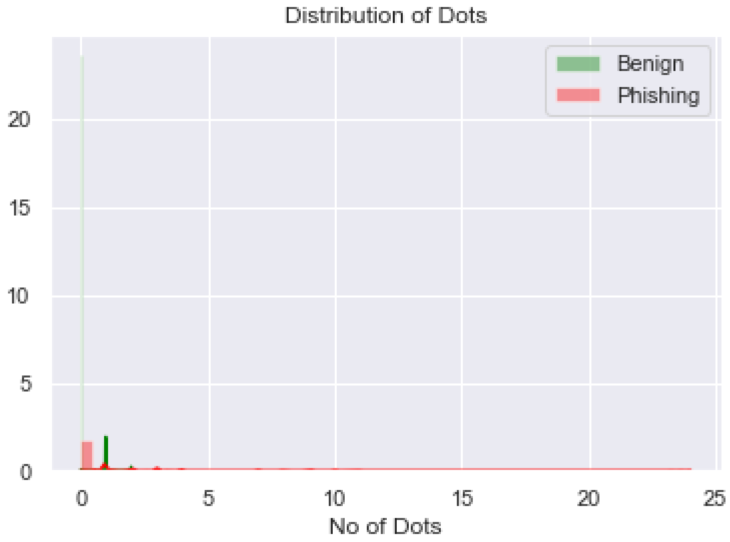
In [16]:

```
sns.set(style="darkgrid")
sns.distplot(featureSet[featureSet['label']=='0']['len of url'],color='green',label='Benign')
sns.distplot(featureSet[featureSet['label']=='1']['len of url'],color='red',label='Phishing')
plt.title('Distribution of URL Length')
plt.legend(loc='upper right')
plt.xlabel('Length of URL')
plt.show()
```



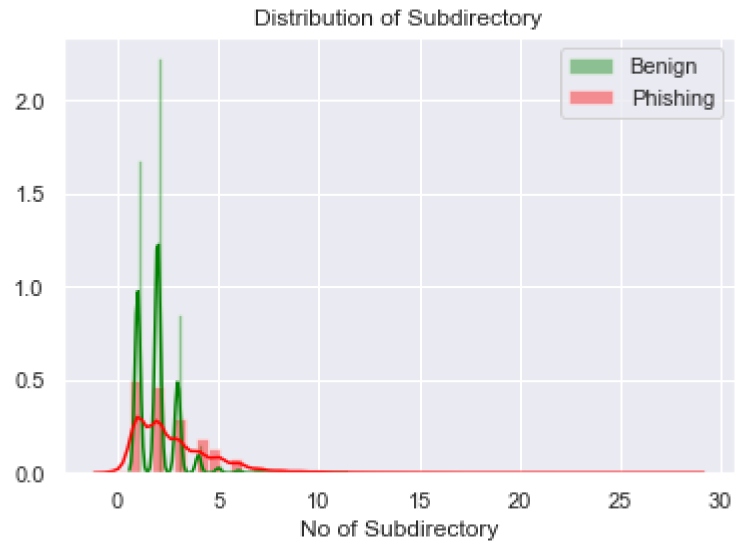
In [126]:

```
sns.set(style="darkgrid")
sns.distplot(featureSet[featureSet['label']=='0']['no of dots'],color='green',label='Benign')
sns.distplot(featureSet[featureSet['label']=='1']['no of dots'],color='red',label='Phishing')
plt.title('Distribution of Dots')
plt.legend(loc='upper right')
plt.xlabel('No of Dots')
plt.show()
```



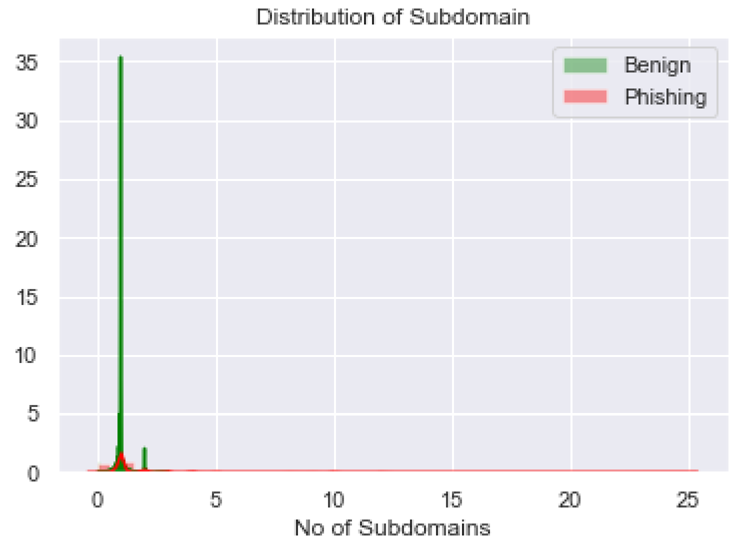
In [127]:

```
sns.set(style="darkgrid")
sns.distplot(featureSet[featureSet['label']=='0']['no of subdir'],color='green',label='Benign')
sns.distplot(featureSet[featureSet['label']=='1']['no of subdir'],color='red',label='Phishing')
plt.title('Distribution of Subdirectory')
plt.legend(loc='upper right')
plt.xlabel('No of Subdirectory')
plt.show()
```



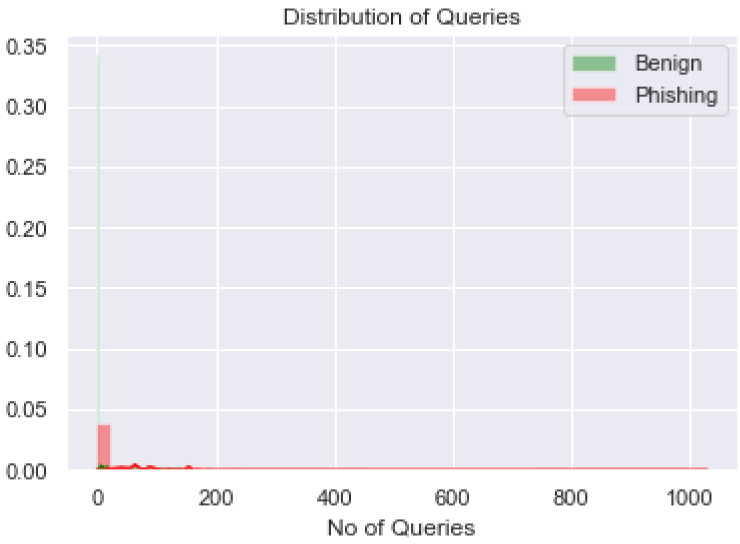
In [128]:

```
sns.set(style="darkgrid")
sns.distplot(featureSet[featureSet['label']=='0']['no of subdomain'],color='green',label='Benign')
sns.distplot(featureSet[featureSet['label']=='1']['no of subdomain'],color='red',label='Phishing')
plt.title('Distribution of Subdomain')
plt.legend(loc='upper right')
plt.xlabel('No of Subdomains')
plt.show()
```



In [129]:

```
sns.set(style="darkgrid")
sns.distplot(featureSet[featureSet['label']=='0']['no of queries'],color='green',label='Benign')
sns.distplot(featureSet[featureSet['label']=='1']['no of queries'],color='red',label='Phishing')
plt.title('Distribution of Queries')
plt.legend(loc='upper right')
plt.xlabel('No of Queries')
plt.show()
```



Splitting the dataset to test and train

In [130]:

```
X=featureSet.iloc[:,1:11].values
Y=featureSet.iloc[:,11].values
X_train,X_test,Y_train,Y_test=train_test_split(X,Y,test_size=0.2,random_state=0)
```

In [131]:

```
print(X_train.shape)
print(Y_train.shape)
```

```
(10999, 10)
(10999,)
```

In [132]:

```
print(X_test.shape)
print(Y_test.shape)
```

```
(2750, 10)
(2750,)
```

Training classifiers and testing without hyper parameter tuning

In [133]:

```
print('Decision Tree Classifier')
clf1 = tree.DecisionTreeClassifier()
clf1.fit(X_train,Y_train)
Y_pred = clf1.predict(X_test)
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
```

```
Decision Tree Classifier
Accuraccy : 0.807636
```

In [134]:

```
print('Adaboost Classifier')
clf2 = AdaBoostClassifier()
clf2.fit(X_train,Y_train)
Y_pred = clf2.predict(X_test)
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
```

```
Adaboost Classifier
Accuraccy : 0.799636
```

In [135]:

```
print('Logistic Regression Classifier')
clf3 = LogisticRegression()
clf3.fit(X_train,Y_train)
Y_pred = clf3.predict(X_test)
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
```

```
Logistic Regression Classifier

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)

Accuraccy : 0.765455
```

In [136]:

```
print('Gaussian NB Classifier')
clf4 = GaussianNB()
clf4.fit(X_train,Y_train)
Y_pred = clf4.predict(X_test)
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
```

```
Gaussian NB Classifier
Accuraccy : 0.658545
```

In [137]:

```
print('KNN Classifier')
clf5 = KNeighborsClassifier()
clf5.fit(X_train,Y_train)
Y_pred = clf5.predict(X_test)
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
```

```
KNN Classifier
Accuraccy : 0.786545
```

Hyper parameter tuning using GridSearch CV

In [138]:

```
print('Decision Tree Classifier')
param_grid = {"criterion" : ["gini", "entropy"],
              "max_depth": [3,5,20,30],
              "splitter" : ["best","random"]
             }
griddt = GridSearchCV(estimator=clf1, param_grid=param_grid)
griddt.fit(X_train,Y_train)
print(griddt)
# summarize the results of the grid search
print(griddt.best_score_)
print(griddt.best_estimator_.max_depth)
print(griddt.best_estimator_.criterion)
print(griddt.best_estimator_.splitter)
```

```
Decision Tree Classifier

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_split.
py:1978: FutureWarning: The default value of cv will change from 3 to 5 in
version 0.22. Specify it explicitly to silence this warning.
  warnings.warn(CV_WARNING, FutureWarning)

GridSearchCV(cv='warn', error_score='raise-deprecating',
             estimator=DecisionTreeClassifier(class_weight=None,
                                              criterion='gini', max_depth=
None,
                                              max_features=None,
                                              max_leaf_nodes=None,
                                              min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,
                                              min_weight_fraction_leaf=0.
0,
                                              presort=False, random_state=
None,
                                              splitter='best'),
             iid='warn', n_jobs=None,
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [3, 5, 20, 30],
                         'splitter': ['best', 'random']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
0.8103463951268297
20
entropy
random
```

In [139]:

```
print('Adaboost Classifier')
param_grid = {"learning_rate" : [1,2,3,5,6],
              "n_estimators": [5,10,15,25,50],
              }
griddt = GridSearchCV(estimator=clf2, param_grid=param_grid)
griddt.fit(X_train,Y_train)
print(griddt)
# summarize the results of the grid search
print(griddt.best_score_)
print(griddt.best_estimator_.learning_rate)
print(griddt.best_estimator_.n_estimators)
```

```
Adaboost Classifier

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_split.
py:1978: FutureWarning: The default value of cv will change from 3 to 5 in
version 0.22. Specify it explicitly to silence this warning.
  warnings.warn(CV_WARNING, FutureWarning)

GridSearchCV(cv='warn', error_score='raise-deprecating',
             estimator=AdaBoostClassifier(algorithm='SAMME.R',
                                          base_estimator=None,
                                          learning_rate=1.0, n_estimators=
50,
                                          random_state=None),
             iid='warn', n_jobs=None,
             param_grid={'learning_rate': [1, 2, 3, 5, 6],
                         'n_estimators': [5, 10, 15, 25, 50]},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
0.798618056186926
1
50
```

In [140]:

```
print('Logistic Regression Classifier')
param_grid = {"penalty" : ["l1","l2"],
              "C": [0.1,0.5,1,1.5],
              }
griddt = GridSearchCV(estimator=clf3, param_grid=param_grid)
griddt.fit(X_train,Y_train)
print(griddt)
# summarize the results of the grid search
print(griddt.best_score_)
print(griddt.best_estimator_.penalty)
print(griddt.best_estimator_.C)
```

Logistic Regression Classifier

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_split.
py:1978: FutureWarning: The default value of cv will change from 3 to 5 in
version 0.22. Specify it explicitly to silence this warning.
  warnings.warn(CV_WARNING, FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
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  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
```

```
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  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)
```

```
GridSearchCV(cv='warn', error_score='raise-deprecating',
             estimator=LogisticRegression(C=1.0, class_weight=None, dual=F
alse,
                                          fit_intercept=True,
                                          intercept_scaling=1, l1_ratio=No
ne,

                                          max_iter=100, multi_class='war
n',

                                          n_jobs=None, penalty='l2',
                                          random_state=None, solver='war
n',

                                          tol=0.0001, verbose=0,
                                          warm_start=False),
             iid='warn', n_jobs=None,
             param_grid={'C': [0.1, 0.5, 1, 1.5], 'penalty': ['l1', 'l
2']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
0.7691608328029821
l1
1
```

In [141]:

```
print('KNN Classifier')
param_grid = {"n_neighbors" : [1,2,3,4,5],
              "weights": ["uniform","distance"],
              }
griddt = GridSearchCV(cv=5,estimator=clf5, param_grid=param_grid)
griddt.fit(X_train,Y_train)
print(griddt)
# summarize the results of the grid search
print(griddt.best_score_)
print(griddt.best_estimator_.n_neighbors)
print(griddt.best_estimator_.weights)
```

```
KNN Classifier
GridSearchCV(cv=5, error_score='raise-deprecating',
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=3
0,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=Non
e,

                                            n_neighbors=5, p=2,
                                            weights='uniform'),
             iid='warn', n_jobs=None,
             param_grid={'n_neighbors': [1, 2, 3, 4, 5],
                         'weights': ['uniform', 'distance']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=Fals
e,
             scoring=None, verbose=0)
0.793163014819529
4
distance
```

Training and validating the classifiers with tuned hyper parameters using learning curves

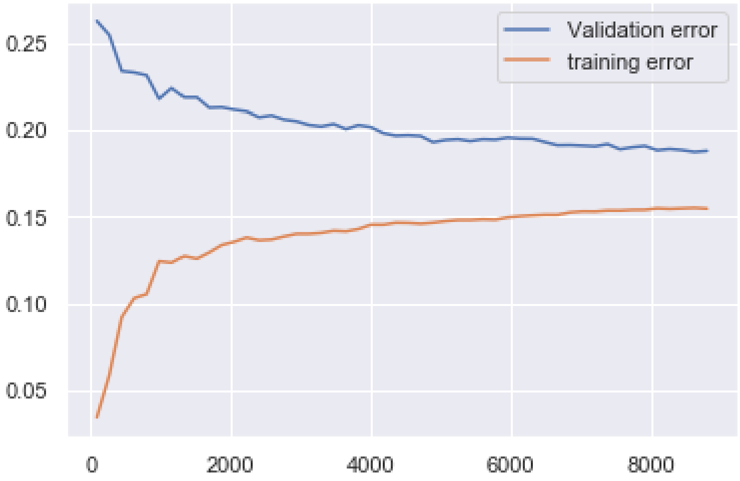
In [142]:

```
print('Decision Tree Classifier')
clf1 = tree.DecisionTreeClassifier(max_depth =30 , criterion = 'gini', splitter = 'random')
clf1.fit(X_train,Y_train)
scores_1 = cross_val_score(clf1, X_train, Y_train, cv=5)
print("Accuracy: %f (+/- %0.2f)" % (scores_1.mean(), scores_1.std() * 2))
train_sizes, train_scores,validation_scores = learning_curve(clf1,X_train,Y_train,cv=5,
scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50)
)
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.plot(train_sizes, train_mean, label = 'training error')
plt.legend()
```

```
Decision Tree Classifier
Accuracy: 0.812345 (+/- 0.01)
```

Out[142]:

```
<matplotlib.legend.Legend at 0x23868bd0240>
```



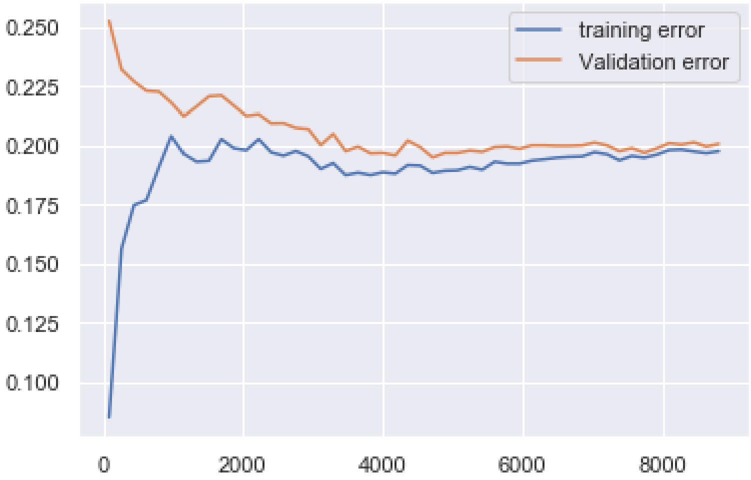
In [143]:

```
print('Adaboost Classifier')
clf2 = AdaBoostClassifier(learning_rate = 1, n_estimators = 50)
clf2.fit(X_train,Y_train)
scores_2 = cross_val_score(clf2, X_train, Y_train, cv=5)
print("Accuracy: %f (+/- %0.2f)" % (scores_2.mean(), scores_2.std() * 2))
train_sizes, train_scores,validation_scores = learning_curve(clf2,X_train,Y_train,cv=5,
scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50)
)
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, train_mean, label = 'training error')
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.legend()
```

```
Adaboost Classifier
Accuracy: 0.799345 (+/- 0.01)
```

Out[143]:

```
<matplotlib.legend.Legend at 0x23867bceef0>
```



In [144]:

```
print('Logistic Regression Classifier')
clf3 = LogisticRegression(penalty = 'l1', C = 1.5)
clf3.fit(X_train,Y_train)
scores_3 = cross_val_score(clf3, X_train, Y_train, cv=5)
print("Accuracy: %f (+/- %0.2f)" % (scores_3.mean(), scores_3.std() * 2))
train_sizes, train_scores,validation_scores=learning_curve(clf3,X_train,Y_train,cv=5,scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50))
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, train_mean, label = 'training error')
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.legend()
```

```
Logistic Regression Classifier

C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
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  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
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  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
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  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.p
y:432: FutureWarning: Default solver will be changed to 'lbfgs' in 0.22. S
pecify a solver to silence this warning.
  FutureWarning)

Accuracy: 0.769524 (+/- 0.01)
```
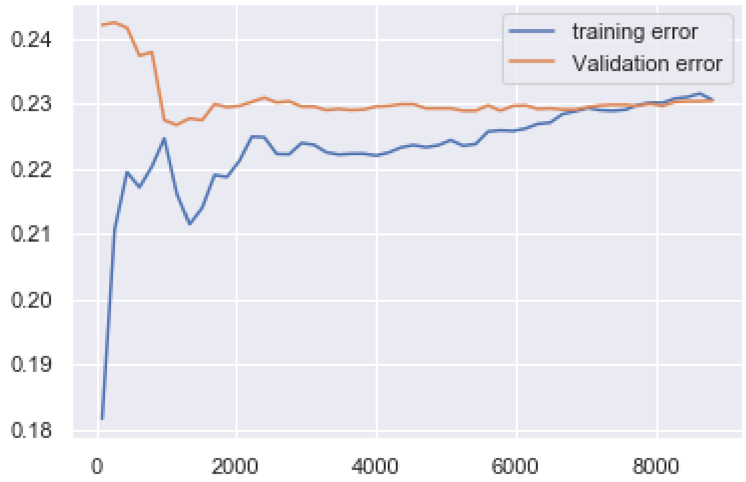

Out[144]:

```
<matplotlib.legend.Legend at 0x23869be0eb8>
```



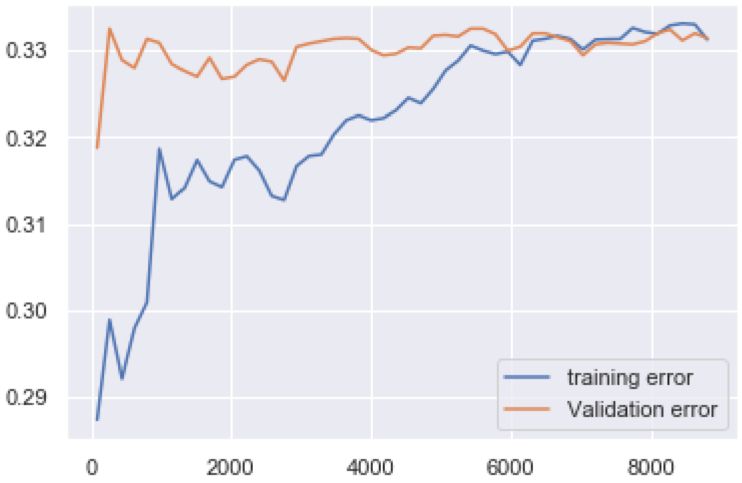
In [145]:

```
print('Gaussian NB Classifier')
clf4 = GaussianNB()
clf4.fit(X_train,Y_train)
scores_4 = cross_val_score(clf4, X_train, Y_train, cv=5)
print("Accuracy: %f (+/- %0.2f)" % (scores_4.mean(), scores_4.std() * 2))
train_sizes, train_scores,validation_scores = learning_curve(clf4,X_train,Y_train,cv=5,
scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50)
)
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, train_mean, label = 'training error')
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.legend()
```

```
Gaussian NB Classifier
Accuracy: 0.668606 (+/- 0.02)
```

Out[145]:

```
<matplotlib.legend.Legend at 0x23868bbde80>
```



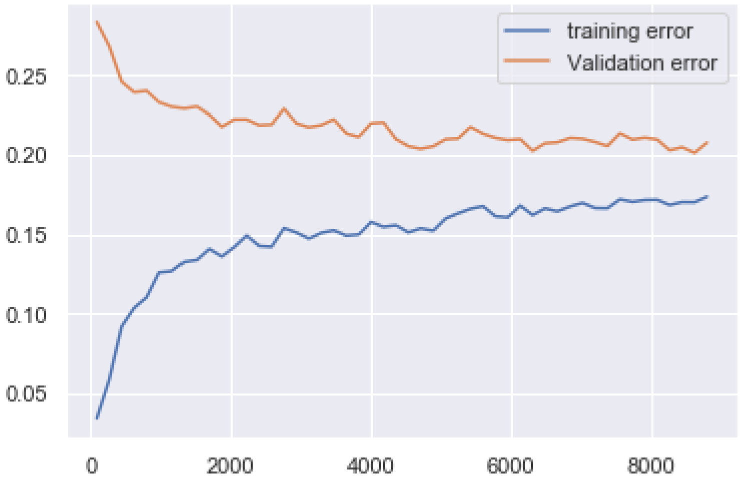
In [146]:

```
print('KNN Classifier')
clf5 = KNeighborsClassifier(n_neighbors = 4, weights = 'distance')
clf5.fit(X_train,Y_train)
scores_5 = cross_val_score(clf5, X_train, Y_train, cv=5)
print("Accuracy: %f (+/- %0.2f)" % (scores_5.mean(), scores_5.std() * 2))
train_sizes, train_scores,validation_scores = learning_curve(clf5,X_train,Y_train,cv=5,
scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50)
)
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, train_mean, label = 'training error')
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.legend()
```

```
KNN Classifier
Accuracy: 0.793163 (+/- 0.01)
```

Out[146]:

```
<matplotlib.legend.Legend at 0x23869bc97b8>
```



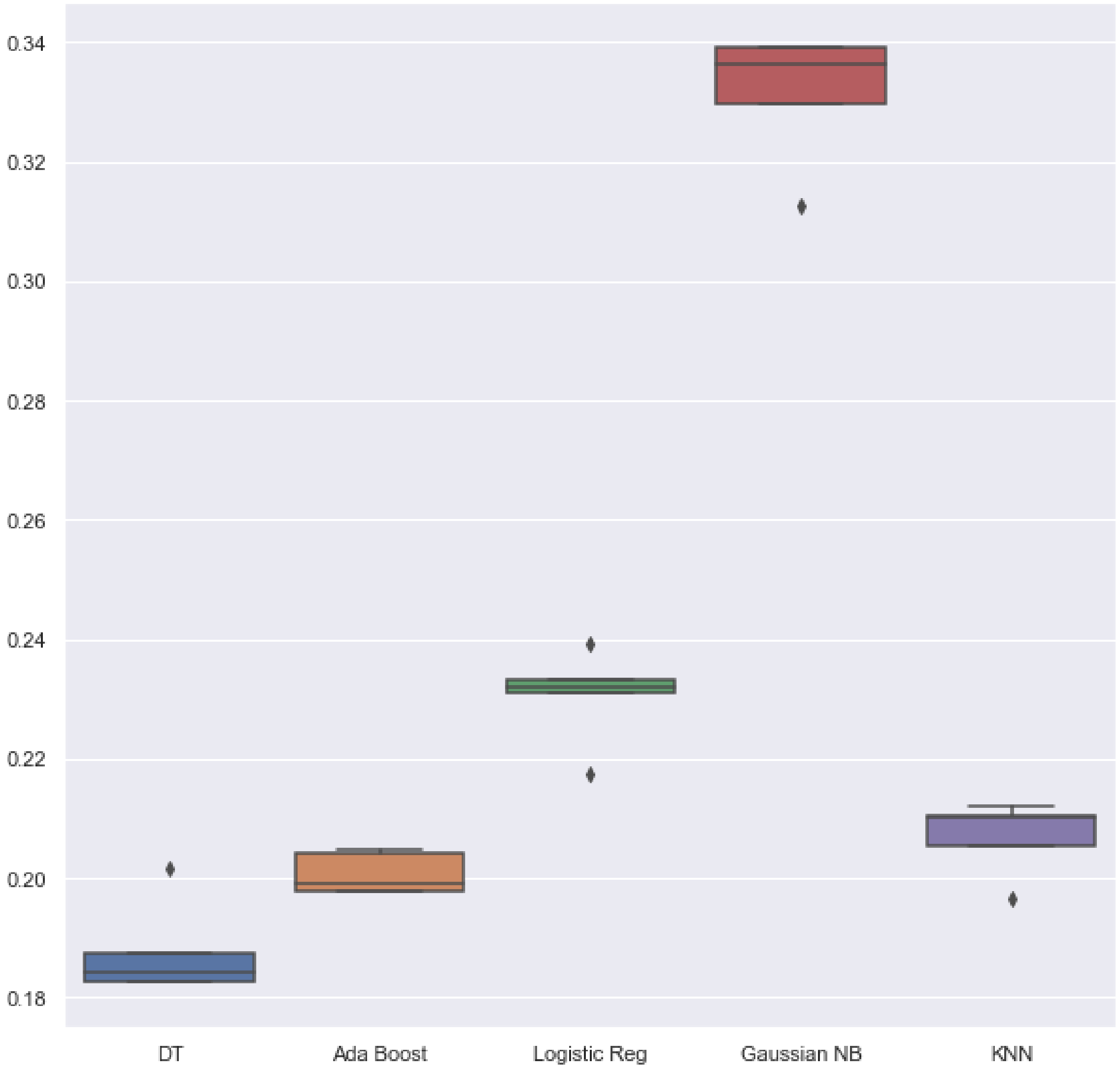
Boxplot of error vs classifiers

In [147]:

```
error = [1-scores_1,1-scores_2,1-scores_3,1-scores_4,1-scores_5]
plt.figure(figsize=(10,10 ))
sns.boxplot(data = error)
plt.xticks([0,1,2,3,4], ['DT','Ada Boost', 'Logistic Reg', 'Gaussian NB', 'KNN'])
```

Out[147]:

```
([<matplotlib.axis.XTick at 0x23868be6b00>,
  <matplotlib.axis.XTick at 0x23869bcc208>,
  <matplotlib.axis.XTick at 0x2386bbb4ef0>,
  <matplotlib.axis.XTick at 0x2386bba21d0>,
  <matplotlib.axis.XTick at 0x23868bcaf60>],
 <a list of 5 Text xticklabel objects>)
```



Reducing the variance of best classifier (DT)

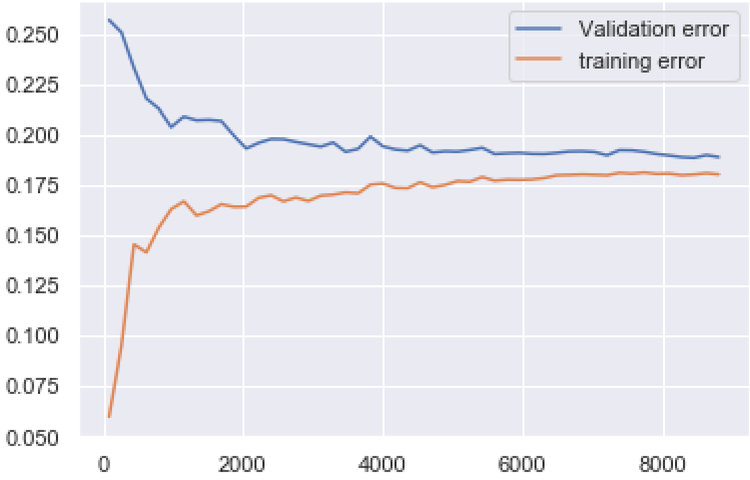
In [148]:

```
print('Decision Tree Classifier')
clf1 = tree.DecisionTreeClassifier(max_depth =7, criterion = 'gini', splitter = 'best')
clf1.fit(X_train,Y_train)
scores_1 = cross_val_score(clf1, X_train, Y_train, cv=10)
print("Accuracy: %f (+/- %0.2f)" % (scores_1.mean(), scores_1.std() * 2))
train_sizes, train_scores,validation_scores = learning_curve(clf1,X_train,Y_train,cv=5,
scoring='accuracy', n_jobs=-1,train_sizes=np.linspace(0.01, 1.0, 50)
)
train_mean = np.mean(1-train_scores, axis=1)
validation_mean = np.mean(1-validation_scores, axis=1)
plt.plot(train_sizes, validation_mean, label = 'Validation error')
plt.plot(train_sizes, train_mean, label = 'training error')
plt.legend()
```

```
Decision Tree Classifier
Accuracy: 0.810617 (+/- 0.02)
```

Out[148]:

```
<matplotlib.legend.Legend at 0x2386bbc32b0>
```

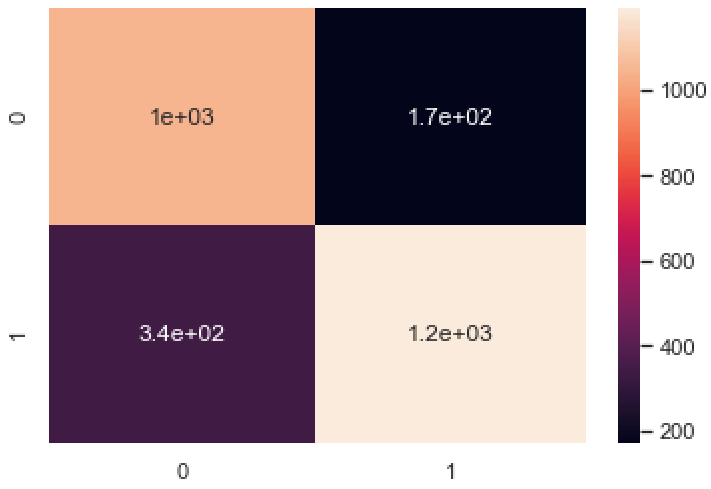


Testing the best classifier (DT)

In [149]:

```
print('Decision Tree Classifier')
Y_pred = clf1.predict(X_test)
from sklearn import metrics
print('Accuraccy : %f' % metrics.accuracy_score(Y_test, Y_pred))
cm = confusion_matrix(Y_test,Y_pred)
cr = classification_report(Y_test,Y_pred)
sns.heatmap(cm,annot=True,cbar=True,xticklabels='auto',yticklabels='auto')
print(cr)
```

```
Decision Tree Classifier
Accuraccy : 0.814545
              precision    recall  f1-score   support

           0       0.75      0.86      0.80      1216
           1       0.88      0.78      0.82      1534

    accuracy                           0.81      2750
   macro avg       0.82      0.82      0.81      2750
weighted avg       0.82      0.81      0.82      2750
```



Transfer learning of best classifier on new dataset using DT

In [150]:

```
dftl=pd.read_csv("url transfer dataset.csv",delimiter = ',',encoding = 'unicode_escape'
, low_memory = False)
```

In [151]:

```
dftl.describe()
```

Out[151]:

	label
count	6500.000000
mean	0.499846
std	0.500038
min	0.000000
25%	0.000000
50%	0.000000
75%	1.000000
max	1.000000

In [152]:

```
featureSettl = pd.DataFrame(columns=('url','no of dots','presence of hyphen','len of ur
l','presence of at',\
'presence of double slash','no of subdir','no of subdomain','len of domain','no of quer
ies','is IP','label'))
```

In [153]:

```
for i in range(len(dftl)):
    featurestl = getFeatures(dftl["domain"].loc[i], dftl["label"].loc[i])
    featureSettl.loc[i] = featurestl
```

In [154]:

```
featureSettl.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 6500 entries, 0 to 6499
Data columns (total 12 columns):
url                         6500 non-null object
no of dots                  6500 non-null object
presence of hyphen          6500 non-null object
len of url                  6500 non-null object
presence of at              6500 non-null object
presence of double slash    6500 non-null object
no of subdir                6500 non-null object
no of subdomain             6500 non-null object
len of domain               6500 non-null object
no of queries               6500 non-null object
is IP                       6500 non-null object
label                       6500 non-null object
dtypes: object(12)
memory usage: 660.2+ KB
```

In [155]:

```
featureSettl.head()
```

Out[155]:

	url	no of dots	presence of hyphen	len of url	presence of at	presence of double slash
0	www313.paypal.ca.36903.securessl-100.mx/js/web...	3	0	84	0	0
1	neil.fraser.name/software/moobrowser/	0	0	37	0	0
2	secure.runescape.com.yywow.asia/m=weblogin/log...	2	0	84	0	0
3	cmc.uib.no/moo/docs/shorter/quick-prog-ref.txt	0	0	46	0	0
4	www179.paypal.ca.92651.securessl-410.mx/js/web...	3	0	82	0	0

In [156]:

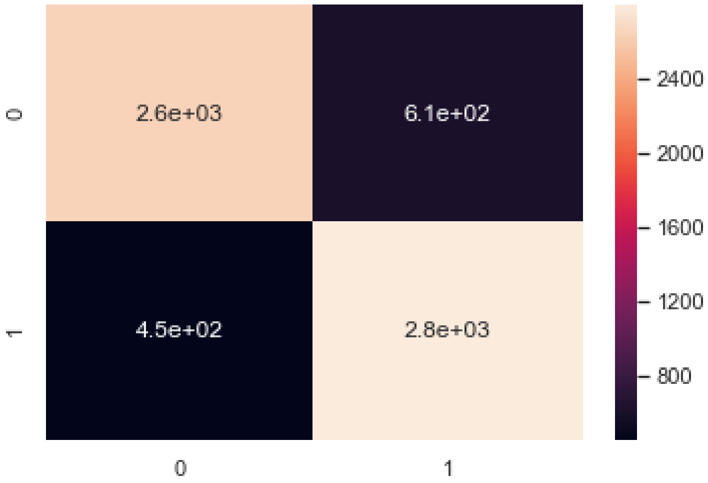
```
X_testtl=featureSettl.iloc[:,1:11].values
Y_testtl=featureSettl.iloc[:,11].values
print(X_testtl.shape)
print(Y_testtl.shape)
```

```
(6500, 10)
(6500,)
```

```
In [157]:
```

```python
print('Decision Tree Classifier')
Y_predtl = clf1.predict(X_testtl)
print('Accuraccy : %f' % metrics.accuracy_score(Y_testtl, Y_predtl))
cm = confusion_matrix(Y_testtl, Y_predtl)
cr = classification_report(Y_testtl, Y_predtl)
sns.heatmap(cm,annot=True,cbar=True,xticklabels='auto',yticklabels='auto')
print(cr)
```

```
Decision Tree Classifier
Accuraccy : 0.836615
              precision    recall  f1-score   support

           0       0.85      0.81      0.83      3251
           1       0.82      0.86      0.84      3249

    accuracy                           0.84      6500
   macro avg       0.84      0.84      0.84      6500
weighted avg       0.84      0.84      0.84      6500
```



Demo using DT

In [158]:

```
result = pd.DataFrame(columns=('url','no of dots','presence of hyphen','len of url','presence of at',\
'presence of double slash','no of subdir','no of subdomain','len of domain','no of queries','is IP','label'))
results = getFeatures('https://www.google.com/', '')
result.loc[0] = results
result = result.drop(['url','label'],axis=1).values
print(clf1.predict(result))
```

```
['0']
```

In [159]:

```
result = pd.DataFrame(columns=('url','no of dots','presence of hyphen','len of url','presence of at',\
'presence of double slash','no of subdir','no of subdomain','len of domain','no of queries','is IP','label'))
results = getFeatures('http://12.34.56.78/firstgenericbank/account-update/', '')
result.loc[0] = results
result = result.drop(['url','label'],axis=1).values
print(clf1.predict(result))
```

```
['1']
```