In [0]:
```
!pip install -U -q PyDrive
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials
# Authenticate and create the PyDrive client.
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)

id1='1lmufFI9aDQcTLyiqjJVhOspYM7olhbH1'
downloaded1 = drive.CreateFile({'id': id1})
downloaded1.GetContentFile('orange_small_train.data')

id2='1J4ePx792hvmcgjACwUI0dokrOnmMd96P'
downloaded1 = drive.CreateFile({'id': id2})
downloaded1.GetContentFile('orange_small_train_churn.labels')
```

In [0]:
```
import pandas as pd
import matplotlib.pyplot as plt
```

In [0]:
```
train=pd.read_csv('orange_small_train.data',sep='\t')
```

In [0]:
```
train['churn']=pd.read_csv('orange_small_train_churn.labels',header=None)
train['appetency']=pd.read_csv('orange_small_train_appetency.labels',header=None)
train['upselling']=pd.read_csv('orange_small_train_upselling.labels',header=None)
```

In [239]:
```
train.head(5)
```

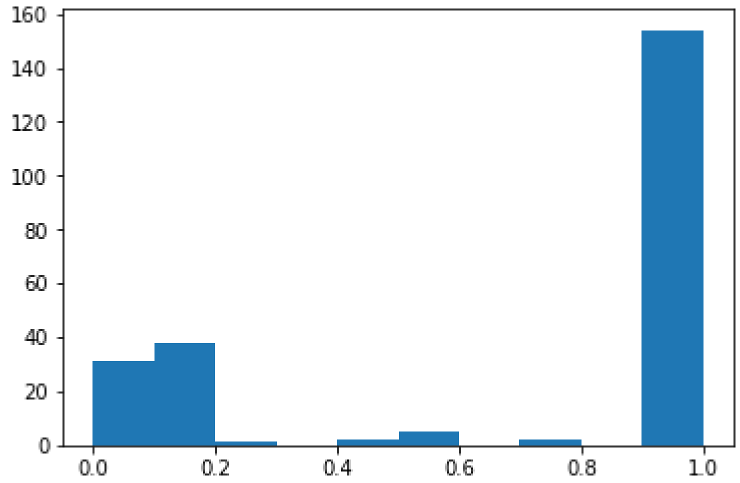
Out[239]:

	Var1	Var2	Var3	Var4	Var5	Var6	Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18	Var19	Var20	Var21
0	NaN	NaN	NaN	NaN	NaN	1526.0	7.0	NaN	NaN	NaN	NaN	NaN	184.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	464.0
1	NaN	NaN	NaN	NaN	NaN	525.0	0.0	NaN	NaN	NaN	NaN	NaN	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	168.0
2	NaN	NaN	NaN	NaN	NaN	5236.0	7.0	NaN	NaN	NaN	NaN	NaN	904.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1212.0
3	NaN	NaN	NaN	NaN	NaN	NaN	0.0	NaN	NaN	NaN	NaN	NaN	0.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
4	NaN	NaN	NaN	NaN	NaN	1029.0	7.0	NaN	NaN	NaN	NaN	NaN	3216.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	64.0

5 rows × 233 columns

In [240]:
```
x=train.isnull().sum()/train.shape[0]

plt.hist(x)
```

Out[240]:
```
(array([ 31.,  38.,   1.,   0.,   2.,   5.,   0.,   2.,   0., 154.]),
 array([0. , 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1. ]),
 <a list of 10 Patch objects>)
```



Here we have many columns which has all values Null so we will be removing those values . Around 28 columns only ehich have no null values and

154 columns which have all null values

In [241]:
```
train.shape
```

Out[241]:
```
(50000, 233)
```

Removing the columns whose null values are more than 80%

In [0]:
```
columns= [cols for cols in train if train[cols].isnull().sum()/train.shape[0] > 0.50]
```

Dropping Those columns

In [0]:
```
train.drop(columns,axis=1,inplace =True)
```

In [244]:
```
len(train.columns)
```

Out[244]:
```
72
```

In [245]:
```
train.dtypes
```

Out[245]:
```
Var6         float64
Var7         float64
Var13        float64
Var21        float64
Var22        float64
Var24        float64
Var25        float64
Var28        float64
Var35        float64
Var38        float64
Var44        float64
Var57        float64
Var65        float64
Var72        float64
Var73          int64
Var74        float64
Var76        float64
Var78        float64
Var81        float64
```

In [246]:
```python
train['Var192'].value_counts()
```

Out[246]:
```
qFpmfo8zhV    385
DHeq9ayfAo    384
zKnr4RXktW    380
8I1r4RXXnK    379
HYTrjIK12c    379
75lr4RXktW    377
1GdOj1KXzC    376
2jirEyXktW    373
CxSr4RXktW    369
oyGrjIXt5a    368
vAsgUHXM47    368
hSogUHXZeb    367
vAsTmBfHUn    363
ZSNrjIX0Db    362
dRavyx7ejg    360
xearjIX0Db    352
avkq9ayfAo    351
wRXmfo875g    349
LDPvyx7IEC    348
```

columns which have Object Datatype

In [0]:
```python
cols=[col for col in train if train[col].dtype=='O']
#Columns with categories / different values less than 500 is used so that we can covert it into one hot or something like
cols_new=[i for i in cols if train[i].nunique() < 500]
```

In [0]:
```python
train_cat=train[cols_new]
```

In [0]:
```python

```

Handling missing categorical values

In [249]:
```
train_cat.isnull().sum()
train_cat['Var192'].value_counts()
```

Out[249]:
```
qFpmfo8zhV    385
DHeq9ayfAo    384
zKnr4RXktW    380
8I1r4RXXnK    379
HYTrjIK12c    379
75lr4RXktW    377
1GdOj1KXzC    376
2jirEyXktW    373
CxSr4RXktW    369
oyGrjIXt5a    368
vAsgUHXM47    368
hSogUHXZeb    367
vAsTmBfHUn    363
ZSNrjIX0Db    362
dRavyx7ejg    360
xearjIX0Db    352
avkq9ayfAo    351
wRXmfo875g    349
LDPvyx7IEC    348
```

In [250]:
```
train_cat['Var223']
```

Out[250]:
```
0       jySVZNlOJy
1       LM8l689qOp
2       jySVZNlOJy
3       LM8l689qOp
4       LM8l689qOp
5       LM8l689qOp
6       LM8l689qOp
7              NaN
8       jySVZNlOJy
9       LM8l689qOp
10      LM8l689qOp
11      LM8l689qOp
12      LM8l689qOp
13      LM8l689qOp
14      LM8l689qOp
15      LM8l689qOp
16      jySVZNlOJy
17      LM8l689qOp
18      jySVZNlOJy
```

After checkimg the columns Var192 and Var223 we noticed to handle the missing values we have use ffill because we cannot replace by maximum number of occured.

In [0]:
```
train_cat=train_cat.ffill(axis=0)
```

In [252]:
```
train_cat.isnull().sum()
```

Out[252]:
```
Var192    0
Var193    0
Var195    0
Var196    0
Var197    0
Var203    0
Var204    0
Var205    0
Var206    0
Var207    0
Var208    0
Var210    0
Var211    0
Var212    0
Var218    0
Var219    0
Var221    0
Var223    0
Var226    0
Var227    0
Var228    0
dtype: int64
```

So no Null values we have till now in categorical columns

In [0]:
```
train_num=train.drop(cols,axis=1)
```

In [254]:
```
train_num.columns
```

Out[254]:
```
Index(['Var6', 'Var7', 'Var13', 'Var21', 'Var22', 'Var24', 'Var25', 'Var28',
       'Var35', 'Var38', 'Var44', 'Var57', 'Var65', 'Var72', 'Var73', 'Var74',
       'Var76', 'Var78', 'Var81', 'Var83', 'Var85', 'Var94', 'Var109',
       'Var112', 'Var113', 'Var119', 'Var123', 'Var125', 'Var126', 'Var132',
       'Var133', 'Var134', 'Var140', 'Var143', 'Var144', 'Var149', 'Var153',
       'Var160', 'Var163', 'Var173', 'Var181', 'churn', 'appetency',
       'upselling'],
      dtype='object')
```

In [0]:

In [255]:
```
train_num.isnull().sum()
```

Out[255]:
```
Var6          5529
Var7          5539
Var13         5539
Var21         5529
Var22         5009
Var24         7230
Var25         5009
Var28         5011
Var35         5009
Var38         5009
Var44         5009
Var57            0
Var65         5539
Var72        22380
Var73            0
Var74         5539
Var76         5009
Var78         5009
Var81         5529
```

In [0]:
```
for i in train_num.columns:
    train_num[i].fillna(train_num[i].mean(),inplace=True)
```

In [257]:
```
print(train_cat.shape)
print(train_num.shape)
```

```
(50000, 21)
(50000, 44)
```

In [0]:
```
train_final=pd.concat([train_num,train_cat],axis=1)
```

In [0]:

Predicting Class change

In [0]:
```
train_final['churn']=(train_final['churn']+1)/2
train_final['appetency']=(train_final['appetency']+1)/2
train_final['upselling']=(train_final['upselling']+1)/2
```

In [0]:
```
train_final['churn']=train_final['churn'].astype('int')
train_final['appetency']=train_final['appetency'].astype('int')
train_final['upselling']=train_final['upselling'].astype('int')
```

In [0]:
```
trai,tes = train_test_split(train_final,test_size=0.2)
```

In [0]:
```
from sklearn.model_selection import train_test_split
X_train = trai.drop(['churn','appetency','upselling'],axis=1)
X_test = tes.drop(['churn','appetency','upselling'],axis=1)

y_train     = trai['churn']
y_test      = tes['churn']
y_train_app  = trai['appetency']
y_test_app = tes['appetency']
y_train_up  = trai['upselling']
y_test_up = tes['upselling']
```

In [0]:
```

```

In [263]:
```
X_test.shape
```

Out[263]:
```
(10000, 62)
```

##Categorical features

We have 21 categorical features so if we assume on an average if each columncorreponds to 100 features so maximum features will be 2100 . Not Bad :)

In [0]:
```
from sklearn.preprocessing import LabelEncoder,OneHotEncoder
import bisect
from scipy.sparse import hstack
```

In [265]:
```
train_cat.columns
```

Out[265]:
```
Index(['Var192', 'Var193', 'Var195', 'Var196', 'Var197', 'Var203', 'Var204',
       'Var205', 'Var206', 'Var207', 'Var208', 'Var210', 'Var211', 'Var212',
       'Var218', 'Var219', 'Var221', 'Var223', 'Var226', 'Var227', 'Var228'],
      dtype='object')
```

In [266]:
```
#https://stackoverflow.com/questions/40321232/handling-unknown-values-for-label-encoding
le=LabelEncoder()
X_train['Var192']=le.fit_transform(X_train['Var192'])
X_test['Var192'] = X_test['Var192'].map(lambda s: 'other' if s not in le.classes_ else s)
le_classes = le.classes_.tolist()
bisect.insort_left(le_classes, 'other')
le.classes_ = le_classes

X_test['Var192']=le.transform(X_test['Var192'])

ohe=OneHotEncoder(handle_unknown='ignore')
X_tr = ohe.fit_transform(X_train['Var192'].values.reshape(-1,1))
X_te = ohe.transform(X_test['Var192'].values.reshape(-1,1))

flag=0
for i in train_cat.columns:

  if (flag!=0):

        le = LabelEncoder()
        X_train[i]=le.fit_transform(X_train[i])
        X_test[i] = X_test[i].map(lambda s: 'other' if s not in le.classes_ else s)
        le_classes = le.classes_.tolist()
        bisect.insort_left(le_classes, 'other')
        le.classes_ = le_classes
        X_test[i]=le.transform(X_test[i])
        ohe=OneHotEncoder(handle_unknown='ignore')
        print(i)
        X_tri = ohe.fit_transform(X_train[i].values.reshape(-1,1))
        X_tei = ohe.transform(X_test[i].values.reshape(-1,1))
        X_tr=hstack((X_tr,X_tri))
        X_te=hstack((X_te,X_tei))

  flag=1
```

```
Var193
Var195
Var196
Var197
Var203
Var204
```

```
Var205
Var206
Var207
Var208
Var210
Var211
Var212
Var218
Var219
Var221
Var223
Var226
Var227
Var228
```

GridSearch

In [0]:

```
from sklearn.model_selection import GridSearchCV
from sklearn.naive_bayes import MultinomialNB
model=MultinomialNB()
para = {'alpha':[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]}
clf = GridSearchCV(model, para, cv=5, scoring='roc_auc',return_train_score=True)
clf.fit(X_tr, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

...

In [0]:

```
from xgboost import XGBClassifier
model=XGBClassifier(n_estimators=100,max_depth=2,class_weight='balanced')
model.fit(X_tr, y_train)

y_test_pred = model.predict_proba(X_te)
roc_auc_score(y_test, y_test_pred[:,1])
```

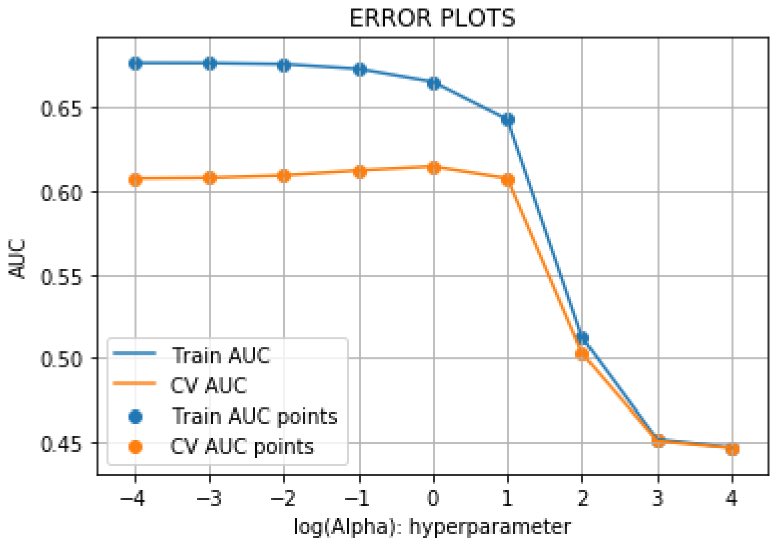
Out[60]:

```
0.6197069181951065
```

In [0]:
```
from sklearn.ensemble import ExtraTreesClassifier, RandomForestClassifier, GradientBoostingClassifier

from xgboost import XGBClassifier
model=RandomForestClassifier(n_estimators = 100, random_state = 0)
model.fit(X_tr, y_train)
y_test_pred = model.predict_proba(X_te)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[66]: 0.5378825184819434

In [0]:
```
from math import log
Alpha=[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
plt.plot([log(y,10) for y in Alpha], train_auc, label='Train AUC')
plt.plot([log(y,10) for y in Alpha], cv_auc, label='CV AUC')
plt.scatter([log(y,10) for y in Alpha], train_auc, label='Train AUC points')
plt.scatter([log(y,10) for y in Alpha], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(Alpha): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



##Numerical Features

In [0]:
```
from sklearn.preprocessing import MinMaxScaler

for i in train_num.columns:
  if i!='churn':
    if i!='appetency':
      if i!='upselling':

          m = MinMaxScaler()
          X_train[i]=m.fit_transform(X_train[i].values.reshape(-1,1))
          X_test[i]=m.transform(X_test[i].values.reshape(-1,1))
```

In [0]:
```
cols=[i for i in train_cat.columns if i not in ['churn','appetency','upselling']]
X_tr_num=X_train.drop(cols,axis=1)
X_te_num=X_test.drop(cols,axis=1)
```

In [269]:
```
X_tr_num.columns
```

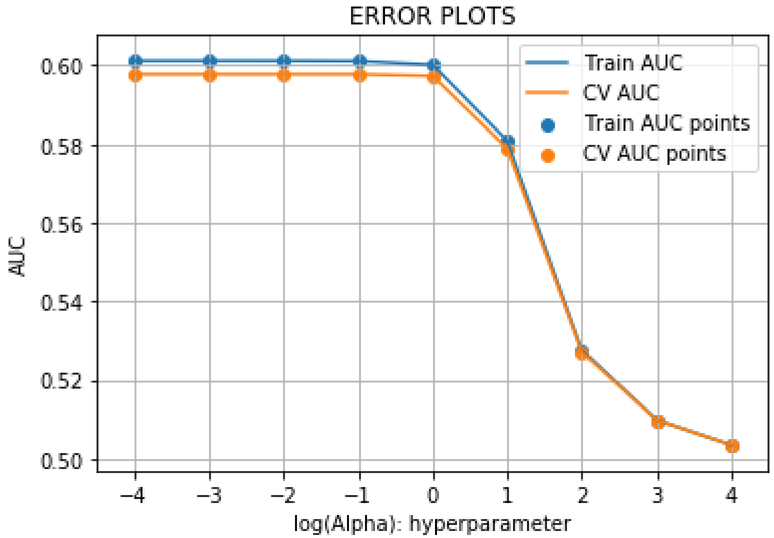
Out[269]:
```
Index(['Var6', 'Var7', 'Var13', 'Var21', 'Var22', 'Var24', 'Var25', 'Var28',
       'Var35', 'Var38', 'Var44', 'Var57', 'Var65', 'Var72', 'Var73', 'Var74',
       'Var76', 'Var78', 'Var81', 'Var83', 'Var85', 'Var94', 'Var109',
       'Var112', 'Var113', 'Var119', 'Var123', 'Var125', 'Var126', 'Var132',
       'Var133', 'Var134', 'Var140', 'Var143', 'Var144', 'Var149', 'Var153',
       'Var160', 'Var163', 'Var173', 'Var181'],
      dtype='object')
```

In [69]:
```
from sklearn.ensemble import ExtraTreesClassifier, RandomForestClassifier, GradientBoostingClassifier
from sklearn.metrics import roc_auc_score
from xgboost import XGBClassifier
model=XGBClassifier(n_estimators = 100,max_depth=2, random_state = 0)
model.fit(X_tr_num, y_train)
y_test_pred = model.predict_proba(X_te_num)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[69]:
```
0.7186206592728834
```

In [0]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.naive_bayes import MultinomialNB
model=MultinomialNB()
para = {'alpha':[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]}
clf = GridSearchCV(model, para, cv=5,

                   scoring='roc_auc',return_train_score=True)
clf.fit(X_tr_num, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

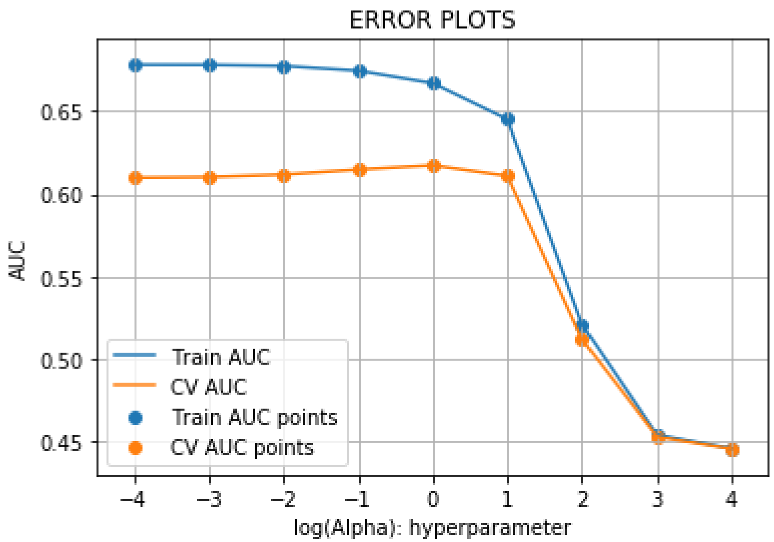
In [0]:
```
from math import log
Alpha=[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
plt.plot([log(y,10) for y in Alpha], train_auc, label='Train AUC')
plt.plot([log(y,10) for y in Alpha], cv_auc, label='CV AUC')
plt.scatter([log(y,10) for y in Alpha], train_auc, label='Train AUC points')
plt.scatter([log(y,10) for y in Alpha], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(Alpha): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



Categorical + Numerical

In [0]:
```
X_tr_final = hstack((X_tr_num,X_tr))
X_te_final = hstack((X_te_num,X_te))
```

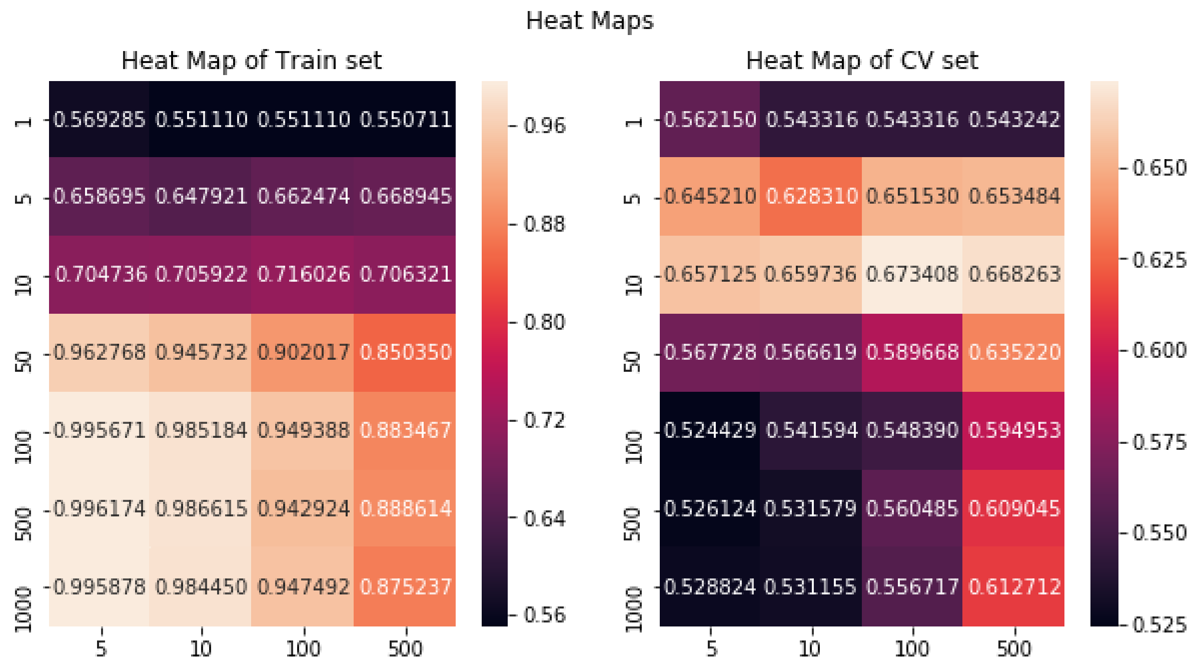
In [0]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.naive_bayes import MultinomialNB
model=MultinomialNB()
para = {'alpha':[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]}
clf = GridSearchCV(model, para, cv=5, scoring='roc_auc',return_train_score=True)
clf.fit(X_tr_final, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
from math import log
Alpha=[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
plt.plot([log(y,10) for y in Alpha], train_auc, label='Train AUC')
plt.plot([log(y,10) for y in Alpha], cv_auc, label='CV AUC')
plt.scatter([log(y,10) for y in Alpha], train_auc, label='Train AUC points')
plt.scatter([log(y,10) for y in Alpha], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(Alpha): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [0]:
```
from sklearn.tree import DecisionTreeClassifier

from sklearn.model_selection import GridSearchCV

model=DecisionTreeClassifier(criterion='gini', splitter='random')

para = {'max_depth':[1, 5, 10, 50, 100, 500,1000],'min_samples_split':[5, 10, 100, 500]}

clf = GridSearchCV(model, para, cv=3, scoring='roc_auc',return_train_score=True,verbose=2,n_jobs=40)
clf.fit(X_tr_final, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 28 candidates, totalling 84 fits

[Parallel(n_jobs=40)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=40)]: Done  48 out of  84 | elapsed:  4.0min remaining:  3.0min
[Parallel(n_jobs=40)]: Done  84 out of  84 | elapsed:  5.2min finished
```

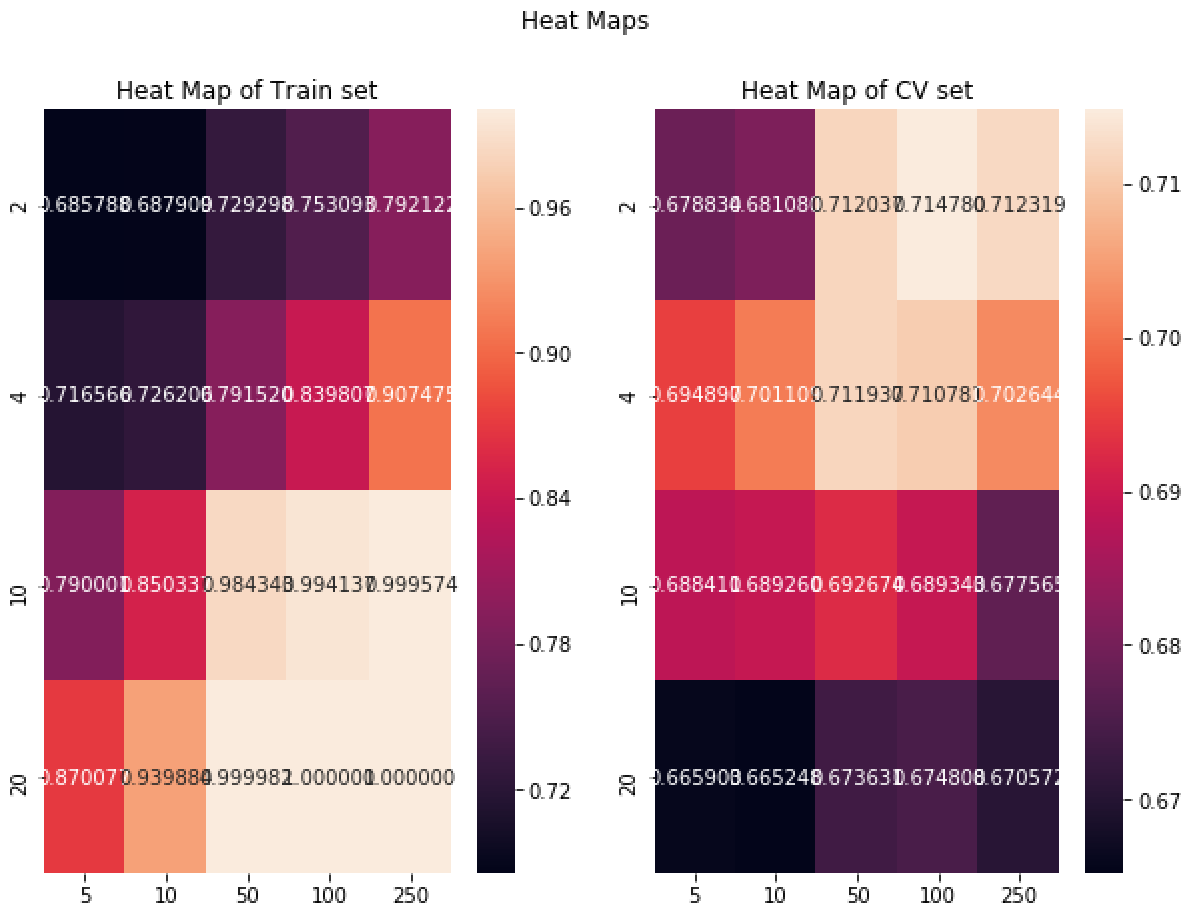
In [0]:
```
import seaborn as sns
import numpy as np
fig, (left, right) = plt.subplots(ncols=2, figsize=(10, 5))
t_auc=np.array(train_auc).reshape(7,4)
a=sns.heatmap(t_auc,annot=True,fmt="f",xticklabels=min_split, yticklabels=Depth,ax=left)
left.set_title('Heat Map of Train set')
c_auc=np.array(cv_auc).reshape(7,4)
b=sns.heatmap(c_auc,annot=True,fmt="f",xticklabels=min_split, yticklabels=Depth,ax=right)
right.set_title('Heat Map of CV set')
fig.suptitle("Heat Maps")
plt.show()
```



In [0]:
```
from xgboost import XGBClassifier
parameters = {'n_estimators':[5,10,50,100,250] , 'max_depth' :[2,4,10,20]}
xb1=XGBClassifier(class_weight='balanced')
clf1=GridSearchCV(xb1,parameters,cv=2,scoring='roc_auc',return_train_score=True,verbose=10,n_jobs=40)
clf1.fit(X_tr_final,y_train)
train_auc= clf1.cv_results_['mean_train_score']
cv_auc = clf1.cv_results_['mean_test_score']
```

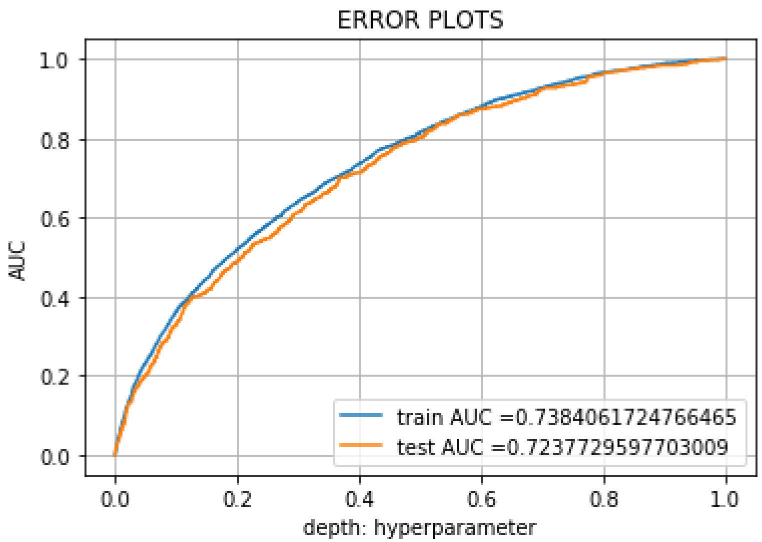
```
Fitting 2 folds for each of 20 candidates, totalling 40 fits

[Parallel(n_jobs=40)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=40)]: Done   1 tasks      | elapsed:   11.1s
[Parallel(n_jobs=40)]: Done   6 out of  40 | elapsed:   49.3s remaining:  4.7min
[Parallel(n_jobs=40)]: Done  11 out of  40 | elapsed:  1.4min remaining:  3.7min
[Parallel(n_jobs=40)]: Done  16 out of  40 | elapsed:  1.8min remaining:  2.6min
[Parallel(n_jobs=40)]: Done  21 out of  40 | elapsed:  2.5min remaining:  2.3min
[Parallel(n_jobs=40)]: Done  26 out of  40 | elapsed:  3.3min remaining:  1.8min
[Parallel(n_jobs=40)]: Done  31 out of  40 | elapsed:  5.0min remaining:  1.4min
[Parallel(n_jobs=40)]: Done  36 out of  40 | elapsed:  6.8min remaining:   45.2s
[Parallel(n_jobs=40)]: Done  40 out of  40 | elapsed:  8.2min finished
```

In [0]:
```
fig, (left, right) = plt.subplots(ncols=2, figsize=(10, 7))
t_auc=np.array(train_auc).reshape(4,5)
a=sns.heatmap(t_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=lef
left.set_title('Heat Map of Train set')
c_auc=np.array(cv_auc).reshape(4,5)
b=sns.heatmap(c_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=rig

right.set_title('Heat Map of CV set')
fig.suptitle("Heat Maps")
plt.show()
```



In [0]:
```
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 cr_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
        y_data_pred.extend(clf.predict_proba(data[tr_loop:])[:,1])

      return y_data_pred
```

In [0]:
```
from sklearn.metrics import roc_curve,auc
best_esti=100
best_depth=2
xg4=XGBClassifier(n_estimators=best_esti,max_depth=best_depth,n_jobs=-1,class_weight='balanced')
xg4.fit(X_tr_final,y_train)

y_train_pred = batch_predict(xg4,X_tr_final.tocsr())
y_test_pred = batch_predict(xg4,X_te_final.tocsr())

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("depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
#Credits:AppliedaAIcourse.com
from sklearn.metrics import confusion_matrix
def predict(proba, threshould, fpr, tpr):
  t = threshould[np.argmax(fpr*(1-tpr))]
  # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
  print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
  predictions = []
  for i in proba:
    if i>=t:
      predictions.append(1)
    else:
      predictions.append(0)
    return predictions
```



In [0]:

```
from sklearn.ensemble import ExtraTreesClassifier, RandomForestClassifier, GradientBoostingClassifier

from xgboost import XGBClassifier
model=XGBClassifier(n_estimators = 100,max_depth=2, random_state = 0)
model.fit(X_tr_final, y_train)
y_test_pred = model.predict_proba(X_te_final)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[72]: 0.7265878086083746

In [273]:

Out[273]: 0.8251691343843911

In [92]:

```
from sklearn.metrics import accuracy_score
y_test_pred = model.predict(X_te)
accuracy_score(y_test, y_test_pred)
```

Out[92]: 0.9265

In [0]:
```
model=GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.001, loss='deviance', max_depth=7,
              max_features=25, max_leaf_nodes=None,
              min_impurity_decrease=0.0, min_impurity_split=None,
              min_samples_leaf=40, min_samples_split=300,
              min_weight_fraction_leaf=0.0, n_estimators=10000,presort='auto', random_state=0,
              subsample=0.8000000000000002,
               verbose=0, warm_start=False)
model.fit(X_tr_final, y_train)
y_test_pred = model.predict_proba(X_te_final)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[76]: 0.7096949951205049

In [0]:
```
from sklearn.neural_network import MLPClassifier

mlp = MLPClassifier(
    hidden_layer_sizes=(1024, 256, 64, 16),
    activation="relu",
    max_iter=int(1e+3),
    early_stopping=True,
    validation_fraction=0.2,
    n_iter_no_change=50,
    random_state=2,
    verbose=True,
)
mlp.fit(X_tr_final, y_train)
y_test_pred = mlp.predict_proba(X_te_final)
```

```
Iteration 1, loss = 0.27214162
Validation score: 0.926375
Iteration 2, loss = 0.24798246
Validation score: 0.926375
Iteration 3, loss = 0.24047966
Validation score: 0.926375
Iteration 4, loss = 0.22143650
Validation score: 0.922125
Iteration 5, loss = 0.18512248
Validation score: 0.905875
Iteration 6, loss = 0.14387142
Validation score: 0.903375
Iteration 7, loss = 0.10792924
Validation score: 0.899750
Iteration 8, loss = 0.07846820
Validation score: 0.894750
Iteration 9, loss = 0.06431966
Validation score: 0.902125
Iteration 10, loss = 0.05080494
```

In [0]:
```
from sklearn.metrics import roc_auc_score
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[44]: 0.626717914277289

In [0]:
```
X_tr_final.shape
```

Out[78]:
```
(40000, 1010)
```

##MLP Classifier

Upsampling the data

In [0]:
```

```

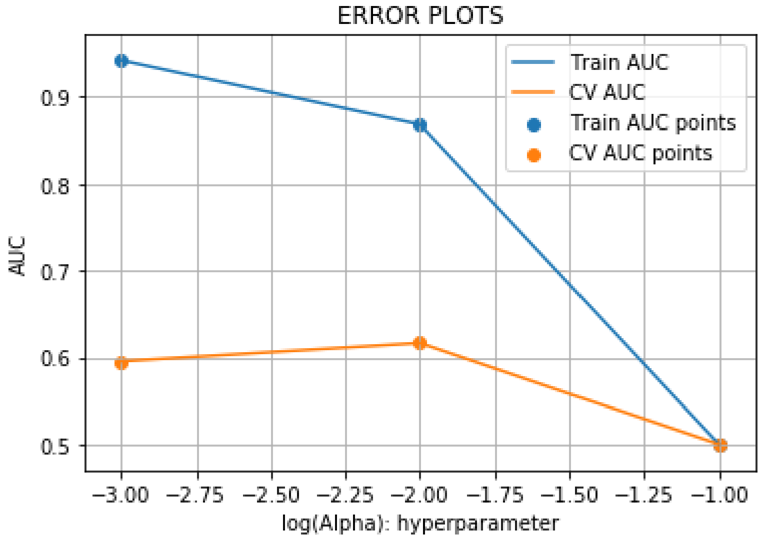
In [0]:
```
from sklearn.neural_network import MLPClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import auc

model=MLPClassifier(hidden_layer_sizes=(130,75,50,30,10),batch_size=500,max_iter=500)

para = {'learning_rate_init':[0.1,0.01,0.001]}

clf = GridSearchCV(model, para, cv=3, scoring='roc_auc',return_train_score=True,verbose=2,n_jobs=40)
clf.fit(X_tr_num, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 3 candidates, totalling 9 fits

[Parallel(n_jobs=40)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=40)]: Done   5 out of   9 | elapsed:  9.4min remaining:  7.5min
[Parallel(n_jobs=40)]: Done   9 out of   9 | elapsed: 10.9min finished
```

In [0]:
```
cv_auc
```

Out[64]:
```
array([0.5       , 0.61635579, 0.59532081])
```

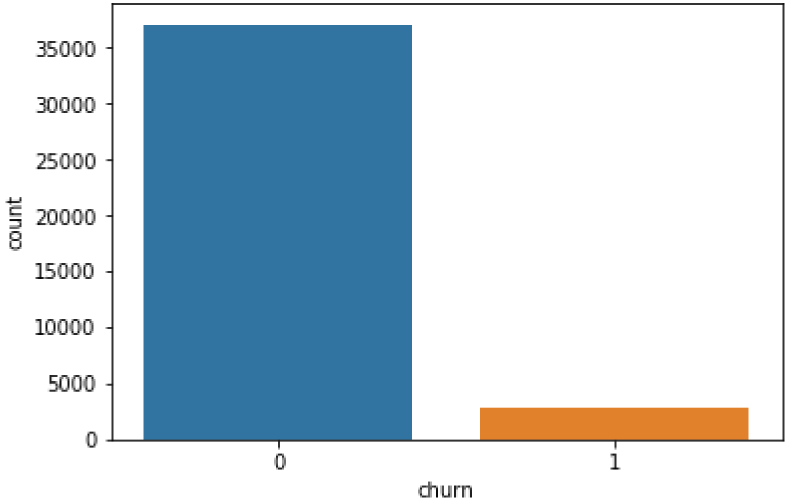
In [0]:
```
from math import log
lr=[0.1,0.01,0.001]
plt.plot([log(y,10) for y in lr], train_auc, label='Train AUC')
plt.plot([log(y,10) for y in lr], cv_auc, label='CV AUC')
plt.scatter([log(y,10) for y in lr], train_auc, label='Train AUC points')
plt.scatter([log(y,10) for y in lr], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(Alpha): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



Upsampling the data

In [0]:
```
import matplotlib.pyplot as plt
import seaborn as sns

sns.countplot(y_train)
```

Out[74]: <matplotlib.axes._subplots.AxesSubplot at 0x7feb09bd1080>



In [0]:
```
from imblearn.over_sampling import SMOTE
sm = SMOTE(random_state=2)
X_tr_num_res, y_tr_num_res = sm.fit_sample(X_tr_num, y_train.ravel())
```

In [0]:
```
from imblearn.over_sampling import SMOTE
sm = SMOTE(random_state=2)
X_te_num_res, y_te_num_res = sm.fit_sample(X_te_num, y_test.ravel())
```

In [0]:
```
X_te_num_res.shape
```

Out[86]: (18444, 41)

In [0]:
```
from sklearn.neural_network import MLPClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import auc

model=MLPClassifier(hidden_layer_sizes=(130,75,50,30,10),batch_size=500,max_iter=500)

para = {'learning_rate_init':[0.01]}

clf = GridSearchCV(model,  para,cv=3,scoring='roc_auc',return_train_score=True,verbose=2,n_jobs=40)
clf.fit(X_te_num_res, y_te_num_res)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

In [0]:

In [0]:
```
clf.cv_results_
```

In [0]:
```
print("train AUC",train_auc)
print("CV AUC",cv_auc)
```

```
train AUC [0.9954992]
CV AUC [0.95130601]
```

In [0]:
```
from sklearn.metrics import roc_curve,auc
model=MLPClassifier(hidden_layer_sizes=(130,75,50,30,10),learning_rate_init=0.01,batch_size=500,max_iter=500)
model.fit(X_tr_num_res, y_tr_num_res)
```

Out[88]:
```
MLPClassifier(activation='relu', alpha=0.0001, batch_size=500, beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(130, 75, 50, 30, 10),
              learning_rate='constant', learning_rate_init=0.01, max_iter=500,
              momentum=0.9, n_iter_no_change=10, nesterovs_momentum=True,
              power_t=0.5, random_state=None, shuffle=True, solver='adam',
              tol=0.0001, validation_fraction=0.1, verbose=False,
              warm_start=False)
```

In [0]:
```
y_test_pred= model.predict_proba(X_te_num)
roc_auc_score(y_test, y_test_pred[:,1])
```

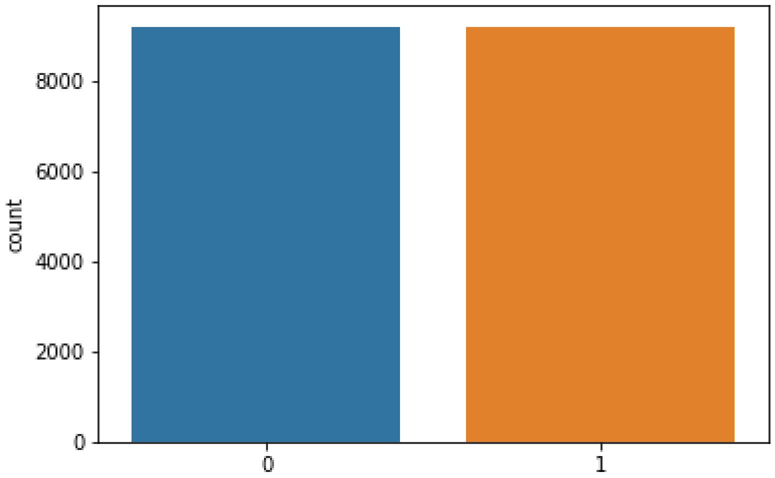
Out[89]: 0.6012187799489206

In [0]:
```
from sklearn.metrics import roc_auc_score
roc_auc_score(y_te_num_res, y_test_pred[:,1])
```

Out[80]: 0.7601658899745692

In [0]:
```
import matplotlib.pyplot as plt
import seaborn as sns

sns.countplot(y_te_num_res)
```

Out[73]: <matplotlib.axes._subplots.AxesSubplot at 0x7feb09c73e10>



In [0]:
```
len(X_te_num_res)
len(y_te_num_res)
len(y_test_pred)
```

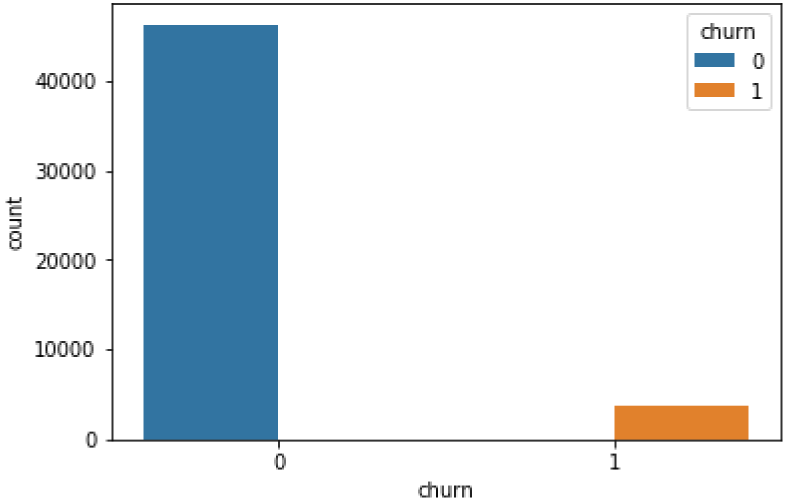
Out[50]: 25992

Upsampling:

In [0]:
```
cols=[i for i in train_cat.columns]
data=train_final.drop(cols,axis=1)
```

In [0]:
```
import seaborn as sns
```

In [0]:
```
sns.countplot(data['churn'],hue=data['churn'])
plt.show()
```



In [0]:
```
data_0 = data[data['churn']==0]
data_1 = data[data['churn']==1]
```

In [0]:
```
from sklearn.utils import resample
data_1_upsampled = resample(data_1,replace=True,n_samples=data_0.shape[0],random_state=50)
```

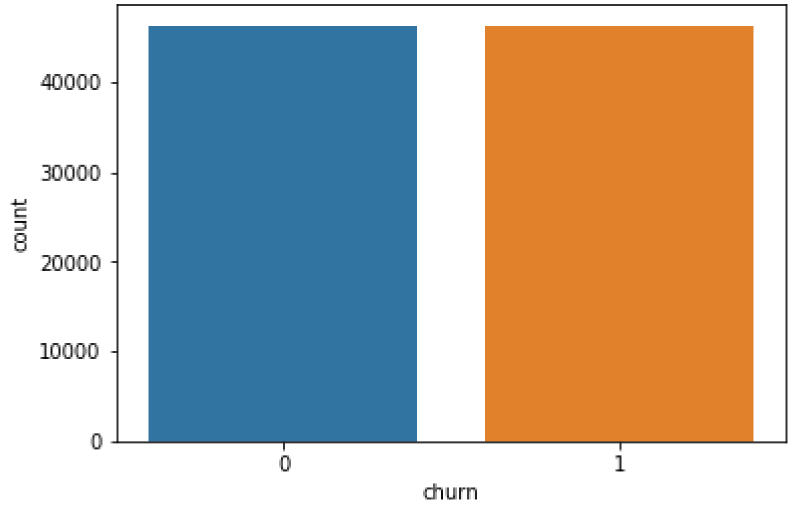
In [0]:
```
print(data_1_upsampled.shape)
print(data_0.shape)
```

```
(46328, 42)
(46328, 42)
```

In [0]:
```
final_sampled_data=pd.concat([data_1_upsampled,data_0])
final_sampled_data.shape
```

Out[54]:
```
(92656, 42)
```

In [0]:
```
sns.countplot(final_sampled_data['churn'])
plt.show()
```



In [0]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(final_sampled_data.drop(['churn'],axis=1),final_sampled_data['churn'],test
```

In [0]:
```
from sklearn.preprocessing import MinMaxScaler

for i in X_train.columns:
  if i!='churn':

        m = MinMaxScaler()
        X_train[i]=m.fit_transform(X_train[i].values.reshape(-1,1))
        X_test[i]=m.transform(X_test[i].values.reshape(-1,1))
```

In [0]:
```
from sklearn.neural_network import MLPClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import auc

model=MLPClassifier(hidden_layer_sizes=(130,75,10,2),batch_size=100,max_iter=500)

para = {'learning_rate_init':[0.001]}

clf = GridSearchCV(model,  para,cv=3,scoring='roc_auc',return_train_score=True,verbose=2,n_jobs=3)
clf.fit(X_train, y_train)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

```
Fitting 3 folds for each of 1 candidates, totalling 3 fits

[Parallel(n_jobs=3)]: Using backend LokyBackend with 3 concurrent workers.
[Parallel(n_jobs=3)]: Done   3 out of   3 | elapsed: 46.7min finished
```

In [0]:
```
#This I ran Initially without normalizing the data and the result was devastating .
#print("Train_AUC:",train_auc)
#print("CV_AUC : ",cv_auc)
```

```
Train_AUC: [0.50000675]
CV_AUC :  [0.50001349]
```

In [0]:
```
print("Train_AUC:",train_auc)
print("CV_AUC : ",cv_auc)
```

```
Train_AUC: [0.78453373]
CV_AUC :  [0.75162872]
```

In [0]:
```
from sklearn.metrics import roc_curve,auc
from sklearn.metrics import roc_auc_score

model=MLPClassifier(hidden_layer_sizes=(130,75,50,30,10,2),learning_rate_init=0.001,batch_size=100,max_iter=500)
model.fit(X_train, y_train)

y_test_pred = model.predict_proba(X_test)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[61]:
```
0.9548330029302081
```

In [0]:
```
y_test_pred = model.predict_proba(X_test)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[62]:
```
0.9548330029302081
```

Test sample without upsampling

In [0]:
```
from sklearn.neural_network import MLPClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import auc
```

In [0]:
```
from sklearn.model_selection import train_test_split
data_train,data_test=train_test_split(data,test_size=0.2)
```

In [0]:
```
data_0 = data_train[data_train['churn']==0]
data_1 = data_train[data_train['churn']==1]

from sklearn.utils import resample
data_1_upsampled = resample(data_1,replace=True,n_samples=data_0.shape[0],random_state=50)


final_sampled_data=pd.concat([data_1_upsampled,data_0])
final_sampled_data.shape

X_train =  final_sampled_data.drop(['churn'],axis=1)
y_train = final_sampled_data['churn']
X_test = data_test.drop(['churn'],axis=1)
y_test = data_test['churn']


from sklearn.preprocessing import MinMaxScaler

for i in X_train.columns:
  if i!='churn':

        m = MinMaxScaler()
        X_train[i]=m.fit_transform(X_train[i].values.reshape(-1,1))
        X_test[i]=m.transform(X_test[i].values.reshape(-1,1))



from sklearn.metrics import roc_curve,auc
from sklearn.metrics import roc_auc_score

model=MLPClassifier(hidden_layer_sizes=(130,75,50,30,10),learning_rate_init=0.001,batch_size=100,max_iter=500)
model.fit(X_train, y_train)

y_test_pred = model.predict_proba(X_test)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[70]: 0.5966307119499122

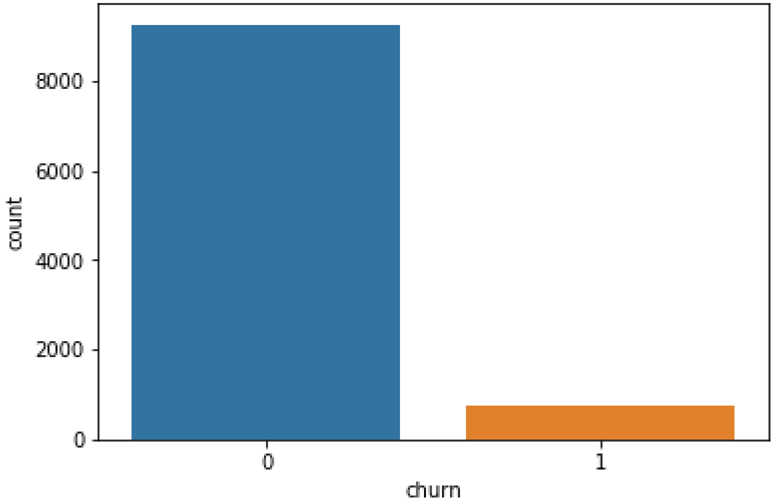
In [0]:
```
model=MLPClassifier(hidden_layer_sizes=(1024,256,64,10),learning_rate_init=0.01,early_stopping=True,batch_size=100,max_it
model.fit(X_train, y_train)
```

Out[74]:
```
MLPClassifier(activation='relu', alpha=0.0001, batch_size=100, beta_1=0.9,
              beta_2=0.999, early_stopping=True, epsilon=1e-08,
              hidden_layer_sizes=(1024, 256, 64, 10), learning_rate='constant',
              learning_rate_init=0.01, max_iter=500, momentum=0.9,
              n_iter_no_change=10, nesterovs_momentum=True, power_t=0.5,
              random_state=None, shuffle=True, solver='adam', tol=0.0001,
              validation_fraction=0.1, verbose=False, warm_start=False)
```

In [0]:
```
y_test_pred = model.predict_proba(X_test)
roc_auc_score(y_test, y_test_pred[:,1])
```

Out[76]:
```
0.6390448526368927
```

In [0]:
```
sns.countplot(y_test)
plt.show()
```



XGBClassifier

In [0]:
```
from xgboost import XGBClassifier
model=XGBClassifier(n_estimators=500,max_depth=2,class_weight='balanced')
model.fit(X_train, y_train)

y_test_pred = model.predict(X_test)
roc_auc_score(y_test, y_test_pred)
```

Out[73]:
```
0.6571282069853994
```

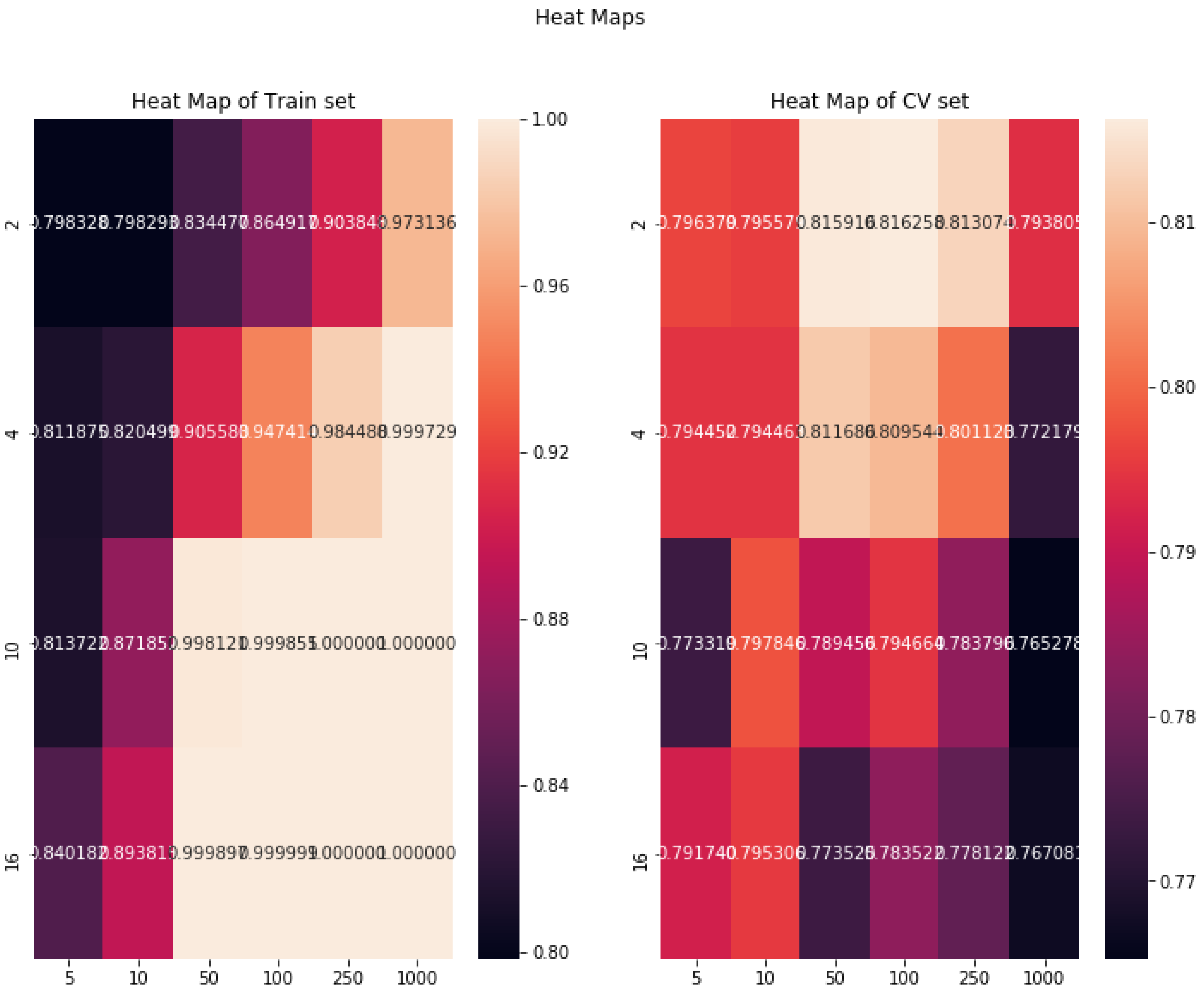
In [0]:
```

```

##Appetency

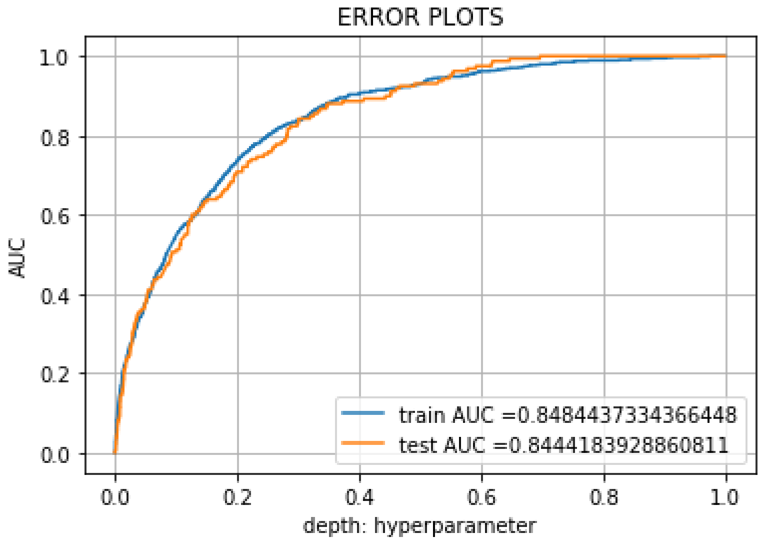
In [275]:
```
from xgboost import XGBClassifier
from sklearn.model_selection import GridSearchCV

parameters = {'n_estimators':[5,10,50,100,250,1000] , 'max_depth' :[2,4,10,16]}
xb1=XGBClassifier(class_weight='balanced')
clf1=GridSearchCV(xb1,parameters,cv=2,scoring='roc_auc',return_train_score=True,verbose=10,n_jobs=40)
clf1.fit(X_tr_final,y_train_app)
train_auc= clf1.cv_results_['mean_train_score']
cv_auc = clf1.cv_results_['mean_test_score']
```

```
Fitting 2 folds for each of 24 candidates, totalling 48 fits

[Parallel(n_jobs=40)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=40)]: Done   4 out of  48 | elapsed:   22.0s remaining:  4.0min
[Parallel(n_jobs=40)]: Done   9 out of  48 | elapsed:  1.2min remaining:  5.2min
[Parallel(n_jobs=40)]: Done  14 out of  48 | elapsed:  2.5min remaining:  6.0min
[Parallel(n_jobs=40)]: Done  19 out of  48 | elapsed:  2.6min remaining:  3.9min
[Parallel(n_jobs=40)]: Done  24 out of  48 | elapsed:  3.9min remaining:  3.9min
[Parallel(n_jobs=40)]: Done  29 out of  48 | elapsed:  6.1min remaining:  4.0min
[Parallel(n_jobs=40)]: Done  34 out of  48 | elapsed:  7.3min remaining:  3.0min
[Parallel(n_jobs=40)]: Done  39 out of  48 | elapsed: 11.3min remaining:  2.6min
[Parallel(n_jobs=40)]: Done  44 out of  48 | elapsed: 13.6min remaining:  1.2min
[Parallel(n_jobs=40)]: Done  48 out of  48 | elapsed: 17.9min finished
```

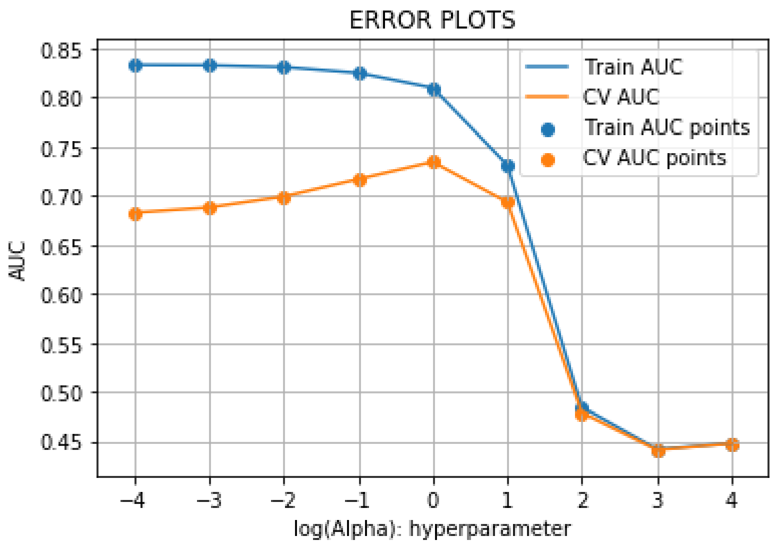
In [276]:
```
import numpy as np
import seaborn as sns
fig, (left, right) = plt.subplots(ncols=2, figsize=(12, 9))
t_auc=np.array(train_auc).reshape(4,6)
a=sns.heatmap(t_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=lef
left.set_title('Heat Map of Train set')
c_auc=np.array(cv_auc).reshape(4,6)
b=sns.heatmap(c_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=rig

right.set_title('Heat Map of CV set')
fig.suptitle("Heat Maps")
plt.show()
```


Heat Maps
Heat Map of Train set
Heat Map of CV set
2
4
10
16
5
10
50
100
250
1000
0.798328
0.798293
0.834477
0.864917
0.903840
0.973136
0.811875
0.820499
0.905580
0.947410
0.984480
0.999729
0.813722
0.871852
0.998121
0.999855
1.000000
1.000000
0.840182
0.893810
0.999897
0.999999
1.000000
1.000000
0.796379
0.795579
0.815916
0.816258
0.813074
0.793805
0.794452
0.794467
0.811686
0.809544
0.801128
0.772179
0.773319
0.797846
0.789456
0.794664
0.783796
0.765278
0.791740
0.795306
0.773528
0.783522
0.778122
0.767081
1.00
0.96
0.92
0.88
0.84
0.80
0.81
0.80
0.79
0.78
0.77

In [279]:
```
from sklearn.metrics import roc_curve,auc
best_esti=100
best_depth=2
xg4=XGBClassifier(n_estimators=best_esti,max_depth=best_depth,n_jobs=10,class_weight='balanced')
xg4.fit(X_tr_final,y_train_app)

y_train_pred = batch_predict(xg4,X_tr_final.tocsr())
y_test_pred = batch_predict(xg4,X_te_final.tocsr())

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train_app, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test_app, 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("depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
#Credits:AppliedaAIcourse.com
from sklearn.metrics import confusion_matrix
def predict(proba, threshould, fpr, tpr):
  t = threshould[np.argmax(fpr*(1-tpr))]
  # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
  print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
  predictions = []
  for i in proba:
    if i>=t:
      predictions.append(1)
    else:
      predictions.append(0)
    return predictions
```


ERROR PLOTS
AUC
depth: hyperparameter
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
train AUC =0.8484437334366448
test AUC =0.8444183928860811

In [274]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.naive_bayes import MultinomialNB
model=MultinomialNB()
para = {'alpha':[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]}
clf = GridSearchCV(model, para, cv=5, scoring='roc_auc',return_train_score=True)
clf.fit(X_tr_final, y_train_app)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
from math import log
Alpha=[0.0001,0.001,0.01,0.1,1,10,100,1000,10000]
plt.plot([log(y,10) for y in Alpha], train_auc, label='Train AUC')
plt.plot([log(y,10) for y in Alpha], cv_auc, label='CV AUC')
plt.scatter([log(y,10) for y in Alpha], train_auc, label='Train AUC points')
plt.scatter([log(y,10) for y in Alpha], cv_auc, label='CV AUC points')
plt.legend()
plt.xlabel("log(Alpha): hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```



In [0]:
```
from sklearn.tree import DecisionTreeClassifier

from sklearn.model_selection import GridSearchCV

model=DecisionTreeClassifier(criterion='gini', splitter='random')

para = {'max_depth':[1, 5, 10, 50, 100, 500,1000],'min_samples_split':[5, 10, 100, 500]}

clf = GridSearchCV(model, para, cv=3, scoring='roc_auc',return_train_score=True,verbose=2,n_jobs=40)
clf.fit(X_tr_final, y_train_app)
train_auc= clf.cv_results_['mean_train_score']
cv_auc = clf.cv_results_['mean_test_score']
```

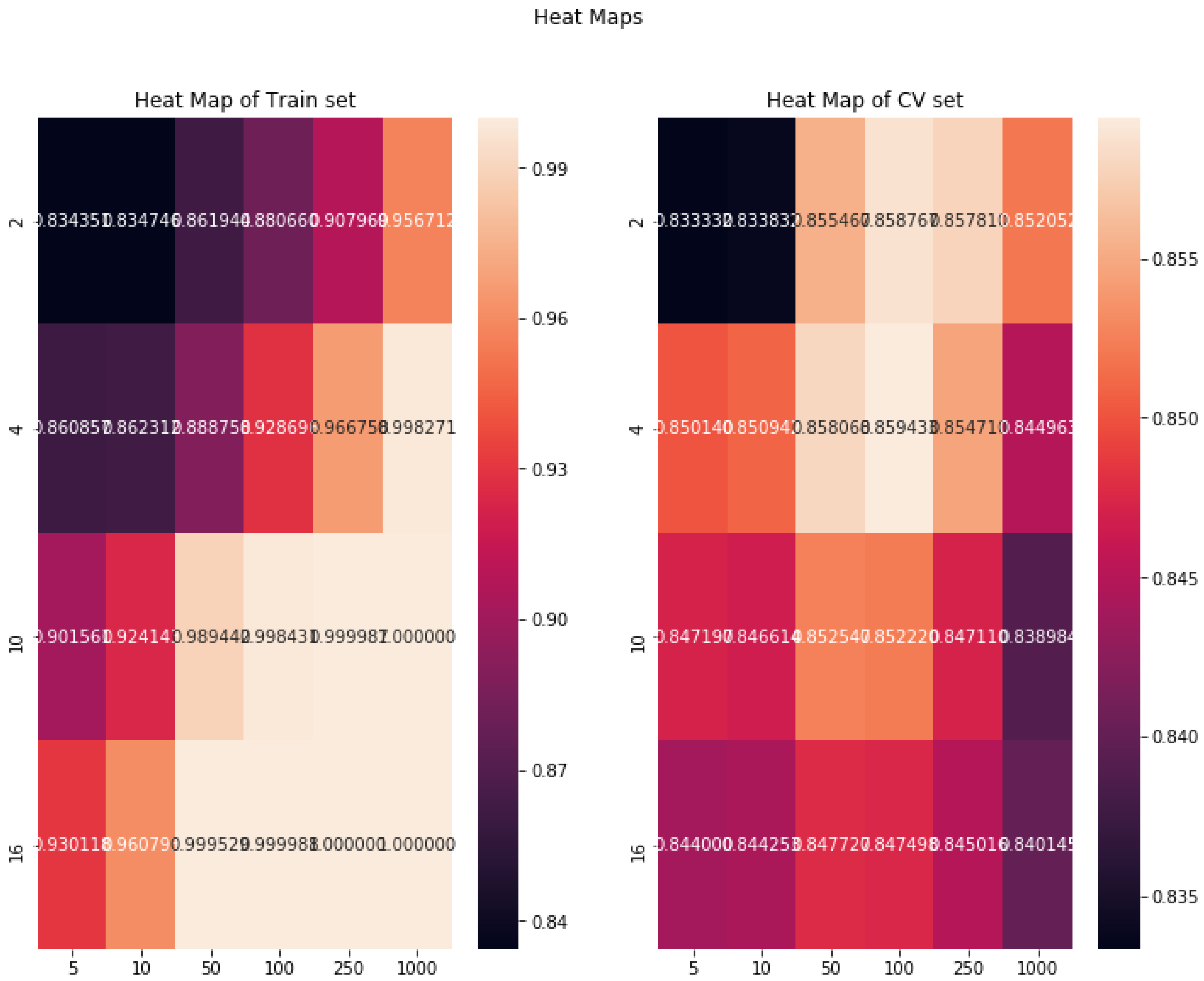
In [0]:
```
import seaborn as sns
import numpy as np
fig, (left, right) = plt.subplots(ncols=2, figsize=(12, 9))
t_auc=np.array(train_auc).reshape(7,4)
a=sns.heatmap(t_auc,annot=True,fmt="f",xticklabels=min_split, yticklabels=Depth,ax=left)
left.set_title('Heat Map of Train set')
c_auc=np.array(cv_auc).reshape(7,4)
b=sns.heatmap(c_auc,annot=True,fmt="f",xticklabels=min_split, yticklabels=Depth,ax=right)
right.set_title('Heat Map of CV set')
fig.suptitle("Heat Maps")
plt.show()
```

In [0]:

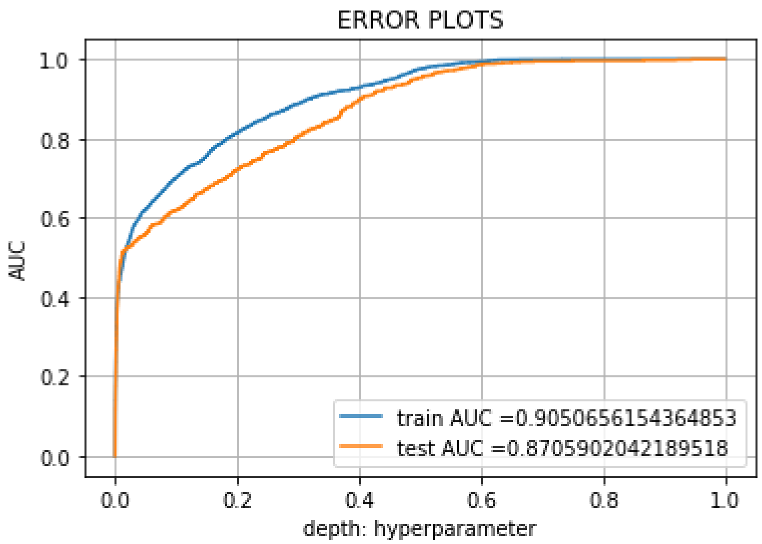
##Upselling

In [280]:
```
from xgboost import XGBClassifier
from sklearn.model_selection import GridSearchCV

parameters = {'n_estimators':[5,10,50,100,250,1000] , 'max_depth' :[2,4,10,16]}
xb1=XGBClassifier(class_weight='balanced')
clf1=GridSearchCV(xb1,parameters,cv=2,scoring='roc_auc',return_train_score=True,verbose=10,n_jobs=40)
clf1.fit(X_tr_final,y_train_up)
train_auc= clf1.cv_results_['mean_train_score']
cv_auc = clf1.cv_results_['mean_test_score']
import numpy as np
import seaborn as sns
fig, (left, right) = plt.subplots(ncols=2, figsize=(12, 9))
t_auc=np.array(train_auc).reshape(4,6)
a=sns.heatmap(t_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=lef
left.set_title('Heat Map of Train set')
c_auc=np.array(cv_auc).reshape(4,6)
b=sns.heatmap(c_auc,annot=True,fmt="f",xticklabels=parameters['n_estimators'], yticklabels=parameters['max_depth'],ax=rig

right.set_title('Heat Map of CV set')
fig.suptitle("Heat Maps")
plt.show()
```

```
Fitting 2 folds for each of 24 candidates, totalling 48 fits

[Parallel(n_jobs=40)]: Using backend LokyBackend with 40 concurrent workers.
[Parallel(n_jobs=40)]: Done   4 out of  48 | elapsed:   30.2s remaining:   5.5min
[Parallel(n_jobs=40)]: Done   9 out of  48 | elapsed:  1.5min remaining:   6.4min
[Parallel(n_jobs=40)]: Done  14 out of  48 | elapsed:  1.9min remaining:   4.7min
[Parallel(n_jobs=40)]: Done  19 out of  48 | elapsed:  2.8min remaining:   4.2min
[Parallel(n_jobs=40)]: Done  24 out of  48 | elapsed:  4.1min remaining:   4.1min
[Parallel(n_jobs=40)]: Done  29 out of  48 | elapsed:  6.6min remaining:   4.3min
[Parallel(n_jobs=40)]: Done  34 out of  48 | elapsed:  7.6min remaining:   3.1min
[Parallel(n_jobs=40)]: Done  39 out of  48 | elapsed: 11.9min remaining:   2.7min
[Parallel(n_jobs=40)]: Done  44 out of  48 | elapsed: 14.5min remaining:   1.3min
[Parallel(n_jobs=40)]: Done  48 out of  48 | elapsed: 21.0min finished
```


Heat Maps
Heat Map of Train set
0.834351 0.834746 0.861944 0.880660 0.907969 0.956712
0.860857 0.862312 0.888758 0.928690 0.966758 0.998271
0.901561 0.924140 0.989442 0.998431 0.999987 1.000000
0.930118 0.960790 0.999529 0.999988 1.000000 1.000000
2
4
10
16
5 10 50 100 250 1000
0.99
0.96
0.93
0.90
0.87
0.84
Heat Map of CV set
0.833332 0.833832 0.855467 0.858767 0.857810 0.852052
0.850140 0.850942 0.858068 0.859433 0.854710 0.844963
0.847197 0.846614 0.852547 0.852220 0.847110 0.838984
0.844000 0.844253 0.847727 0.847498 0.845016 0.840145
2
4
10
16
5 10 50 100 250 1000
0.855
0.850
0.845
0.840
0.835

In [282]:
```
from sklearn.metrics import roc_curve,auc
best_esti=100
best_depth=4
xg4=XGBClassifier(n_estimators=best_esti,max_depth=best_depth,n_jobs=10,class_weight='balanced')
xg4.fit(X_tr_final,y_train_up)

y_train_pred = batch_predict(xg4,X_tr_final.tocsr())
y_test_pred = batch_predict(xg4,X_te_final.tocsr())

train_fpr, train_tpr, tr_thresholds = roc_curve(y_train_up, y_train_pred)
test_fpr, test_tpr, te_thresholds = roc_curve(y_test_up, 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("depth: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
#Credits:AppliedaAIcourse.com
from sklearn.metrics import confusion_matrix
def predict(proba, threshould, fpr, tpr):
  t = threshould[np.argmax(fpr*(1-tpr))]
  # (tpr*(1-fpr)) will be maximum if your fpr is very low and tpr is very high
  print("the maximum value of tpr*(1-fpr)", max(tpr*(1-fpr)), "for threshold", np.round(t,3))
  predictions = []
  for i in proba:
    if i>=t:
      predictions.append(1)
    else:
      predictions.append(0)
    return predictions
```



In [0]:

##Conclusion : Final

We can see that using upsampling on the data both train ans the test an implemeting the MLP Classifier
We are getting the good auc score around 0.95 .But using upsampling only for train set model overfits in train data.

Till now the best model is XGBClassifier with n_iteration = 100 and depth = 2 which is giving a AUC score of 0.72 for churn
It is cross validated and an tested on test data.
For Appetency XGBClassifier is best model AUC=0.84
For Upsampling XGBClassifier is best model AUC=0.87
and overall AUC =0.81

In [289]:
```
#Conclusion for CHURN
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Algorithm", "AUC","Remarks"]
x.add_row(["Multinomial NB/Baseline Model ", 0.62,"Good"])
x.add_row(["DecisionTreeClassifier ", 0.67,"Good"])
x.add_row(["XGBClassifierClassifier", 0.72,"Best - Class Weight is Balanced"])
x.add_row(["Upsampling/ MLPClassifier /SMOTE", 0.71,'Same as XGBClassifier without upsampling'])
x.add_row(["Upsampling/ MLPClassifier /SMOTE/On Train Data", 0.60,'Bad/ Overfitting'])
x.add_row(["Upsampling/ MLPClassifier /Upsampling", 0.90,'Good but data is upsampled'])
x.add_row(["Upsampling/ MLPClassifier /Upsampling/On Train Data", 0.60,'Overfitting'])

print(x)
```

```
+---------------------------------------------------+------+-----------------------------------------+
|                     Algorithm                     | AUC  |                 Remarks                 |
+---------------------------------------------------+------+-----------------------------------------+
|           Multinomial NB/Baseline Model           | 0.62 |                   Good                  |
|              DecisionTreeClassifier               | 0.67 |                   Good                  |
|              XGBClassifierClassifier              | 0.72 |     Best - Class Weight is Balanced     |
|          Upsampling/ MLPClassifier /SMOTE         | 0.71 | Same as XGBClassifier without upsampling |
|   Upsampling/ MLPClassifier /SMOTE/On Train Data  | 0.6  |             Bad/ Overfitting            |
|       Upsampling/ MLPClassifier /Upsampling       | 0.9  |        Good but data is upsampled       |
| Upsampling/ MLPClassifier /Upsampling/On Train Data | 0.6  |               Overfitting               |
+---------------------------------------------------+------+-----------------------------------------+
```

After seeing the data Appetency and Upselling follows the same path but giving better results on XGBClassifier.

In [295]:
```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Estimator","Model" ,"AUC"]
x.add_row(["Churn", "XGBClassifier n_iter=100, depth=2", 0.72])
x.add_row(["Appetency", "XGBClassifier n_iter=100, depth=2", 0.84])
x.add_row(["Upsampling","XGBClassifier n_iter=100, depth=4", 0.87])
x.add_row(["Total", "Overall", 0.81])
print(x)
```

```
+------------+-----------------------------------+------+
| Estimator  |               Model               | AUC  |
+------------+-----------------------------------+------+
|   Churn    | XGBClassifier n_iter=100, depth=2 | 0.72 |
| Appetency  | XGBClassifier n_iter=100, depth=2 | 0.84 |
| Upsampling | XGBClassifier n_iter=100, depth=4 | 0.87 |
|   Total    |              Overall              | 0.81 |
+------------+-----------------------------------+------+
```