In [1]:

```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import sqlite3
import csv
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
from wordcloud import WordCloud
import re
import os
from sqlalchemy import create_engine # database connection
import datetime as dt
from nltk.corpus import stopwords
from nltk.tokenize import word_tokenize
from nltk.stem.snowball import SnowballStemmer
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.multiclass import OneVsRestClassifier
from sklearn.linear_model import SGDClassifier
from sklearn import metrics
from sklearn.metrics import f1_score,precision_score,recall_score
from sklearn import svm
from sklearn.linear_model import LogisticRegression

from datetime import datetime
from sklearn.externals import joblib

from sklearn.model_selection import GridSearchCV
```

## 3.3 Cleaning and preprocessing of Questions

## 3.3.1 Preprocessing

1. Sample 1M data points
2. Separate out code-snippets from Body
3. Remove Spcial characters from Question title and description (not in code)
4. Remove stop words (Except 'C')
5. Remove HTML Tags
6. Convert all the characters into small letters
7. Use SnowballStemmer to stem the words

In [2]:

```
def striphtml(data):
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr, ' ', str(data))
    return cleantext
stop_words = set(stopwords.words('english'))
stemmer = SnowballStemmer("english")
```

In [3]:

```
#http://www.sqlitetutorial.net/sqlite-python/create-tables/
def create_connection(db_file):
    """ create a database connection to the SQLite database
        specified by db_file
    :param db_file: database file
    :return: Connection object or None
    """
    try:
        conn = sqlite3.connect(db_file)
        return conn
    except Error as e:
        print(e)

    return None

def create_table(conn, create_table_sql):
    """ create a table from the create_table_sql statement
    :param conn: Connection object
    :param create_table_sql: a CREATE TABLE statement
    :return:
    """
    try:
        c = conn.cursor()
        c.execute(create_table_sql)
    except Error as e:
        print(e)

def checkTableExists(dbcon):
    cursr = dbcon.cursor()
    str = "select name from sqlite_master where type='table'"
    table_names = cursr.execute(str)
    print("Tables in the databse:")
    tables =table_names.fetchall()
    print(tables[0][0])
    return(len(tables))

def create_database_table(database, query):
    conn = create_connection(database)
    if conn is not None:
        create_table(conn, query)
        checkTableExists(conn)
    else:
        print("Error! cannot create the database connection.")
    conn.close()

sql_create_table = """CREATE TABLE IF NOT EXISTS QuestionsProcessed (question
create_database_table("Processed.db", sql_create_table)
```

```
Tables in the databse:
```

```
QuestionsProcessed
```

# 4. Machine Learning Models

## 4.1 Converting tags for multilabel problems

| X | y1 | y2 | y3 | y4 |
|---|---|---|---|---|
| x1 | 0 | 1 | 1 | 0 |
| x1 | 1 | 0 | 0 | 0 |
| x1 | 0 | 1 | 0 | 0 |

## 4.5 Modeling with less data points (0.5M data points) and more weight to title and 500 tags only.

In [4]:

```
sql_create_table = """CREATE TABLE IF NOT EXISTS QuestionsProcessed (questior
create_database_table("Titlemoreweight.db", sql_create_table)
```

```
Tables in the databse:
QuestionsProcessed
```

In [5]:

```
# http://www.sqlitetutorial.net/sqlite-delete/
# https://stackoverflow.com/questions/2279706/select-random-row-from-a-sqlite

read_db = 'train_no_dup.db'
write_db = 'Titlemoreweight.db'
train_datasize = 400000
if os.path.isfile(read_db):
    conn_r = create_connection(read_db)
    if conn_r is not None:
        reader =conn_r.cursor()
        # for selecting first 0.5M rows
        reader.execute("SELECT Title, Body, Tags From no_dup_train LIMIT 5000
        # for selecting random points
        #reader.execute("SELECT Title, Body, Tags From no_dup_train ORDER BY

if os.path.isfile(write_db):
    conn_w = create_connection(write_db)
    if conn_w is not None:
        tables = checkTableExists(conn_w)
        writer =conn_w.cursor()
        if tables != 0:
            writer.execute("DELETE FROM QuestionsProcessed WHERE 1")
            print("Cleared All the rows")
```

```
Tables in the databse:
QuestionsProcessed
Cleared All the rows
```

### 4.5.1 Preprocessing of questions

1. Separate Code from Body
2. Remove Spcial characters from Question title and description (not in code)
3. **Give more weightage to title : Add title three times to the question**

```
    <li> Remove stop words (Except 'C') </li>
    <li> Remove HTML Tags </li>
    <li> Convert all the characters into small letters </li>
    <li> Use SnowballStemmer to stem the words </li>
```

In [6]:

```
#http://www.bernzilla.com/2008/05/13/selecting-a-random-row-from-an-sqlite-ta
start = datetime.now()
preprocessed_data_list=[]
reader.fetchone()
questions_with_code=0
len_pre=0
len_post=0
questions_proccesed = 0
for row in reader:

    is_code = 0

    title, question, tags = row[0], row[1], str(row[2])

    if '<code>' in question:
        questions_with_code+=1
        is_code = 1
    x = len(question)+len(title)
    len_pre+=x

    code = str(re.findall(r'<code>(.*?)</code>', question, flags=re.DOTALL))

    question=re.sub('<code>(.*?)</code>', '', question, flags=re.MULTILINE|re
    question=striphtml(question.encode('utf-8'))

    title=title.encode('utf-8')

    # adding title three time to the data to increase its weight
    # add tags string to the training data

    question=str(title)+" "+str(title)+" "+str(title)+" "+question

#     if questions_proccesed<=train_datasize:
#         question=str(title)+" "+str(title)+" "+str(title)+" "+question+" "+
#     else:
#         question=str(title)+" "+str(title)+" "+str(title)+" "+question

    question=re.sub(r'[^A-Za-z0-9#+.\-]+',' ',question)
    words=word_tokenize(str(question.lower()))

    #Removing all single letter and and stopwords from question exceptt for t
    question=' '.join(str(stemmer.stem(j)) for j in words if j not in stop_wo

    len_post+=len(question)
    tup = (question,code,tags,x,len(question),is_code)
    questions_proccesed += 1
    writer.execute("insert into QuestionsProcessed(question,code,tags,words_p
    if (questions_proccesed%100000==0):
        print("number of questions completed=",questions_proccesed)
```

```
no_dup_avg_len_pre=(len_pre*1.0)/questions_proccesed
no_dup_avg_len_post=(len_post*1.0)/questions_proccesed

print( "Avg. length of questions(Title+Body) before processing: %d"%no_dup_av
print( "Avg. length of questions(Title+Body) after processing: %d"%no_dup_avg
print ("Percent of questions containing code: %d"%((questions_with_code*100.

print("Time taken to run this cell :", datetime.now() - start)
```

```
number of questions completed= 100000
number of questions completed= 200000
number of questions completed= 300000
number of questions completed= 400000
number of questions completed= 500000
Avg. length of questions(Title+Body) before processing: 1239
Avg. length of questions(Title+Body) after processing: 424
Percent of questions containing code: 57
Time taken to run this cell : 0:14:13.702826
```

In [7]:

```
# never forget to close the conections or else we will end up with database l
conn_r.commit()
conn_w.commit()
conn_r.close()
conn_w.close()
```

__ Sample quesitons after preprocessing of data __

In [8]:

```
if os.path.isfile(write_db):
    conn_r = create_connection(write_db)
    if conn_r is not None:
        reader =conn_r.cursor()
        reader.execute("SELECT question From QuestionsProcessed LIMIT 10")
        print("Questions after preprocessed")
        print('='*100)
        reader.fetchone()
        for row in reader:
            print(row)
            print('-'*100)
conn_r.commit()
conn_r.close()
```

```
Questions after preprocessed
==============================================================
======================================
('dynam datagrid bind silverlight dynam datagrid bind silverli
ght dynam datagrid bind silverlight bind datagrid dynam code w
rote code debug code block seem bind correct grid come column 
form come grid column although necessari bind nthank repli adv
ance..',)
--------------------------------------------------------------
--------------------------------------
('java.lang.noclassdeffounderror javax servlet jsp tagext tagl
ibraryvalid java.lang.noclassdeffounderror javax servlet jsp t
agext taglibraryvalid java.lang.noclassdeffounderror javax ser
vlet jsp tagext taglibraryvalid follow guid link instal jstl g
ot follow error tri launch jsp page java.lang.noclassdeffounde
rror javax servlet jsp tagext taglibraryvalid taglib declar in
stal jstl 1.1 tomcat webapp tri project work also tri version 
1.2 jstl still messag caus solv',)
--------------------------------------------------------------
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('java.sql.sqlexcept microsoft odbc driver manag invalid descr
iptor index java.sql.sqlexcept microsoft odbc driver manag inv
alid descriptor index java.sql.sqlexcept microsoft odbc driver
manag invalid descriptor index use follow code display caus so
lv',)
--------------------------------------------------------------
--------------------------------------
('better way updat feed fb php sdk better way updat feed fb ph
p sdk better way updat feed fb php sdk novic facebook api read
mani tutori still confused.i find post feed api method like co
rrect second way use curl someth like way better',)
--------------------------------------------------------------
--------------------------------------
('btnadd click event open two window record ad btnadd click ev
ent open two window record ad btnadd click event open two wind
ow record ad open window search.aspx use code hav add button s
earch.aspx nwhen insert record btnadd click event open anoth w
indow nafter insert record close window',)
--------------------------------------------------------------
--------------------------------------
('sql inject issu prevent correct form submiss php sql inject 
issu prevent correct form submiss php sql inject issu prevent 
correct form submiss php check everyth think make sure input f
ield safe type sql inject good news safe bad news one tag mess
form submiss place even touch life figur exact html use templa
t file forgiv okay entir php script get execut see data post n
one forum field post problem use someth titl field none data g
et post current use print post see submit noth work flawless s
tatement though also mention script work flawless local machin
use host come across problem state list input test mess',)
--------------------------------------------------------------
--------------------------------------
('countabl subaddit lebesgu measur countabl subaddit lebesgu m
easur countabl subaddit lebesgu measur let lbrace rbrace seque
nc set sigma -algebra mathcal want show left bigcup right leq 
sum left right countabl addit measur defin set sigma algebra m
athcal think use monoton properti somewher proof start appreci
littl help nthank ad han answer make follow addit construct gi
ven han answer clear bigcup bigcup cap emptyset neq left bigcu
p right left bigcup right sum left right also construct subset
monoton left right leq left right final would sum leq sum resu
lt follow',)
--------------------------------------------------------------
--------------------------------------
('hql equival sql queri hql equival sql queri hql equival sql 
queri hql queri replac name class properti name error occur hq
l error',)
--------------------------------------------------------------
--------------------------------------
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erenc error undefin symbol architectur i386 objc class skpsmtp
messag referenc error undefin symbol architectur i386 objc cla
ss skpsmtpmessag referenc error import framework send email ap
plic background import framework i.e skpsmtpmessag somebodi su
ggest get error collect2 ld return exit status import framewor
k correct sorc taken framework follow mfmailcomposeviewcontrol
question lock field updat answer drag drop folder project clic
k copi nthat',)
--------------------------------------------------------------
--------------------------------------
```

__ Saving Preprocessed data to a Database __

In [9]:

```
#Taking 0.5 Million entries to a dataframe.
write_db = 'Titlemoreweight.db'
if os.path.isfile(write_db):
    conn_r = create_connection(write_db)
    if conn_r is not None:
        preprocessed_data = pd.read_sql_query("""SELECT question, Tags FROM (
conn_r.commit()
conn_r.close()
```

In [10]:

```
preprocessed_data.head()
```

Out[10]:

| | question | tags |
|---|---|---|
| **0** | dynam datagrid bind silverlight dynam datagrid... | c# silverlight data-binding |
| **1** | dynam datagrid bind silverlight dynam datagrid... | c# silverlight data-binding columns |
| **2** | java.lang.noclassdeffounderror javax servlet j... | jsp jstl |
| **3** | java.sql.sqlexcept microsoft odbc driver manag... | java jdbc |
| **4** | better way updat feed fb php sdk better way up... | facebook api facebook-php-sdk |

In [11]:

```
print("number of data points in sample :", preprocessed_data.shape[0])
print("number of dimensions :", preprocessed_data.shape[1])
```

```
number of data points in sample : 500000
number of dimensions : 2
```

__ Converting string Tags to multilable output variables __

In [12]:

```
vectorizer = CountVectorizer(tokenizer = lambda x: x.split(), binary='true')
multilabel_y = vectorizer.fit_transform(preprocessed_data['tags'])
```

__ Selecting 500 Tags __

In [13]:

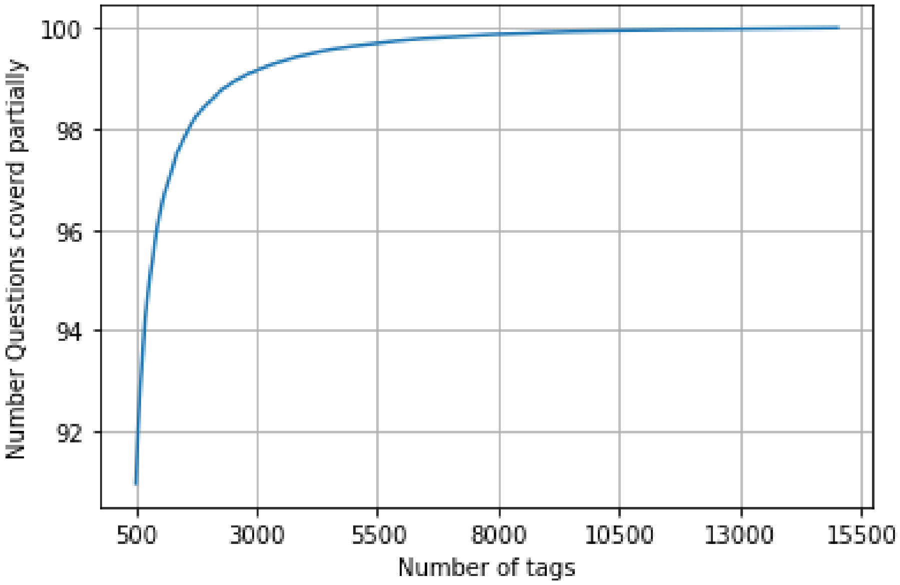
```
def tags_to_choose(n):
    t = multilabel_y.sum(axis=0).tolist()[0]
    sorted_tags_i = sorted(range(len(t)), key=lambda i: t[i], reverse=True)
    multilabel_yn=multilabel_y[:,sorted_tags_i[:n]]
    return multilabel_yn

def questions_explained_fn(n):
    multilabel_yn = tags_to_choose(n)
    x= multilabel_yn.sum(axis=1)
    return (np.count_nonzero(x==0))
```

In [14]:

```
questions_explained = []
total_tags=multilabel_y.shape[1]
total_qs=preprocessed_data.shape[0]
for i in range(500, total_tags, 100):
    questions_explained.append(np.round(((total_qs-questions_explained_fn(i))
```

In [15]:

```
fig, ax = plt.subplots()
ax.plot(questions_explained)
xlabel = list(500+np.array(range(-50,450,50))*50)
ax.set_xticklabels(xlabel)
plt.xlabel("Number of tags")
plt.ylabel("Number Questions coverd partially")
plt.grid()
plt.show()
# you can choose any number of tags based on your computing power, minimun is
print("with ",5500,"tags we are covering ",questions_explained[50],"% of ques
print("with ",500,"tags we are covering ",questions_explained[0],"% of questi
```



```
with  5500 tags we are covering  99.157 % of questions
with  500 tags we are covering  90.956 % of questions
```

In [16]:

```
# we will be taking 500 tags
multilabel_yx = tags_to_choose(500)
print("number of questions that are not covered :", questions_explained_fn(50
```

```
number of questions that are not covered : 45221 out of  50000
0
```

In [17]:

```
x_train=preprocessed_data.head(train_datasize)
x_test=preprocessed_data.tail(preprocessed_data.shape[0] - 400000)

y_train = multilabel_yx[0:train_datasize,:]
y_test = multilabel_yx[train_datasize:preprocessed_data.shape[0],:]
```

In [18]:

```
print("Number of data points in train data :", y_train.shape)
print("Number of data points in test data :", y_test.shape)
```

```
Number of data points in train data : (400000, 500)
Number of data points in test data : (100000, 500)
```

### 4.5.2 Featurizing data with TfIdf vectorizer

In [23]:

```
start = datetime.now()
vectorizer = TfidfVectorizer(min_df=0.00009, max_features=200000, smooth_idf=
                             tokenizer = lambda x: x.split(), sublinear_tf=Fa
x_train_multilabel = vectorizer.fit_transform(x_train['question'])
x_test_multilabel = vectorizer.transform(x_test['question'])
print("Time taken to run this cell :", datetime.now() - start)
```

```
Time taken to run this cell : 0:02:51.543164
```

In [24]:

```
print("Dimensions of train data X:",x_train_multilabel.shape, "Y :",y_train.s
print("Dimensions of test data X:",x_test_multilabel.shape,"Y:",y_test.shape)
```

```
Dimensions of train data X: (400000, 94928) Y : (400000, 500)
Dimensions of test data X: (99998, 94928) Y: (99998, 500)
```

### 4.5.3 Applying Logistic Regression with OneVsRest Classifier

In [25]:

```
start = datetime.now()
classifier = OneVsRestClassifier(SGDClassifier(loss='log', alpha=0.00001, per
classifier.fit(x_train_multilabel, y_train)
predictions = classifier.predict (x_test_multilabel)


print("Accuracy :",metrics.accuracy_score(y_test, predictions))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions))


precision = precision_score(y_test, predictions, average='micro')
recall = recall_score(y_test, predictions, average='micro')
f1 = f1_score(y_test, predictions, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

precision = precision_score(y_test, predictions, average='macro')
recall = recall_score(y_test, predictions, average='macro')
f1 = f1_score(y_test, predictions, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

print (metrics.classification_report(y_test, predictions))
print("Time taken to run this cell :", datetime.now() - start)
```

```
Accuracy : 0.23705474109482189
Hamming loss  0.0027796155923118463
Micro-average quality numbers
Precision: 0.7220, Recall: 0.3258, F1-measure: 0.4490
Macro-average quality numbers
Precision: 0.5483, Recall: 0.2582, F1-measure: 0.3350
              precision    recall  f1-score   support

           0       0.94      0.64      0.76      5519
           1       0.69      0.26      0.37      8189
           2       0.81      0.37      0.51      6529
           3       0.81      0.43      0.56      3231
           4       0.81      0.41      0.54      6430
           5       0.81      0.34      0.48      2878
           6       0.87      0.49      0.63      5086
           7       0.88      0.54      0.67      4533
           8       0.60      0.13      0.21      3000
           9       0.81      0.53      0.64      2765
          10       0.59      0.16      0.25      3051
          11       0.70      0.33      0.45      3000
```

In [28]:

```
joblib.dump(classifier, 'lr_with_more_title_weight.pkl')
```

Out[28]:

```
['lr_with_more_title_weight.pkl']
```

In [29]:

```
start = datetime.now()
classifier_2 = OneVsRestClassifier(LogisticRegression(penalty='l1'), n_jobs=-
classifier_2.fit(x_train_multilabel, y_train)
predictions_2 = classifier_2.predict(x_test_multilabel)
print("Accuracy :",metrics.accuracy_score(y_test, predictions_2))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions_2))


precision = precision_score(y_test, predictions_2, average='micro')
recall = recall_score(y_test, predictions_2, average='micro')
f1 = f1_score(y_test, predictions_2, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

precision = precision_score(y_test, predictions_2, average='macro')
recall = recall_score(y_test, predictions_2, average='macro')
f1 = f1_score(y_test, predictions_2, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

print (metrics.classification_report(y_test, predictions_2))
print("Time taken to run this cell :", datetime.now() - start)
```

```
Accuracy : 0.251065021300426
Hamming loss  0.0027028740574811497
Micro-average quality numbers
Precision: 0.7172, Recall: 0.3673, F1-measure: 0.4858
Macro-average quality numbers
Precision: 0.5571, Recall: 0.2951, F1-measure: 0.3711
              precision    recall  f1-score   support

           0       0.94      0.72      0.82      5519
           1       0.70      0.34      0.45      8189
           2       0.80      0.42      0.55      6529
           3       0.82      0.49      0.61      3231
           4       0.80      0.44      0.57      6430
           5       0.82      0.38      0.52      2878
           6       0.86      0.53      0.66      5086
           7       0.87      0.58      0.70      4533
           8       0.60      0.13      0.22      3000
           9       0.82      0.57      0.67      2765
          10       0.60      0.20      0.30      3051
```

# 1. Use bag of words upto 4 grams

In [19]:

```
vectorizer_bow = CountVectorizer(min_df=0.00009, ngram_range=(1,4), max_featu
vectorizer_bow.fit(x_train['question'].values) # fit has to happen only on tr

X_train_bow = vectorizer_bow.transform(x_train['question'].values)
X_test_bow = vectorizer_bow.transform(x_test['question'].values)

print("After vectorizations")
print(X_train_bow.shape, y_train.shape)
print(X_test_bow.shape, y_test.shape)
```

```
After vectorizations
(400000, 99057) (400000, 500)
(100000, 99057) (100000, 500)
```

In [ ]:

```
#Saving bows
'''from sklearn.externals import joblib
#data points with 0.5 million data
joblib.dump(X_train_bow, 'X_train_bow.pkl')
joblib.dump(X_test_bow, 'X_test_bow.pkl')

#target class i.e multilabel classes with 0.5 million
joblib.dump(y_train, 'y_train.pkl')
joblib.dump(y_test, 'y_test.pkl')'''
```

In [2]:

```
from sklearn.externals import joblib
X_train_bow = joblib.load('X_train_bow.pkl')
X_test_bow = joblib.load('X_test_bow.pkl')
y_train = joblib.load('y_train.pkl')
y_test = joblib.load('y_test.pkl')
```

In [3]:

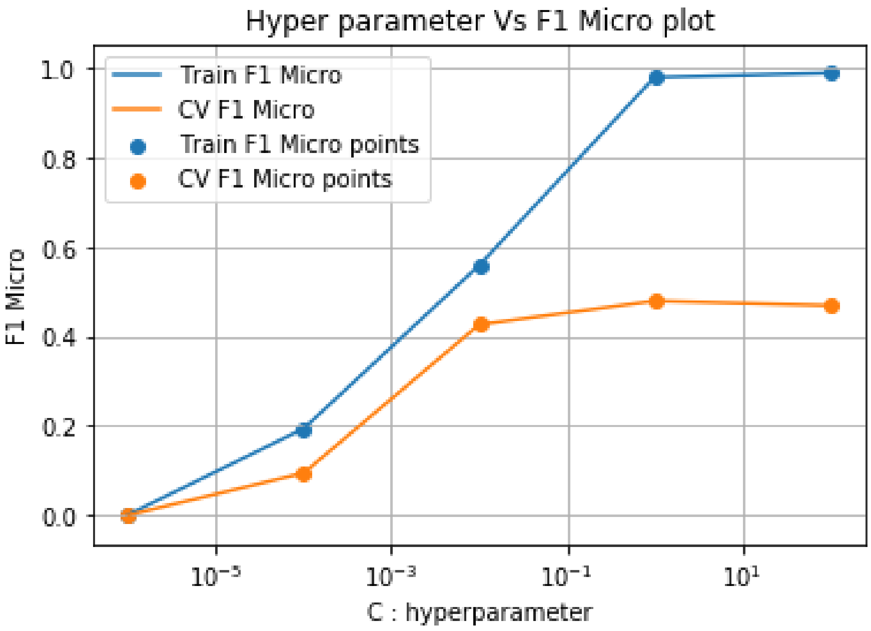
```
print(X_train_bow.shape, y_train.shape)
print(X_test_bow.shape, y_test.shape)
```

```
(400000, 99057) (400000, 500)
(100000, 99057) (100000, 500)
```

## 2. Perform hyperparameter tuning for Logistic regression using GridSearch

In [20]:

```
start = datetime.now()
parameters = {'estimator__C' : [1e-06, 1e-04, 1e-02, 1, 100]}
ovr = OneVsRestClassifier(LogisticRegression())
clf = GridSearchCV(ovr, parameters, cv=2, scoring='f1_micro', return_train_sc
clf.fit(X_train_bow, y_train)

results = pd.DataFrame.from_dict(clf.cv_results_)
results = results.sort_values(['param_estimator__C'])

train_f1_micro= results['mean_train_score']
train_f1_micro_std= results['std_train_score']
cv_f1_micro = results['mean_test_score']
cv_f1_micro_std= results['std_test_score']
K =  results['param_estimator__C']

plt.plot(K, train_f1_micro, label='Train F1 Micro')
plt.plot(K, cv_f1_micro, label='CV F1 Micro')
plt.scatter(K, train_f1_micro, label='Train F1 Micro points')
plt.scatter(K, cv_f1_micro, label='CV F1 Micro points')
plt.legend()
plt.xlabel("C : hyperparameter")
plt.xscale('log')
plt.ylabel("F1 Micro")
plt.title("Hyper parameter Vs F1 Micro plot")
plt.grid()
plt.show()
print("Time taken to run this cell :", datetime.now() - start)
```



```
Time taken to run this cell : 3:33:54.567605
```

## Compute the micro f1 score with Logistic regression(OvR)

In [10]:

```
classifier_2 = OneVsRestClassifier(LogisticRegression(C = 0.01), n_jobs=-1)
classifier_2.fit(X_train_bow, y_train)
predictions_2 = classifier_2.predict(X_test_bow)
print("Accuracy :",metrics.accuracy_score(y_test, predictions_2))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions_2))


precision = precision_score(y_test, predictions_2, average='micro')
recall = recall_score(y_test, predictions_2, average='micro')
f1 = f1_score(y_test, predictions_2, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

precision = precision_score(y_test, predictions_2, average='macro')
recall = recall_score(y_test, predictions_2, average='macro')
f1 = f1_score(y_test, predictions_2, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

print (metrics.classification_report(y_test, predictions_2))
```

```
          44       0.66      0.45      0.54       626
          45       0.68      0.32      0.43       852
          46       0.72      0.35      0.47       534
          47       0.38      0.17      0.23       350
          48       0.72      0.49      0.58       496
          49       0.79      0.57      0.66       785
          50       0.23      0.05      0.09       475
          51       0.37      0.16      0.22       305
          52       0.40      0.02      0.05       251
          53       0.65      0.38      0.48       914
          54       0.47      0.17      0.25       728
          55       0.31      0.03      0.06       258
          56       0.44      0.21      0.28       821
          57       0.42      0.11      0.17       541
          58       0.77      0.26      0.39       748
          59       0.94      0.66      0.78       724
          60       0.36      0.07      0.12       660
          61       0.75      0.21      0.33       235
          62       0.91      0.67      0.77       718
          63       0.84      0.62      0.72       468
```

## Hyperparameter tuning Linear-SVM (SGDClassifier with loss-hinge)

In [24]:

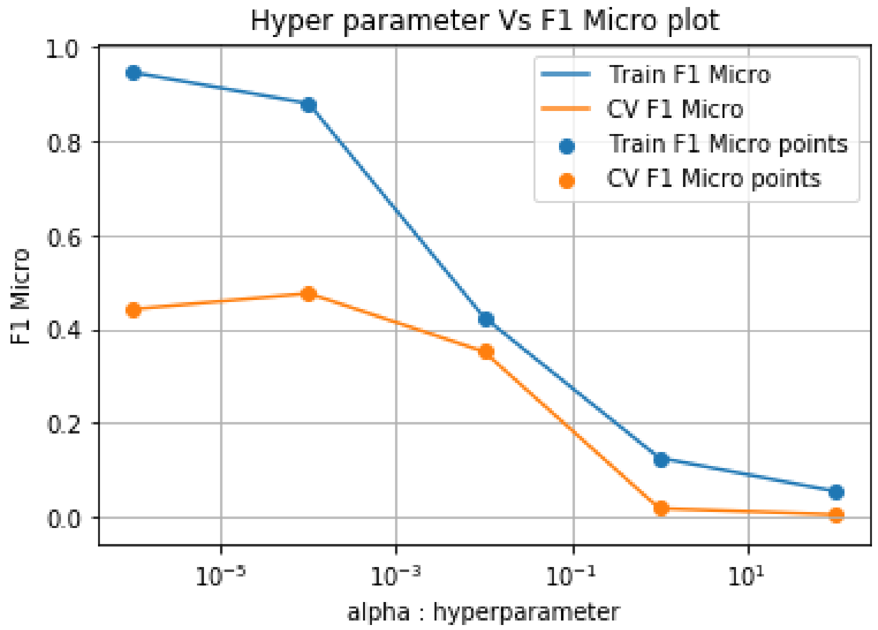
```
parameters = {'estimator__alpha' : [1e-06, 1e-04, 1e-02, 1, 100]}
ovr = OneVsRestClassifier(SGDClassifier(loss='hinge'))
clf = GridSearchCV(ovr, parameters, cv=2, scoring='f1_micro', return_train_sc
clf.fit(X_train_bow, y_train)

results_2 = pd.DataFrame.from_dict(clf.cv_results_)
results_2 = results.sort_values(['param_estimator__alpha'])

train_f1_micro= results_2['mean_train_score']
train_f1_micro_std= results_2['std_train_score']
cv_f1_micro = results_2['mean_test_score']
cv_f1_micro_std= results_2['std_test_score']
K =  results_2['param_estimator__alpha']

plt.plot(K, train_f1_micro, label='Train F1 Micro')
plt.plot(K, cv_f1_micro, label='CV F1 Micro')
plt.scatter(K, train_f1_micro, label='Train F1 Micro points')
plt.scatter(K, cv_f1_micro, label='CV F1 Micro points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.xscale('log')
plt.ylabel("F1 Micro")
plt.title("Hyper parameter Vs F1 Micro plot")
plt.grid()
plt.show()
```

```
-----------------------------------------------------------
----------------
KeyError                                  Traceback (most r
ecent call last)
<ipython-input-24-3fb0d96df475> in <module>
      5 
      6 results_2 = pd.DataFrame.from_dict(clf.cv_results_)
----> 7 results_2 = results.sort_values(['param_estimator__
alpha'])
      8 
      9 train_f1_micro= results_2['mean_train_score']

c:\users\addu\appdata\local\programs\python\python37\lib\si
te-packages\pandas\core\frame.py in sort_values(self, by, a
xis, ascending, inplace, kind, na_position)
   5006 
   5007             by = by[0]
-> 5008             k = self._get_label_or_level_values(by,
axis=axis)
   5009 
   5010             if isinstance(ascending, (tuple, list))
:

c:\users\addu\appdata\local\programs\python\python37\lib\si
```

```
te-packages\pandas\core\generic.py in _get_label_or_level_v
alues(self, key, axis)
   1772                 values = self.axes[axis].get_level_valu
es(key)._values
   1773             else:
-> 1774                 raise KeyError(key)
   1775 
   1776             # Check for duplicates

KeyError: 'param_estimator__alpha'
```

In [36]:

```
results_2 = results_2.sort_values(['param_estimator__alpha'])

train_f1_micro= results_2['mean_train_score']
train_f1_micro_std= results_2['std_train_score']
cv_f1_micro = results_2['mean_test_score']
cv_f1_micro_std= results_2['std_test_score']
K =  results_2['param_estimator__alpha']

plt.plot(K, train_f1_micro, label='Train F1 Micro')
plt.plot(K, cv_f1_micro, label='CV F1 Micro')
plt.scatter(K, train_f1_micro, label='Train F1 Micro points')
plt.scatter(K, cv_f1_micro, label='CV F1 Micro points')
plt.legend()
plt.xlabel("alpha : hyperparameter")
plt.xscale('log')
plt.ylabel("F1 Micro")
plt.title("Hyper parameter Vs F1 Micro plot")
plt.grid()
plt.show()
```



# 3. Try OneVsRestClassifier with Linear-SVM (SGDClassifier with loss-hinge)

In [9]:

```
classifier = OneVsRestClassifier(SGDClassifier(loss = 'hinge', alpha = 0.01),
classifier.fit(X_train_bow, y_train)
predictions = classifier.predict (X_test_bow)


print("Accuracy :",metrics.accuracy_score(y_test, predictions))
print("Hamming loss ",metrics.hamming_loss(y_test,predictions))


precision = precision_score(y_test, predictions, average='micro')
recall = recall_score(y_test, predictions, average='micro')
f1 = f1_score(y_test, predictions, average='micro')

print("Micro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

precision = precision_score(y_test, predictions, average='macro')
recall = recall_score(y_test, predictions, average='macro')
f1 = f1_score(y_test, predictions, average='macro')

print("Macro-average quality numbers")
print("Precision: {:.4f}, Recall: {:.4f}, F1-measure: {:.4f}".format(precisio

print (metrics.classification_report(y_test, predictions))
```

```
Accuracy : 0.20205
Hamming loss  0.00294848
Micro-average quality numbers
Precision: 0.7831, Recall: 0.2100, F1-measure: 0.3312
Macro-average quality numbers
Precision: 0.4435, Recall: 0.1134, F1-measure: 0.1617
              precision    recall  f1-score   support

           0       0.96      0.56      0.71      5519
           1       0.64      0.09      0.15      8190
           2       0.83      0.30      0.44      6529
           3       0.79      0.23      0.36      3231
           4       0.87      0.35      0.49      6430
           5       0.81      0.31      0.45      2879
           6       0.88      0.48      0.62      5086
           7       0.90      0.50      0.64      4533
           8       0.52      0.15      0.23      3000
           9       0.83      0.50      0.62      2765
          10       0.69      0.05      0.09      3051
```

# Conclusion

In [13]:

```
from prettytable import PrettyTable

table = PrettyTable()
table.field_names = ["Vectorizer", "Model", "Hyper Parameters", "Precision",
table.add_row(['TFIDF', 'Logestic Regression (SGD)', 'Alpha = 0.00001', 0.72
table.add_row(['TFIDF', 'Logestic Regression', 'C =  1', 0.7172, 0.4858])
table.add_row(['','','','',''])
table.add_row(['BOW', 'Logestic Regression', 'C = 0.01', 0.6875, 0.4380])
table.add_row(['BOW', 'Linear SVM (SGD)', 'Alpha =  0.01', 0.7831, 0.3312])
print(table)
```

```
+------------+---------------------------+------------------+-
----------+----------+
| Vectorizer |           Model           | Hyper Parameters |
Precision | F1-Micro |
+------------+---------------------------+------------------+-
----------+----------+
|   TFIDF    | Logestic Regression (SGD) | Alpha = 0.00001  |
0.722    |   0.49   |
|   TFIDF    |    Logestic Regression    |      C =  1      |
0.7172   |  0.4858  |
|            |                           |                  |
|          |
|    BOW     |    Logestic Regression    |     C = 0.01     |
0.6875   |  0.438   |
|    BOW     |      Linear SVM (SGD)     |  Alpha =  0.01   |
0.7831   |  0.3312  |
+------------+---------------------------+------------------+-
----------+----------+
```

# Summary

- Used 0.5 Million data points and Top 500 Tags
- As the dataset is large, performed 2 folds cross validation using GridSearchCV
- The best model obtained is Linear SVM with Alpha = 0.01
- BOW vectorizer on Linear SVM gave the best Precision of 78.31
- Precision was improved from 72.2 to 78.31