Loading important packages

In [11]:
```python
import pandas as pd
import numpy as np
import pickle
import re
import nltk
import string
from nltk.tokenize import TreebankWordTokenizer
from nltk.corpus import stopwords
from nltk.tokenize import sent_tokenize, word_tokenize
import matplotlib.pyplot as plt
from nltk.stem import WordNetLemmatizer
from nltk.stem import PorterStemmer
from nltk.tag import pos_tag
import numpy as np
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import MultinomialNB
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
from sklearn.metrics import mean_squared_error
from sklearn.model_selection import RandomizedSearchCV
import matplotlib.pyplot as plt
from pandas import DataFrame
```

Data Preprocessing

In [3]:
```python
# df1 = pd.read_csv('./datasets/2020-08-19.csv') '''not required for our project'''
df2 = pd.read_csv('./datasets/bgg-15m-reviews.csv')
# df3 = pd.read_csv('./datasets/games_detailed_info.csv') '''not required for our projec
```

Dropping columns which are not required.

Use once

In [4]:
```python
del df2['Unnamed: 0']
del df2['ID']
del df2['name']
del df2['user']
```

Dropping rows with NaN values.

In [5]:
```python
df = df2.dropna()
```

In [6]:
```python
df.shape
```

Out[6]:
```
(2995023, 2)
```

In [7]:
```python
df['rating'].unique()
```

Out[7]:
```
array([10.     ,  9.8    ,  9.5    , ...,  7.98525,  9.03333,  5.767  ])
```

In [9]:
```python
decimals = pd.Series([0], index=['rating'])
df = df.round(decimals)
```

In [13]:
```python
df['rating'].unique()
```

Out[13]:
```
array([10.,  9.,  8.,  7.,  6.,  5.,  4.,  3.,  2.,  1.,  0.])
```

Rounding up the ratings for better efficieny of the model

In [14]:
```python
def rating_enhancement(rating):
    if rating == 10.0:
        return int(10)
    elif rating >=9.5 and rating <10:
        return int(10)
    elif rating <9.5 and rating >=9:
        return int(9)
    elif rating >=8.5 and rating <9:
        return int(9)
    elif rating <8.5 and rating >=8:
        return int(8)
    elif rating >=7.5 and rating <8:
        return int(8)
    elif rating <7.5 and rating >=7:
        return int(7)
    elif rating >=6.5 and rating <7:
        return int(7)
    elif rating <6.5 and rating >=6:
        return int(6)
    elif rating >=5.5 and rating <6:
        return int(6)
    elif rating <5.5 and rating >=5:
        return int(5)
    elif rating >=4.5 and rating <5:
        return int(5)
    elif rating <4.5 and rating >=4:
        return int(4)
    elif rating >=3.5 and rating <4:
        return int(4)
    elif rating <3.5 and rating >=3:
        return int(3)
    elif rating >=2.5 and rating <3:
        return int(3)
    elif rating <2.5 and rating >=2:
        return int(2)
    elif rating >=1.5 and rating <2:
        return int(2)
    elif rating <1.5 and rating >=1:
        return int(1)
```

In [15]:
```python
df['rating'] = df['rating'].apply(rating_enhancement)
df['rating'] = df['rating'].apply(rating_enhancement)
```

In [16]:
```python
df = df.dropna()
```

In [17]:
```python
df['rating'].unique()
```

Out[17]:
```
array([10.,  9.,  8.,  7.,  6.,  5.,  4.,  3.,  2.,  1.,  0.])
```

In [18]:
```python
df.shape
```

Out[18]:
```
(2995023, 2)
```

In [19]:
```python
df
```

Out[19]:

	rating	comment
1	10.0	Hands down my favorite new game of BGG CON 200...
2	10.0	I tend to either love or easily tire of co-op ...
4	10.0	This is an amazing co-op game. I play mostly ...
5	10.0	Hey! I can finally rate this game I've been pl...
8	10.0	Love it- great fun with my son. 2 plays so far...
...	...	...
15823242	10.0	KS Collector's Bundle with a friend of mine
15823247	10.0	Belekokio Gerumo...
15823253	10.0	Excelente!! lo mejor que probé.
15823264	8.0	Turn based preview looks very promising. The g...
15823265	8.0	KS

2995023 rows × 2 columns

Storing in a pickle object as dataset is too large

In [20]:
```python
 with open('./datasets/pickle_data/dataset_preclean.pkl', 'wb') as pickle_file:
        pickle.dump(df, pickle_file)
```

Loading the pickle object

In [3]:
```python
with open('./datasets/pickle_data/dataset_preclean.pkl', 'rb') as pickle_file:
        df = pickle.load(pickle_file)
```

Cleaning the comments

In [12]:
```python
def clean_comments(text):
    text = re.sub(r'<.*?>', ' ', text)
    text = re.sub(r"won't", "will not", text)
    text = re.sub(r"can't", "can not", text)
    text = re.sub(r"n't", " not", text)
    text = re.sub(r"'ve", " have", text)
    text = re.sub(r"'ll", " will", text)
    text = re.sub(r"'re", " are", text)

    text = re.sub(r"[0-9]+", ' ', text)
    text = re.sub(r"-", ' ', text)


    text = text.strip().lower()


    default_stop_words = set(stopwords.words('english'))
    default_stop_words.difference_update({'no', 'not', 'nor', 'too', 'any'})
    stop_words = default_stop_words.union({"'m", "n't", "'d", "'re", "'s",
                                           'would','must',"'ve","'ll",'may'})

    word_list = word_tokenize(text)
    filtered_list = [w for w in word_list if not w in stop_words]
    text = ' '.join(filtered_list)

    text = re.sub(r"'", ' ', text)


    filters='!"\'#$%&()*+,-./:;<=>?@[\\]^_`{|}~\t\n'
    translate_dict = dict((i, " ") for i in filters)
    translate_map = str.maketrans(translate_dict)
    text = text.translate(translate_map)


    text = ' '.join([w for w in text.split() if len(w)>1])

    # Replace multiple space with one space
    text = re.sub(' +', ' ', text)

    text = ''.join(text)

    return text
```

In [23]:
```python
%%time
df['clean_comment'] = df['comment'].apply(clean_comments)
```

```
Wall time: 30min 23s
```

In [24]:
```python
freq_train1 = pd.Series(' '.join(df['clean_comment']).split()).value_counts()
less_five_freq_train1 = freq_train1[(freq_train1 <10)]
print('Words occuring less than 5 are: ')
print('')
print(less_five_freq_train1)
```

```
Words occuring less than 5 are:

aparatoso      9
fólia          9
usen           9
jinks          9
kedv           9
              ..
narodowe       1
rusht          1
torkollhat     1
inflaba        1
selebrarion    1
Length: 491238, dtype: int64
```

In [25]:
```python
%%time
df['clean_comment'] = df['clean_comment'].apply(lambda x: ' '.join(x for x in x.split() if x
not in less_five_freq_train1))
```

```
Wall time: 58.2 s
```

In [13]:
```python
def NormalizeWithPOS(text):
    # Lemmatization & Stemming according to POS tagging

    word_list = word_tokenize(text)
    rev = []
    lemmatizer = WordNetLemmatizer()
    stemmer = PorterStemmer()
    for word, tag in pos_tag(word_list):
        if tag.startswith('J'):
            w = lemmatizer.lemmatize(word, pos='a')
        elif tag.startswith('V'):
            w = lemmatizer.lemmatize(word, pos='v')
        elif tag.startswith('N'):
            w = lemmatizer.lemmatize(word, pos='n')
        elif tag.startswith('R'):
            w = lemmatizer.lemmatize(word, pos='r')
        else:
            w = word
        w = stemmer.stem(w)
        rev.append(w)
    review = ' '.join(rev)
    return review
```

In [30]:
```python
%%time
df['clean_comment'] = df['clean_comment'].apply(NormalizeWithPOS)
```

```
Wall time: 1h 51min 2s
```

In [6]:
```python
df
```

Out[6]:

	rating	comment
1	10.0	Hands down my favorite new game of BGG CON 200...
2	10.0	I tend to either love or easily tire of co-op ...
4	10.0	This is an amazing co-op game. I play mostly ...
5	10.0	Hey! I can finally rate this game I've been pl...
8	10.0	Love it- great fun with my son. 2 plays so far...
...	...	...
15823242	10.0	KS Collector's Bundle with a friend of mine
15823247	10.0	Belekokio Gerumo...
15823253	10.0	Excelente!! lo mejor que probé.
15823264	8.0	Turn based preview looks very promising. The g...
15823265	8.0	KS

2995023 rows × 2 columns

Pickling the cleaned data

In [32]:
```python
with open('./datasets/pickle_data/dataset.pkl', 'wb') as pickle_file:
        pickle.dump(df, pickle_file)
```

Load the cleaned data object

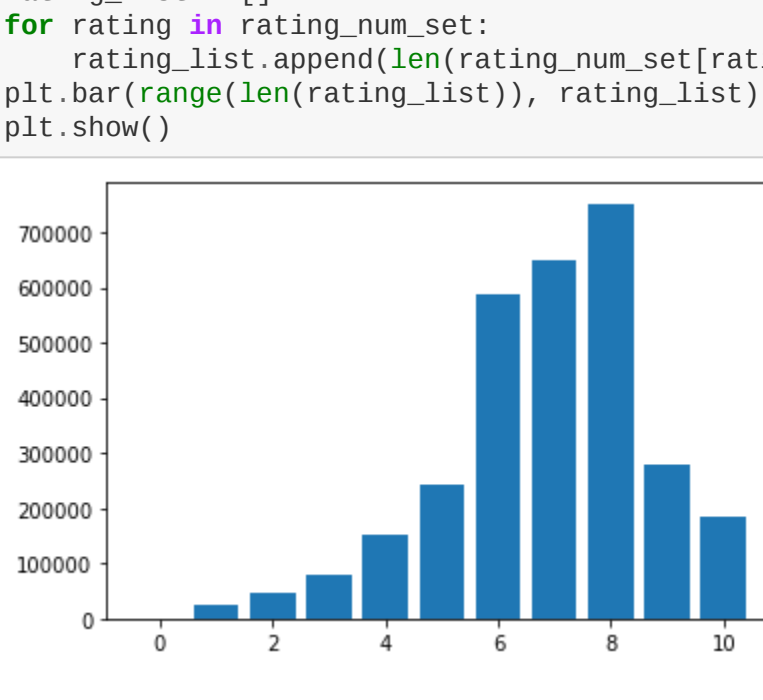
In [14]:
```python
with open('./datasets/pickle_data/dataset.pkl', 'rb') as pickle_file:
        dataset = pickle.load(pickle_file)
```

In [15]:
```python
rating_num_set = {}
for rating in (10-dataset['rating'].unique()):
    new_comment_rating = dataset.loc[dataset['rating'] >= (rating - 0.5)]
    new_comment_rating = new_comment_rating.loc[new_comment_rating['rating'] <= (rating + 0.
5)]
    new_comment_rating = new_comment_rating.sample(frac = 1).reset_index(drop = True)
    rating_num_set[rating] = new_comment_rating

for rating in rating_num_set:
```

```
rating:  0.0 rating num: 9
rating:  1.0 rating num: 23513
rating:  2.0 rating num: 45046
rating:  3.0 rating num: 79101
rating:  4.0 rating num: 151068
rating:  5.0 rating num: 242647
rating:  6.0 rating num: 587568
rating:  7.0 rating num: 650409
rating:  8.0 rating num: 751962
rating:  9.0 rating num: 279371
rating:  10.0 rating num: 184329
```

In [16]:
```python
rating_list = []
for rating in rating_num_set:
    rating_list.append(len(rating_num_set[rating]))
plt.bar(range(len(rating_list)), rating_list)
plt.show()
```



In [17]:
```python
print("A review example of dataset before cleaning:")
print(dataset.iloc[0]['comment'], end='\n\n')

print("clean_text:")
print(dataset.iloc[0]['clean_comment'], end="\n\n")
```

```
A review example of dataset before cleaning:
Hands down my favorite new game of BGG CON 2007.  We played it 5 times in a row -- it's just
that good.  Too bad Pandemic won't be in stores until January of 2008.  If you like pure coöp
games (Lord of the Rings, Feurio, etc.), this should be right up your alley.  Having 5 roles
to choose from gives the game some extra variability.  Also, once you get good you can ramp u
p the difficulty by adding more Epidemic cards.  9 -> 10

clean_text:
hand favorit new game bgg con play time row good too bad pandem not store januari like pure c
oöp game lord ring feurio etc right alley role choos give game extra variabl also get good ra
```

Train and Test Split

In [101]:
```python
X_train, X_test, y_train, y_test = train_test_split(dataset['clean_comment'], dataset['ratin
g'], test_size=0.25, random_state=42)
```

In [102]:
```python
X_train.index = [x for x in range(1, len(X_train.values)+1)]
X_test.index = [x for x in range(1, len(X_test.values)+1)]
y_train.index = [x for x in range(1, len(y_train.values)+1)]
y_test.index = [x for x in range(1, len(y_test.values)+1)]
```

In [103]:
```python
with open('./datasets/pickle_data/X_train.pkl', 'wb') as pickle_file:
    pickle.dump(X_train, pickle_file)
with open('./datasets/pickle_data/X_test.pkl', 'wb') as pickle_file:
    pickle.dump(X_test, pickle_file)
with open('./datasets/pickle_data/y_train.pkl', 'wb') as pickle_file:
    pickle.dump(y_train, pickle_file)
with open('./datasets/pickle_data/y_test.pkl', 'wb') as pickle_file:
    pickle.dump(y_test, pickle_file)
```

In [18]:
```python
with open('./datasets/pickle_data/X_train.pkl', 'rb') as pickle_file:
    X_train = pickle.load(pickle_file)
with open('./datasets/pickle_data/X_test.pkl', 'rb') as pickle_file:
    X_test = pickle.load(pickle_file)
with open('./datasets/pickle_data/y_train.pkl', 'rb') as pickle_file:
    y_train = pickle.load(pickle_file)
with open('./datasets/pickle_data/y_test.pkl', 'rb') as pickle_file:
    y_test = pickle.load(pickle_file)
```

Create Bag of Words

In [19]:
```python
vectorizer = CountVectorizer(stop_words='english')
```

In [20]:
```python
%%time

training_features = vectorizer.fit_transform(X_train)
testing_features = vectorizer.transform(X_test)
```

```
Wall time: 58.2 s
```

In [21]:
```python
with open('./datasets/pickle_data/vectorizer.pkl', 'wb') as pickle_file:
    pickle.dump(vectorizer, pickle_file)
```

Pickling the bow object

In [22]:
```python
with open('./datasets/pickle_data/training_features.pkl', 'wb') as pickle_file:
    pickle.dump(training_features, pickle_file)
with open('./datasets/pickle_data/testing_features.pkl', 'wb') as pickle_file:
    pickle.dump(testing_features, pickle_file)
```

In [23]:
```python
with open('./datasets/pickle_data/training_features.pkl', 'rb') as pickle_file:
    training_features = pickle.load(pickle_file)
with open('./datasets/pickle_data/testing_features.pkl', 'rb') as pickle_file:
    testing_features = pickle.load(pickle_file)
```

In [24]:
```python
training_features.shape
```

Out[24]:
```
(2246267, 50737)
```

In [25]:
```python
testing_features.shape
```

Out[25]:
```
(748756, 50737)
```

Multinomial Naive Bayes

Model creation

In [26]:
```python
model = MultinomialNB()
```

In [27]:
```python
%%time

model.fit(training_features, y_train)
```

```
Wall time: 1.13 s
```

Out[27]:
```
MultinomialNB()
```

In [28]:
```python
predict_total = model.predict(testing_features)
```

In [29]:
```python
predict_total
```

Out[29]:
```
array([ 6.,  7.,  8., ...,  4.,  6., 10.])
```

In [30]:
```python
y_test
```

Out[30]:
```
1         8.0
2         8.0
3         6.0
4         5.0
5         5.0
         ...
748752    3.0
748753    8.0
748754    5.0
748755    7.0
748756    8.0
Name: rating, Length: 748756, dtype: float64
```

Hyperparameter Tuning

Choosing mean squared error as my accuracy metric.

In [31]:
```python
print(model.get_params())
```

```
{'alpha': 1.0, 'class_prior': None, 'fit_prior': True}
```

In [32]:
```python
alpha = np.linspace(0,1,100)
```

In [33]:
```python
random_grid = {'alpha': alpha,
               'fit_prior': [True,False]}
print(random_grid)
```

```
{'alpha': array([0.        , 0.01010101, 0.02020202, 0.03030303, 0.04040404,
       0.05050505, 0.06060606, 0.07070707, 0.08080808, 0.09090909,
       0.1010101 , 0.11111111, 0.12121212, 0.13131313, 0.14141414,
       0.15151515, 0.16161616, 0.17171717, 0.18181818, 0.19191919,
       0.2020202 , 0.21212121, 0.22222222, 0.23232323, 0.24242424,
       0.25252525, 0.26262626, 0.27272727, 0.28282828, 0.29292929,
       0.3030303 , 0.31313131, 0.32323232, 0.33333333, 0.34343434,
       0.35353535, 0.36363636, 0.37373737, 0.38383838, 0.39393939,
       0.4040404 , 0.41414141, 0.42424242, 0.43434343, 0.44444444,
       0.45454545, 0.46464646, 0.47474747, 0.48484848, 0.49494949,
       0.50505051, 0.51515152, 0.52525253, 0.53535354, 0.54545455,
       0.55555556, 0.56565657, 0.57575758, 0.58585859, 0.5959596 ,
       0.60606061, 0.61616162, 0.62626263, 0.63636364, 0.64646465,
       0.65656566, 0.66666667, 0.67676768, 0.68686869, 0.6969697 ,
       0.70707071, 0.71717172, 0.72727273, 0.73737374, 0.74747475,
       0.75757576, 0.76767677, 0.77777778, 0.78787879, 0.7979798 ,
       0.80808081, 0.81818182, 0.82828283, 0.83838384, 0.84848485,
       0.85858586, 0.86868687, 0.87878788, 0.88888889, 0.8989899 ,
       0.90909091, 0.91919192, 0.92929293, 0.93939394, 0.94949495,
       0.95959596, 0.96969697, 0.97979798, 0.98989899, 1.        ]), 'fit_prior': [True, Fals
```

In [34]:
```python
model_random = RandomizedSearchCV(estimator = model, param_distributions = random_grid, n_it
er = 100, cv = 3, verbose=2, random_state=42, n_jobs = -1)
```

In [35]:
```python
model_random.fit(training_features, y_train)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 12 concurrent workers.
[Parallel(n_jobs=-1)]: Done  17 tasks      | elapsed:   40.3s
[Parallel(n_jobs=-1)]: Done 138 tasks      | elapsed:  1.7min
[Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed:  2.8min finished
```

Out[35]:
```
RandomizedSearchCV(cv=3, estimator=MultinomialNB(), n_iter=100, n_jobs=-1,
                   param_distributions={'alpha': array([0.        , 0.01010101, 0.02020202,
0.03030303, 0.04040404,
       0.05050505, 0.06060606, 0.07070707, 0.08080808, 0.09090909,
       0.1010101 , 0.11111111, 0.12121212, 0.13131313, 0.14141414,
       0.15151515, 0.16161616, 0.17171717, 0.18181818, 0.19191919,
       0.2020202 , 0.21212121, 0.22222222,...
       0.70707071, 0.71717172, 0.72727273, 0.73737374, 0.74747475,
       0.75757576, 0.76767677, 0.77777778, 0.78787879, 0.7979798 ,
       0.80808081, 0.81818182, 0.82828283, 0.83838384, 0.84848485,
       0.85858586, 0.86868687, 0.87878788, 0.88888889, 0.8989899 ,
       0.90909091, 0.91919192, 0.92929293, 0.93939394, 0.94949495,
       0.95959596, 0.96969697, 0.97979798, 0.98989899, 1.        ]),
                                        'fit_prior': [True, False]},
```

In [36]:
```python
model_random.best_estimator_
```

Out[36]:
```
MultinomialNB(alpha=0.9797979797979799)
```

In [37]:
```python
def evaluate(model, test_features, test_labels):
    predictions = model.predict(test_features)
    errors = abs(predictions - test_labels)
    MSE = mean_squared_error(test_labels,predictions)
    accuracy = accuracy_score(test_labels,predictions)*100
    print('Model Performance')
    print('Average Error: {:0.4f} degrees.'.format(np.mean(errors)))
    print('Accuracy = {:0.2f}%.'.format(accuracy))
    print('MSE = {:0.2f}.'.format(MSE))

    return accuracy
```

In [50]:
```python
base_model = MultinomialNB(alpha = 0.5)
base_model.fit(training_features, y_train)
base_accuracy = evaluate(base_model, testing_features, y_test)
```

```
Model Performance
Average Error: 1.2601 degrees.
Accuracy = 30.50%.
MSE = 3.30.
```

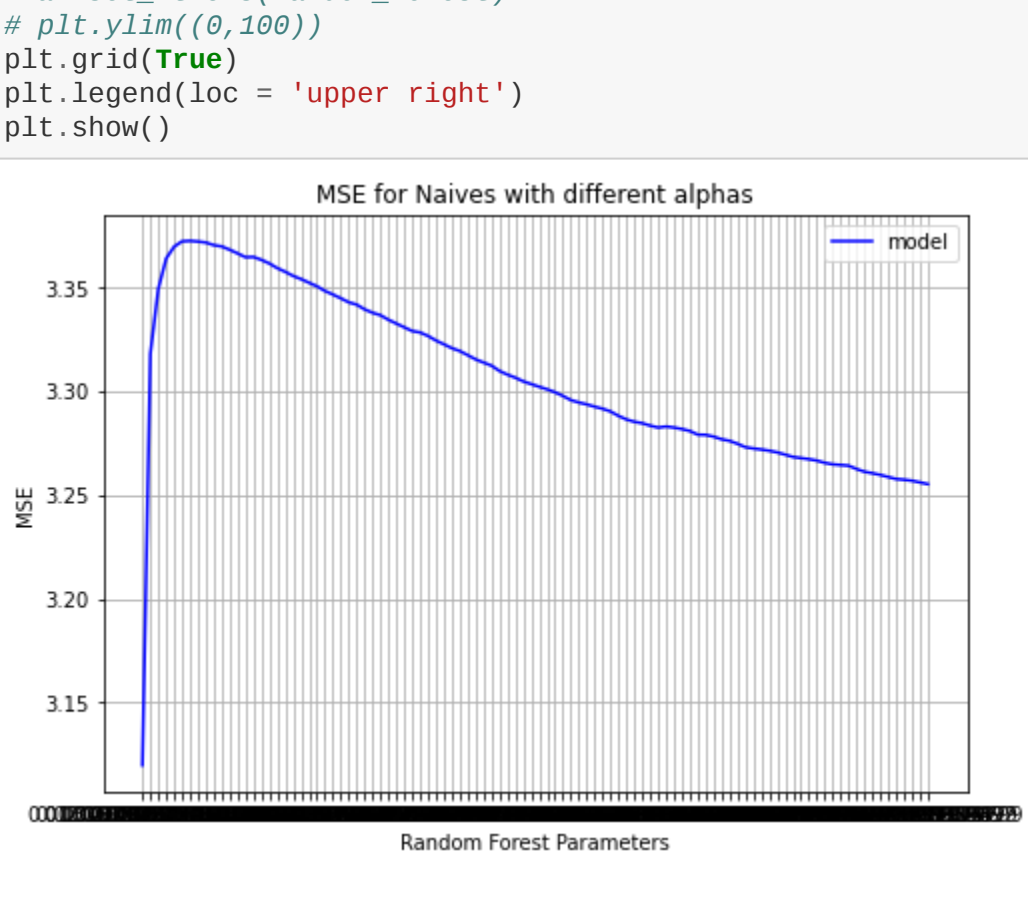
In [39]:
```python
best_random = model_random.best_estimator_
random_accuracy = evaluate(best_random, testing_features, y_test)
```

```
Model Performance
Average Error: 1.2516 degrees.
Accuracy = 30.64%.
MSE = 3.26.
```

In [45]:
```python
meanSquaredError1 = []
hyper_cond1 = []
alpha = np.linspace(0,1,100)
for i in alpha:
    nb_model = MultinomialNB(alpha = i)
    nb_model.fit(training_features, y_train)
    predictions = nb_model.predict(testing_features)
    MSE = mean_squared_error(y_test,predictions)
    meanSquaredError1.append(MSE)
    hyper_cond1.append(''+str(i))
```

```
C:\Users\jonat\anaconda3\lib\site-packages\sklearn\naive_bayes.py:511: UserWarning: alpha too
small will result in numeric errors, setting alpha = 1.0e-10
  warnings.warn('alpha too small will result in numeric errors, '
```

In [48]:
```python
fig = plt.figure()
ax = fig.add_axes([0,0,1,1])
ax.plot(hyper_cond1, meanSquaredError1, color = 'b', label ='model')
ax.set_ylabel('MSE')
ax.set_xlabel('Random Forest Parameters')
ax.set_title('MSE for Naives with different alphas')
# ax.set_xticks(random_forest)
# plt.ylim((0,100))
plt.grid(True)
plt.legend(loc = 'upper right')
plt.show()
```



From the above we can coclude that aplha value of 0 gives me the least mean squared error.

Model post Hyperparameter tuning

In [52]:
```python
final_model_multinomial = MultinomialNB(alpha = 0)
```

In [53]:
```python
%%time
final_model_multinomial.fit(training_features, y_train)
```

```
Wall time: 1.17 s
```

```
C:\Users\jonat\anaconda3\lib\site-packages\sklearn\naive_bayes.py:511: UserWarning: alpha too
small will result in numeric errors, setting alpha = 1.0e-10
  warnings.warn('alpha too small will result in numeric errors, '
```

Out[53]:
```
MultinomialNB(alpha=0)
```

In [54]:
```python
predict_total = final_model_multinomial.predict(testing_features)
```

In [55]:
```python
mean_squared_error(y_test,predict_total)
```

Out[55]:
```
3.119694533332621
```

In [56]:
```python
with open('./datasets/pickle_data/final_model_multinomial.pkl', 'wb') as pickle_file:
    pickle.dump(final_model_multinomial, pickle_file)
```

User Input and model predictions

In [28]:
```python
Input = input('Please enter a review: ')
```

```
Please enter a review: worst bad useless hated
```

In [29]:
```python
%%time

Input = [Input]
input_df = DataFrame(Input,columns=['comment'])
input_df['clean_comment'] = input_df['comment'].apply(clean_comments)
input_df['clean_comment'] = input_df['clean_comment'].apply(NormalizeWithPOS)
input_testing_features = vectorizer.transform(input_df['clean_comment'])
predict = model.predict(input_testing_features)
```

```
Wall time: 1.48 s
```

In [30]:
```python
predict[0]
```

Out[30]:
```
1.0
```