In [1]:
```
#importing all the required modules
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
from plotly import graph_objs as go
import plotly.express as px
import plotly.figure_factory as ff
from collections import Counter
from plotly.offline import plot, iplot

from PIL import Image
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator

from textblob import TextBlob
import nltk
from nltk.corpus import stopwords
nltk.download('stopwords')
nltk.download('wordnet')
from bs4 import BeautifulSoup

from tqdm import tqdm
import os
import nltk
import random,re,string
import numpy as np
import cufflinks as cf
cf.go_offline()
cf.set_config_file(offline=False, world_readable=True)
from sklearn.feature_extraction.text import CountVectorizer

import warnings
warnings.filterwarnings("ignore")
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\aksha\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\aksha\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

In [2]:
```
#importing edited dataset
train = pd.read_csv('data4.csv')
test = pd.read_csv('data5.csv')
```

In [3]:
```
#preview of training dataset
train.head()
```

Out[3]:

	rating	title	desc
0	5	Inspiring	I hope a lot of people hear this cd. We need m...
1	5	The best soundtrack ever to anything.	I'm reading a lot of reviews saying that this ...
2	4	Chrono Cross OST	The music of Yasunori Misuda is without questi...
3	5	Too good to be true	Probably the greatest soundtrack in history! U...
4	5	There's a reason for the price	There's a reason this CD is so expensive, even...

In [4]:
```
#preview of testing dataset
test.head()
```

Out[4]:

	rating	title	desc
0	1	mens ultrasheer	This model may be ok for sedentary types, but ...
1	4	Surprisingly delightful	This is a fast read filled with unexpected hum...
2	2	Works, but not as advertised	I bought one of these chargers..the instructio...
3	2	Oh dear	I was excited to find a book ostensibly about ...
4	2	Incorrect disc!	I am a big JVC fan, but I do not like this mod...

In [5]:
```
#combining both to make model better at working
train = pd.concat([train,test])
```

In [6]:
```
#newly obtained df shape
train.shape
```

Out[6]:
```
(3649999, 3)
```

In [7]:
```
#preview of newly obtained df
train.head()
```

Out[7]:

	rating	title	desc
0	5	Inspiring	I hope a lot of people hear this cd. We need m...
1	5	The best soundtrack ever to anything.	I'm reading a lot of reviews saying that this ...
2	4	Chrono Cross OST	The music of Yasunori Misuda is without questi...
3	5	Too good to be true	Probably the greatest soundtrack in history! U...
4	5	There's a reason for the price	There's a reason this CD is so expensive, even...

In [8]:
```
#combining description and title of reviews
train['desc'] = train.title + ' ' + train.desc
```

In [9]:
```
train.head()
```

Out[9]:

	rating	title	desc
0	5	Inspiring	Inspiring I hope a lot of people hear this cd....
1	5	The best soundtrack ever to anything.	The best soundtrack ever to anything. I'm read...
2	4	Chrono Cross OST	Chrono Cross OST The music of Yasunori Misuda ...
3	5	Too good to be true	Too good to be true Probably the greatest soun...
4	5	There's a reason for the price	There's a reason for the price There's a reaso...

In [10]:
```
train.shape
```

Out[10]:
```
(3649999, 3)
```

In [11]:
```
train.desc = train.desc.astype(str)
```

In [12]:
```
#creating a new column polarity using textblob module
train['polarity'] = train['desc'].map(lambda text: TextBlob(text).sentiment.polarity)
```

In [13]:
```
#new column depicting review length
train['review_len'] = train['desc'].astype(str).apply(len)
```

In [14]:
```
#new column depicting word count
train['word_count'] = train['desc'].apply(lambda x: len(str(x).split()))
```

In [15]:
```
#preview of new df
train.head()
```

Out[15]:

	rating	title	desc	polarity	review_len	word_count
0	5	Inspiring	Inspiring I hope a lot of people hear this cd....	0.445076	214	38
1	5	The best soundtrack ever to anything.	The best soundtrack ever to anything. I'm read...	0.261111	508	97
2	4	Chrono Cross OST	Chrono Cross OST The music of Yasunori Misuda ...	0.283750	410	68
3	5	Too good to be true	Too good to be true Probably the greatest soun...	0.294234	397	70
4	5	There's a reason for the price	There's a reason for the price There's a reaso...	0.250000	224	43

In [16]:
```
print('5 random reviews with the highest positive sentiment polarity: \n')
cl = train.loc[train.polarity == 1, ['desc']].sample(5).values
for c in cl:
    print(c[0])
```

```
5 random reviews with the highest positive sentiment polarity:

The Borrowers VHS with Ian Holm This was a wonderful TV series, but this VHS looks as if it was made by someone sitting in their living room videotaping it with a camera from the TV screen. It's un
watchable.
Correlle dishes The product arrived on time . The dishes were of excellent quality. I would definetely recommend this product,for a starter set .
Another great book from Dr. Sears Everything you need to know about Breastfeeding your baby is here in this book. Dr. Sears Attachment Parenting style shines through as he helps you over the bumps
and bruises of breastfeeding your newborn, all the way through to extended breastfeeding of your toddler. A must have for all AP mommies!
McCartney's done it again One word... MagnificentSir Paul McCartney, to me is THE greatest song writer/performer ever, even 30 years after the beatles, paul has still got it.
Are these flushable, biodegradable? or do you wash them? I can't rate them because I'm yet to use them. However, I also couldn't tell if you rinse the liner along with the diaper and throw in the w
asher or if these are best for those with a diaper service...
```

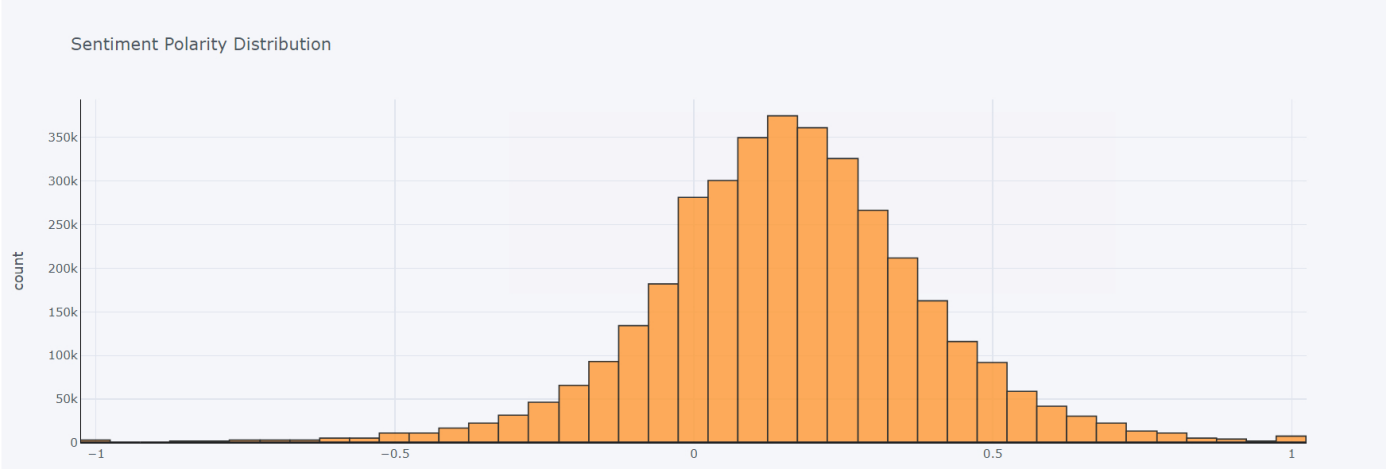
In [17]:
```
print('5 random reviews with the most neutral sentiment(zero) polarity: \n')
cl = train.loc[train.polarity == 0, ['desc']].sample(5).values
for c in cl:
    print(c[0])
```

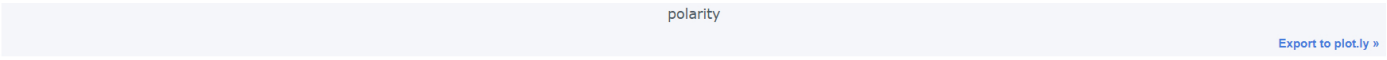
```
5 random reviews with the most neutral sentiment(zero) polarity:

Should be titled "War on Christianity" Although Gibson could have written a longer book with more insight into the entire anti-christian movement, he was trying to stick to one topic. This work sho
ws how blatant and discernible the radicals have become in their "war" against anything they disagree with. Especially when it comes to pushing their views on Republicans and Democrats alike. Infor
mative reading but not too deep.
same leaks i bought this and it leaked,tried to contact some 1 but no responce as of yet,it leaks at seam and drain
Not all the songs you thought you was purchasing came with the album I only got 5 songs i did not get all the songs that's suppose to come with the entire album
DID SEEM TO MAKE DIFFEANCE USED THIS PRODUCT FOR 6 MONTHS AND NOTICED A DIFFEANCE IN HAIR GROWTH AND COLOR I AM STILL USING IF AMONST FRIENDS
SK 89300 12 Piece Wrench Set SK 89300 12 Piece 8 Millmeter to 19 millimeter spline GPro racheting wrench set not made in USA. Made in TawainSpoke to a person in SK corporation today. Katie at custo
rmer svc saids their GPro series wrenches and some of their air tools are made in Taiwan. 708-485-4574 SK will not refund the money I spend; however, going to disclose in SK website that GPRO serie
s wrenches are made in Taiwin. 9/10/2007
```

In [29]:
```
print('5 reviews with the most negative polarity: \n')
cl = train.loc[train.polarity == -1, ['desc']].sample(5).values
for c in cl:
    print(c[0])
```

```
5 reviews with the most negative polarity:

hate non arrived!!!!!!!!!!! Commande soi-disant "shipped" fin octobre 2009 et toujours pas arrivée ce 20 décembre 2009..... Comment faire pour se plaindre auprès d'Amazon?
worst book ever made read. book boring. went whites like Indians. stunk like..... stunk.
pain hinny buy party bus... worst piece polly pocket toys. bus maze put together take apart. Durability nada... keep shopping..
$299: mind? must crazy! $299! thinking? one DVD? planet from? Deffinitily Earth! Woop!
looking for. didVictoria Johnson: Power Shaping, Vol. 2I like workout. find boring.
```

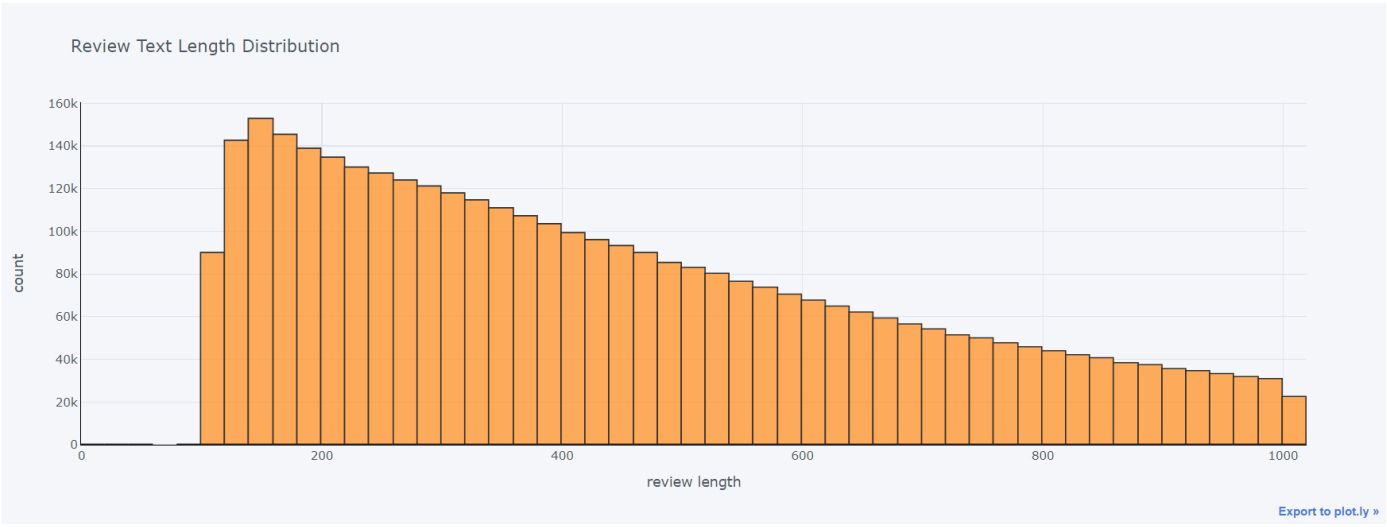
In [19]:
```
train['polarity'].iplot(
    kind='hist',
    bins=50,
    xTitle='polarity',
    linecolor='black',
    yTitle='count',
    title='Sentiment Polarity Distribution')
```



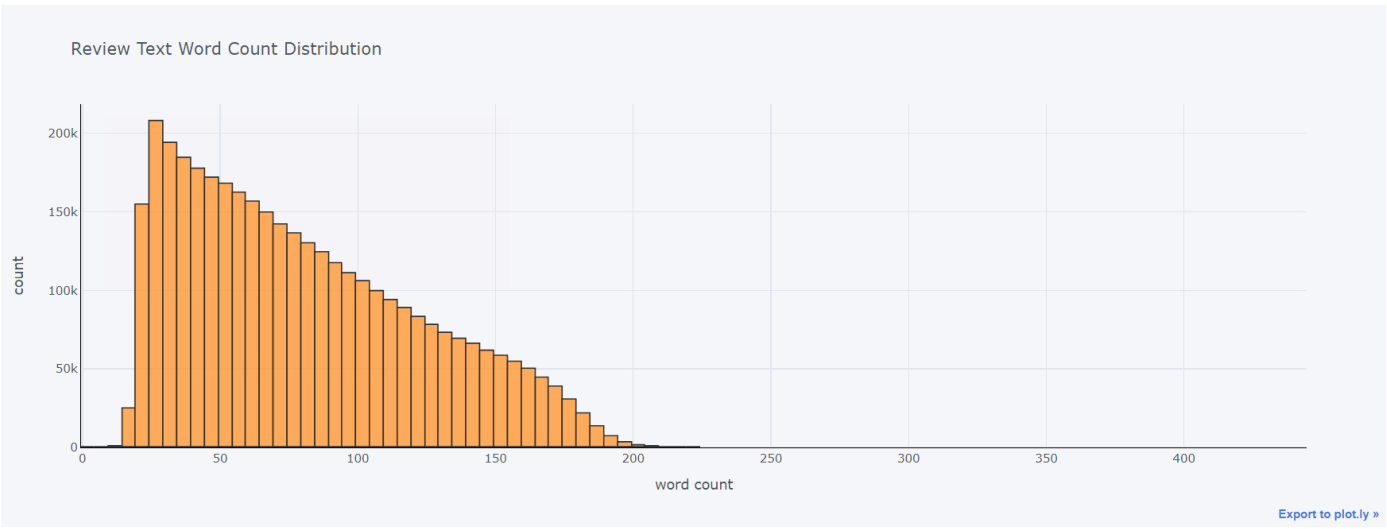


In [20]:
```
# we can see overall polarity is on positive side
```

In [21]:
```
train['review_len'].iplot(
    kind='hist',
    bins=100,
    xTitle='review length',
    linecolor='black',
    yTitle='count',
    title='Review Text Length Distribution')
```



In [22]:
```
train['word_count'].iplot(
    kind='hist',
    bins=100,
    xTitle='word count',
    linecolor='black',
    yTitle='count',
    title='Review Text Word Count Distribution')
```



In [23]:
```
#deleting non-required columns
del train['title']
```

In [24]:
```
#preview of df on which we will finally work
train.head()
```

Out[24]:

	rating	desc	polarity	review_len	word_count
0	5	Inspiring I hope a lot of people hear this cd....	0.445076	214	38
1	5	The best soundtrack ever to anything. I'm read...	0.261111	508	97
2	4	Chrono Cross OST The music of Yasunori Misuda ...	0.283750	410	68
3	5	Too good to be true Probably the greatest soun...	0.294234	397	70
4	5	There's a reason for the price There's a reaso...	0.250000	224	43

In [13]:
```
#removing reviews with neutral sentiment
train = train[train.rating != 3]
```

In [14]:
```
#freq. of rest of reviews inn terms of rating
train.rating.value_counts()
```

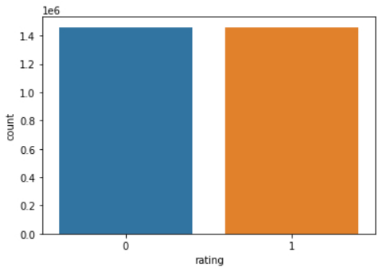
Out[14]:
```
5    730000
4    730000
1    730000
2    730000
```

```
Name: rating, dtype: int64
```

In [15]:
```python
#naming reviews with 1 and 2 rating as negative review while those with rating of 4 and 5 are termed as positive
train.rating = train.rating.replace([1,2,4,5],[0,0,1,1])
```

In [50]:
```python
sns.countplot(x = train.rating)
```

Out[50]:
```
<AxesSubplot:xlabel='rating', ylabel='count'>
```



In [ ]:
```python
#both the categories are in almost same ratio. So the dataset is already balanced.
```

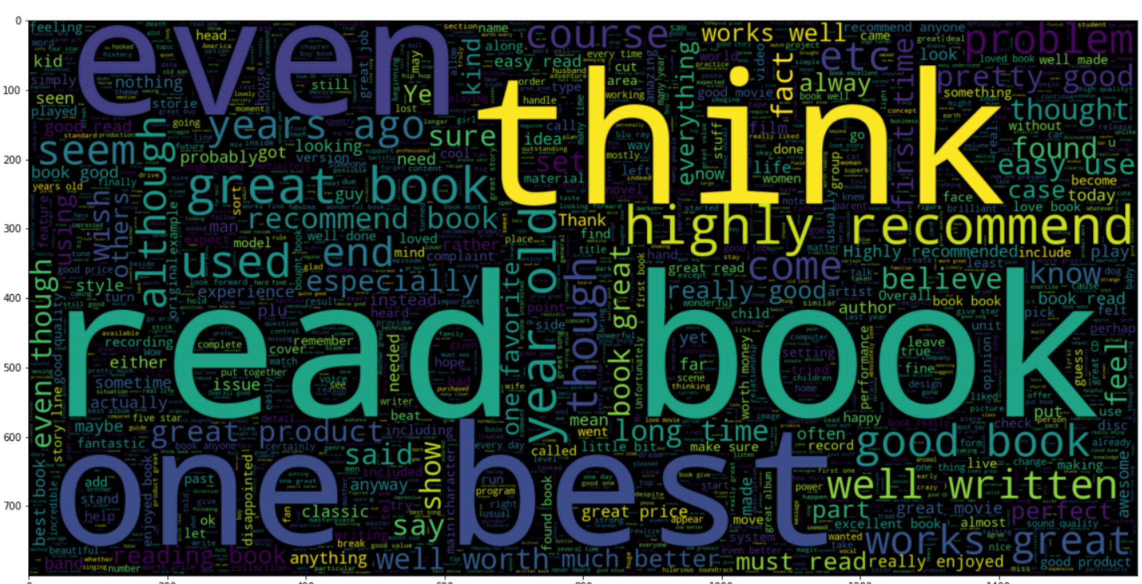
In [25]:
```python
#importing stopwords to remove general terms
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords


stop = set(stopwords.words('english'))
punctuation = list(string.punctuation)
stop.update(punctuation)
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\aksha\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

In [26]:
```python
#defining functions for text cleaning
def strip_html(text):
    soup = BeautifulSoup(text, "html.parser")
    return soup.get_text()

#Removing the square brackets
def remove_between_square_brackets(text):
    return re.sub('\[[^]]*\]', '', text)
# Removing URL's
def remove_between_square_brackets(text):
    return re.sub(r'http\S+', '', text)
#Removing the stopwords from text
def remove_stopwords(text):
    final_text = []
    for i in text.split():
        if i.strip().lower() not in stop:
            final_text.append(i.strip())
    return " ".join(final_text)
#Removing the noisy text
def denoise_text(text):
    text = strip_html(text)
    text = remove_between_square_brackets(text)
    text = remove_stopwords(text)
    return text
#Apply function on review column
train['desc'] = train['desc'].apply(denoise_text)
```

In [42]:
```python
plt.figure(figsize = (20,20)) # positive reviews wordplot to spot frequent terms in postive reviews
wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords = STOPWORDS).generate(" ".join(train[train.rating == 1].desc))
plt.imshow(wc , interpolation = 'bilinear')
```

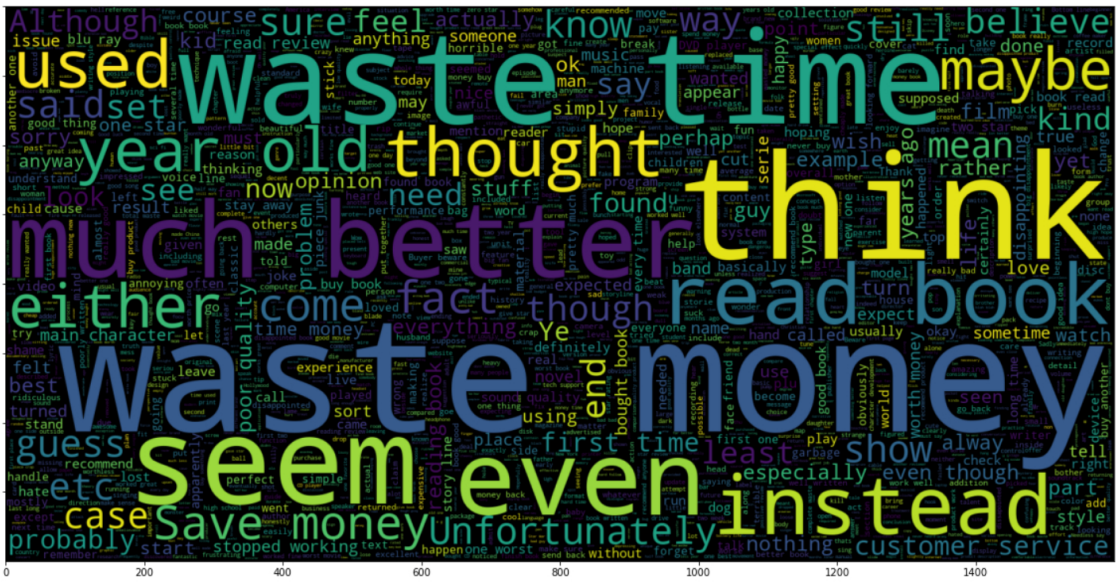
Out[42]:
```
<matplotlib.image.AxesImage at 0x23dece98400>
```



In [44]:
```python
plt.figure(figsize = (20,20)) # negative reviews wordplot to spot frequent terms in negative reviews
wc = WordCloud(max_words = 2000 , width = 1600 , height = 800 , stopwords = STOPWORDS).generate(" ".join(train[train.rating == 0].desc))
plt.imshow(wc , interpolation = 'bilinear')
```

```
<matplotlib.image.AxesImage at 0x24768b85970>
```

Out[44]:



In [46]:
```
# No irrelevent word found in both the categories, (words that do not belong to their respective category)
```

In [20]:
```
#importing necessary modules for building a sequential model
from sklearn.preprocessing import LabelBinarizer
import nltk
from sklearn.preprocessing import LabelBinarizer
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
from wordcloud import WordCloud,STOPWORDS
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import word_tokenize,sent_tokenize
from bs4 import BeautifulSoup
import re,string,unicodedata
from keras.preprocessing import text, sequence
from nltk.tokenize.toktok import ToktokTokenizer
from sklearn.metrics import classification_report,confusion_matrix,accuracy_score
from sklearn.model_selection import train_test_split
from string import punctuation
from nltk import pos_tag
from nltk.corpus import wordnet
import keras
from keras.models import Sequential
from keras.layers import Dense,Embedding,LSTM,Dropout,CuDNNLSTM
import tensorflow as tf
```

In [21]:
```
#splitting data into training and testing data
x_train,x_test,y_train,y_test = train_test_split(train.desc,train.rating,random_state = 0)
```

In [22]:
```
max_features = 10000
maxlen = 300
```

In [23]:
```
#tokenizing data
tokenizer = text.Tokenizer(num_words=max_features)
tokenizer.fit_on_texts(x_train)
tokenized_train = tokenizer.texts_to_sequences(x_train)
x_train = sequence.pad_sequences(tokenized_train, maxlen=maxlen)
```

In [24]:
```
tokenized_test = tokenizer.texts_to_sequences(x_test)
X_test = sequence.pad_sequences(tokenized_test, maxlen=maxlen)
```

In [25]:
```
#importing GloVe embedding file
EMBEDDING_FILE = 'D:\Downloads\Compressed\glove.twitter\glove.twitter.27B.1000d.txt'
```

In [26]:
```
def get_coefs(word, *arr):
    return word, np.asarray(arr, dtype='float32')
embeddings_index = dict(get_coefs(*o.rstrip().rsplit(' ')) for o in open(EMBEDDING_FILE))
```

In [27]:
```
all_embs = np.stack(embeddings_index.values())
emb_mean,emb_std = all_embs.mean(), all_embs.std()
embed_size = all_embs.shape[1]

word_index = tokenizer.word_index
nb_words = min(max_features, len(word_index))
#change below line if computing normal stats is too slow
embedding_matrix = embedding_matrix = np.random.normal(emb_mean, emb_std, (nb_words, embed_size))
for word, i in word_index.items():
    if i >= max_features: continue
    embedding_vector = embeddings_index.get(word)
    if embedding_vector is not None: embedding_matrix[i] = embedding_vector
```

In [28]:
```
#specifying values for our sequential model
batch_size = 256
epochs = 10
embed_size = 100
```

In [29]:
```
#importing module for reducing learning rate in case of training curve plateau
from keras.callbacks import ReduceLROnPlateau
```

In [30]:
```
learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy', patience = 2, verbose=1,factor=0.5, min_lr=0.00001)
```

In [31]:
```
#Defining Neural Network
model = Sequential()
#Non-trainable embeddidng layer
model.add(Embedding(max_features, output_dim=embed_size, weights=[embedding_matrix], input_length=maxlen, trainable=False))
#LSTM
model.add(CuDNNLSTM(units=128 , return_sequences = True ))
model.add(CuDNNLSTM(units=64 ))
model.add(Dense(units = 32 , activation = 'relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer=keras.optimizers.Adam(lr = 0.01), loss='binary_crossentropy', metrics=['accuracy'])
```

In [32]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding (Embedding)        (None, 300, 100)          1000000
_________________________________________________________________
cu_dnnlstm (CuDNNLSTM)       (None, 300, 128)          117760
_________________________________________________________________
cu_dnnlstm_1 (CuDNNLSTM)     (None, 64)                49664
_________________________________________________________________
dense (Dense)                (None, 32)                2080
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 33
=================================================================
Total params: 1,169,537
Trainable params: 169,537
Non-trainable params: 1,000,000
_________________________________________________________________
```

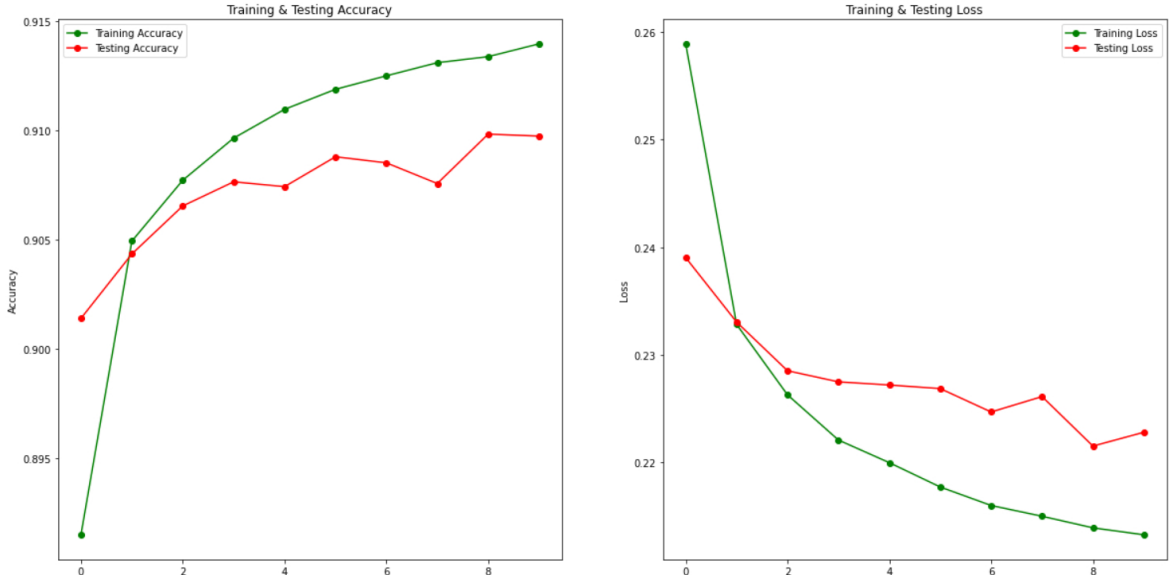
In [33]:
```
history = model.fit(x_train, y_train, batch_size = batch_size , validation_data = (X_test,y_test) , epochs = epochs)
```

```
Epoch 1/10
8555/8555 [==============================] - 1176s 136ms/step - loss: 0.2912 - accuracy: 0.8731 - val_loss: 0.2390 - val_accuracy: 0.9014
Epoch 2/10
8555/8555 [==============================] - 1210s 141ms/step - loss: 0.2326 - accuracy: 0.9050 - val_loss: 0.2330 - val_accuracy: 0.9043
Epoch 3/10
8555/8555 [==============================] - 1208s 141ms/step - loss: 0.2261 - accuracy: 0.9079 - val_loss: 0.2285 - val_accuracy: 0.9065
Epoch 4/10
8555/8555 [==============================] - 1210s 141ms/step - loss: 0.2207 - accuracy: 0.9104 - val_loss: 0.2275 - val_accuracy: 0.9077
Epoch 5/10
8555/8555 [==============================] - 1211s 142ms/step - loss: 0.2192 - accuracy: 0.9112 - val_loss: 0.2272 - val_accuracy: 0.9074
Epoch 6/10
8555/8555 [==============================] - 1208s 141ms/step - loss: 0.2160 - accuracy: 0.9126 - val_loss: 0.2269 - val_accuracy: 0.9088
Epoch 7/10
8555/8555 [==============================] - 1208s 141ms/step - loss: 0.2149 - accuracy: 0.9130 - val_loss: 0.2247 - val_accuracy: 0.9085
Epoch 8/10
8555/8555 [==============================] - 1209s 141ms/step - loss: 0.2138 - accuracy: 0.9137 - val_loss: 0.2261 - val_accuracy: 0.9076
Epoch 9/10
8555/8555 [==============================] - 1210s 141ms/step - loss: 0.2124 - accuracy: 0.9142 - val_loss: 0.2215 - val_accuracy: 0.9098
Epoch 10/10
8555/8555 [==============================] - 1210s 141ms/step - loss: 0.2117 - accuracy: 0.9147 - val_loss: 0.2228 - val_accuracy: 0.9097
```

In [34]:
```
print("Accuracy of the model on Training Data is - " , model.evaluate(x_train,y_train)[1]*100)
print("Accuracy of the model on Testing Data is - " , model.evaluate(X_test,y_test)[1]*100)
```

```
68438/68438 [==============================] - 2404s 35ms/step - loss: 0.2073 - accuracy: 0.9167
Accuracy of the model on Training Data is -  91.66904091835022
22813/22813 [==============================] - 773s 34ms/step - loss: 0.2228 - accuracy: 0.9097
Accuracy of the model on Testing Data is -  90.97479581832886
```

In [35]:
```
epochs = [i for i in range(10)]
fig , ax = plt.subplots(1,2)
train_acc = history.history['accuracy']
train_loss = history.history['loss']
val_acc = history.history['val_accuracy']
val_loss = history.history['val_loss']
fig.set_size_inches(20,10)

ax[0].plot(epochs , train_acc , 'go-' , label = 'Training Accuracy')
ax[0].plot(epochs , val_acc , 'ro-' , label = 'Testing Accuracy')
ax[0].set_title('Training & Testing Accuracy')
ax[0].legend()
ax[0].set_xlabel("Epochs")
ax[0].set_ylabel("Accuracy")

ax[1].plot(epochs , train_loss , 'go-' , label = 'Training Loss')
ax[1].plot(epochs , val_loss , 'ro-' , label = 'Testing Loss')
ax[1].set_title('Training & Testing Loss')
ax[1].legend()
ax[1].set_xlabel("Epochs")
ax[1].set_ylabel("Loss")
plt.show()
```



Epochs

Epochs

In [45]:
```
#no overfitting spotted as seen from above plots
```

In [36]:
```
pred = model.predict_classes(X_test)
pred[:5]
```

Out[36]:
```
array([[0],
       [1],
       [1],
       [1],
       [1]])
```

In [37]:
```
print(classification_report(y_test, pred, target_names = ['Negative','Positive']))
```

```
              precision    recall  f1-score   support

    Negative       0.91      0.91      0.91    364397
    Positive       0.91      0.91      0.91    365603

    accuracy                           0.91    730000
   macro avg       0.91      0.91      0.91    730000
weighted avg       0.91      0.91      0.91    730000
```

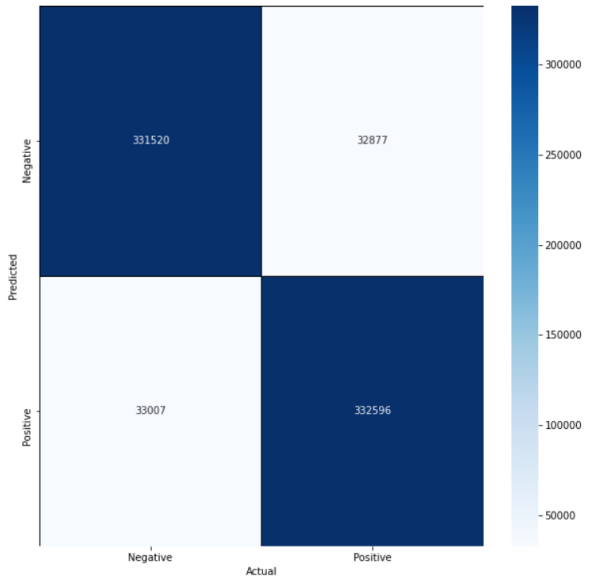
In [38]:
```
cm = confusion_matrix(y_test,pred)
cm
```

Out[38]:
```
array([[331520,  32877],
       [ 33007, 332596]], dtype=int64)
```

In [39]:
```
cm = pd.DataFrame(cm , index = ['Negative','Positive'] , columns = ['Negative','Positive'])
```

In [40]:
```
#plotting the confusion matrix obtained in previous steps
plt.figure(figsize = (10,10))
sns.heatmap(cm,cmap= "Blues", linecolor = 'black' , linewidth = 1 , annot = True, fmt='' , xticklabels = ['Negative','Positive'] , yticklabels = ['Negative','Positive'])
plt.xlabel("Actual")
plt.ylabel("Predicted")
```

Out[40]:
```
Text(69.0, 0.5, 'Predicted')
```



In [41]:
```
# Suggestions to improve performance--
#1. Using UlmFit instead, for massively faster processing or even better results.
#2. Changing parameters of our sequential model.
#3. Ratings with 3 stars were removed, as they can be considered neutral. If they can be utilised it would be much better.
#4. Using LSTM layer with recurrent dropout and other parameters instead of CuDNNLSTM for better results. (It would increase accuracy but massively decrease speed of model training on discrete GPU
```