In [1]:

```
import numpy as np # linear algebra
import pandas as pd # data processing
```

In [2]:

```
from google.colab import drive
drive.mount("/content/gdrive")
```

```
Mounted at /content/gdrive
```

In [3]:

```
data=pd.read_csv('/content/gdrive/My Drive/sentiment analysis/Reviews.csv')
data.head()
```

Out[3]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	S
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	5	1303862400	I
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	1	1346976000	A
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	4	1219017600	
3	4	B000UA0QIQ	A395BORC6FGVXV	Karl	3	3	2	1307923200	
4	5	B006K2ZZ7K	A1UQRSCLF8GW1T	Michael D. Bigham "M. Wassir"	0	0	5	1350777600	G

In [4]:

```
#preprocessing the data
data.shape
```

Out[4]:

```
(568454, 10)
```

In [5]:

```
data.dtypes
```

Out[5]:

```
Id                      int64
```

```
ProductId                object
UserId                   object
ProfileName              object
HelpfulnessNumerator      int64
HelpfulnessDenominator    int64
Score                     int64
Time                      int64
Summary                  object
Text                     object
dtype: object
```

In [6]:

```
data.describe().transpose()
```

Out[6]:

	count	mean	std	min	25%	50%	75%	
Id	568454.0	2.842275e+05	1.640987e+05	1.0	1.421142e+05	2.842275e+05	4.263408e+05	5.68
HelpfulnessNumerator	568454.0	1.743817e+00	7.636513e+00	0.0	0.000000e+00	0.000000e+00	2.000000e+00	8.66
HelpfulnessDenominator	568454.0	2.228810e+00	8.289740e+00	0.0	0.000000e+00	1.000000e+00	2.000000e+00	9.23
Score	568454.0	4.183199e+00	1.310436e+00	1.0	4.000000e+00	5.000000e+00	5.000000e+00	5.00
Time	568454.0	1.296257e+09	4.804331e+07	939340800.0	1.271290e+09	1.311120e+09	1.332720e+09	1.35

In [7]:

```
# Check null values
data.isna().sum().to_frame(name='# of missing values')
```

Out[7]:

	# of missing values
Id	0
ProductId	0
UserId	0
ProfileName	16
HelpfulnessNumerator	0
HelpfulnessDenominator	0
Score	0
Time	0
Summary	27
Text	0

In [8]:

```
total_rows =  data.shape[0]
data.dropna(how='any',inplace=True)
remaining_rows= data.shape[0]

removed_rows = total_rows-remaining_rows
print("No. of rows removed :", removed_rows)

print(f"\nPercentage of data removed:{np.round((removed_rows/total_rows)*100,2)}%")
print(f"Percentage of data remaining:{np.round((remaining_rows/total_rows)*100,2)}%")
```

```
No. of rows removed : 43

Percentage of data removed:0.01%
Percentage of data remaining:99.99%
```

In [9]:

```
#remove duplicate rows
a =  data.shape[0]
data.drop_duplicates(inplace=True, subset=['Score','Text'])
b = data.shape[0]

print("No. of rows removed :", a-b)

print(f"\nPercentage of data removed: {np.round(((a-b)/total_rows)*100,2)}%")
print(f"Percentage of data remaining: {np.round((b/total_rows)*100,2)}%")
```

```
No. of rows removed : 174750

Percentage of data removed: 30.74%
Percentage of data remaining: 69.25%
```

Splitting the dataset into positive ,negative and neutal values i.e. neutral: score = 3 positive: score > 3 negative: score <3

In [10]:

```
#Create target column using Score

def create_target(x):

    return "Positive" if x>3 else "Negative" if x<3 else "Neutral"

data.loc[:, 'target'] = data.Score.apply(create_target)
```

In [11]:

```
## `Score` > 3 : "Positive"
## `Score` == 3 : "Neutral"
## `Score` < 3 : "Negative"
positive = data[data['Score'] > 3]
negative = data[data['Score'] < 3]
neutral = data[data['Score'] == 3]
```

In [12]:

```
negative.head()
```

Out[12]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	1	1346976000
3	4	B000UA0QIQ	A395BORC6FGVXV	Karl	3	3	2	1307923200
12	13	B0009XLVG0	A327PCT23YH90	LT	1	1	1	1339545600
16	17	B001GVISJM	A3KLWF6WQ5BNYO	Erica Neathery	0	0	2	1348099200

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time
26	27	B001GVISJM	A3RXAU2N8KV45G	lady21	0	1	1	1332633600

In [13]:

```
positive.head()
```

Out[13]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	5	1303862400
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	4	1219017600
4	5	B006K2ZZ7K	A1UQRSCLF8GW1T	Michael D. Bigham "M. Wassir"	0	0	5	1350777600
5	6	B006K2ZZ7K	ADT0SRK1MGOEU	Twoapennything	0	0	4	1342051200
6	7	B006K2ZZ7K	A1SP2KVKFXXRU1	David C. Sullivan	0	0	5	1340150400

In [14]:

```
# target column
data[['Score', 'target']].sample(10)
```

Out[14]:

	Score	target
476202	5	Positive
298274	5	Positive
231859	5	Positive
284911	2	Negative
449524	5	Positive
476844	5	Positive
242728	5	Positive
554918	5	Positive
109837	3	Neutral

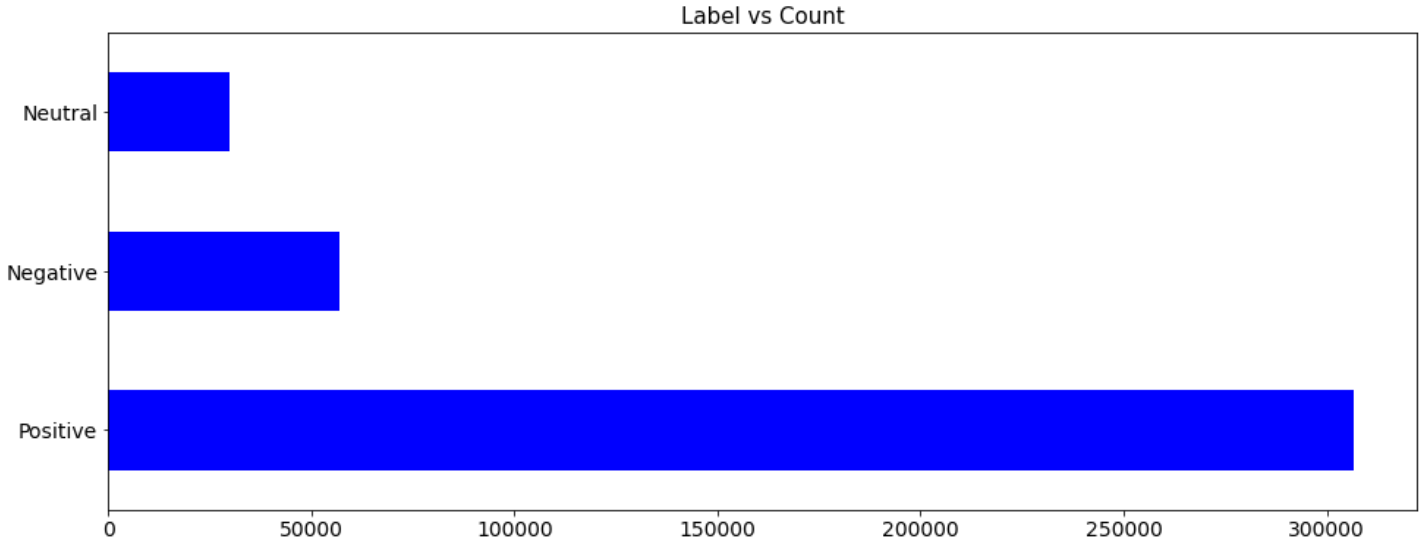
	Score	target
280370	5	Positive

In [15]:

```
import matplotlib.pyplot as plt
import seaborn as sns
```

In [16]:

```
#Target distribution (Before)
fig, ax = plt.subplots(figsize=(16, 6))

vc = data.target.value_counts()
vc.plot.barh(color="blue",fontsize=14,ax=ax)
ax.set_title("Label vs Count", fontsize=15)
plt.show()
```



In [17]:

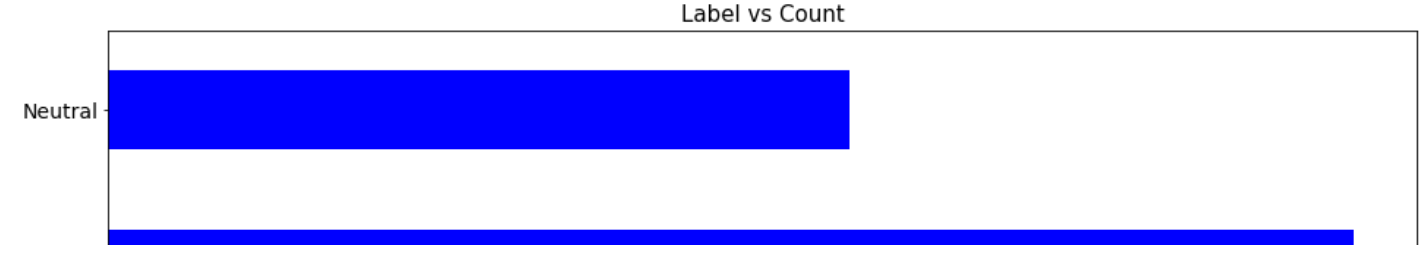
```
#down sampling
#remove some positive and negative reviews
neutral = data.loc[data.target=="Neutral"]

positive = data.loc[data.target=="Positive"].sample(50000)

negative = data.loc[data.target=="Negative"].sample(50000)

data = pd.concat([positive, negative, neutral])
data.shape
```

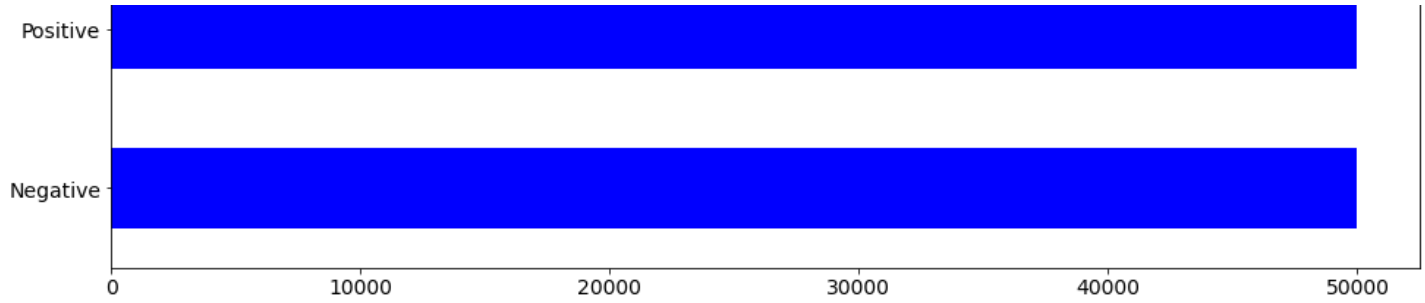
Out[17]:

```
(129770, 11)
```

In [18]:

```
#Target distribution (after)
fig, ax = plt.subplots(figsize=(16, 6))

vc = data.target.value_counts()
vc.plot.barh(color="blue",fontsize=14,ax=ax)
ax.set_title("Label vs Count", fontsize=15)
plt.show()
```





STOP WORDS

In [19]:

```
import nltk
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

Out[19]:

```
True
```

In [20]:

```
from wordcloud import WordCloud, STOPWORDS
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import accuracy_score, confusion_matrix

import string
import re

from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer

from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import MultinomialNB
```

In [21]:

```
# stopwords
total_stopwords = set(stopwords.words('english'))
# subtract negative stop words like no, not, don't etc.. from total_stopwords
negative_stop_words = set(word for word in total_stopwords
                          if "n't" in word or 'no' in word)
final_stopwords = total_stopwords - negative_stop_words
final_stopwords.add("one")
print(final_stopwords)
```

```
{'in', 'hasn', 'ours', 'too', 'their', 'being', "it's", 'once', 'to', 'ourselves', 'what'
, 'won', 'itself', 'are', 'down', 're', 'is', 'aren', 'into', 'needn', 's', 'can', 'thems
elves', "that'll", 'other', 'so', 'with', 'than', 'few', 'further', 'wasn', 'from', 'did'
, 'this', 'as', 'its', "you're", 'above', 'after', 'an', 'both', 'yours', 'myself', 'a',
'wouldn', 'under', 'between', 'against', 'were', 'mightn', 'm', 'but', "you'll", 'about',
'at', 'been', 'yourselves', 'just', 'your', 'through', 'for', "you've", 'up', 'don', 'me'
, 'one', 'the', 'and', 'shouldn', 'our', 'on', 'there', 'hers', 'yourself', 'ain', 'shoul
d', 'himself', 'again', 'during', 'he', 'you', 'most', "she's", 'over', 'ma', 'because',
'if', 'was', 'couldn', 'here', 'they', 'shan', 'those', 'having', 'hadn', 'why', 'when',
'we', 'isn', "should've", 'each', 'be', 'same', 'doing', 'while', 'd', 'she', 'it', 'own'
, 'didn', 'doesn', 'y', 'out', 'weren', 'very', 'his', 've', 'will', 'or', 'until', 'o',
'do', 'such', 'by', 'her', 'herself', 'more', 'am', 't', 'them', "you'd", 'that', 'theirs
', 'where', 'off', 'these', 'who', 'how', 'which', 'before', 'only', 'below', 'mustn', 'a
ny', 'some', 'll', 'him', 'whom', 'my', 'has', 'have', 'haven', 'of', 'then', 'had', 'doe
s', 'all', 'i'}
```

Remove unwanted words from reviews LIKE html tags,white space etc.

In [22]:

```
#stemming object
stemmer = PorterStemmer()

# -----------------------------------------
HTMLTAGS = re.compile('<.*?>')
table = str.maketrans(dict.fromkeys(string.punctuation))
remove_digits = str.maketrans('', '', string.digits)
MULTIPLE_WHITESPACE = re.compile(r"\s+")
# -----------------------------------------
```

In [23]:

```
def preprocessor(review):
    # remove html tags
    review = HTMLTAGS.sub(r'', review)

    # remove puncutuation
    review = review.translate(table)

    # remove digits
    review = review.translate(remove_digits)

    # lower case all letters
    review = review.lower()

    # replace multiple white spaces with single space
    review = MULTIPLE_WHITESPACE.sub(" ", review).strip()

    # remove stop words
    review = [word for word in review.split()
              if word not in final_stopwords]

    # stemming
    review = ' '.join([stemmer.stem(word) for word in review])

    return review
```

In [24]:

```
print("Before preprocessing : ")
data.Text.iloc[3]
```

Before preprocessing :

Out[24]:

'I usually avoid cold coffee drinks. They are usually too oily, sweet, milky or bland. I was most pleasantly surprised by this drink. The touch of sugar adds more smoothness than sweetness to the robust expresso bite. It contains no fat but has 12 grams of carbs. The small, slender can is easy to transport and the pop top makes for easy opening.

I enjoyed this product. In addition to using it as a beverage, a little bit enhances t he flavor of chocolate baked goods (think brownies) and cuts the sweetness of buttercream frosting. So skip the run to Dunkin Donuts for an iced coffe and pop open a can of illy i ssimo instead.'

In [25]:

```
data.Text = data.Text.apply(preprocessor)
print("After preprocessing : ")
data.Text.iloc[3]
```

After preprocessing :

Out[25]:

'usual avoid cold coffe drink usual oili sweet milki bland pleasantli surpris drink touch sugar add smooth sweet robust expresso bite contain no fat gram carb small slender easi t ransport pop top make easi openingi enjoy product addit use beverag littl bit enhanc flav or chocol bake good think browni cut sweet buttercream frost skip run dunkin donut ice co ff pop open illi issimo instead'

Word clouds

In [26]:

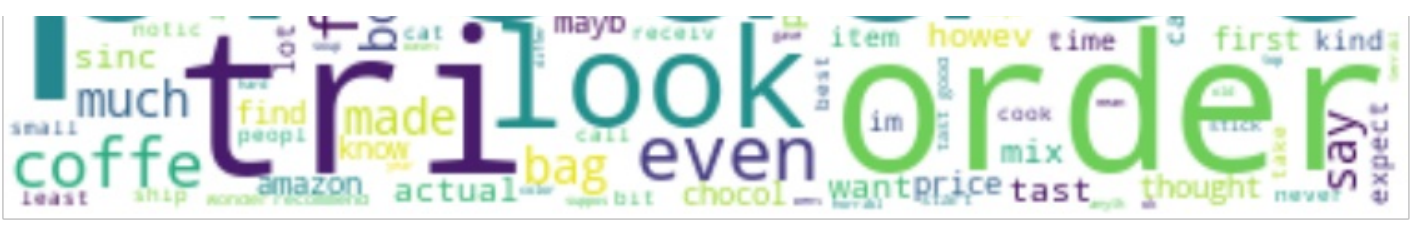
```
def generate_wcloud(text):
    stopwords = set(STOPWORDS)

    wordcloud = WordCloud(stopwords=stopwords, background_color='white')
    wordcloud.generate(text)

    plt.figure(figsize=(15,7))
    plt.axis('off')
    plt.imshow(wordcloud, interpolation='bilinear')
    return plt.show()
```

In [27]:

```
#Word cloud for Positive reviews
pos = data.loc[data.target=="Positive"].Text
text = " ".join(review for review in pos.astype(str))
generate_wcloud(text)
```

In [28]:

```
#Word cloud for Negative reviews
neg=data.loc[data.target=="Negative"].Text
text = " ".join(review for review in neg.astype(str))
generate_wcloud(text)
```



TRAIN-TEST DATA

In [29]:

```
#Train set : 70% of data
#Test set : 30% of data
X = data.Text
y = data.target

X_train, X_test, y_train, y_test = train_test_split(

    X, y, test_size=0.20, random_state=1, stratify=y)
```

In [30]:

```
X_train.shape, X_test.shape
```

Out[30]:

```
((103816,), (25954,))
```

In [31]:

```
#TF_IDF vectorization
tfidf_vectorizer = TfidfVectorizer(max_features=10000)
tfidf_vectorizer.fit(X_train)

# transform
tfidf_X_train = tfidf_vectorizer.transform(X_train)
tfidf_X_test = tfidf_vectorizer.transform(X_test)
```

In [32]:

```
#LABEL encoder
labelEncoder = LabelEncoder()

y_train = labelEncoder.fit_transform(y_train)
y_test = labelEncoder.transform(y_test)

labels = labelEncoder.classes_.tolist()
print(labels)
```

```
['Negative', 'Neutral', 'Positive']
```

In [36]:

```
#Model training
def train_and_eval(model, trainX, trainY, testX, testY):

    # training
    _ = model.fit(trainX, trainY)

    # predictions
    y_preds_train = model.predict(trainX)
    y_preds_test = model.predict(testX)

    # evaluation
    print()
    print(model)
    print(f"Train accuracy score : {accuracy_score(y_train, y_preds_train)}")
    print(f"Test accuracy score : {accuracy_score(y_test, y_preds_test)}")
    print('\n',40*'-')
```

Logistic Regression with Tf-Idf

In [43]:

```
# Hyperparameters
C = [0.001, 0.01, 0.1, 1, 10]

for c in C:
    # Define model
    log_model = LogisticRegression(C=c, max_iter=500, random_state=1)

    # Train and evaluate model
    train_and_eval(model=log_model,
                   trainX=tfidf_X_train,
                   trainY=y_train,
                   testX=tfidf_X_test,
                   testY=y_test)
```

```
LogisticRegression(C=0.001, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
Train accuracy score : 0.6459505278569777
Test accuracy score : 0.6415966710333667

 ----------------------------------------

LogisticRegression(C=0.01, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
Train accuracy score : 0.6798951991985821
Test accuracy score : 0.6715727826153964

 ----------------------------------------

LogisticRegression(C=0.1, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
Train accuracy score : 0.7307351467981814
Test accuracy score : 0.7157278261539647

 ----------------------------------------

LogisticRegression(C=1, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
Train accuracy score : 0.7633120135624567
Test accuracy score : 0.7197734453263466

 ----------------------------------------

LogisticRegression(C=10, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
Train accuracy score : 0.7866032210834554
Test accuracy score : 0.70879247900131

 ----------------------------------------

/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Convergence
Warning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [44]:

```
#Best model : Logistic Regression(C=0.1) with TfIdf data
bmodel = LogisticRegression(C=0.1, max_iter=500, random_state=1)
bmodel.fit(tfidf_X_train, y_train)
```

Out[44]:

```
LogisticRegression(C=0.1, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=500,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=1, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [45]:

```
# predictions
y_preds_train = bmodel.predict(tfidf_X_train)
y_preds_test = bmodel.predict(tfidf_X_test)
```

In [46]:

```
#accuracy
print(f"Train accuracy score : {accuracy_score(y_train, y_preds_train)}")
print(f"Test accuracy score : {accuracy_score(y_test, y_preds_test)}")
```

```
Train accuracy score : 0.7307351467981814
Test accuracy score : 0.7157278261539647
```

DEPLOYMENT

In [50]:

```
#SAVE MODEL AND TRANSFORMER
import pickle
with open("transformer.pkl", "wb") as f:
    pickle.dump(tfidf_vectorizer, f)

with open("model.pkl", "wb") as f:
    pickle.dump(bmodel, f)
```

Prediction on single review

In [51]:

```
# labels = ['Negative', 'Neutral', 'Positive']
def get_sentiment(review):
    # preprocessing
    x = preprocessor(review)
    #vectorization
    x = tfidf_vectorizer.transform([x])
    #prediction
    y = int(bmodel.predict(x.reshape(1,-1)))
    return labels[y]
```

In [52]:

```
# negative review
review = "This chips packet is not good. I don't recommend this!"
print(f"This is a {get_sentiment(review)} review!")
```

```
This is a Negative review!
```

In [53]:

In [53]:

```
# positve review
review = "This product is good.Very cheap and highly recommandable"
print(f"This is a {get_sentiment(review)} review!")
```

```
This is a Positive review!
```

In [54]:

```
# positve review
review = "Titanic is a great movie!"
print(f"This is a {get_sentiment(review)} review!")
```

```
This is a Positive review!
```