In [1]:
```
# import the required libraries
import pandas as pd
import numpy as np
import re
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import style
style.use('ggplot')
from nltk.tokenize import word_tokenize
from nltk.stem import WordNetLemmatizer
from nltk.corpus import stopwords
stop_words = set(stopwords.words('english'))
from wordcloud import WordCloud
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report, confusion
```

In [2]:
```
tweet_df = pd.read_csv('hateDetection_train.csv')
```

In [3]:
```
tweet_df.head()
```

Out[3]:

	id	label	tweet
0	1	0	@user when a father is dysfunctional and is s...
1	2	0	@user @user thanks for #lyft credit i can't us...
2	3	0	bihday your majesty
3	4	0	#model i love u take with u all the time in ...
4	5	0	factsguide: society now #motivation

In [4]:
```
tweet_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 31962 entries, 0 to 31961
Data columns (total 3 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   id      31962 non-null  int64 
 1   label   31962 non-null  int64 
 2   tweet   31962 non-null  object
dtypes: int64(2), object(1)
memory usage: 749.2+ KB
```

In [5]:
```
# printing random tweets
print(tweet_df['tweet'].iloc[0],"\n")
print(tweet_df['tweet'].iloc[1],"\n")
print(tweet_df['tweet'].iloc[2],"\n")
print(tweet_df['tweet'].iloc[3],"\n")
print(tweet_df['tweet'].iloc[4],"\n")
```

```
 @user when a father is dysfunctional and is so selfish he drags his kids int
o his dysfunction.   #run

@user @user thanks for #lyft credit i can't use cause they don't offer wheelc
hair vans in pdx.    #disapointed #getthanked

  bihday your majesty

#model   i love u take with u all the time in urð□□±!!! ð□□□ð□□□ð□□□ð□□□ð□□¦
ð□□¦ð□□¦

 factsguide: society now    #motivation
```

In [18]:
```
#creating a function to process the data
def data_processing(tweet):
    tweet = tweet.lower()
    tweet = re.sub(r"https\S+|www\S+http\S+", '', tweet, flags = re.MULTILIN
    tweet = re.sub(r'\@w+|\#','', tweet)
    tweet = re.sub(r'[^\w\s]','',tweet)
    tweet = re.sub(r'ð','',tweet)
    tweet_tokens = word_tokenize(tweet)
    filtered_tweets = [w for w in tweet_tokens if not w in stop_words]
    return " ".join(filtered_tweets)
```

In [19]:
```
tweet_df.tweet = tweet_df['tweet'].apply(data_processing)
```

In [20]:
```
tweet_df = tweet_df.drop_duplicates('tweet')
```

In [21]:
```
lemmatizer = WordNetLemmatizer()
def lemmatizing(data):
    tweet = [lemmarizer.lemmatize(word) for word in data]
    return data
```

In [22]:
```
tweet_df['tweet'] = tweet_df['tweet'].apply(lambda x: lemmatizing(x))
```

In [23]:
```
# printing the data to see the effect of preprocessing
print(tweet_df['tweet'].iloc[0],"\n")
print(tweet_df['tweet'].iloc[1],"\n")
print(tweet_df['tweet'].iloc[2],"\n")
print(tweet_df['tweet'].iloc[3],"\n")
print(tweet_df['tweet'].iloc[4],"\n")
```

```
user father dysfunctional selfish drags kids dysfunction run

user user thanks lyft credit cant use cause dont offer wheelchair vans pdx di
sapointed getthanked

bihday majesty

model love u take u time ur

factsguide society motivation
```

In [24]:
```
tweet_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 29345 entries, 0 to 31961
Data columns (total 3 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   id      29345 non-null  int64 
 1   label   29345 non-null  int64 
 2   tweet   29345 non-null  object
dtypes: int64(2), object(1)
memory usage: 917.0+ KB
```

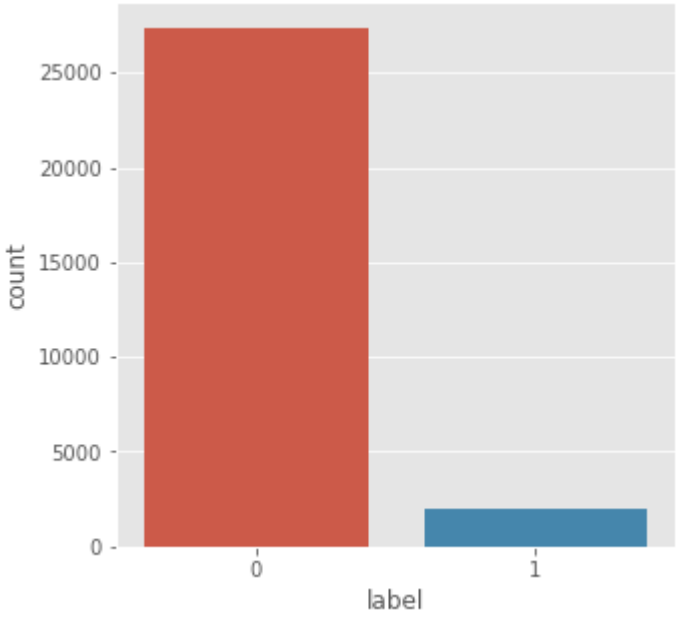
In [25]:
```
tweet_df['label'].value_counts()
```

Out[25]:
```
0    27352
1     1993
Name: label, dtype: int64
```

Data visualization

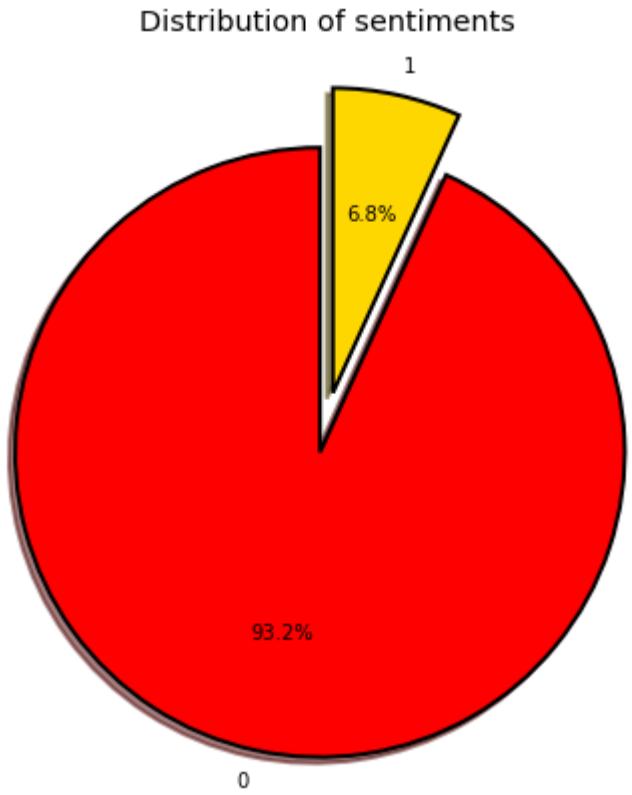
In [26]:
```
fig = plt.figure(figsize=(5,5))
sns.countplot(x='label', data = tweet_df)
```

Out[26]:
```
<AxesSubplot:xlabel='label', ylabel='count'>
```



In [27]:
```
fig = plt.figure(figsize=(7,7))
colors = ("red", "gold")
wp = {'linewidth':2, 'edgecolor':"black"}
tags = tweet_df['label'].value_counts()
explode = (0.1, 0.1)
tags.plot(kind='pie',autopct = '%1.1f%%', shadow=True, colors = colors, star
          wedgeprops = wp, explode = explode, label='')
plt.title('Distribution of sentiments')
```

Out[27]: Text(0.5, 1.0, 'Distribution of sentiments')



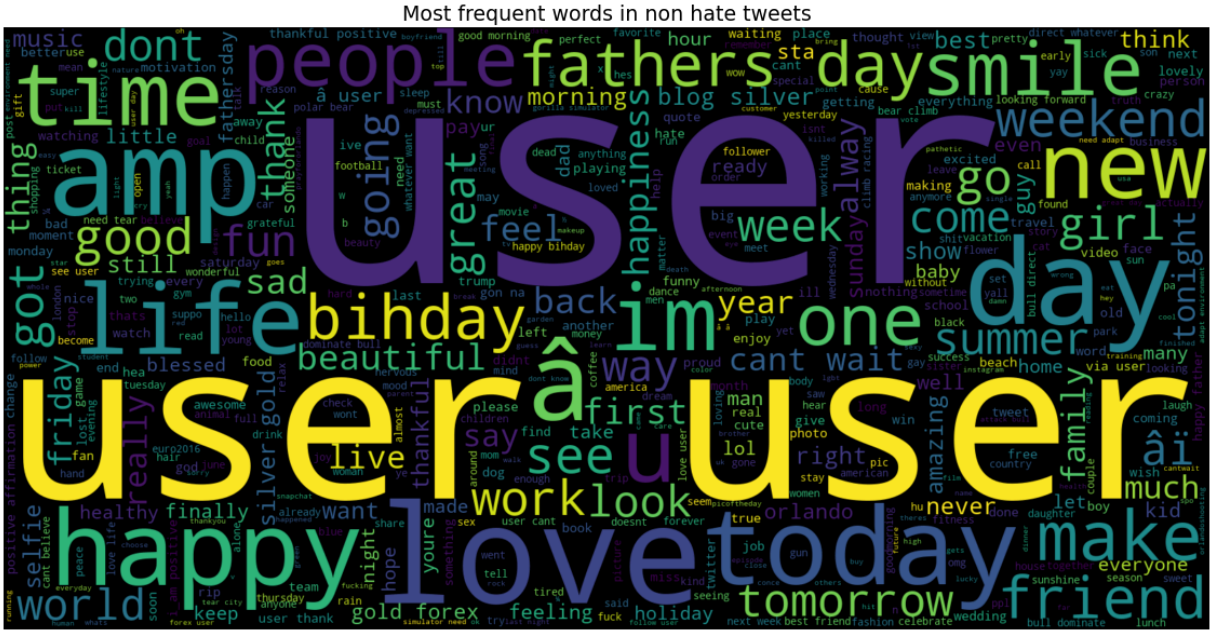
In [28]:
```
non_hate_tweets = tweet_df[tweet_df.label == 0]
non_hate_tweets.head()
```

Out[28]:

	id	label	tweet
0	1	0	user father dysfunctional selfish drags kids d...
1	2	0	user user thanks lyft credit cant use cause do...
2	3	0	bihday majesty
3	4	0	model love u take u time ur
4	5	0	factsguide society motivation

In [30]:
```
text = ' '.join([word for word in non_hate_tweets['tweet']])
plt.figure(figsize=(20,15), facecolor='None')
wordcloud = WordCloud(max_words=500, width=1600, height=800).generate(text)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.title('Most frequent words in non hate tweets', fontsize = 19)
plt.show()
```

Most frequent words in non hate tweets



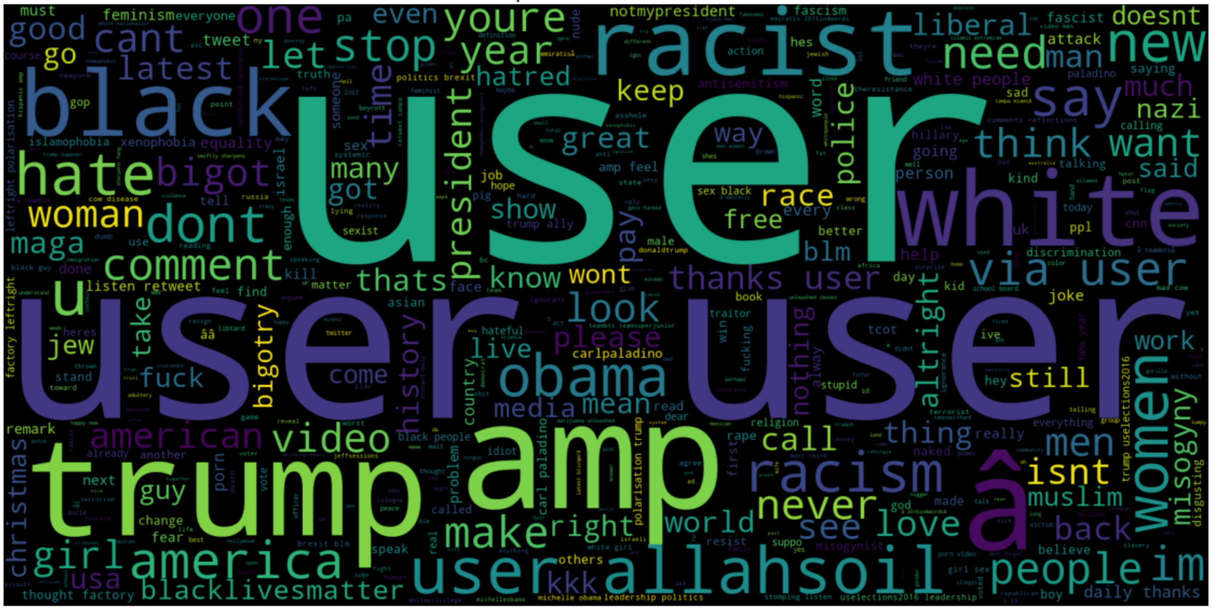
In [31]:
```
neg_tweets = tweet_df[tweet_df.label == 1]
neg_tweets.head()
```

Out[31]:

	id	label	tweet
13	14	1	user cnn calls michigan middle school build wa...
14	15	1	comment australia opkillingbay seashepherd hel...
17	18	1	retweet agree
23	24	1	user user lumpy says prove lumpy
34	35	1	unbelievable 21st century wed need something l...

In [32]:
```
text = ' '.join([word for word in neg_tweets['tweet']])
plt.figure(figsize=(20,15), facecolor='None')
wordcloud = WordCloud(max_words=500, width=1600, height=800).generate(text)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis('off')
plt.title('Most frequent words in hate tweets', fontsize = 19)
plt.show()
```

Most frequent words in hate tweets




```
In [35]: vect = TfidfVectorizer(ngram_range=(1,2)).fit(tweet_df['tweet'])
```

```
In [36]: feature_names = vect.get_feature_names()
         print("Number of features: {}\n".format(len(feature_names)))
         print("First 20 features: \n{}".format(feature_names[:20]))
```

```
Number of features: 208579

First 20 features:
['0000001', '0000001 polluting', '00027', '00027 photooftheday', '001', '003
5', '00h30', '01', '01 4995', '01 7900', '01 blog', '01 croatia', '01 may',
'01 shopalyssas', '0115', '0115 8599968', '0161', '0161 manny', '019', '019 p
revious']
```

```
In [37]: vect = TfidfVectorizer(ngram_range=(1,3)).fit(tweet_df['tweet'])
```

```
In [38]: feature_names = vect.get_feature_names()
         print("Number of features: {}\n".format(len(feature_names)))
         print("First 20 features: \n{}".format(feature_names[:20]))
```

```
Number of features: 380305

First 20 features:
['0000001', '0000001 polluting', '0000001 polluting niger', '00027', '00027 p
hotooftheday', '00027 photooftheday music', '001', '0035', '00h30', '01', '01
4995', '01 4995 rustic', '01 7900', '01 7900 shopalyssas', '01 blog', '01 blo
g silver', '01 croatia', '01 croatia happy', '01 may', '01 may actual']
```

Model Building

```
In [39]: X = tweet_df['tweet']
         Y = tweet_df['label']
         X = vect.transform(X)
```

In [40]:
```
x_train, x_test, y_train, y_test = train_test_split(X, Y, test_size=0.2, ran
```

In [41]:
```
print("Size of x_train:", (x_train.shape))
print("Size of y_train:", (y_train.shape))
print("Size of x_test: ", (x_test.shape))
print("Size of y_test: ", (y_test.shape))
```

```
Size of x_train: (23476, 380305)
Size of y_train: (23476,)
Size of x_test:  (5869, 380305)
Size of y_test:  (5869,)
```

In [42]:
```
logreg = LogisticRegression()
logreg.fit(x_train, y_train)
logreg_predict = logreg.predict(x_test)
logreg_acc = accuracy_score(logreg_predict, y_test)
print("Test accuarcy: {:.2f}%".format(logreg_acc*100))
```

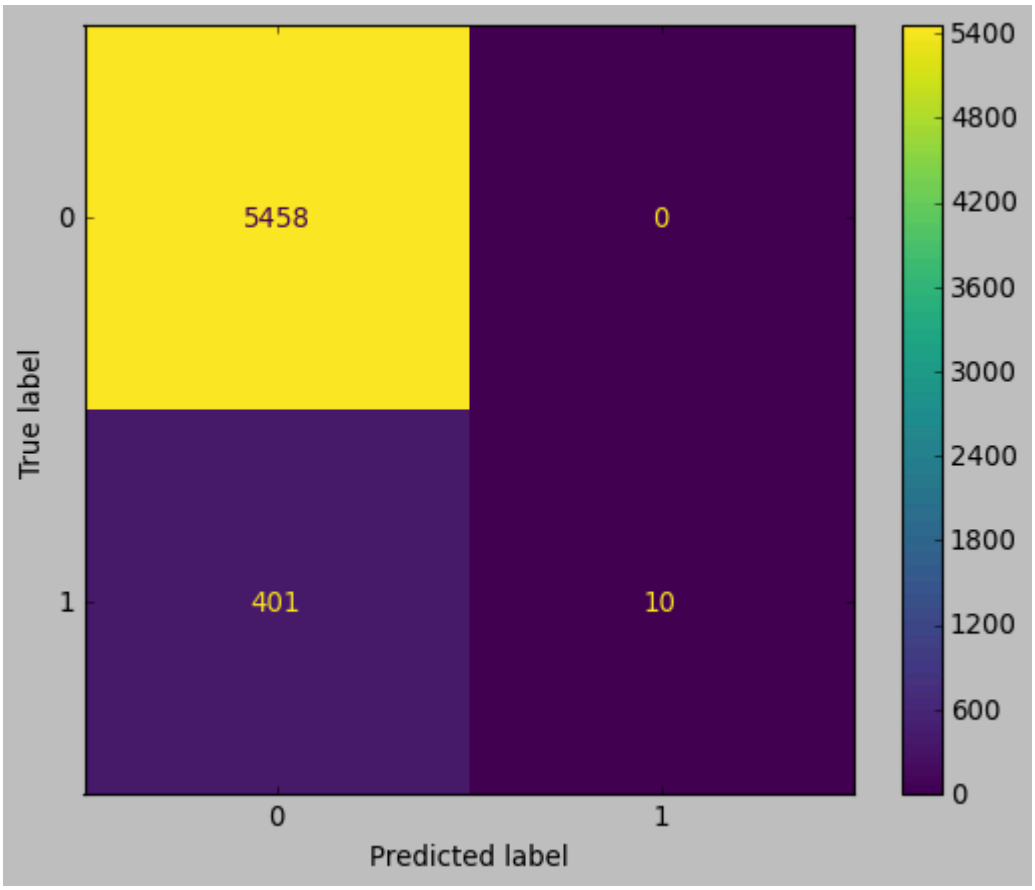
```
Test accuarcy: 93.17%
```

In [43]:
```
print(confusion_matrix(y_test, logreg_predict))
print("\n")
print(classification_report(y_test, logreg_predict))
```

```
[[5458    0]
 [ 401   10]]


              precision    recall  f1-score   support

           0       0.93      1.00      0.96      5458
           1       1.00      0.02      0.05       411

    accuracy                           0.93      5869
   macro avg       0.97      0.51      0.51      5869
weighted avg       0.94      0.93      0.90      5869
```

In [44]:
```
style.use('classic')
cm = confusion_matrix(y_test, logreg_predict, labels=logreg.classes_)
disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=logreg.cla
disp.plot()
```

Out[44]:
```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x1f17be5
f2e0>
```



In [45]:
```
from sklearn.model_selection import GridSearchCV
import warnings
warnings.filterwarnings('ignore')
```

In [46]:
```
param_grid = {'C':[100, 10, 1.0, 0.1, 0.01], 'solver' :['newton-cg', 'lbfgs'
grid = GridSearchCV(LogisticRegression(), param_grid, cv = 5)
grid.fit(x_train, y_train)
print("Best Cross validation score: {:.2f}".format(grid.best_score_))
print("Best parameters: ", grid.best_params_)
```

```
Best Cross validation score: 0.95
Best parameters:  {'C': 100, 'solver': 'newton-cg'}
```

In [47]:
```
y_pred = grid.predict(x_test)
```

In [48]:
```
logreg_acc = accuracy_score(y_pred, y_test)
print("Test accuracy: {:.2f}%".format(logreg_acc*100))
```

```
Test accuracy: 94.89%
```

In [49]:
```
print(confusion_matrix(y_test, y_pred))
print("\n")
print(classification_report(y_test, y_pred))
```

```
[[5450    8]
 [ 292  119]]
```

	precision	recall	f1-score	support
0	0.95	1.00	0.97	5458
1	0.94	0.29	0.44	411
accuracy			0.95	5869
macro avg	0.94	0.64	0.71	5869
weighted avg	0.95	0.95	0.94	5869