Feature Engineering on Facebook Dataset

```
#Importing Libraries
# please do go through this python notebook:
import warnings
warnings.filterwarnings("ignore")

import csv
import pandas as pd#pandas to create small dataframes
import datetime #Convert to unix time
import time #Convert to unix time

# if numpy is not installed already : pip3 install numpy
import numpy as np#Do aritmetic operations on arrays

# matplotlib: used to plot graphs
import matplotlib
import matplotlib.pylab as plt
import seaborn as sns#Plots
from matplotlib import rcParams#Size of plots
from sklearn.cluster import MiniBatchKMeans, KMeans#Clustering
import math
import pickle
import os

# to install xgboost: pip3 install xgboost
import xgboost as xgb

import warnings
import networkx as nx
import pdb
import pickle
from pandas import HDFStore,DataFrame
from pandas import read_hdf
from scipy.sparse.linalg import svds, eigs
import gc
from tqdm import tqdm
```

1. Reading Data

```
#Reading data from CSV file
original_dataset = pd.read_csv('train.csv')
original_dataset.shape
```

```
(9437519, 2)
```

```
original_dataset.head()#Displaying first 5 values
```

	source_node	destination_node
0	1	690569
1	1	315892
2	1	189226
3	2	834328
4	2	1615927

```
original_dataset.info()#Displaying dataset info
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9437519 entries, 0 to 9437518
Data columns (total 2 columns):
 #   Column            Dtype
---  ------            -----
 0   source_node       int64
 1   destination_node  int64
dtypes: int64(2)
memory usage: 144.0 MB
```

```
original_dataset.isnull().sum()#Checking for null values in dataset
```

```
source_node         0
destination_node    0
dtype: int64
```

```
original_dataset.duplicated().sum()#Checking duplicated values
```

```
0
```

Sampling the 1 Million records

```
#training dataset
train_subset = pd.read_csv('train.csv', nrows=1000000)
train_subset.to_csv('train_subset.csv',header=False,index=False)
```

```
#Shape of the training dataset
train_subset.shape
```

```
(1000000, 2)
```

```
train_subset.head()
```

	source_node	destination_node
0	1	690569
1	1	315892
2	1	189226
3	2	834328
4	2	1615927

```
train_subset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 2 columns):
 #   Column            Non-Null Count    Dtype
---  ------            --------------    -----
 0   source_node       1000000 non-null  int64
 1   destination_node  1000000 non-null  int64
dtypes: int64(2)
memory usage: 15.3 MB
```

```
train_subset.isnull().sum()
```

```
source_node         0
destination_node    0
dtype: int64
```

```
train_subset.duplicated().sum()
```

```
0
```

```
#To find number of edges and nodes
graph = nx.read_edgelist('train_subset.csv',delimiter=',',create_using=nx.DiGraph(),nodetype=
print(nx.info(graph))
```

```
DiGraph with 685775 nodes and 1000000 edges
```

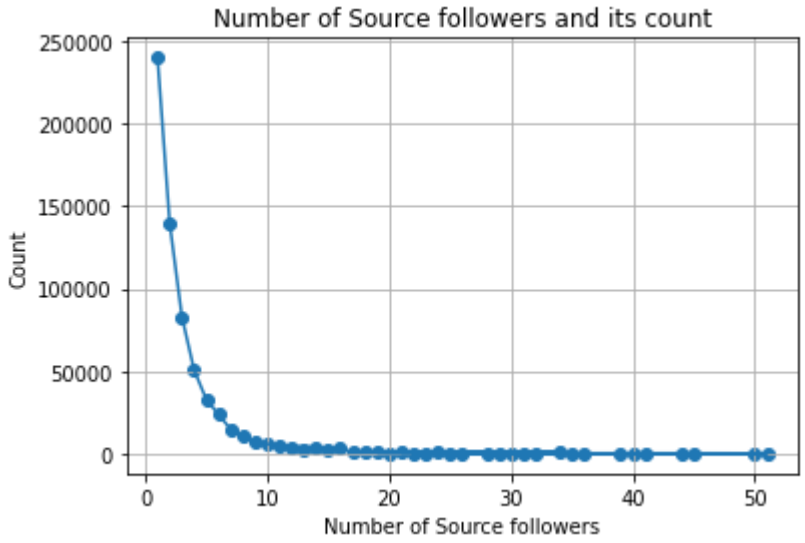
Number of Followers and Followees

```
#Defining number of followers function
def num_followers(a):
    return len(list(set(graph.predecessors(a))))
```

```
##Defining number of followees function
def num_followees(a):
    return len(list(set(graph.successors(a))))

train_subset['num_of_source_followers'] = train_subset.source_node.apply(num_followers)


train_subset.num_of_source_followers.unique()
```

```
array([ 1,  0,  2,  3,  4,  5,  6, 10,  9, 44,  8,  7, 17, 39, 18, 23, 28,
       11, 12, 32, 34, 14, 21, 13, 16, 19, 40, 15, 35, 22, 36, 29, 25, 20,
       45, 26, 50, 24, 30, 51, 31, 41])
```

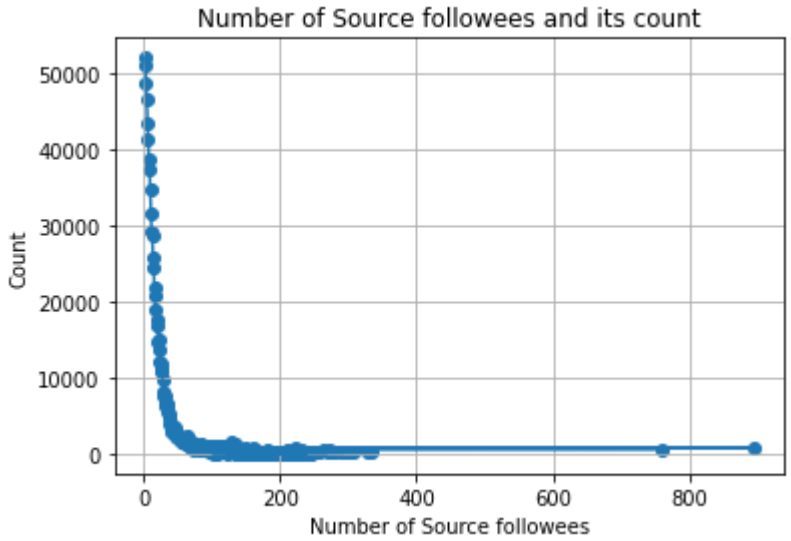
```
#Counting values from list
value_counts = train_subset.num_of_source_followers.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]


#Plotting scatter plot
plt.plot(values, counts)
plt.scatter(values, counts)

plt.xlabel("Number of Source followers")
plt.ylabel("Count")
plt.title("Number of Source followers and its count")
plt.grid()
plt.show()
```




```
train_subset['num_of_source_followees'] = train_subset.source_node.apply(num_followees)


#Displaying Unique Values
train_subset.num_of_source_followees.unique()
```

```
array([  3,   6,   2,   1,  12,  15,   5,   4,  30,   8,   9,  16,  21,
        17,   7,  11,  27,  13,  23,  47,  10,  37,  38,  20,  19,  18,
        14,  24,  29,  36,  32,  54,  50,  31,  35,  53,  34,  55,  57,
        22, 216,  26,  78,  25,  43,  52,  81,  41,  83, 134,  59, 110,
        33,  48,  40,  39,  42,  60,  73, 270,  70,  28,  58,  80,  44,
        66,  45, 194,  63,  97,  67,  92, 242,  51, 895,  71, 219, 101,
       107,  74, 112, 115,  64,  72,  91,  86, 126,  49,  46,  75,  65,
       118, 140,  69, 138, 123, 137,  56, 160,  82, 143, 164, 113,  79,
        68,  61,  85, 103, 106, 108, 100, 184,  93, 130,  62, 144,  87,
        98, 149, 239, 104, 120,  90, 249, 135,  77,  89,  94, 132, 155,
       148,  95,  99, 150, 125, 181, 142, 102, 280, 121, 217, 105, 205,
       116, 152, 109, 293,  88, 119, 165, 174, 275,  84, 156, 133, 131,
       327, 124, 117, 212, 252, 111, 154, 169, 183, 211, 129,  96, 228,
        76, 128, 175, 122, 210, 226, 208, 223, 200, 236, 176, 146, 229,
       264, 196, 173, 276, 221, 185, 245, 218, 166, 145, 231, 227, 147,
       159, 215, 235, 153, 158, 274, 171, 213, 759, 187, 136, 190, 241,
       258, 151, 251, 141, 178, 301, 139, 291, 214, 203, 161, 204, 198,
       307, 253, 300, 168, 333, 202, 167, 240])
```

```
#Counting values from list
value_counts = train_subset.num_of_source_followees.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]


plt.plot(values, counts)
plt.scatter(values, counts)#Scatter Plot

plt.xlabel("Number of Source followees")
plt.ylabel("Count")
plt.title("Number of Source followees and its count")
plt.grid()
plt.show()
```

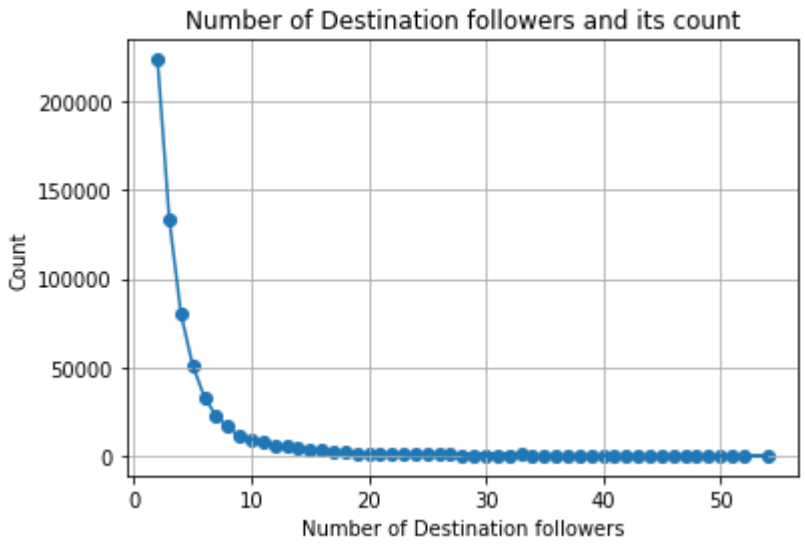



```
train_subset['num_of_destination_followers'] = train_subset.destination_node.apply(num_follow
```

```
train_subset.num_of_destination_followers.unique()
```

```
array([ 3,  2,  5,  4,  1,  8, 11,  9,  6,  7, 10, 12, 18, 17, 13, 14, 28,
       15, 16, 20, 27, 24, 25, 41, 51, 48, 54, 49, 37, 39, 45, 44, 40, 42,
       43, 38, 34, 36, 33, 32, 23, 29, 30, 35, 31, 26, 22, 19, 21, 50, 46,
       47, 52])
```

```
value_counts = train_subset.num_of_destination_followers.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]


plt.plot(values, counts)
plt.scatter(values, counts)#Scatter Plot

plt.xlabel("Number of Destination followers")
plt.ylabel("Count")
plt.title("Number of Destination followers and its count")
plt.grid()
plt.show()
```



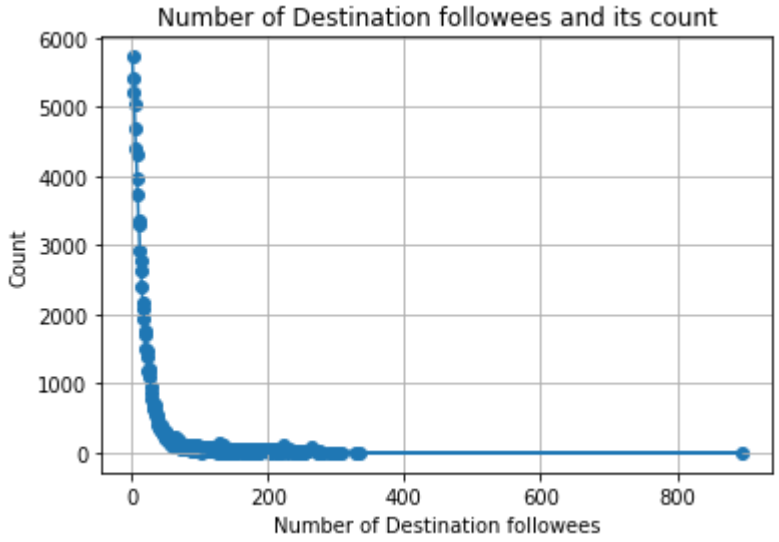

```
train_subset['num_of_destination_followees'] = train_subset.destination_node.apply(num_follow
```

```
train_subset.num_of_destination_followees.unique()
```

```
array([  0,   4,  14,  31,   3,  19,  63,  18,   1,   2,  10,  13,  15,
        20,  17,  29,  11,  22,  32,  12,  24,   7,   6,  16,  26,   8,
        38,  27,   5,  44,  23,  36,   9,  40,  89,  51,  34,  28,  80,
        37,  33,  39,  25,  48,  21,  42,  61,  30,  35,  66,  56, 107,
       181,  65,  64,  84,  60,  72,  81,  41,  93, 200, 223, 212, 138,
       164, 235, 154, 160, 258, 128, 185, 122, 125, 158, 264, 121, 152,
        73,  97, 174,  99,  91, 130,  85, 169,  47, 196,  68,  53,  92,
       105,  52, 156,  98, 104, 147,  45,  49,  59,  69,  58,  71,  46,
       118, 123, 120, 100,  77,  94, 155,  57,  43, 106,  78, 187, 110,
```

```
       205, 245, 231, 139, 211, 153, 213, 135, 132,  62,  50,  74,  55,
       133,  83,  79,  76,  67, 216, 227, 165, 202, 198, 219, 166, 203,
       167,  87, 113, 109, 116, 144, 291,  54, 176,  75, 124, 136,  82,
        86,  95,  88, 140,  96, 141, 115, 148, 142, 103, 270, 173,  90,
       137,  70, 239, 129, 210, 117, 143, 252, 194, 184, 111, 274, 293,
       307, 161, 102, 150, 171, 217, 112, 126, 168, 134, 249, 119, 236,
       242, 228, 131, 145, 149, 178, 215, 229, 226, 276, 208, 190, 108,
       204, 333, 301, 183, 280, 159, 101, 275, 240, 253, 151, 241, 251,
       146, 895, 221, 214, 300, 175, 327, 218])
```

```
value_counts = train_subset.num_of_destination_followees.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]


plt.plot(values, counts)
plt.scatter(values, counts)#Scatter Plot

plt.xlabel("Number of Destination followees")
plt.ylabel("Count")
plt.title("Number of Destination followees and its count")
plt.grid()
plt.show()
```



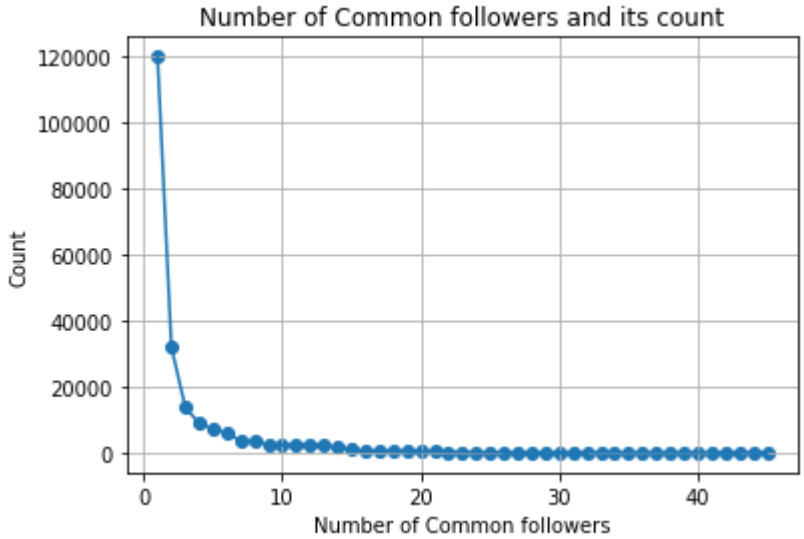
Number of common followers and common followees

```
#Defining Number of common followers function
def num_of_common_followers(a,b):
    a_followers = list(set(graph.predecessors(a)))
    if b in a_followers:
        a_followers.remove(b)
    b_followers = list(set(graph.predecessors(b)))
    if a in b_followers:
```

```
        b_followers.remove(a)
    return len(set(a_followers).intersection(set(b_followers)))

#Defining Number of common followees function
def num_of_common_followees(a,b):
    a_followees = list(set(graph.successors(a)))
    if b in a_followees:
        a_followees.remove(b)
    b_followees = list(set(graph.successors(b)))
    if a in b_followees:
        b_followees.remove(a)
    return len(set(a_followees).intersection(set(b_followees)))


train_subset['num_of_common_followers'] = train_subset.apply(lambda row: num_of_common_follow


train_subset.num_of_common_followers.unique()
```

```
array([ 1,  0,  2,  3,  4, 22, 12, 24, 39, 43, 42, 32, 33, 41, 38, 35, 37,
       36, 31, 30, 34, 27, 29, 25, 18, 28, 26, 23, 21, 16, 11, 20, 17, 14,
       15, 13, 10,  9,  7,  6, 19,  5,  8, 44, 40, 45])
```

```
value_counts = train_subset.num_of_common_followers.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]


plt.plot(values, counts)
plt.scatter(values, counts)#Scatter Plot

plt.xlabel("Number of Common followers")
plt.ylabel("Count")
plt.title("Number of Common followers and its count")
plt.grid()
plt.show()
```



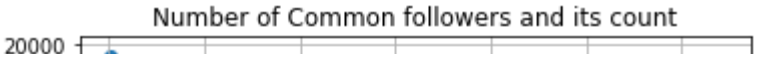
```
train_subset['num_of_common_followees'] = train_subset.apply(lambda row: num_of_common_follow
```

```
train_subset.num_of_common_followees.unique()
```

```
array([  0,   1,   3,   2,   9,   4,  10,   8,   5,   7,   6,  11,  13,
        15,  25,  12,  49,  51,  31,  17,  20,  48, 134, 113, 121, 155,
       209, 129, 152, 149, 111, 170,  88, 109, 143,  24,  21,  37,  19,
        75,  60,  36,  58,  76,  14,  16,  61,  65,  70,  66,  27,  18,
       103, 107, 105,  69,  92,  81,  93,  39,  33,  32,  56,  47,  43,
        45,  34,  22, 131, 106, 203, 241, 162, 104,  77,  28, 226, 102,
       138, 151, 136,  72,  38,  63,  35,  59,  57, 178, 112, 173, 126,
       175, 154, 145, 128, 148, 174,  30,  46,  23,  86,  91,  82,  29,
        40,  41,  50,  53,  44,  90,  71,  68,  74,  52,  67,  78,  95,
        79,  94, 114,  96,  62,  55,  84,  42,  26,  89, 123, 122, 118,
       110, 101,  64, 120, 135, 116, 108,  83, 115,  80,  87, 159, 158,
       133, 150, 117, 119, 141, 161,  73, 125,  54,  98, 100,  85,  97,
       144, 124,  99, 130, 139, 140, 167, 157, 214, 198, 196, 187, 211,
       210, 219, 229, 202, 248, 171, 164, 160, 132, 137, 220, 217, 255,
       201, 224, 320, 232, 242, 246, 190, 181, 163, 199, 165, 180, 172,
       147, 127, 169, 206, 212, 184, 197, 166, 193, 204, 191, 223, 192,
       208, 221, 231, 207, 183, 185, 188, 176, 168, 153, 189, 213, 186,
       230, 156, 292, 252, 263, 238, 215])
```

```
value_counts = train_subset.num_of_common_followees.value_counts()
values = list(value_counts.index)[1:]
counts = list(value_counts)[1:]
```

```
plt.plot(values, counts)
plt.scatter(values, counts)#Scatter plot

plt.xlabel("Number of Common followers")
plt.ylabel("Count")
plt.title("Number of Common followers and its count")
plt.grid()
plt.show()
```

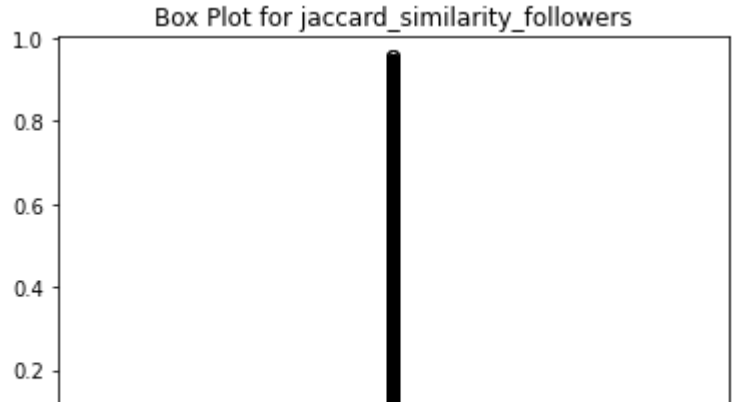


Jaccard Similarity for Followers and Followees


```
#Defining Jaccard Similarity for Followers function
def jaccard_followers(a,b):
    try:
        X = set(graph.predecessors(a))
        Y = set(graph.predecessors(b))
        if len(X) == 0  | len(Y) == 0:
            return 0
        similarity = len(X.intersection(Y))/len(X.union(Y))
        return similarity
    except:
        return 0


#Defining Jaccard Similarity for Followees function
def jaccard_followees(a,b):
    try:
        X = set(graph.successors(a))
        Y = set(graph.successors(b))
        if len(X) == 0  | len(Y) == 0:
            return 0
        similarity = len(X.intersection(Y))/len(X.union(Y))
    except:
        return 0
    return similarity


train_subset['jaccard_similarity_followers'] = train_subset.apply(lambda row: jaccard_followe


train_subset['jaccard_similarity_followers'].head()
```

```
0    0.333333
1    0.000000
2    0.000000
3    0.000000
4    0.000000
Name: jaccard_similarity_followers, dtype: float64
```

```
train_subset['jaccard_similarity_followers'].plot.box()
plt.title("Box Plot for jaccard_similarity_followers")#Box Plot
plt.show()
```




```
train_subset['jaccard_similarity_followers'].describe()
```

```
count    1000000.000000
mean           0.075920
std            0.174328
min            0.000000
25%            0.000000
50%            0.000000
75%            0.000000
max            0.954545
Name: jaccard_similarity_followers, dtype: float64
```

```
#Percentiles of jaccard_similarity_followers
print("Following are the Percentiles of jaccard_similarity_followers")
print("-"*50)
print("The 80 percentile values is : ",train_subset['jaccard_similarity_followers'].quantile(
print("The 90 percentile values is : ",train_subset['jaccard_similarity_followers'].quantile(
print("The 95 percentile values is : ",train_subset['jaccard_similarity_followers'].quantile(
print("The 99 percentile values is : ",train_subset['jaccard_similarity_followers'].quantile(
print("The 100 percentile values is : ",train_subset['jaccard_similarity_followers'].quantile
```

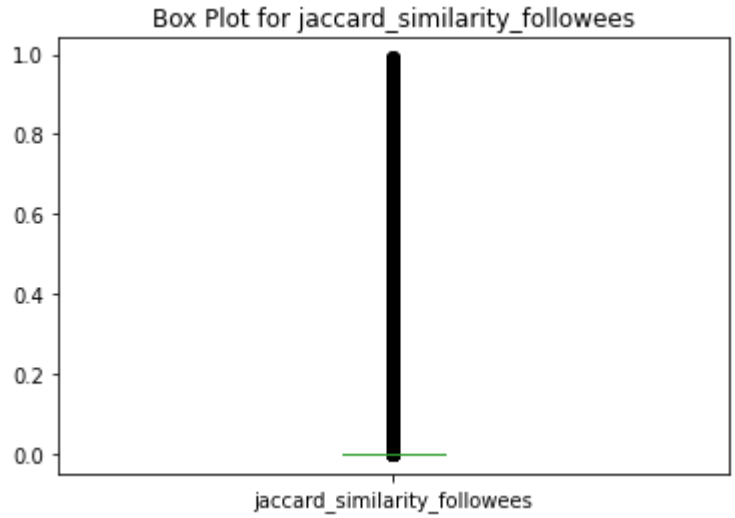
```
Following are the Percentiles of jaccard_similarity_followers
--------------------------------------------------
The 80 percentile values is :  0.09090909090909091
The 90 percentile values is :  0.3333333333333333
The 95 percentile values is :  0.5
The 99 percentile values is :  0.75
The 100 percentile values is :  0.9545454545454546
```

```
train_subset['jaccard_similarity_followees'] = train_subset.apply(lambda row: jaccard_followe
```

```
train_subset['jaccard_similarity_followees'].head()
```

```
0    0.000000
1    0.000000
2    0.166667
3    0.000000
4    0.000000
Name: jaccard_similarity_followees, dtype: float64
```

```
train_subset['jaccard_similarity_followees'].plot.box()
plt.title("Box Plot for jaccard_similarity_followees")#Box Plot
plt.show()
```




```
train_subset['jaccard_similarity_followees'].describe()
```

```
count    1000000.000000
mean           0.011588
std            0.068378
min            0.000000
25%            0.000000
50%            0.000000
75%            0.000000
max            0.991379
Name: jaccard_similarity_followees, dtype: float64
```

```
#the Percentiles of jaccard_similarity_followees
print("Following are the Percentiles of jaccard_similarity_followees")
print("-"*50)
print("The 80 percentile values is : ",train_subset['jaccard_similarity_followees'].quantile(
print("The 90 percentile values is : ",train_subset['jaccard_similarity_followees'].quantile(
print("The 95 percentile values is : ",train_subset['jaccard_similarity_followees'].quantile(
print("The 99 percentile values is : ",train_subset['jaccard_similarity_followees'].quantile(
print("The 100 percentile values is : ",train_subset['jaccard_similarity_followees'].quantile
```

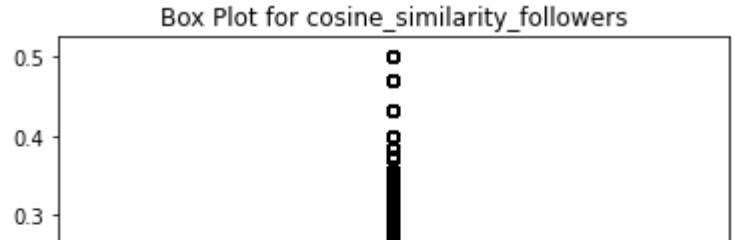
```
Following are the Percentiles of jaccard_similarity_followees
--------------------------------------------------
The 80 percentile values is :  0.0
The 90 percentile values is :  0.0
The 95 percentile values is :  0.04
The 99 percentile values is :  0.3333333333333333
The 100 percentile values is :  0.9913793103448276
```

Cosine Similarity for Followers and Followees

```
#Defining Cosine Similarity for followers function
def cosine_followees(a,b):
    try:
        X = set(graph.successors(a))
        Y = set(graph.successors(b))
        if len(X) == 0  | len(Y) == 0:
            return 0
        similarity = len(X.intersection(Y))/(math.sqrt(len(X))*(len(Y)))
        return similarity
    except:
        return 0


#Defining Cosine Similarity for followees function
def cosine_followers(a,b):
    try:
        X = set(graph.predecessors(a))
        Y = set(graph.predecessors(b))
        if len(X) == 0  | len(Y) == 0:
            return 0
        similarity = len(X.intersection(Y))/(math.sqrt(len(X))*(len(Y)))
        return similarity
    except:
        return 0


train_subset['cosine_similarity_followers'] = train_subset.apply(lambda row: cosine_followers


train_subset['cosine_similarity_followers'].head()
```

```
 0    0.333333
 1    0.000000
 2    0.000000
 3    0.000000
 4    0.000000
 Name: cosine_similarity_followers, dtype: float64
```

```
train_subset['cosine_similarity_followers'].plot.box()
plt.title("Box Plot for cosine_similarity_followers")#Box Plot
plt.show()
```




```
train_subset['cosine_similarity_followers'].describe()
```

```
count    1000000.000000
mean           0.054660
std            0.121311
min            0.000000
25%            0.000000
50%            0.000000
75%            0.000000
max            0.500000
Name: cosine_similarity_followers, dtype: float64
```

```
#Percentiles of cosine_similarity_followers
print("Following are the Percentiles of cosine_similarity_followers")
print("-"*50)
print("The 80 percentile values is : ",train_subset['cosine_similarity_followers'].quantile(0
print("The 90 percentile values is : ",train_subset['cosine_similarity_followers'].quantile(0
print("The 95 percentile values is : ",train_subset['cosine_similarity_followers'].quantile(0
print("The 99 percentile values is : ",train_subset['cosine_similarity_followers'].quantile(0
print("The 100 percentile values is : ",train_subset['cosine_similarity_followers'].quantile(
```

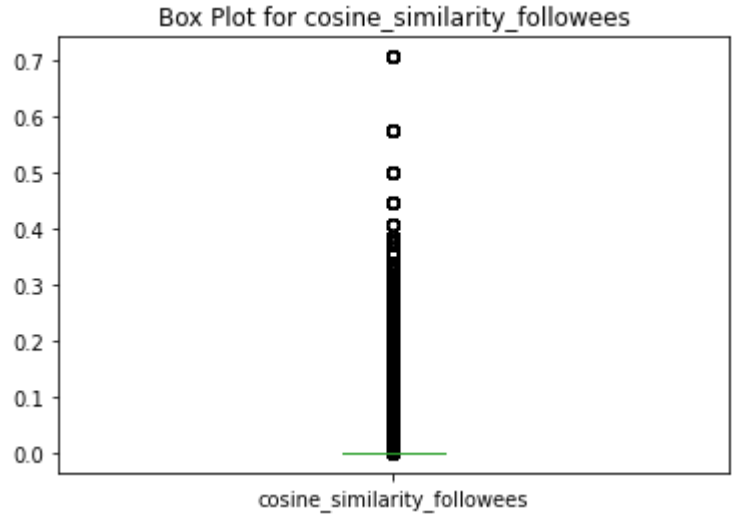
```
Following are the Percentiles of cosine_similarity_followers
--------------------------------------------------
The 80 percentile values is :  0.07155417527999328
The 90 percentile values is :  0.25
The 95 percentile values is :  0.35355339059327373
The 99 percentile values is :  0.5
The 100 percentile values is :  0.5
```

```
train_subset['cosine_similarity_followees'] = train_subset.apply(lambda row: cosine_followees
```

```
train_subset['cosine_similarity_followees'].head()
```

```
0    0.000000
1    0.000000
2    0.144338
3    0.000000
4    0.000000
Name: cosine_similarity_followees, dtype: float64
```

```
train_subset['cosine_similarity_followees'].plot.box()
plt.title("Box Plot for cosine_similarity_followees")#Box Plot
plt.show()
```




```
train_subset['cosine_similarity_followees'].describe()
```

```
count    1000000.000000
mean           0.005297
std            0.028907
min            0.000000
25%            0.000000
50%            0.000000
75%            0.000000
max            0.707107
Name: cosine_similarity_followees, dtype: float64
```

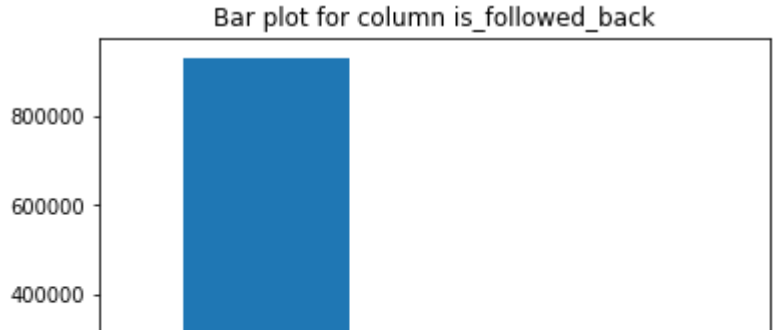
```
train_subset.drop(['cosine_similarity_followees'], axis=1,inplace=True)
```

Is Detination Follows Back

```
#Defining follow back function
def follows_back(a,b):
    return 1 if graph.has_edge(b,a) else 0
```

```
train_subset['is_followed_back'] = train_subset.apply(lambda row: follows_back(row['source_no
```

```
train_subset['is_followed_back'].value_counts().plot(kind='bar')
plt.title("Bar plot for column is_followed_back")#Bar Plot
plt.show()
```




```
#Displaying The final Features:
print("The final Feature we have so far:")
print("-"*50)
for column in train_subset.columns:
    print(column)
print("-"*50)
print("Total created features are :",len(train_subset.columns)-2)
```

```
The final Feature we have so far:
--------------------------------------------------
source_node
destination_node
num_of_source_followers
num_of_source_followees
num_of_destination_followers
num_of_destination_followees
num_of_common_followers
num_of_common_followees
jaccard_similarity_followers
jaccard_similarity_followees
cosine_similarity_followers
is_followed_back
--------------------------------------------------
Total created features are : 10
```

Final Submission

Shortest Path Length

```
#Defining get_shorterst_path_length function
def get_shorterst_path_length(source,target):
    if graph.has_edge(source,target):
        graph.remove_edge(source,target)
        try :
            length = nx.shortest_path_length(graph, source=source, target= target)
        except :
            length = -1
        graph.add_edge(source,target)
```

```
        return length
    else :
        if nx.has_path(graph,source, target):
            length = nx.shortest_path_length(graph, source=source, target= target)
        else :
            length = -1
        return length


get_shorterst_path_length(1, 690569)
```

```
2
```

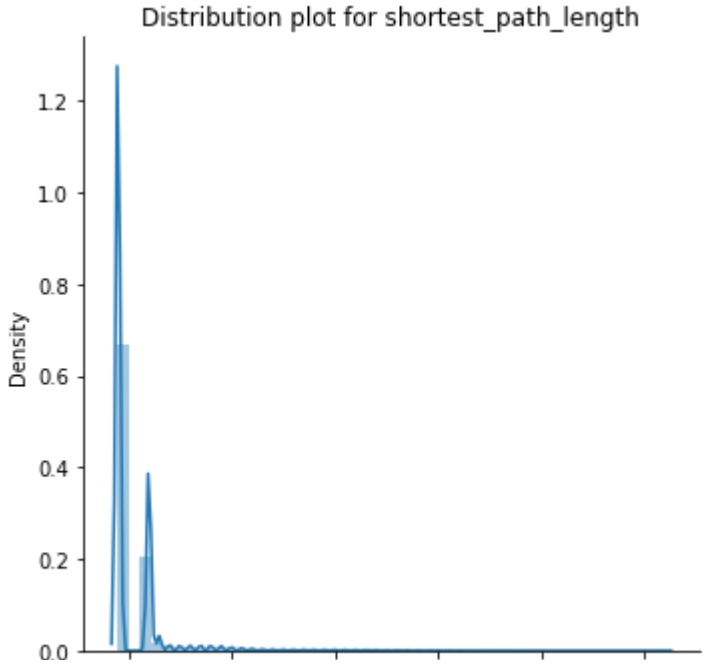
```
train_subset['shortest_path_length'] = train_subset.apply(lambda row: get_shorterst_path_leng


train_subset.head(1)
```

	source_node	destination_node	num_of_source_followers	num_of_source_followees	num
0	1	690569	1	3	

1 rows × 25 columns

```
train_subset['shortest_path_length'].head()
```

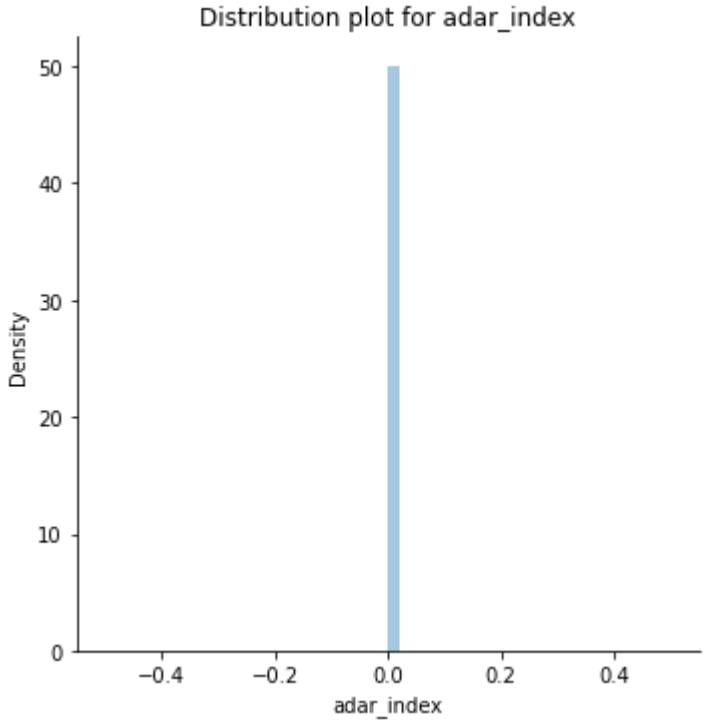
```
0    2
1   -1
2   -1
3   -1
4   -1
Name: shortest_path_length, dtype: int64


#importing seaborn library
import seaborn as sns


#Displaying·data·in·form·of·grid·using·Facetgrid·
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "shortest_path_length") \
   .add_legend();
#Distribution plot
plt.title("Distribution plot for shortest_path_length")
plt.show();
```



The Adamic/Adar index is a measure according to the number of shared links between two vertices. It is defined as the sum of the inverse logarithmic degree centrality of the neighbors shared by the two vertices.

```
#Defining Adar index function
def get_adar_index(a,b):
    total=0
    set_a = set(graph.successors(a))
    set_b = set(graph.successors(b))
    n_nodes=list(set_a.intersection(set_b))
    if len(n_nodes)!=0:
        return 0
    else:
        try :
            for n in n_nodes:
                total=total+(1/np.log10(len(list(graph.predecessors(n)))))
            return total
        except:
            return 0


train_subset['adar_index'] = train_subset.apply(lambda row: get_adar_index(row['source_node']
train_subset['adar_index'].head(5)

     0    0
     1    0
     2    0
     3    0
     4    0
     Name: adar_index, dtype: int64


#Displaying data in form of grid using Facetgrid.
```

```
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "adar_index") \
   .add_legend();
#Distribution plot
plt.title("Distribution plot for adar_index")
plt.show();
```



Page Rank

```
#PageRank of the nodes in the graph.
pr = nx.pagerank(graph, alpha=0.9)
```

```
pr.get(1)
```

```
1.4666738837006319e-06
```

```
train_subset['page_rank_source'] = train_subset['source_node'].map(pr)
train_subset.head()
```

	source_node	destination_node	num_of_source_followers	num_of_source_followees	num
0	1	690569	1	3	
1	1	315892	1	3	
2	1	189226	1	3	

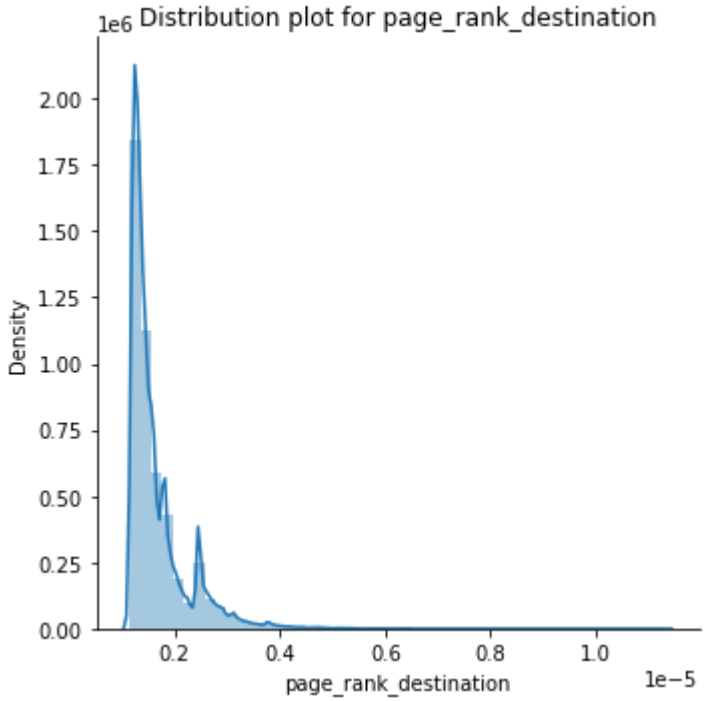
```
train_subset['page_rank_destination'] = train_subset['destination_node'].map(pr)
train_subset.head()
```

	source_node	destination_node	num_of_source_followers	num_of_source_followees	num
0	1	690569	1	3	
1	1	315892	1	3	
2	1	189226	1	3	
3	2	834328	0	6	
4	2	1615927	0	6	

```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "page_rank_source") \
   .add_legend();
#Distribution plot
plt.title("Distribution plot for page_rank_source")
plt.show();
```

Distribution plot for page_rank_source

```
##Displaying·data·in·form·of·grid·using·Facetgrid·
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "page_rank_destination") \
   .add_legend();
#Distribution Plot
plt.title("Distribution plot for page_rank_destination")
plt.show();
```



Hit Score

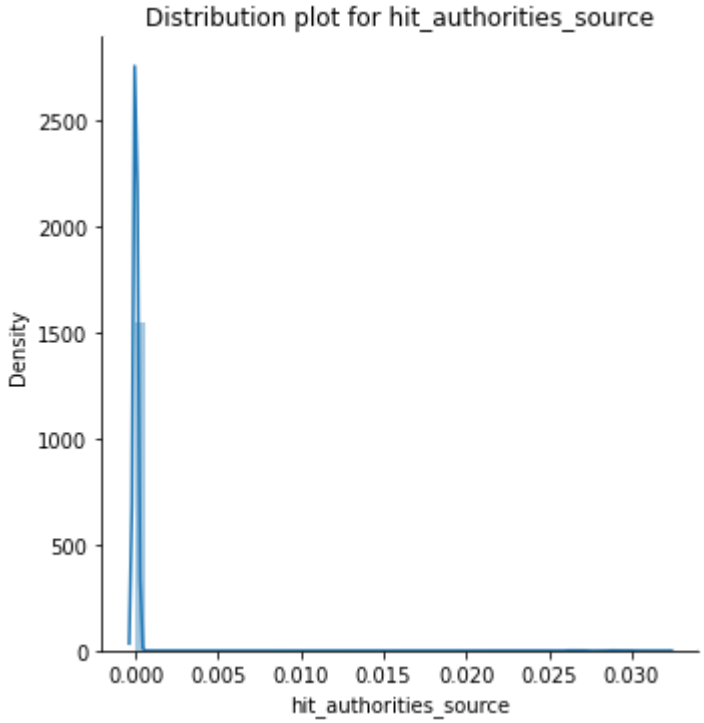
```
#Returning HITS hubs and authorities values for nodes.
hits = nx.hits(graph, max_iter=100, tol=1e-08, nstart=None, normalized=True)
```

```
train_subset['hit_authorities_source'] = train_subset['source_node'].map(hits[0])
train_subset['hit_authorities_source'].head()
```

```
0    2.398910e-21
1    2.398910e-21
2    2.398910e-21
3    1.496101e-21
4    1.496101e-21
Name: hit_authorities_source, dtype: float64
```

```
##Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "hit_authorities_source") \
   .add_legend();
```

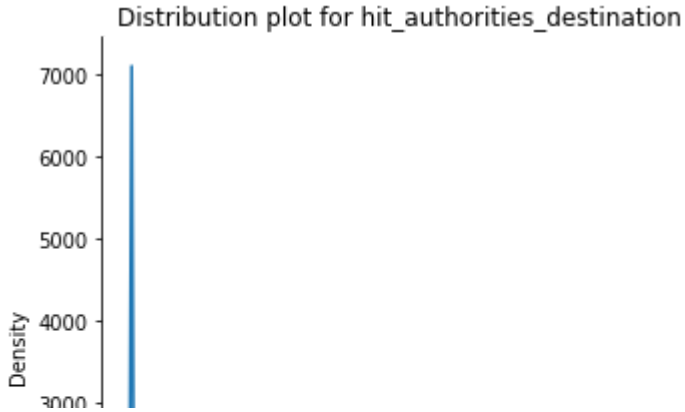
```
    .add_legend();
#Distribution Plot
plt.title("Distribution plot for hit_authorities_source")
plt.show();
```




```
train_subset['hit_authorities_destination'] = train_subset['destination_node'].map(hits[0])
train_subset['hit_authorities_destination'].head()
```

```
0   -0.000000e+00
1   -0.000000e+00
2    2.736062e-21
3   -0.000000e+00
4   -0.000000e+00
Name: hit_authorities_destination, dtype: float64
```

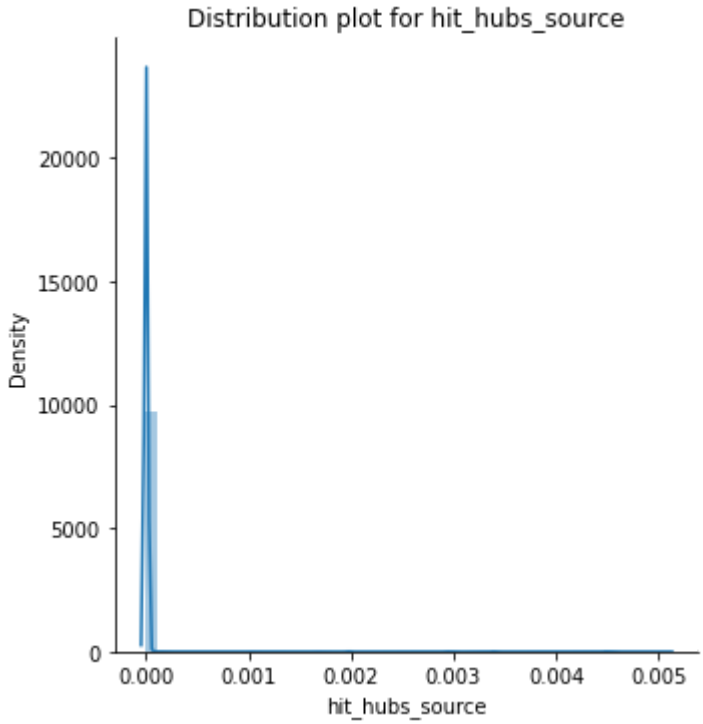
```
##Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "hit_authorities_destination") \
   .add_legend();
plt.title("Distribution plot for hit_authorities_destination")#Distribution Plot
plt.show();
```




```
train_subset['hit_hubs_source'] = train_subset['source_node'].map(hits[1])
train_subset['hit_hubs_source'].head()
```

```
0    2.660412e-22
1    2.660412e-22
2    2.660412e-22
3   -0.000000e+00
4   -0.000000e+00
Name: hit_hubs_source, dtype: float64
```

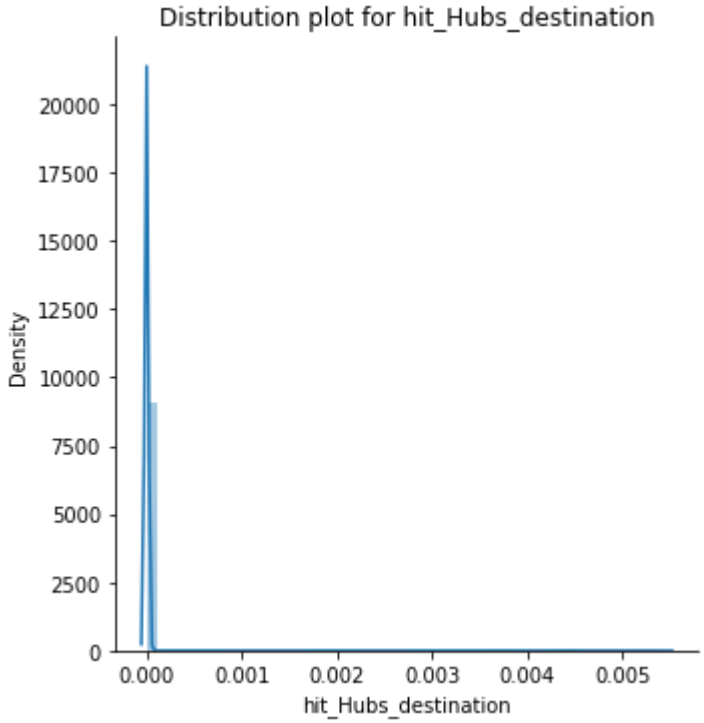
```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "hit_hubs_source") \
   .add_legend();
plt.title("Distribution plot for hit_hubs_source")#Distribution Plot
plt.show();
```




```
train_subset['hit_Hubs_destination'] = train_subset['destination_node'].map(hits[1])
train_subset['hit_Hubs_destination'].head()
```

```
0    5.770346e-20
1   -4.305351e-22
2   -8.469637e-23
3    4.247012e-22
4    3.714818e-21
Name: hit_Hubs_destination, dtype: float64
```

```
##Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "hit_Hubs_destination") \
   .add_legend();
plt.title("Distribution plot for hit_Hubs_destination")#Distribution Plot
plt.show();
```



Indegree and Out degree centrality

```
#Defining get_indegree_centrality function
def get_indegree_centrality(a):
    try :
        return nx.group_in_degree_centrality(graph, list(graph.predecessors(a)))
    except :
        return 0
```

```
#Defining get_outdegree_centrality function
def get_outdegree_centrality(a):
    try :
```

```
        return nx.group_out_degree_centrality(graph, list(graph.successors(a)))
    except :
        return 0
```

Degree Centrality

```
#The degree centrality for a node
degree_centrality = nx.degree_centrality(graph)
```

```
#Displaying Degree Centrality
degree_centrality
```

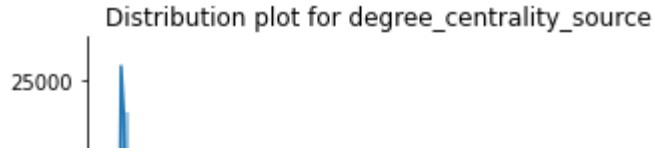
```
      1825254: 1.4582063478638736e-06,
      927274: 2.916412695727747e-06,
      912681: 1.4582063478638736e-06,
      799586: 1.4582063478638736e-06,
      187805: 2.916412695727747e-06,
      1400484: 1.4582063478638736e-06,
      864239: 2.916412695727747e-06,
      172: 3.4996952348732964e-05,
      4769: 8.749238087183241e-05,
      906059: 1.4582063478638736e-05,
      372997: 7.291031739319368e-06,
      1208963: 1.1665650782910989e-05,
      346991: 1.1665650782910989e-05,
      1172153: 5.832825391455494e-06,
      161309: 1.3123857130774862e-05,
      200086: 4.3746190435916205e-06,
      642842: 1.0207444435047115e-05,
      153393: 5.395363487096332e-05,
      625473: 4.3746190435916205e-06,
      1453902: 8.749238087183241e-06,
      703254: 2.916412695727747e-06,
      1591526: 7.291031739319368e-06,
      94719: 8.749238087183241e-06,
      1851039: 2.916412695727747e-06,
      1556441: 1.4582063478638736e-06,
      1359168: 1.4582063478638736e-06,
      1233403: 2.916412695727747e-06,
      891719: 1.4582063478638736e-06,
      174: 1.4582063478638736e-06,
      1454201: 1.4582063478638736e-06,
      175: 5.832825391455494e-06,
      262454: 7.291031739319368e-06,
      945369: 7.291031739319368e-06,
      979716: 2.916412695727747e-06,
      176: 1.4582063478638736e-06,
      1410138: 8.749238087183241e-06,
      177: 1.4582063478638736e-06,
      1337513: 1.4582063478638736e-06,
      178: 5.832825391455494e-06,
      185820: 1.4582063478638736e-06,
```

```
 31865: 7.291031739319368e-06,
 336157: 1.4582063478638736e-06,
 179: 2.9164126957277472e-05,
 1483220: 1.0207444435047115e-05,
 271130: 5.832825391455494e-06,
 1084031: 5.832825391455494e-06,
 861489: 4.3746190435916205e-06,
 781383: 2.916412695727747e-06,
 1228513: 1.0207444435047115e-05,
 1567328: 1.4582063478638736e-06,
 96588: 2.3331301565821977e-05,
 1497030: 4.3746190435916205e-06,
 462643: 4.3746190435916205e-06,
 330270: 4.3746190435916205e-06,
 1786977: 4.3746190435916205e-06,
 310769: 7.291031739319368e-06,
 232801: 4.3746190435916205e-06,
 1503576: 2.916412695727747e-06,
 486560: 2.916412695727747e-06,
```

```
train_subset['degree_centrality_source'] = train_subset['source_node'].map(degree_centrality)
train_subset['degree_centrality_source'].head()
```

```
0    0.000006
1    0.000006
2    0.000006
3    0.000009
4    0.000009
Name: degree_centrality_source, dtype: float64
```

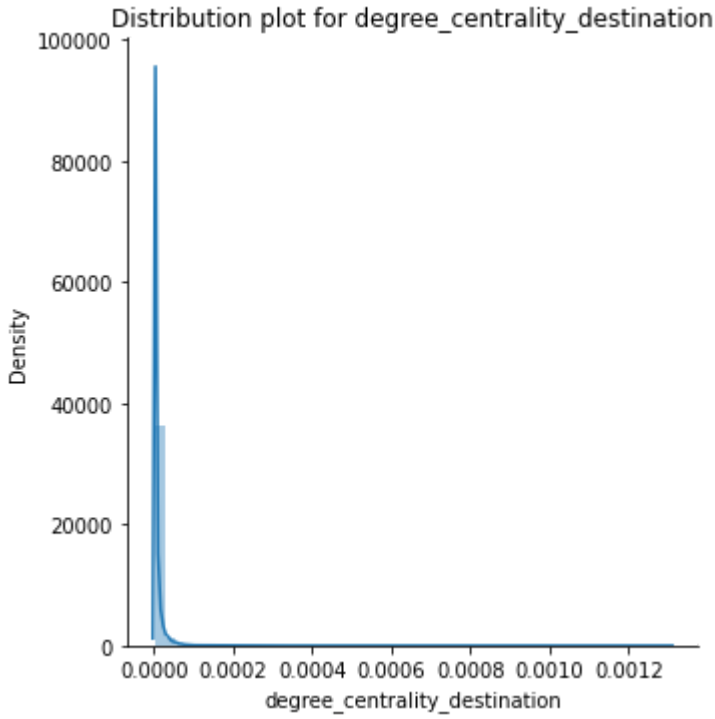
```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "degree_centrality_source") \
   .add_legend();
plt.title("Distribution plot for degree_centrality_source")#Distribution Plot
plt.show();
```




```
train_subset['degree_centrality_destination'] = train_subset['destination_node'].map(degree_c
train_subset['degree_centrality_destination'].head()
```

```
0    0.000004
1    0.000003
2    0.000009
3    0.000007
4    0.000003
Name: degree_centrality_destination, dtype: float64
```

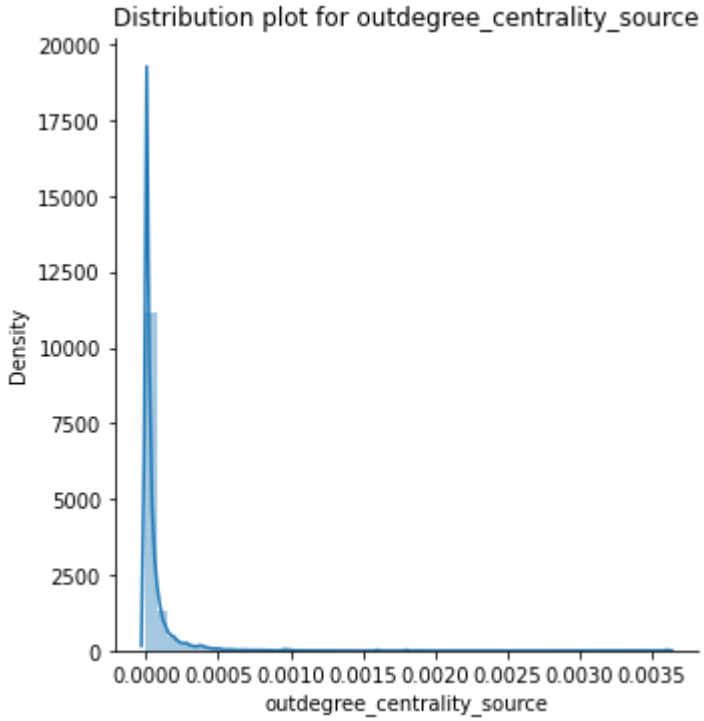
```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "degree_centrality_destination") \
   .add_legend();
plt.title("Distribution plot for degree_centrality_destination")#Distribution Plot
plt.show();
```




```
train_subset['outdegree_centrality_source'] = train_subset['source_node'].apply(get_outdegree
train_subset['outdegree_centrality_source'].head()
```

```
0    0.000004
1    0.000004
2    0.000004
3    0.000000
4    0.000000
Name: outdegree_centrality_source, dtype: float64
```

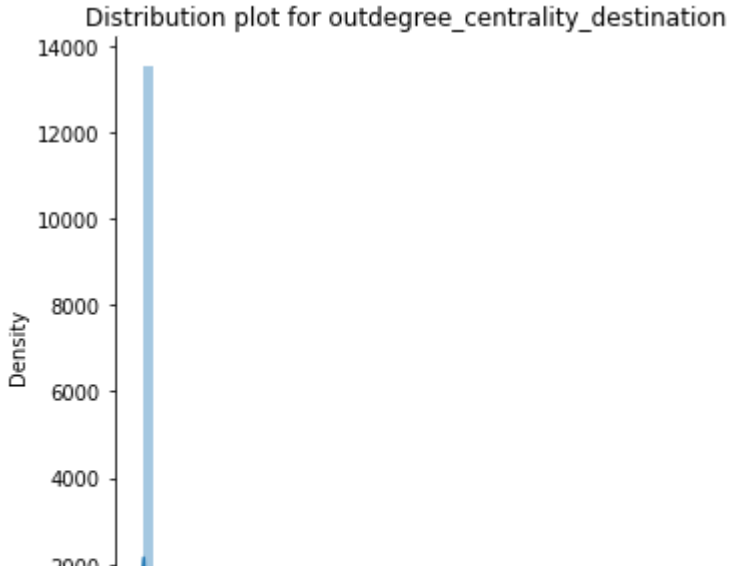
```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "outdegree_centrality_source") \
   .add_legend();
plt.title("Distribution plot for outdegree_centrality_source")#Distribution Plot
plt.show();
```




```
train_subset['outdegree_centrality_destination'] = train_subset['destination_node'].apply(get
train_subset['outdegree_centrality_destination'].head()
```

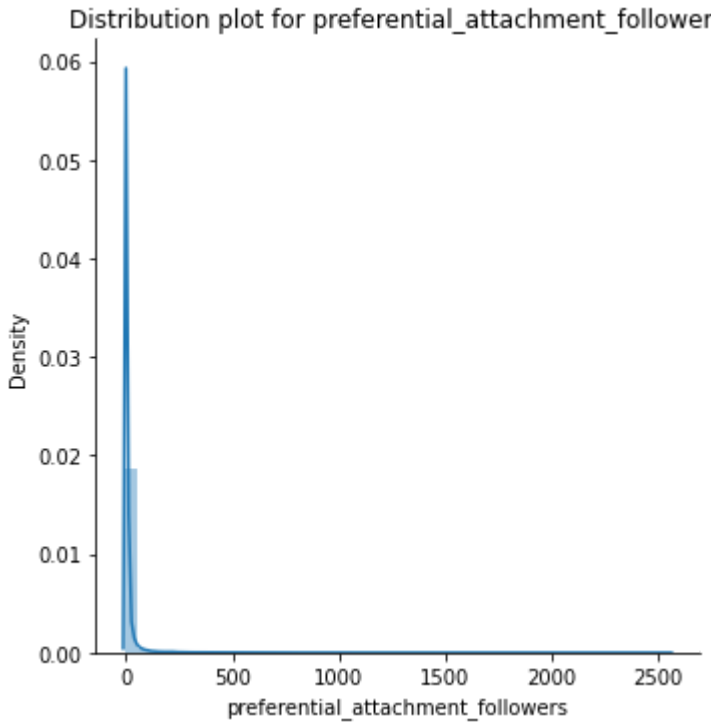
```
0    0.000000
1    0.000000
2    0.000004
3    0.000000
4    0.000000
Name: outdegree_centrality_destination, dtype: float64
```

```
#Displaying·data·in·form·of·grid·using·Facetgrid·
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "outdegree_centrality_destination") \
   .add_legend();
plt.title("Distribution plot for outdegree_centrality_destination")#Distribution Plot
plt.show();
```




```
#Defining preferential_attachment_followees function
def preferential_attachment_followees(a,b):
    try:
        if len(set(graph.successors(a))) == 0  | len(set(graph.successors(b))) == 0:
            return 0
        score = len(set(graph.successors(a)))*len(set(graph.successors(b)))
    except:
        return 0
    return score


##Defining preferential_attachment_followers function
def preferential_attachment_followers(a,b):
    try:
        if len(set(graph.predecessors(a))) == 0  | len(set(graph.predecessors(b))) == 0:
            return 0
        score = len(set(graph.predecessors(a)))*len(set(graph.predecessors(b)))
    except:
        return 0
    return score


train_subset['preferential_attachment_followers'] = train_subset.apply(lambda row:
                                            preferential_attachment_followers(row['source_nod


train_subset['preferential_attachment_followers'].head()

     0    3
     1    2
     2    2
     3    0
     4    0
     Name: preferential_attachment_followers, dtype: int64


#Displaying data in form of grid using Facetgrid
```

```
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "preferential_attachment_followers") \
   .add_legend();
plt.title("Distribution plot for preferential_attachment_followers")#Distribution Plot
plt.show();
```

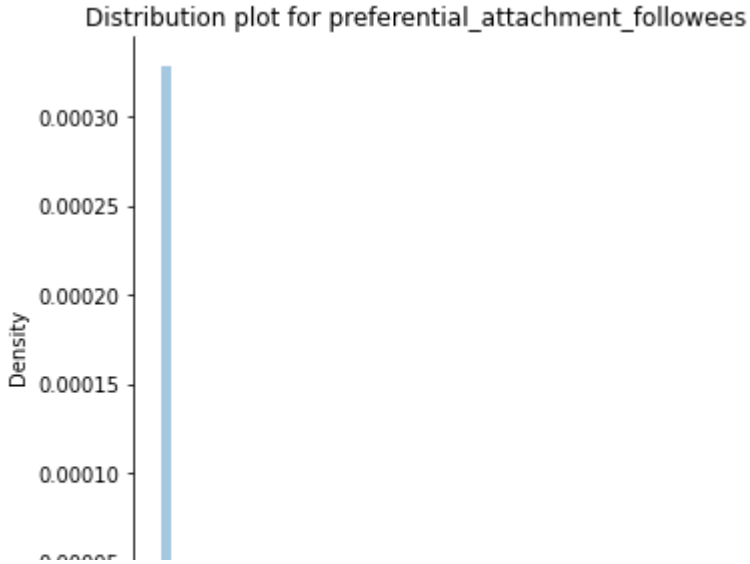



```
train_subset['preferential_attachment_followees'] = train_subset.apply(lambda row:
                                            preferential_attachment_followees(row['source_nod
```

```
train_subset['preferential_attachment_followees'].head()
```

```
0     0
1     0
2    12
3     0
4     0
Name: preferential_attachment_followees, dtype: int64
```

```
#Displaying data in form of grid using Facetgrid
sns.FacetGrid(train_subset, height=5) \
   .map(sns.distplot, "preferential_attachment_followees") \
   .add_legend();
plt.title("Distribution plot for preferential_attachment_followees")#Distribution Plot
plt.show();
```




```
train_subset.head(5)
```

	source_node	destination_node	num_of_source_followers	num_of_source_followees	num
0	1	690569	1	3	
1	1	315892	1	3	
2	1	189226	1	3	
3	2	834328	0	6	
4	2	1615927	0	6	

5 rows × 26 columns

```
train_subset.columns
```

```
Index(['source_node', 'destination_node', 'num_of_source_followers',
       'num_of_source_followees', 'num_of_destination_followers',
       'num_of_destination_followees', 'num_of_common_followers',
       'num_of_common_followees', 'jaccard_similarity_followers',
       'jaccard_similarity_followees', 'cosine_similarity_followers',
       'is_followed_back', 'shorterst_path_length', 'adar_index',
       'page_rank_source', 'page_rank_destination', 'hit_authorities_source',
       'hit_authorities_destination', 'hit_hubs_source',
       'hit_Hubs_destination', 'degree_centrality_source',
       'degree_centrality_destination', 'outdegree_centrality_source',
       'outdegree_centrality_destination', 'preferential_attachment_followers',
       'preferential_attachment_followees'],
      dtype='object')
```

```
train_subset.drop(['adar_index','preferential_attachment_followees'],axis=1,inplace=True)
```

```
#Displaying Final Features
print("The final features are:")
for i,column in enumerate(train_subset.columns):
    print("{}. {}".format(i+1,column))
```

```
 The final features are:
 1. source_node
 2. destination_node
 3. num_of_source_followers
 4. num_of_source_followees
 5. num_of_destination_followers
 6. num_of_destination_followees
 7. num_of_common_followers
 8. num_of_common_followees
 9. jaccard_similarity_followers
 10. jaccard_similarity_followees
 11. cosine_similarity_followers
 12. is_followed_back
 13. shorterst_path_length
 14. page_rank_source
 15. page_rank_destination
 16. hit_authorities_source
 17. hit_authorities_destination
 18. hit_hubs_source
 19. hit_Hubs_destination
 20. degree_centrality_source
 21. degree_centrality_destination
 22. outdegree_centrality_source
 23. outdegree_centrality_destination
 24. preferential_attachment_followers
```

✓ 4s completed at 6:58 PM