YOUTUBE NETWORK ANALYSIS

Project by

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1) Load the dataset into NetworkX to create an undirected graph

```
import networkx as nx
from networkx.algorithms import community
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import random
plt.rcParams.update({'figure.max_open_warning': 50})
```

Generates a plot with the degrees of distribution of the connected components. To facilitate the representation it was decided to also use the loglog contained in numpy.Plot of the histogram degree distribution

```
---------------------------------------------------
Input: G---> Graphs
          A networkx graph
Output: a list of values of the degree distribution
```

```
def plot_degree_dist(G):
    degrees = G.degree()
    degrees = dict(degrees)
    values = sorted(set(degrees.values()))
    histo = [list(degrees.values()).count(x) for x in values]
    P_k = [x / G.order() for x in histo]

    plt.figure()
    plt.plot(values, P_k, "ro-")
```

```
    plt.xlabel("k")
    plt.ylabel("p(k)")
    plt.title("Degree Distribution")
    plt.show()

    plt.figure()
    plt.grid(False)
    plt.loglog(values, P_k, "bo-")
    plt.xlabel("log k")
    plt.ylabel("log p(k)")
    plt.title("log Degree Distribution")
    plt.show()
    plt.figure()
    degrees = [G.degree(n) for n in G.nodes()]
    counts = dict()
    for i in degrees:
        counts[i] = counts.get(i, 0) + 1
    axes = plt.gca()
    axes.set_xlim([0,100])
    axes.set_ylim([0,1000])
    plt.grid(False)
    plt.bar(list(counts.keys()), counts.values(), color='r')
    plt.title("Degree Histogram")
    plt.ylabel("Count")
    plt.xlabel("Degree")
    plt.show()
```

Generates a plot with the IN/OUT degrees of distribution of the connected components. To facilitate the representation it was decided to also use the loglog contained in numpy

```
  Parameters
 Input: G---> Graphs
       A networkx graph
 Output: a list of values of the degree distribution
```

```
def plot_degree_In(G):
    N = G.order()
    in_degrees = G.in_degree()  #built-in function to estimate in-degree distribution
    in_degrees = dict(in_degrees)
    in_values= sorted(set(in_degrees.values()))
    in_hist = [list(in_degrees.values()).count(x) for x in in_values]
    in_P_k = [x / N for x in in_hist]
    out_degrees = G.out_degree()   #built-in function to estimate out-degree distribution
    out_degrees = dict(out_degrees)
    out_values = sorted(set(out_degrees.values()))
    out_hist = [list(out_degrees.values()).count(x) for x in out_values]
    out_P_k = [x / N for x in out_hist]
```

```
    plt.figure()
    plt.grid(False)
    plt.plot(in_values ,in_P_k, "r.")
    plt.plot(out_values,out_P_k, "b.")
    plt.legend(['In-degree','Out-degree'])
    plt.xlabel("k")
    plt.ylabel("p(k)")
    plt.title("Degree Distribution")
    plt.show()

    plt.figure()
    plt.grid(False)
    plt.loglog(in_values ,in_P_k, "r.")
    plt.loglog(out_values,out_P_k, "b.")
    plt.legend(['In-degree','Out-degree'])
    plt.xlabel("log k")
    plt.ylabel("log p(k)")
    plt.title("log log Degree Distribution")
    plt.show()
```

Generates a plot with the clustering coefficientof.It is a measure of the degree to which nodes in a graph tend to cluster together.To facilitate the representation it was decided to also use the loglog contained in numpy

```
 Parameters
Input: G---> Graphs
Output: a list of values of the degree distribution
```

```
def plot_clustering_coefficient(G):
        clust_coefficients = nx.clustering(G)  #built-in function to estimate clustering c
        clust_coefficients = dict(clust_coefficients)
        values1= sorted(set(clust_coefficients.values()))
        histo1 = [list(clust_coefficients.values()).count(x) for x in values1]

        plt.figure()
        plt.grid(False)
        plt.plot(values1,histo1, "r.")
        plt.xlabel("k")
        plt.ylabel("C (Clustering Coeff)")
        plt.title("Clustering Coefficients")
        plt.show()
        plt.figure()
        plt.grid(False)
        plt.loglog(values1,histo1, "r.")
        plt.xlabel("log degree k")
```

```
        plt.ylabel("c (clustering coeff)")
        plt.title("log log Clustering Coefficients")
        plt.show()

        plt.figure()
        degrees1 = [nx.clustering(G,n) for n in G.nodes()]
        plt.hist(degrees1)
        plt.xlabel("log degree k")
        plt.ylabel("C (Clustering Coeff) hist")
        plt.title("Clustering Coefficients")
        plt.show()
```

Generate a view of lattice graph

```
    Parameters:
    •G (NetworkX graph) –
    k (node) – number of adjacent nodes
Returns:
    graphs – a graph lattice view
Return type: networkx graph
```

```
def adjacent_edges(nodes, halfk):

    n = len(nodes)
    for i, u in enumerate(nodes):
        for j in range(i+1, i+halfk+1):
            v = nodes[j % n]
            yield u,v



def make_ring_lattice(n,k):
    G = nx.Graph()
    nodes = range(n)
    G.add_nodes_from(nodes)
    G.add_edges_from(adjacent_edges(nodes, k//2))
    return G

def flip(p):
    return np.random.random() < p

def rewire(G,p):
    nodes = set(G)
    for u, v in G.edges():
        if flip(p):
            choices = nodes - {u} - set(G[u])
            new_v = np.random.choice(list(choices))
            G.remove_edge(u, v)
            G.add_edge(u, new_v)
```

```
def small_world(n,k,p):
    sw = make_ring_lattice(n,k)
    rewire(sw,p)
    return sw
```

Return the core number for each vertex.A k-core is a maximal subgraph that contains nodes of degree k or more.The core number of a node is the largest value k of a k-core containing that node.

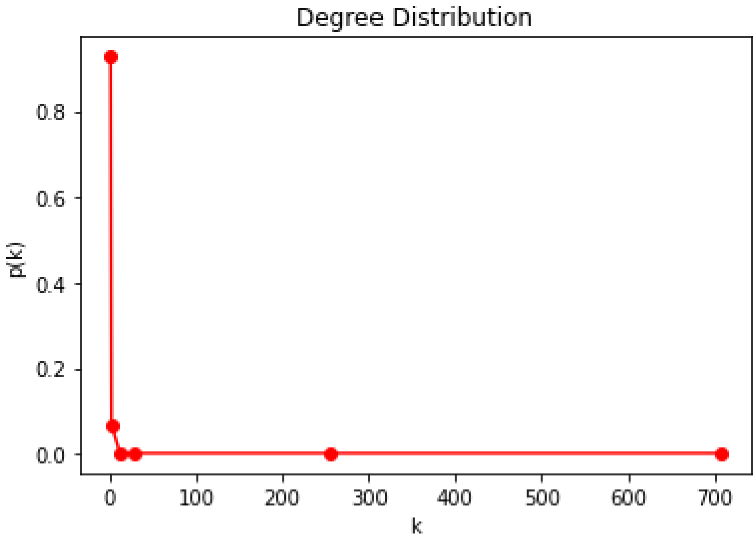
```
Parameters
----------
G : NetworkX graph
   A graph or directed graph
Returns
-------
core_number : dictionary
   A dictionary keyed by node to the core number
```

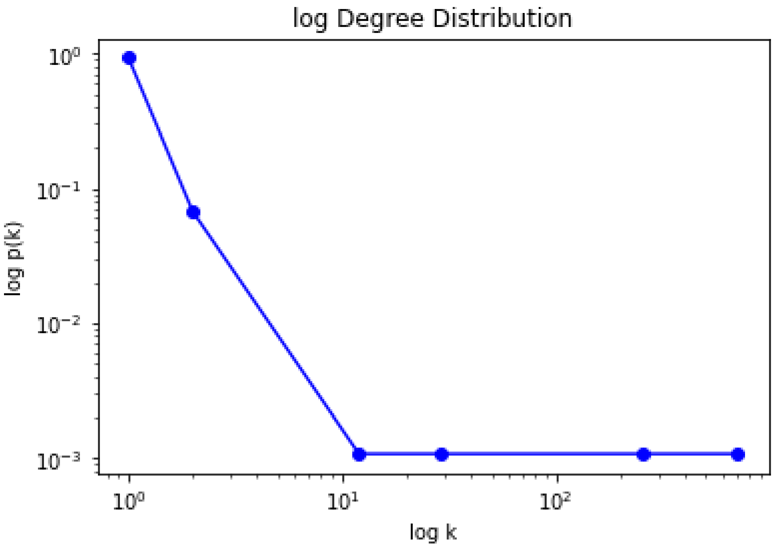
```
def k_core(G,k,t):
        H=G.copy()
        i=1
        while (i>0):
            i=0
            for node in list(H.nodes()):
                if H.degree(node)<k:
                    H.remove_node(node)
                    i+=1
        if (H.order()!=0):
            plt.figure()
            plt.title(str(k) +'-core decomposition of' + t)
            nx.draw(H,with_labels=True)
        return H

def full_k_core_decomposition(G,t):
    empty = False
    k=1
    while (empty==False):
        H = k_core(G,k,t)
        k+=1
        if (H.order()==0):
            empty = True
```

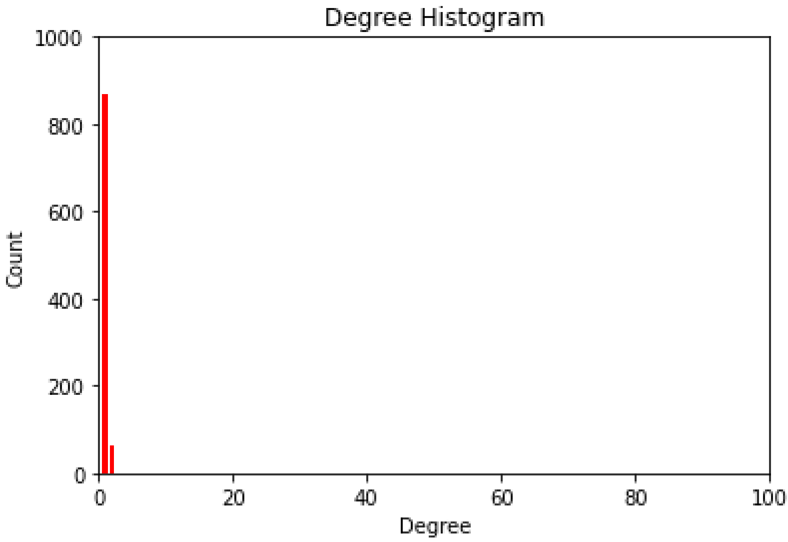
```
graphs = nx.read_edgelist('com-youtube.ungraph.txt',create_using=nx.Graph(), nodetype=int)
```

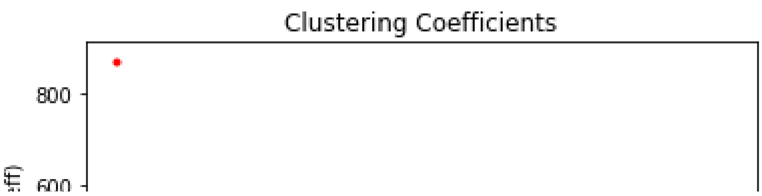
```
subset = 1000
edges = graphs.edges()
edges = list(edges)[:int(subset)]
edges = [list(elem) for elem in edges]


#%% formatting necessary to allow performing nx.parse_edglist

_newlist = []
_list = []

for subsets in edges:
    for element in subsets:
        _list.append(element)

_temp= int(len(_list)*0.5)

for i in range (_temp):
    _newlist.append(str(_list[2*i]) + " " + str(_list[2*i +1]) )
print(_newlist)
graphs = nx.parse_edgelist(_newlist, nodetype = int)
#%%
"""1 Original Graphs Measures"""
N=graphs.order()
E = graphs.number_of_edges()
Av_deg_undirected = float(2*E)/N

print ("\n ORIGINAL GRAPH: ")
print("The number of nodes is:", N)
print("The number of edges is:", E)
print("The average degree (undirected graph) is:", Av_deg_undirected)

plot_degree_dist(graphs)
plot_clustering_coefficient(graphs)
print ('The average clustering coefficient is: ' + str(nx.average_clustering(graphs)))
```

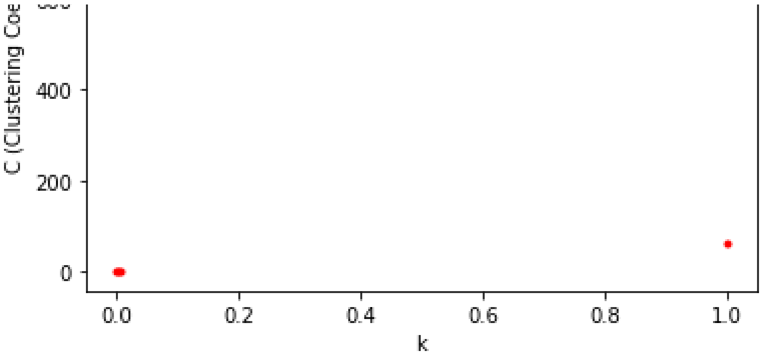
```
['1 2', '1 3', '1 4', '1 5', '1 6', '1 7', '1 8', '1 9', '1 10', '1 11', '1 12', '1

 ORIGINAL GRAPH:
The number of nodes is: 937
The number of edges is: 1000
The average degree (undirected graph) is: 2.134471718249733
```

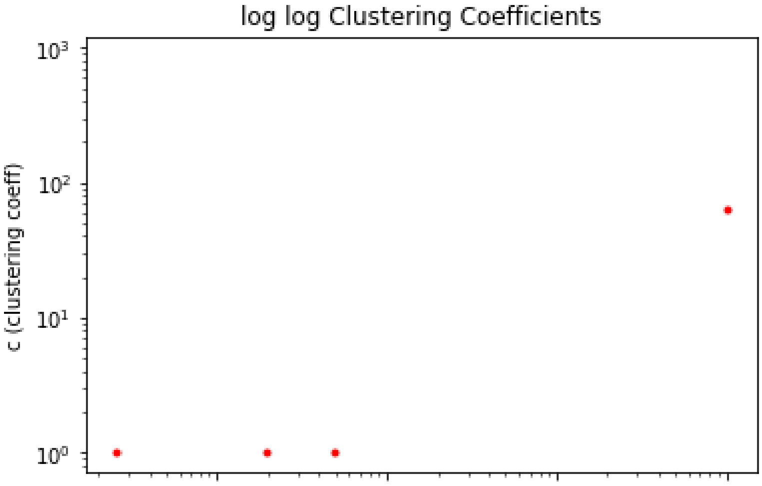












Community Generation

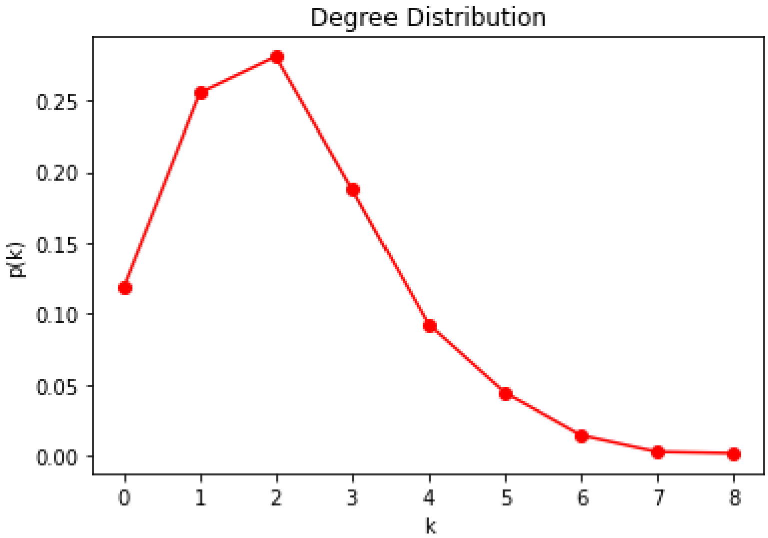
```
communities_gen = community.girvan_newman(graphs)
top_level_communities = next(communities_gen)
next_level_communities = next(communities_gen)
a=sorted(map(sorted,next_level_communities))
```

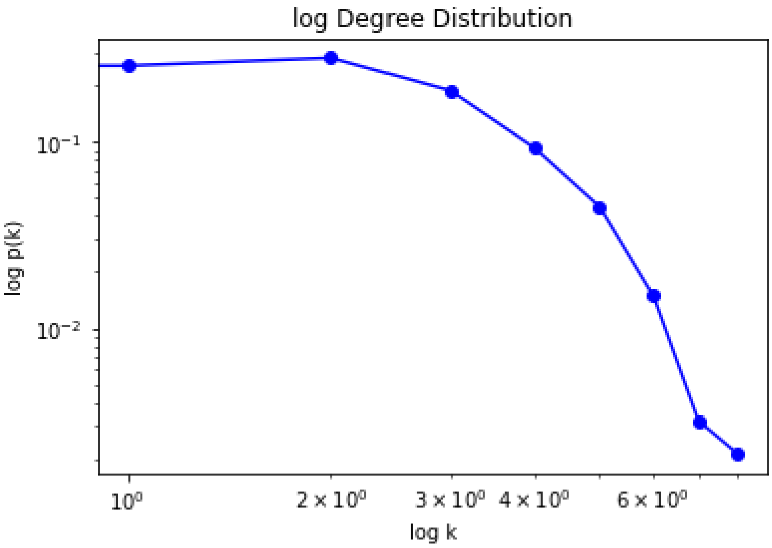
GENERATION OF THE SBM GRAPH

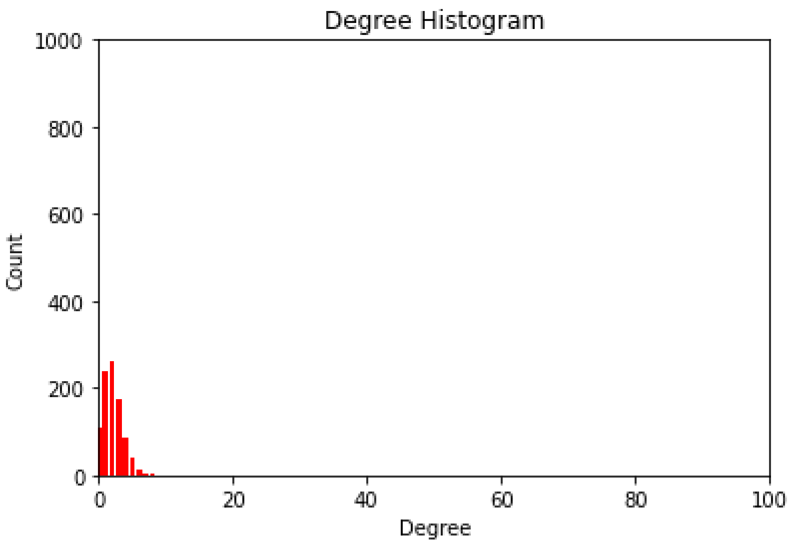
```
sizes = []
probs = []
for com in a:
  sizes.append(len(com))

num11 = sizes[0] * (sizes[0]-1)*0.5
num12 = sizes[0] * sizes[1]
num13 = sizes[0] * sizes[2]
num22 = sizes[1] * (sizes[1]-1)*0.5
num23 = sizes[1] * sizes[2]
num33 = sizes[2] * (sizes[2]-1)*0.5

num_edges11,num_edges22,num_edges33,num_edges12,num_edges13,num_edges23 = [0,0,0,0,0,0]
for g in edges:
    g[0] = int(g[0])
    g[1] = int(g[1])
for h in edges:
```

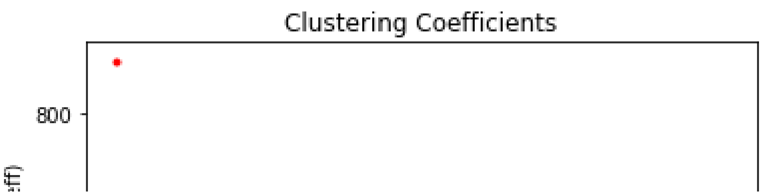
```
      if (h[0] in a[0] and h[1] in a[0]):
        num_edges11+=1
      elif (h[0] in a[1] and h[1] in a[1]):
        num_edges22+=1
      elif (h[0] in a[2] and h[1] in a[2]):
        num_edges33+=1
      elif ((h[0] in a[0] and h[1] in a[1]) or (h[0] in a[1] and h[1] in a[0])):
        num_edges12+=1
      elif ((h[0] in a[0] and h[1] in a[2]) or (h[0] in a[2] and h[1] in a[0])):
        num_edges13+=1
      else:
          (h[0] in a[1] and h[1] in a[2]) or (h[0] in a[2] and h[1] in a[1])
          num_edges23+=1
    p11 = float (num_edges11/num11)
    p12 = float (num_edges12/num12)
    p13 = float (num_edges13/num13)
    p22 = float (num_edges22/num22)
    p23 = float (num_edges23/num23)
    p33 = float (num_edges33/num33)

    probs1 = [p11,p12,p13],[p12,p22,p23],[p13,p23,p33]

    print(probs1)
    #%% It is now possible to generate the SBM and calculate some statistic measures on it

    SBM = nx.stochastic_block_model(sizes, probs1, seed=0)

    """2a STATISTICS ABOUT MEASURES - SBM"""
    SBM_nodes=SBM.order()
    SBM_Edges = SBM.number_of_edges()
    Av_deg_SBM = float(2*SBM_Edges)/SBM_nodes

    print ("\n SBM GRAPH: ")
    print("The number of nodes is:", SBM_nodes)
    print("The number of edges is:", SBM_Edges)
    print("The average degree (undirected graph) is:", Av_deg_SBM)

    plot_degree_dist(SBM)
    plot_clustering_coefficient(SBM)
    print ('The average clustering coefficient is: ' + str(nx.average_clustering(SBM)))
```

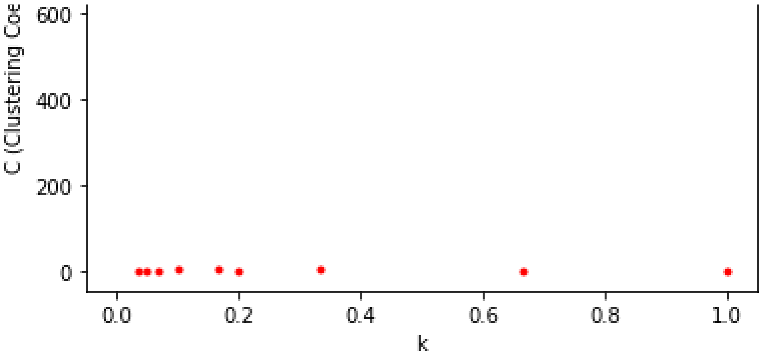
```
([0.05128205128205128, 0.00010055304172951231, 7.975435658172828e-05], [0.0001005530

 SBM GRAPH:
The number of nodes is: 937
The number of edges is: 986
The average degree (undirected graph) is: 2.104589114194237
```

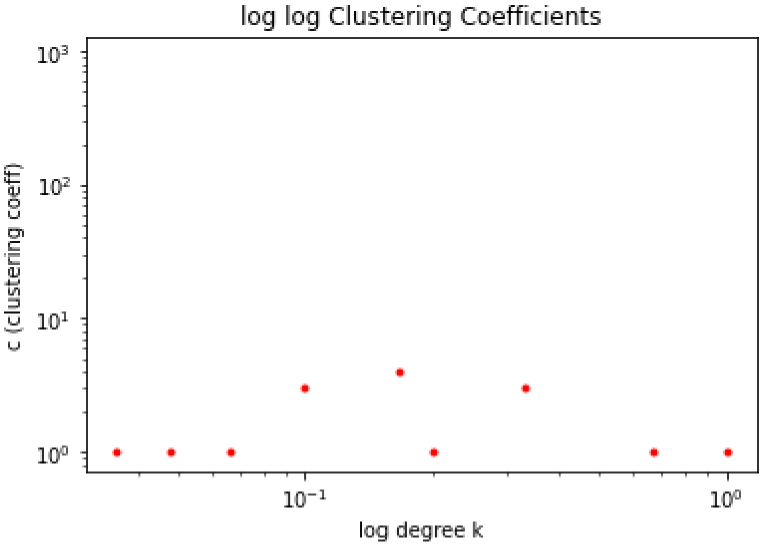








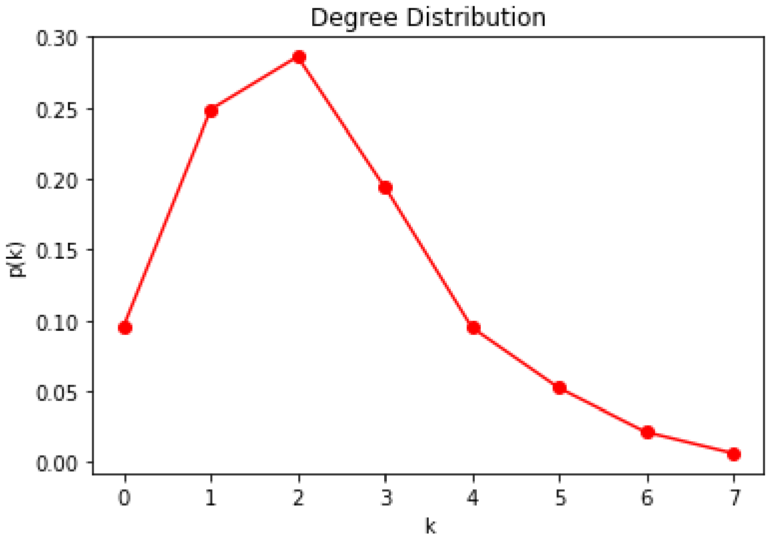


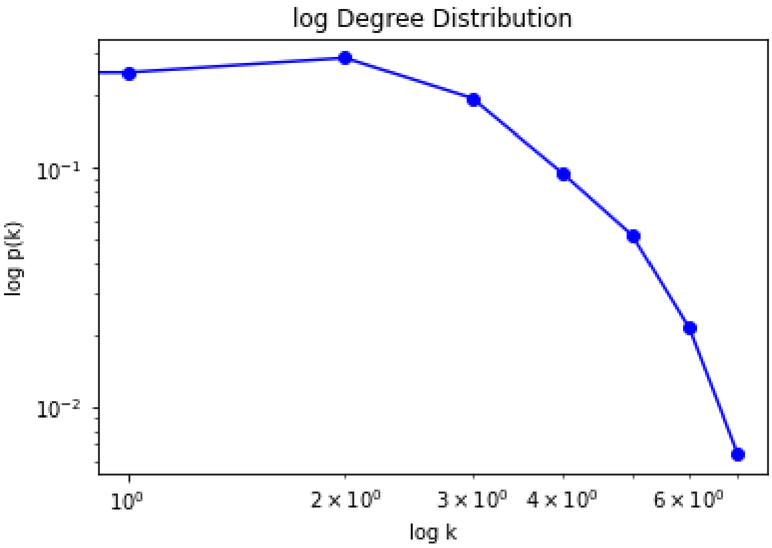


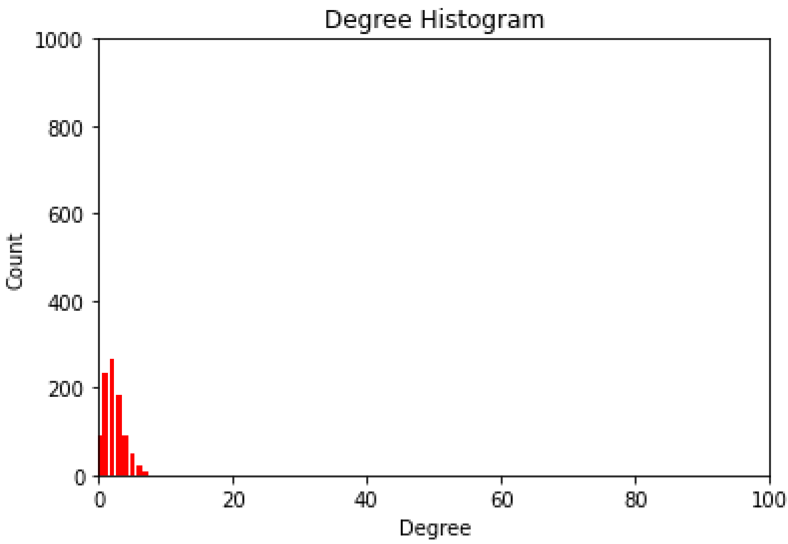
Generation of Erdos-Renyi random graph

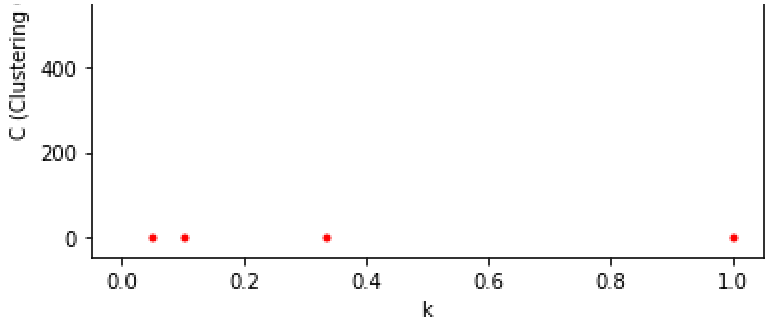
```
"""2b STATISTICS ABOUT MEASURES - ERDOS-RENYI"""

Proba = E/(N*(N-1)/2)
Erdos_renyi = nx.erdos_renyi_graph (N, Proba)
Nodes_erdos=Erdos_renyi.order()
Edges_erdos = Erdos_renyi.number_of_edges()
Av_deg_und_erdos = float(2*Edges_erdos)/Nodes_erdos

print ("\n ERDOS-RENYI GRAPH: ")
print("The number of nodes is:", Nodes_erdos)
print("The number of edges is:", Edges_erdos)
print("The average degree (undirected graph) is:", Av_deg_und_erdos)

plot_degree_dist(Erdos_renyi)
plot_clustering_coefficient(Erdos_renyi)
print ('The average clustering coefficient is: ' + str(nx.average_clustering(Erdos_renyi))
```

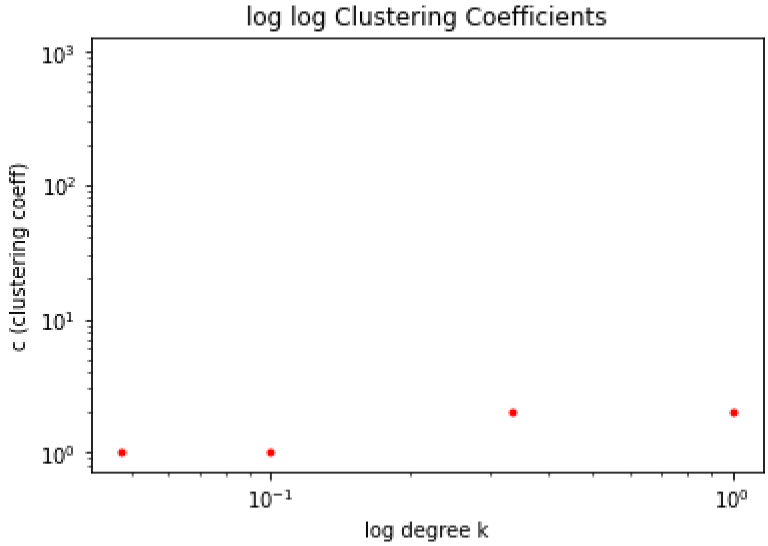
```
 ERDOS-RENYI GRAPH:
The number of nodes is: 937
The number of edges is: 1039
The average degree (undirected graph) is: 2.2177161152614726
```





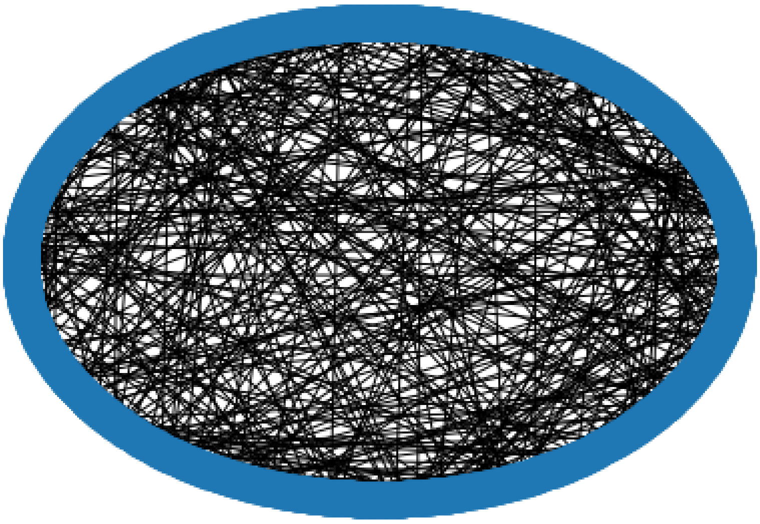


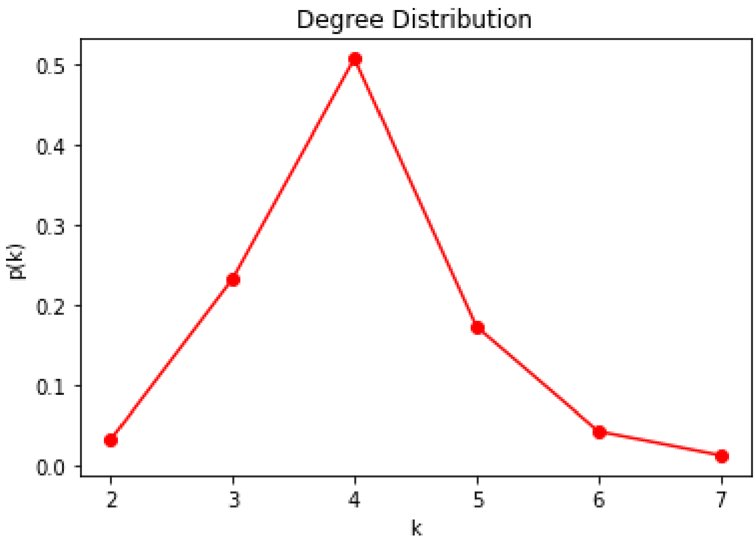


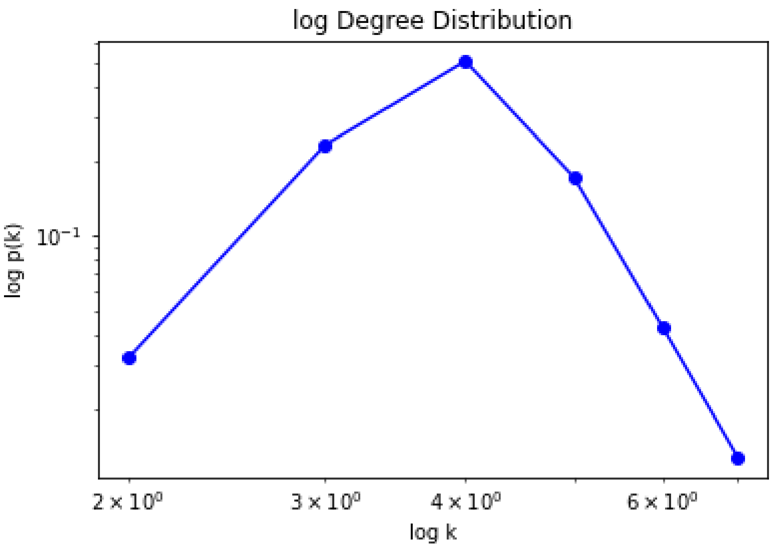


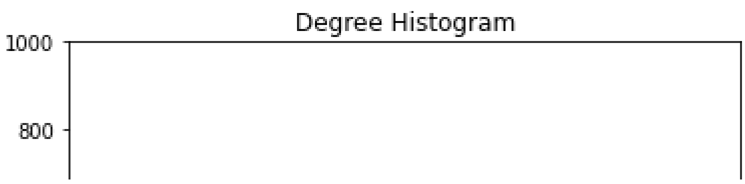

```
"""2b STATISTICS ABOUT MEASURES - SMALL WORLD"""

Small_World = small_world(N,4,0.2)
nx.draw_circular(Small_World)

Nodes_SW=Small_World.order()
Edge_SW = Small_World.number_of_edges()
Av_deg_SW = float(2*Edge_SW)/Nodes_SW
print ("\n SMALL WORLD GRAPH: ")
print("The number of nodes is:", Nodes_SW)
print("The number of edges is:", Edge_SW)
print("The average degree (undirected graph) is:", Av_deg_SW)

plot_degree_dist(Small_World)
plot_clustering_coefficient(Small_World)
print ('The average clustering coefficient is: ' + str(nx.average_clustering(Small_World))
```

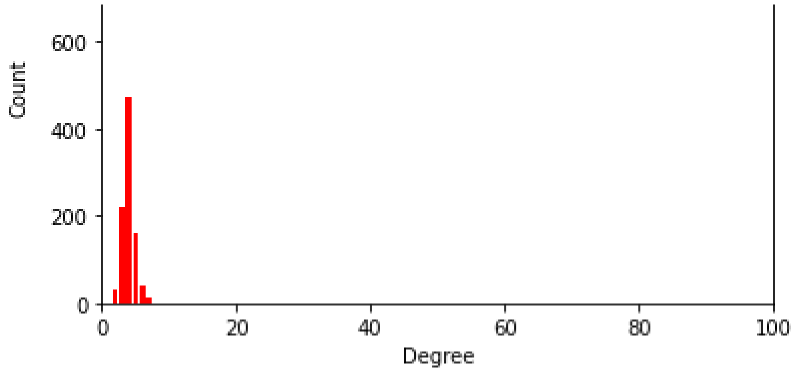
```
 SMALL WORLD GRAPH:
The number of nodes is: 937
The number of edges is: 1874
The average degree (undirected graph) is: 4.0
```

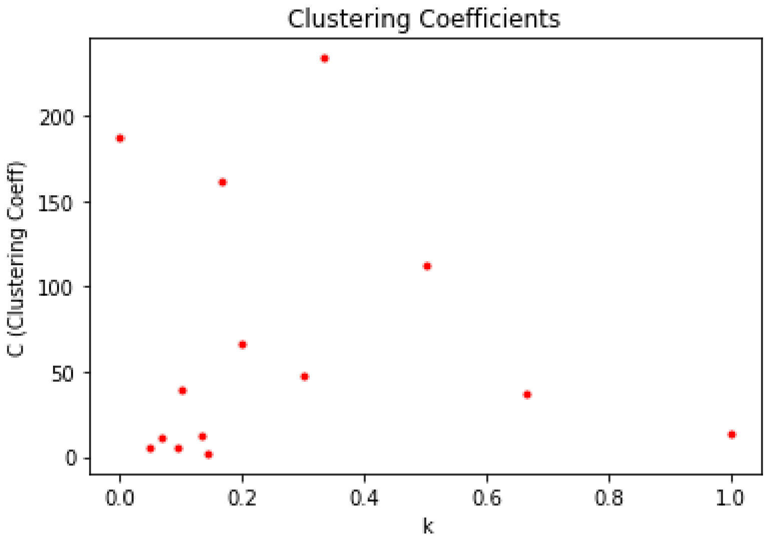


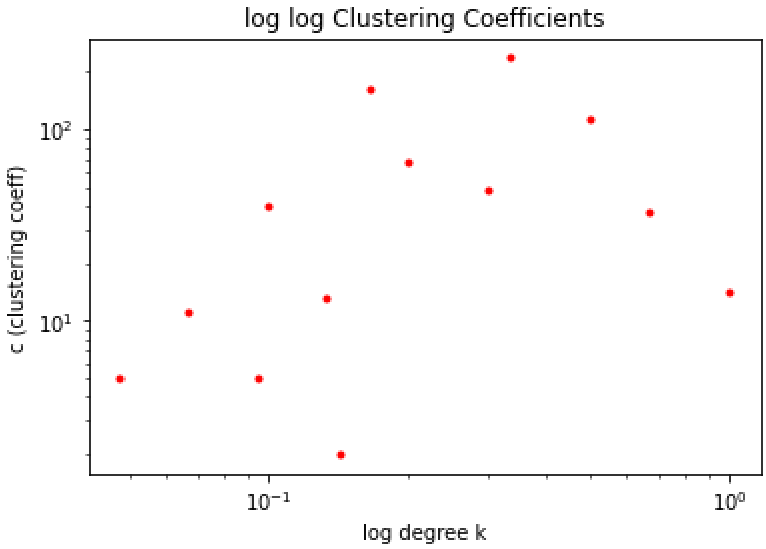


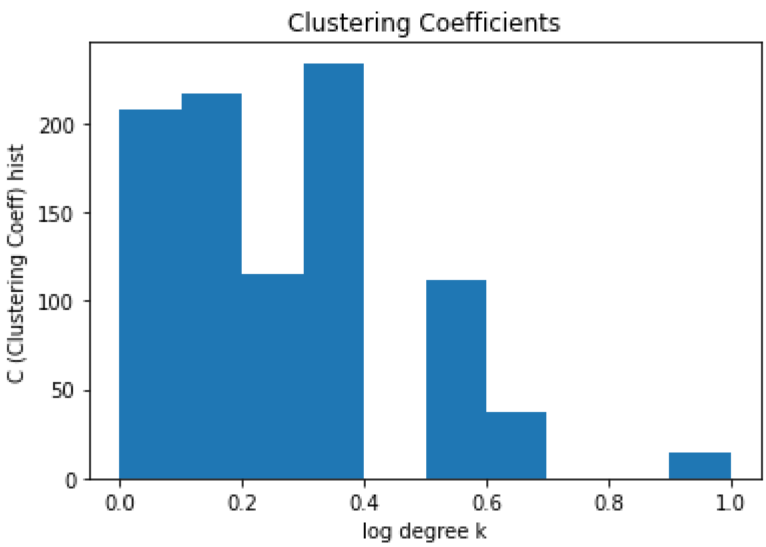





Count
Degree

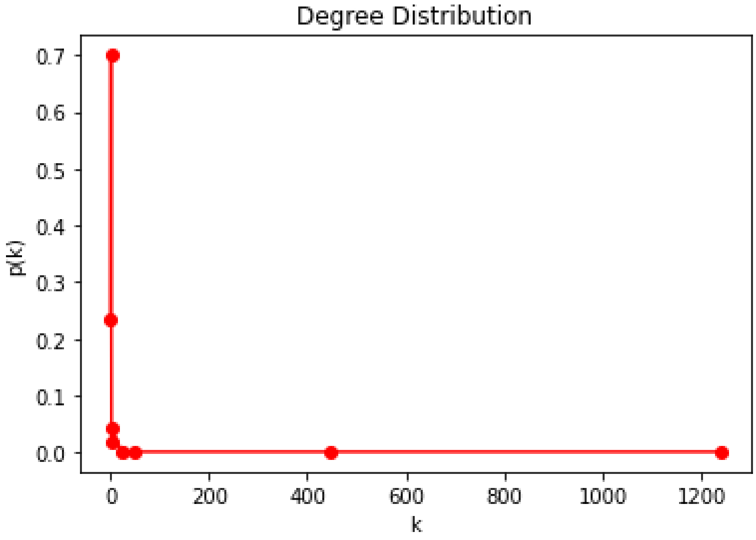

Clustering Coefficients
C (Clustering Coeff)
k

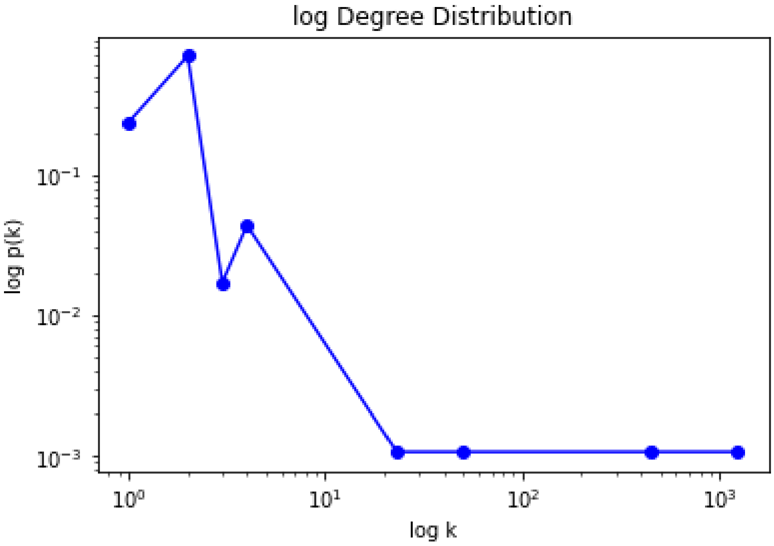

log log Clustering Coefficients
c (clustering coeff)
log degree k

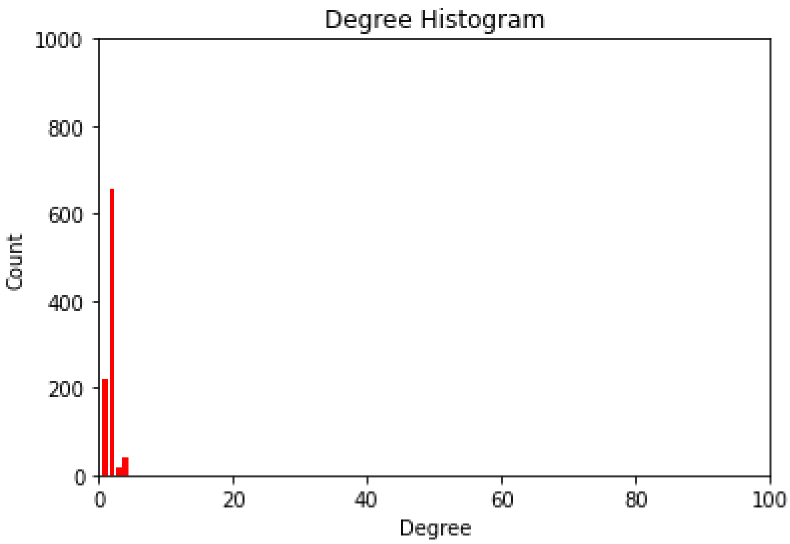

Clustering Coefficients
C (Clustering Coeff) hist
log degree k

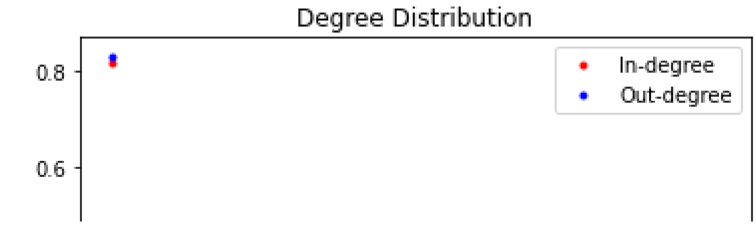
```
"""4 DIRECTED VERSION WITHOUT 25% OF THE LINKS"""

k = int(E*0.25)
DG = graphs.copy()
DG = DG.to_directed()
edges_d = DG.edges()
list_edges_d = list(edges_d)
random.shuffle(list_edges_d)

for edgee in list_edges_d:
    if (DG.degree(edgee[0]) != 1 and DG.degree(edgee[1]) != 1):
        DG.remove_edge(edgee[0],edgee[1])
        k-=1
    if (k==0):
        break

N4=DG.order()
E4 = DG.number_of_edges()
Av_deg_d = float(E)/N

print ("\n DIRECTED VERSION WITHOUT 25% OF THE LINKS: ")
print("The number of nodes is:", N4)
print("The number of edges is:", E4)
print("The average degree (directed graph) is:", Av_deg_d)

plot_degree_dist(DG)
plot_degree_In(DG)
plot_clustering_coefficient(DG)
DG = DG.to_undirected()
print ('The average clustering coefficient is: ' + str(nx.average_clustering(DG)))
```

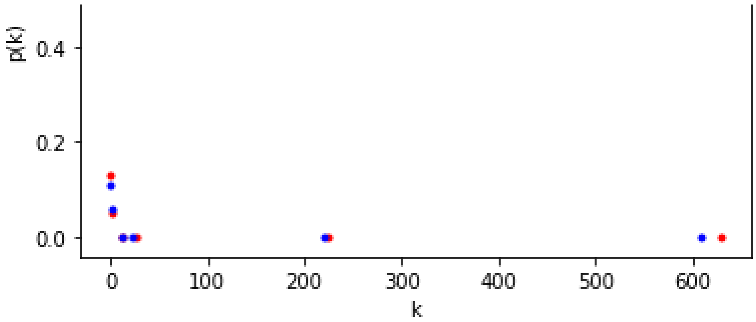
```
 DIRECTED VERSION WITHOUT 25% OF THE LINKS:
The number of nodes is: 937
The number of edges is: 1750
The average degree (directed graph) is: 1.0672358591248665
```

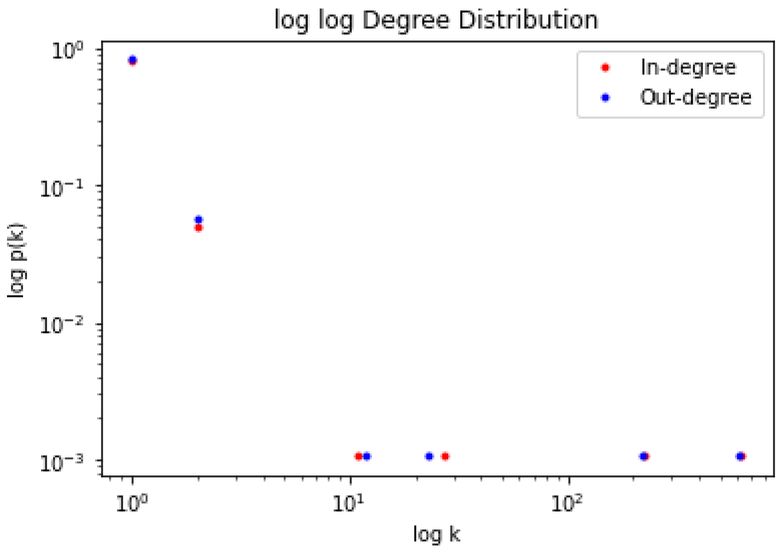


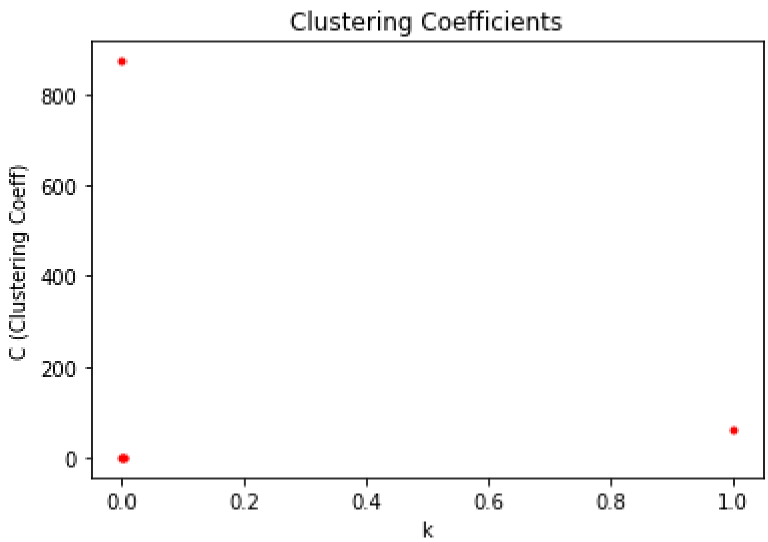


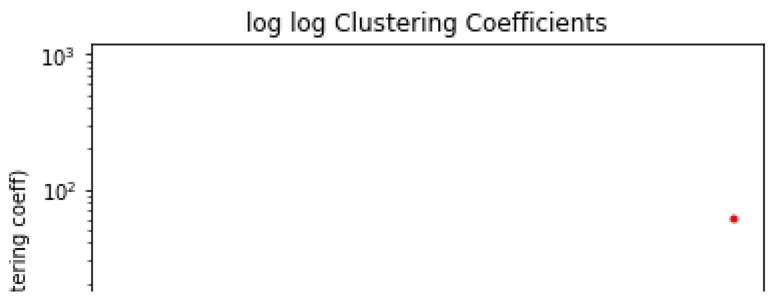












Page Rank Calculations

```
nodes = dict()
val = 0
for node in list(graphs.nodes()):
```

```
    nodes[node] = val
    val += 1
```

```
# We have calculated page rank using three measures - simple pagerank, personalized pagera
simple_pagerank = nx.pagerank(graphs, alpha=0.85)
personalized_pagerank = nx.pagerank(graphs, alpha=0.85, personalization=nodes)
nstart_pagerank = nx.pagerank(graphs, alpha=0.85, nstart=nodes)
weighted_pagerank = nx.pagerank(graphs, alpha=0.85)
weighted_personalized_pagerank = nx.pagerank(graphs, alpha=0.85, personalization=nodes)

df_metrics = pd.DataFrame(dict(
    simple_pagerank = simple_pagerank,
    personalized_pagerank = personalized_pagerank,
    nstart_pagerank = nstart_pagerank,
    weighted_pagerank = weighted_pagerank,
    weighted_personalized_pagerank = weighted_personalized_pagerank,
))
df_metrics.index.name='Nodes'
df_metrics
```

Nodes	simple_pagerank	personalized_pagerank	nstart_pagerank	weighted_pagerank
1	0.013706	0.003337	0.013704	0.013706
2	0.112634	0.063337	0.112636	0.112634
3	0.006097	0.003030	0.006096	0.006097
4	0.329266	0.390945	0.329277	0.329266
5	0.000562	0.000099	0.000562	0.000562
...	...	...	...	...
18008	0.000556	0.000788	0.000556	0.000556
18009	0.000556	0.000789	0.000556	0.000556
18010	0.000556	0.000789	0.000556	0.000556
18011	0.000556	0.000789	0.000556	0.000556
18012	0.000556	0.000790	0.000556	0.000556

937 rows × 5 columns

```
page_rank = nx.pagerank(graphs)
page_rank
```

```
391: 0.0005555972112576775,
402: 0.0005555972112576775,
404: 0.0009292361516007721,
406: 0.0005555972112576775,
407: 0.0005555972112576775,
412: 0.0005555972112576775,
420: 0.0005555972112576775,
446: 0.0005337243192118247,
448: 0.0005555972112576775,
455: 0.0009292361516007721,
```

```
 468: 0.000555972112576775,
 470: 0.000555972112576775,
 480: 0.0009292361516007721,
 495: 0.0009292361516007721,
 496: 0.000555972112576775,
 511: 0.000555972112576775,
 514: 0.0009292361516007721,
 518: 0.000555972112576775,
 519: 0.000555972112576775,
 530: 0.000555972112576775,
 534: 0.0005337243192118247,
 556: 0.000555972112576775,
 559: 0.000555972112576775,
 617: 0.000555972112576775,
 622: 0.000555972112576775,
 624: 0.000555972112576775,
 631: 0.000555972112576775,
 688: 0.0009292361516007721,
 701: 0.000555972112576775,
 707: 0.000555972112576775,
 710: 0.000555972112576775,
 718: 0.0009292361516007721,
 723: 0.0009292361516007721,
 727: 0.000555972112576775,
 730: 0.0009292361516007721,
 743: 0.000555972112576775,
 745: 0.000555972112576775,
 760: 0.000555972112576775,
 762: 0.0005337243192118247,
 773: 0.000555972112576775,
 776: 0.0009292361516007721,
 797: 0.0005337243192118247,
 803: 0.0009292361516007721,
 806: 0.000555972112576775,
 811: 0.000555972112576775,
 822: 0.000555972112576775,
 826: 0.000555972112576775,
 832: 0.000555972112576775,
 834: 0.000555972112576775,
 839: 0.0005337243192118247,
 840: 0.0005337243192118247,
 844: 0.000555972112576775,
 845: 0.000555972112576775,
 847: 0.0005337243192118247,
 848: 0.0009292361516007721,
 850: 0.000555972112576775,
 851: 0.0005337243192118247,
 863: 0.000555972112576775,
 866: 0.000555972112576775,
```

Degree Centrality

```
dict_degree_centrality = nx.degree_centrality(graphs)
dict_degree_centrality
```

```
{1: 0.030982905982905987,
 2: 0.27350427350427353,
```

```
3: 0.012820512820512822,
4: 0.7553418803418804,
5: 0.0010683760683760685,
6: 0.0010683760683760685,
7: 0.0010683760683760685,
8: 0.0010683760683760685,
9: 0.0010683760683760685,
10: 0.0010683760683760685,
11: 0.002136752136752137,
12: 0.0010683760683760685,
13: 0.0010683760683760685,
14: 0.0010683760683760685,
15: 0.0010683760683760685,
16: 0.0010683760683760685,
17: 0.0010683760683760685,
18: 0.0010683760683760685,
19: 0.0010683760683760685,
20: 0.0010683760683760685,
21: 0.0010683760683760685,
22: 0.0010683760683760685,
40: 0.0010683760683760685,
45: 0.0010683760683760685,
47: 0.0010683760683760685,
63: 0.0010683760683760685,
68: 0.0010683760683760685,
77: 0.0010683760683760685,
78: 0.0010683760683760685,
91: 0.0010683760683760685,
100: 0.0010683760683760685,
104: 0.0010683760683760685,
106: 0.002136752136752137,
107: 0.0010683760683760685,
114: 0.0010683760683760685,
115: 0.0010683760683760685,
117: 0.0010683760683760685,
121: 0.0010683760683760685,
126: 0.0010683760683760685,
134: 0.0010683760683760685,
140: 0.0010683760683760685,
142: 0.0010683760683760685,
154: 0.0010683760683760685,
165: 0.0010683760683760685,
183: 0.0010683760683760685,
195: 0.0010683760683760685,
204: 0.0010683760683760685,
210: 0.0010683760683760685,
213: 0.0010683760683760685,
225: 0.0010683760683760685,
242: 0.0010683760683760685,
247: 0.002136752136752137,
249: 0.0010683760683760685,
269: 0.0010683760683760685,
276: 0.002136752136752137,
291: 0.002136752136752137,
297: 0.0010683760683760685,
304: 0.0010683760683760685.
```

Closeness Centrality

```
dict_closeness_centrality = nx.closeness_centrality(graphs)
dict_closeness_centrality
```

```
{1: 0.5078676071622354,
 2: 0.5752919483712354,
 3: 0.33962264150943394,
 4: 0.7959183673469388,
 5: 0.3369330453563715,
 6: 0.3369330453563715,
 7: 0.3369330453563715,
 8: 0.3369330453563715,
 9: 0.3369330453563715,
 10: 0.3369330453563715,
 11: 0.4515195369030391,
 12: 0.3369330453563715,
 13: 0.3369330453563715,
 14: 0.3369330453563715,
 15: 0.3369330453563715,
 16: 0.3369330453563715,
 17: 0.3369330453563715,
 18: 0.3369330453563715,
 19: 0.3369330453563715,
 20: 0.3369330453563715,
 21: 0.3369330453563715,
 22: 0.3369330453563715,
 40: 0.36533957845433257,
 45: 0.443391757460919,
 47: 0.443391757460919,
 63: 0.443391757460919,
 68: 0.443391757460919,
 77: 0.443391757460919,
 78: 0.443391757460919,
 91: 0.443391757460919,
 100: 0.443391757460919,
 104: 0.443391757460919,
 106: 0.4880083420229406,
 107: 0.36533957845433257,
 114: 0.443391757460919,
 115: 0.443391757460919,
 117: 0.443391757460919,
 121: 0.443391757460919,
 126: 0.36533957845433257,
 134: 0.36533957845433257,
 140: 0.443391757460919,
 142: 0.443391757460919,
 154: 0.443391757460919,
 165: 0.443391757460919,
 183: 0.443391757460919,
 195: 0.443391757460919,
 204: 0.443391757460919,
 210: 0.443391757460919,
 213: 0.443391757460919,
 225: 0.443391757460919,
 242: 0.36533957845433257,
 247: 0.4880083420229406,
 249: 0.443391757460919,
 269: 0.443391757460919,
 276: 0.4880083420229406,
```

```
291: 0.4880083420229406,
297: 0.443391757460919,
```

Harmonic Centrality

```
dict_harmonic_centrality = nx.harmonic_centrality(graphs)
dict_harmonic_centrality
```

```
{1: 482.5,
 2: 594.1666666666665,
 3: 324.6666666666658,
 4: 819.6666666666667,
 5: 317.33333333333275,
 6: 317.33333333333275,
 7: 317.33333333333275,
 8: 317.33333333333275,
 9: 317.33333333333275,
 10: 317.33333333333275,
 11: 435.16666666666623,
 12: 317.33333333333275,
 13: 317.33333333333275,
 14: 317.33333333333275,
 15: 317.33333333333275,
 16: 317.33333333333275,
 17: 317.33333333333275,
 18: 317.33333333333275,
 19: 317.33333333333275,
 20: 317.33333333333275,
 21: 317.33333333333275,
 22: 317.33333333333275,
 40: 354.2499999999977,
 45: 429.41666666666634,
 47: 429.41666666666634,
 63: 429.41666666666634,
 68: 429.41666666666634,
 77: 429.41666666666634,
 78: 429.41666666666634,
 91: 429.41666666666634,
 100: 429.41666666666634,
 104: 429.41666666666634,
 106: 461.9166666666667,
 107: 354.2499999999977,
 114: 429.41666666666634,
 115: 429.41666666666634,
 117: 429.41666666666634,
 121: 429.41666666666634,
 126: 354.2499999999977,
 134: 354.2499999999977,
 140: 429.41666666666634,
 142: 429.41666666666634,
 154: 429.41666666666634,
 165: 429.41666666666634,
 183: 429.41666666666634,
 195: 429.41666666666634,
 204: 429.41666666666634,
 210: 429.41666666666634,
 213: 429.41666666666634,
```

```
 225: 429.41666666666634,
 242: 354.2499999999977,
 247: 461.9166666666667,
 249: 429.41666666666634,
 269: 429.41666666666634,
 276: 461.9166666666667,
 291: 461.9166666666667,
 297: 429.41666666666634,
 304: 429.41666666666634,
```

Betweenness Centrality

```
dict_betweeness=nx.betweenness_centrality(graphs)
dict_betweeness
```

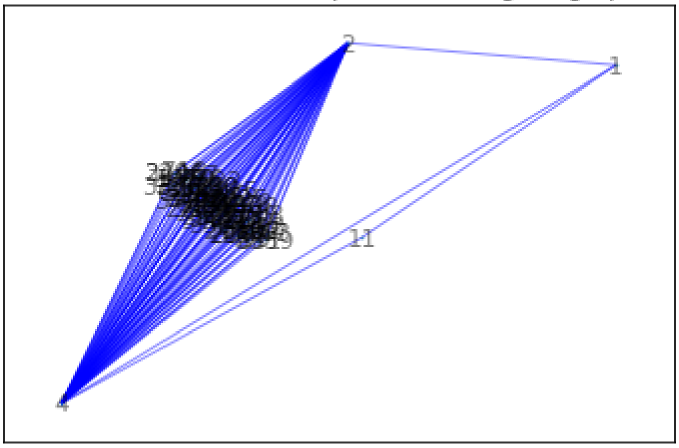
```
 4950: 0.0,
 4952: 0.0,
 4966: 0.0,
 4983: 0.0,
 5011: 0.0,
 5025: 0.0,
 5038: 0.0,
 5050: 0.0,
 5054: 0.0,
 5057: 0.0,
 5061: 0.0,
 5073: 0.0,
 5094: 0.0,
 5135: 0.0,
 5157: 0.0,
 5171: 0.0,
 5173: 0.0,
 5205: 0.0,
 5220: 0.0,
 5229: 0.0,
 5235: 0.0,
 5274: 0.0,
 5425: 0.0,
 5426: 0.0,
 5451: 0.0,
 5457: 0.0,
 5559: 0.0,
 5721: 0.0,
 5738: 0.0,
 5764: 0.0,
 5804: 0.0,
 5819: 0.0,
 5904: 0.0,
 5906: 0.0,
 5927: 0.0,
 5976: 0.0,
 5996: 0.0,
 6068: 0.0,
 6094: 0.0,
 6138: 0.0,
 6245: 0.0,
 6288: 0.0,
 6349: 0.0,
```

```
        6358: 0.0,
        6361: 0.0,
        6386: 0.0,
        6387: 0.0,
        6428: 0.0,
        6430: 0.0,
        6447: 0.0,
        6454: 0.0,
        6470: 0.0,
        6479: 0.0,
        6482: 0.0,
        6524: 0.0,
        6541: 0.0,
        6551: 0.0,
        6559: 0.0,
        6573: 0.0.
```

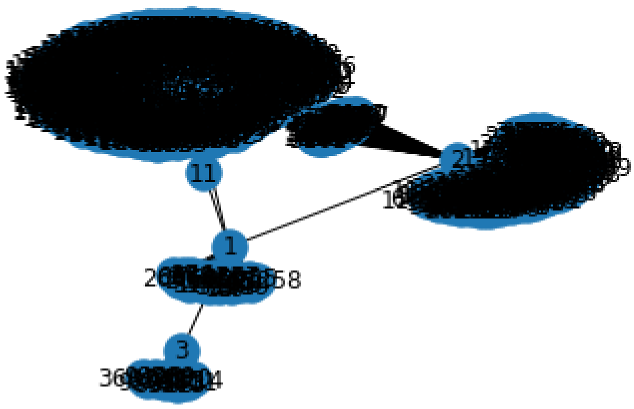
6 K-CORE DECOMPOSITION

```
_G_CORE = nx.k_core(graphs, 2)
pos = nx.spring_layout(graphs)
plt.figure()
plt.title(' networkx 2-core decomposition of Original graph')
nx.draw_networkx(_G_CORE , pos = pos, node_size = 1, edge_color = "blue", alpha = 0.5, wit
Original_Graph = full_k_core_decomposition(graphs, ' Original graph')
SBM_graph = full_k_core_decomposition(SBM, ' Stochastic Block Model graph')
Erdos_Renyi_graph = full_k_core_decomposition(Erdos_renyi, ' Erdos Renyi graph')
Smal_Word_graph = full_k_core_decomposition(Small_World, ' Small World graph')
Degraded_Graphs = full_k_core_decomposition(DG, ' degraded graph')
```

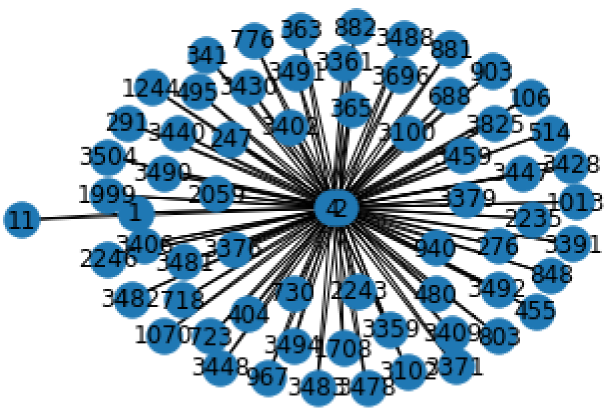
networkx 2-core decomposition of Original graph



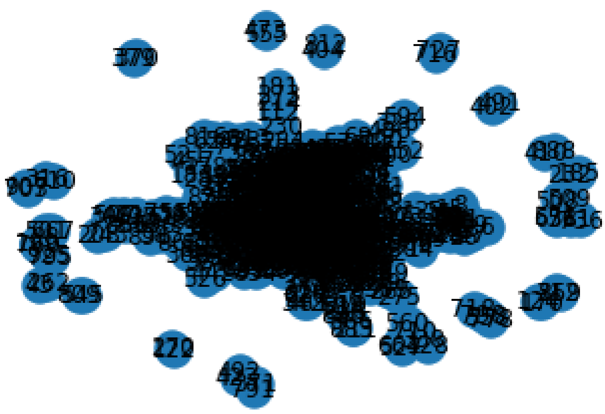
1-core decomposition of Original graph



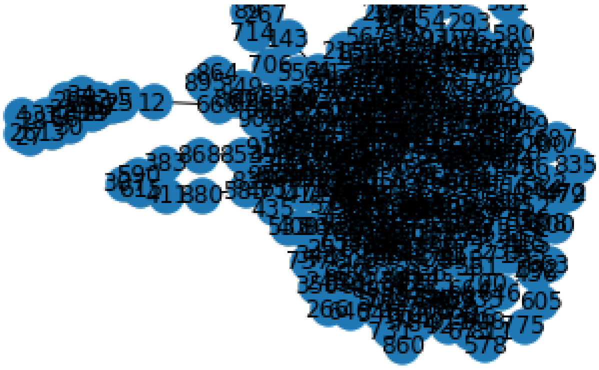
2-core decomposition of Original graph



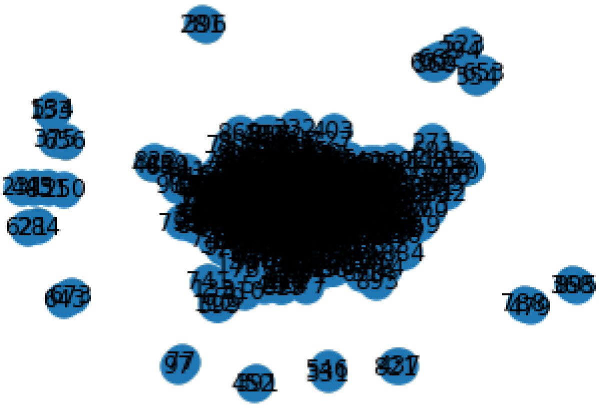
1-core decomposition of Stochastic Block Model graph



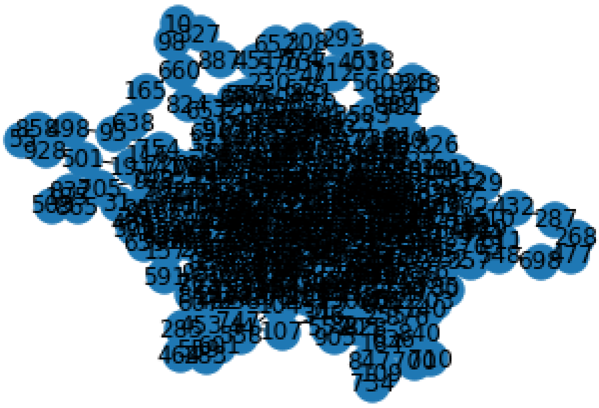
2-core decomposition of Stochastic Block Model graph



1-core decomposition of Erdos Renyi graph



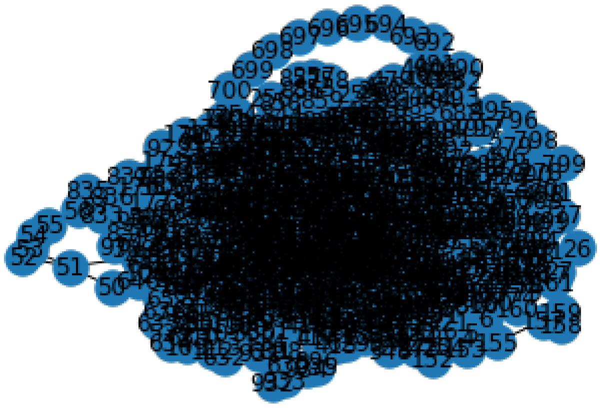
2-core decomposition of Erdos Renyi graph



1-core decomposition of Small World graph

2-core decomposition of Small World graph

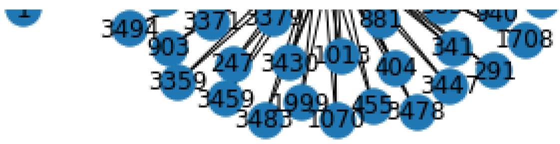
3-core decomposition of Small World graph



1-core decomposition of degraded graph

Analysis & Considerations:

The k-core decomposition on the original network generates graphs that seem to follow a preferential attachment behavior. There are nodes with very high degree and very few with low degree. This is compatible with the starting network, which is a natural. The decomposition of the Random and Small world graphs is not easily observable but surely for ER the subgraphs are random because the original distribution is normal and consequentially the sub graph distribution are normal and thus random. The same evaluation applies to SW. Degraded graphs also follow how it is possible to observe a power law.



✓ 1m 28s completed at 9:27 PM