

Complex Networks - DATA.ML.430-2021-2022-1

ComplexNetworksGroup

NIPS-EGO (Facebook Network)

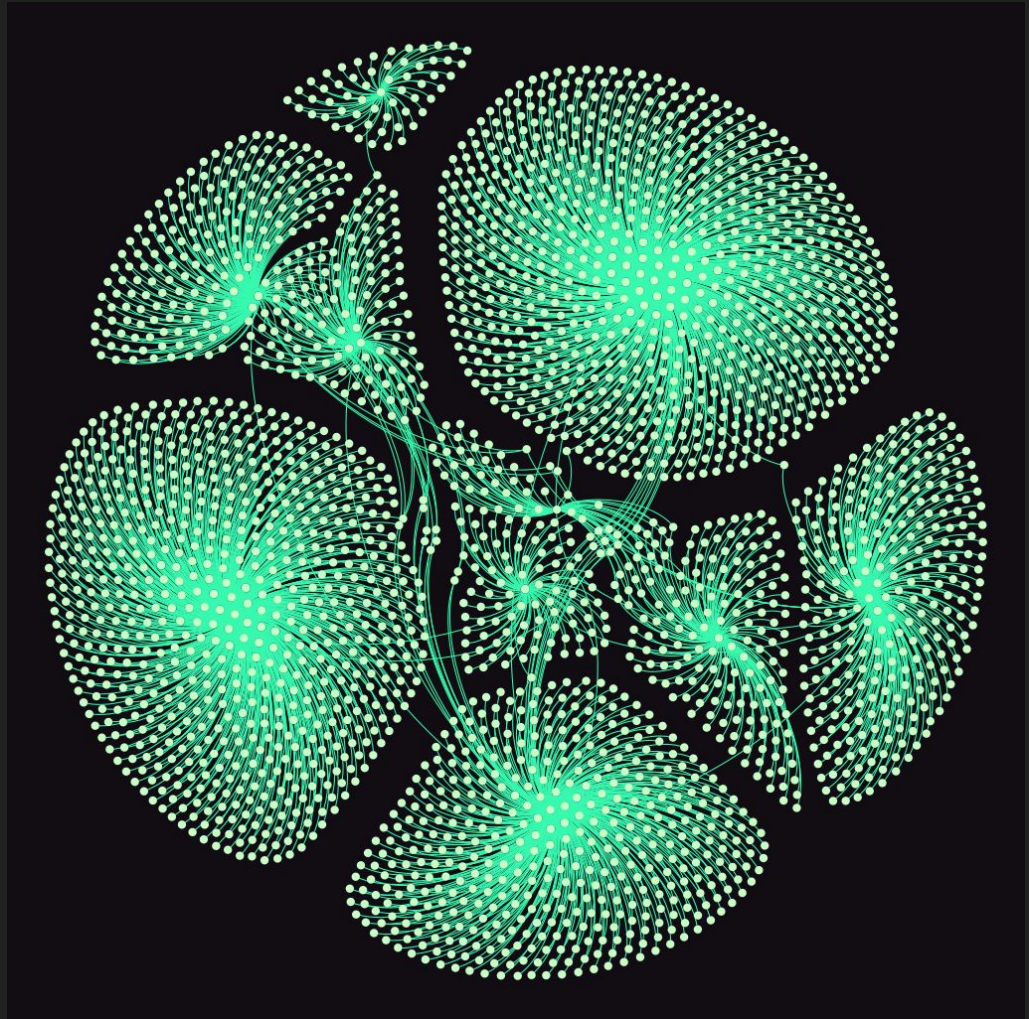
Team Members: Georgios Gerasimos Leventopoulos, Muhammad Zunair, Haris Khan

Final Project Presentation

NIPS-EGO (Facebook Real Network)

- We collected the data from networkrepository.com: [here](#)
- We visualized the data using GraphVis: [here](#)
- Number of nodes: 2.9K
- Number of links/edges: 3K
- Average degree: 2
- Collected Dataset: A social friendship network extracted from Facebook consisting of people (nodes) with edges representing friendship ties.

- The first visualization of the Network
- Nodes represent the people
- Edges represent friendship
- This network is interesting for us, because social media are part of our lives nowadays



Part III 1.

Project Description:

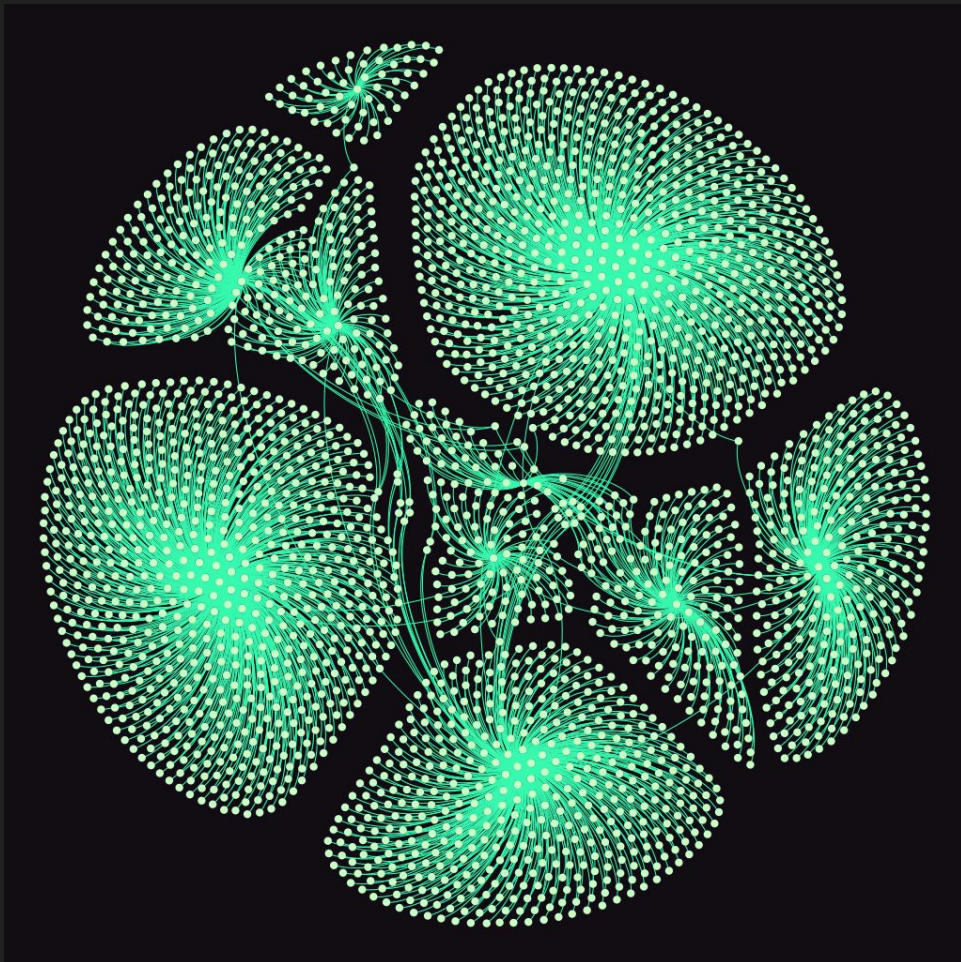
- This network is a Facebook social network.
- A social friendship network extracted from Facebook consists of people (nodes) with edges representing friendship ties.
- The vertex type is “Person” and the “Edge Type” is Friendship/social relationship between two people.
- The format is “undirected” and the edge weights are “unweighted”.
- The choice of this network is motivated by the fact that social media takes a big part of our lives. We believe as a team that social media usage is increasing day by day, and it is very important to understand people's relationships.
- Facebook is a very famous social media platform, so that is why we think analyzing this network and comparing it with another type of graph will help us to see the differences between a real word network and a randomly generated network.

Similar to the network that we picked:

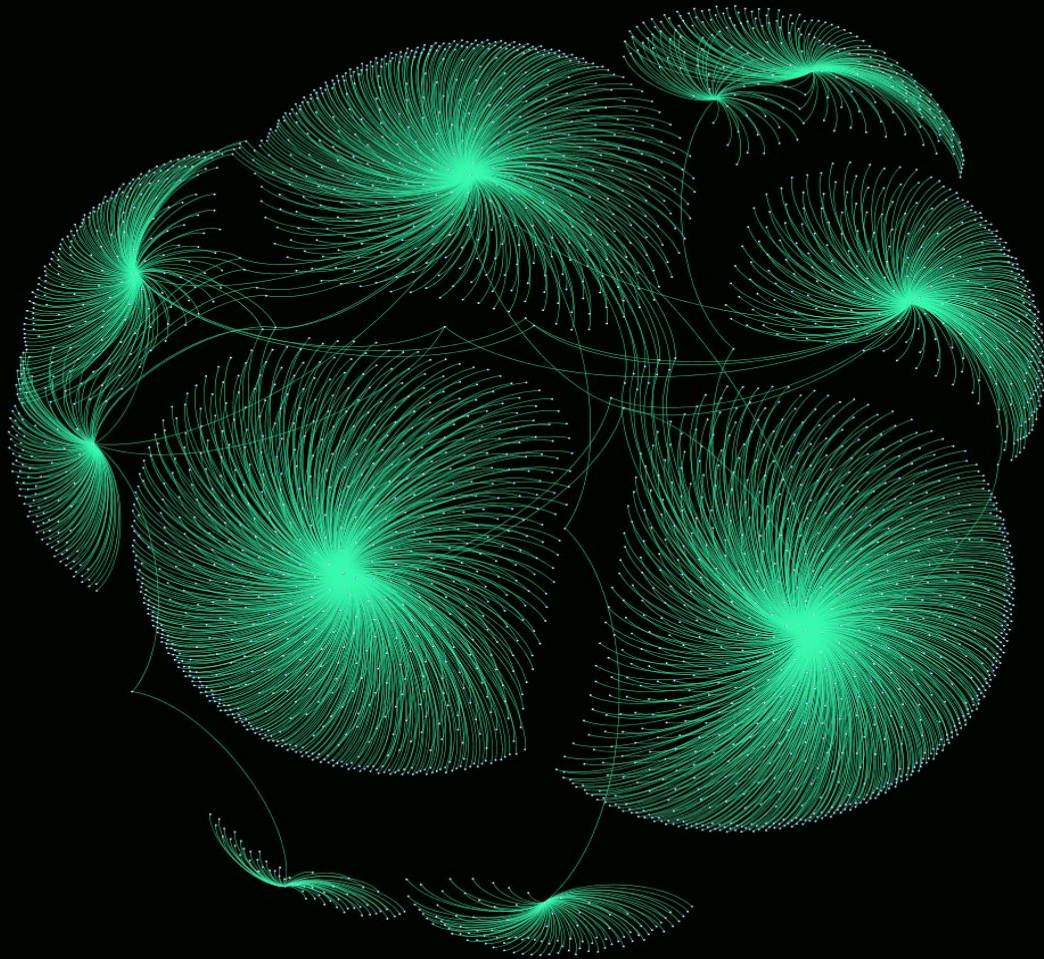
- Covid 19 Tweets [dataset](#)
- Social Circles: Facebook [dataset](#)
- Most followed accounts on Instagram [dataset](#)
- 1.7 Billion Reddit Comments [dataset](#)
- Twitter Friends [dataset](#)

Part III 2. (Visualization and Statistics)

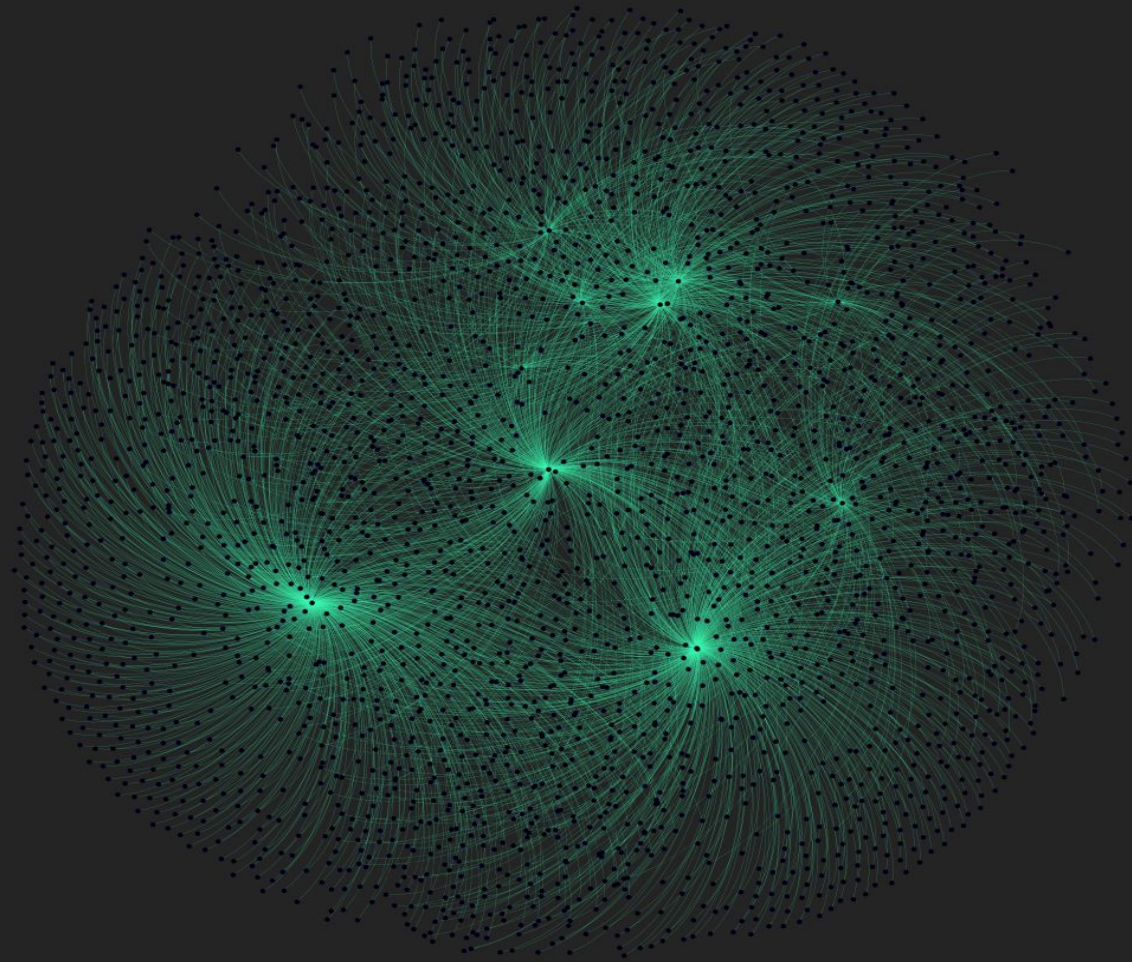
- NIPS-EGO (Facebook Network)
- Erdős-Rényi
- Barabási-Albert



NIPS-EGO (Facebook Network) Visualization

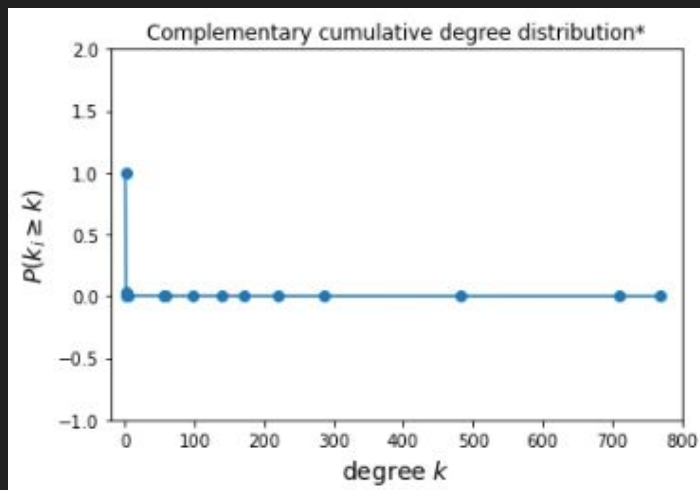
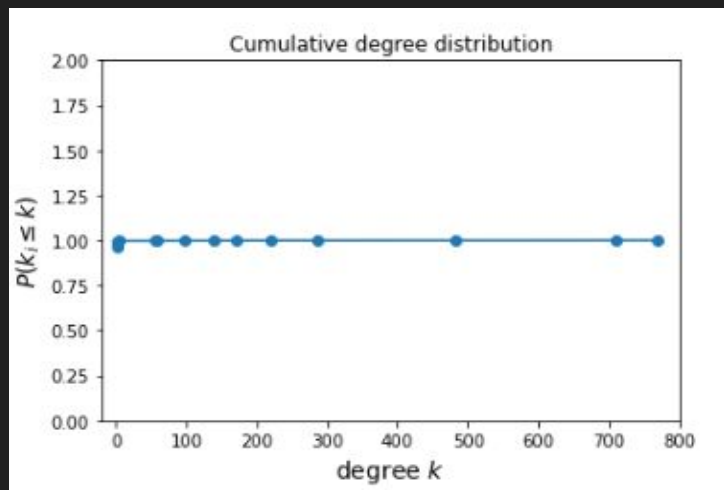
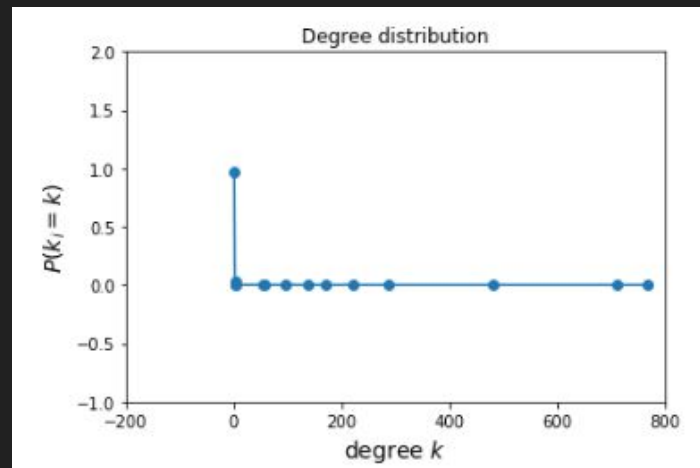
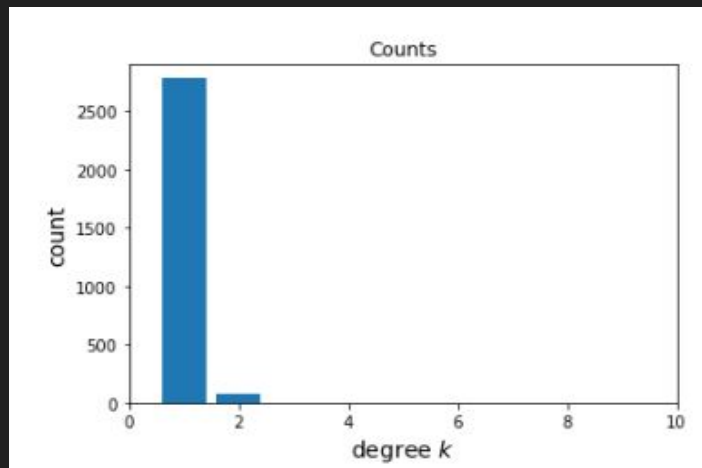


Erdős-Rényi Graph Visualization

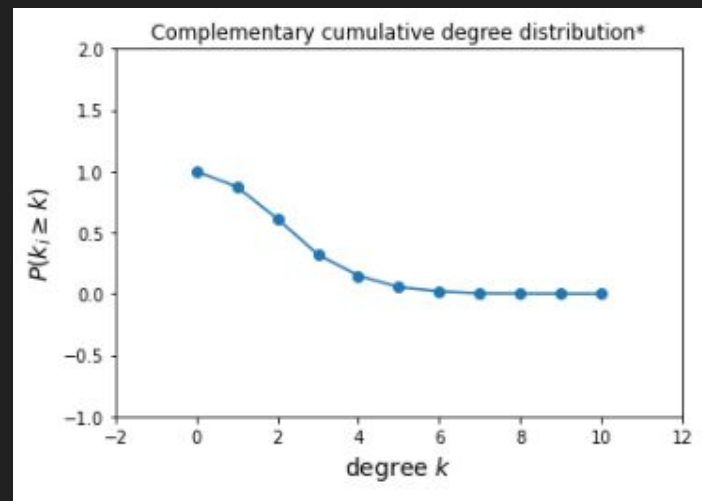
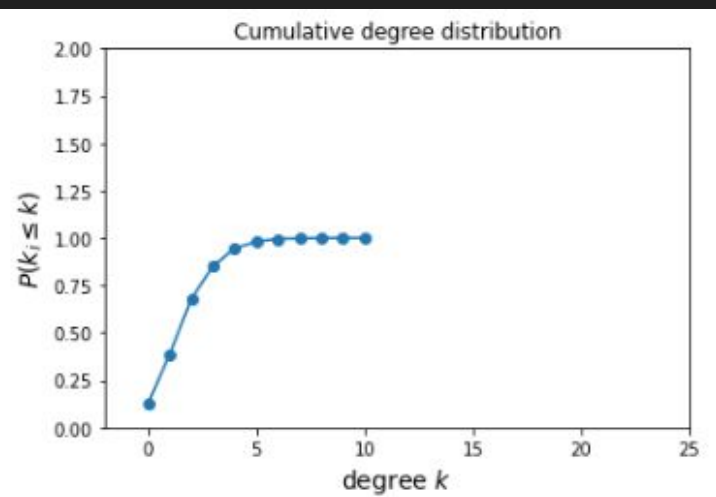
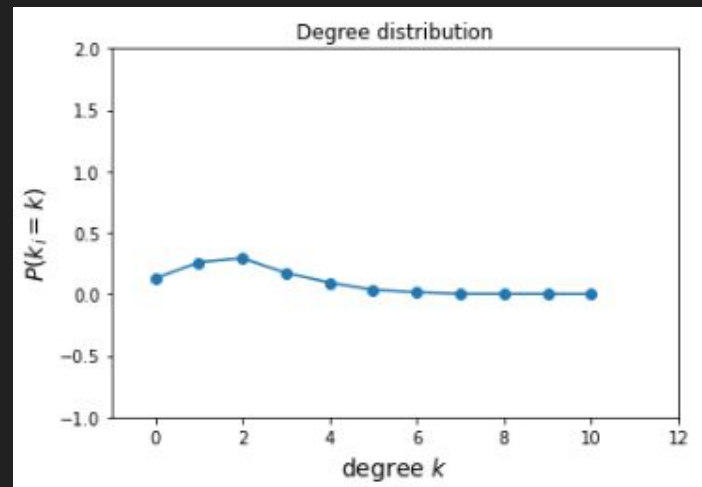
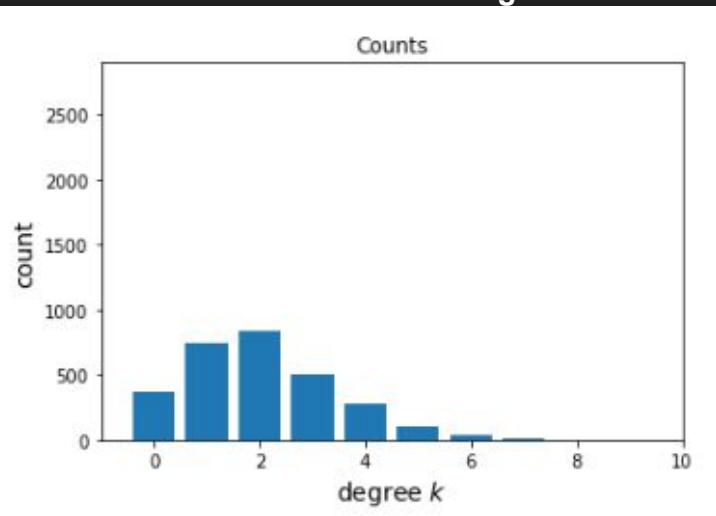


Barabási-Albert Graph Visualization

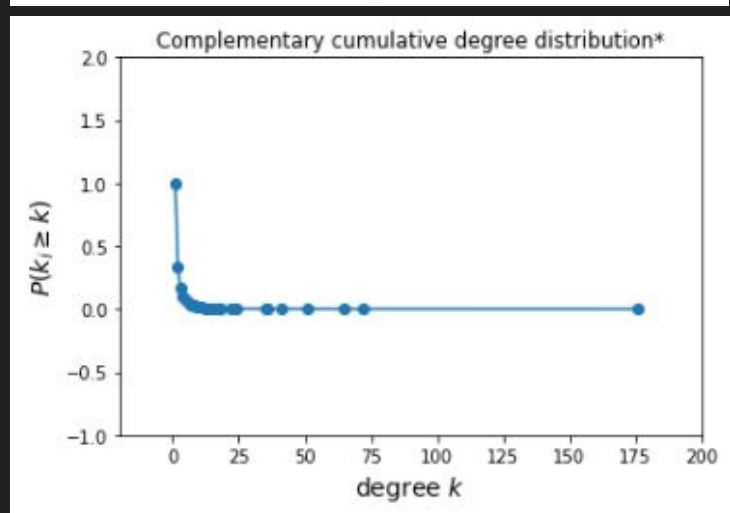
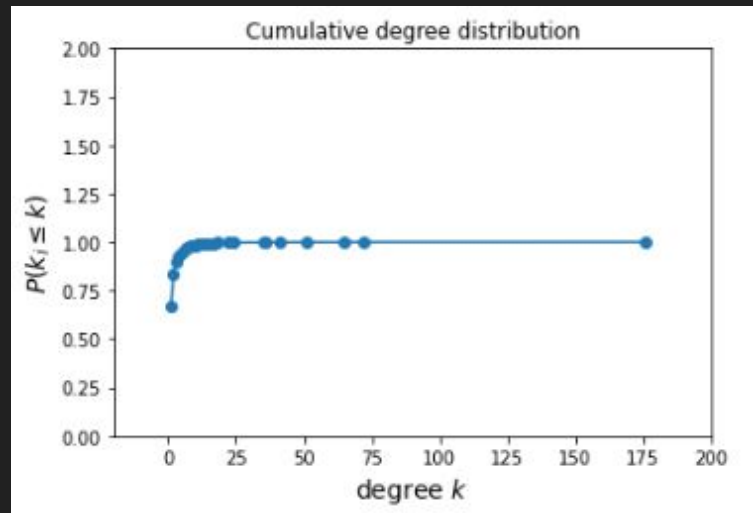
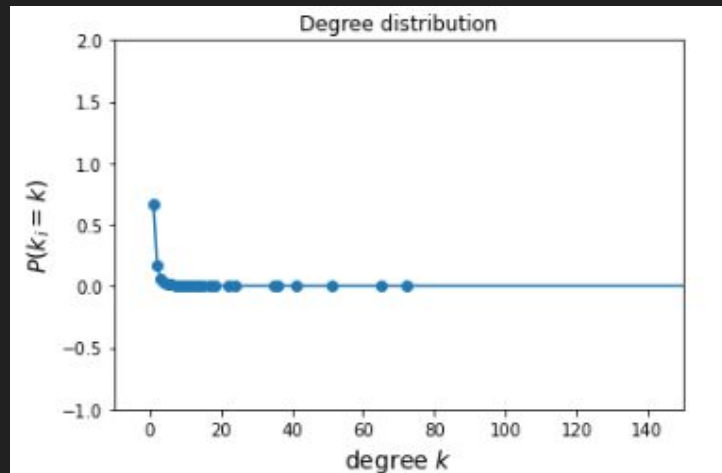
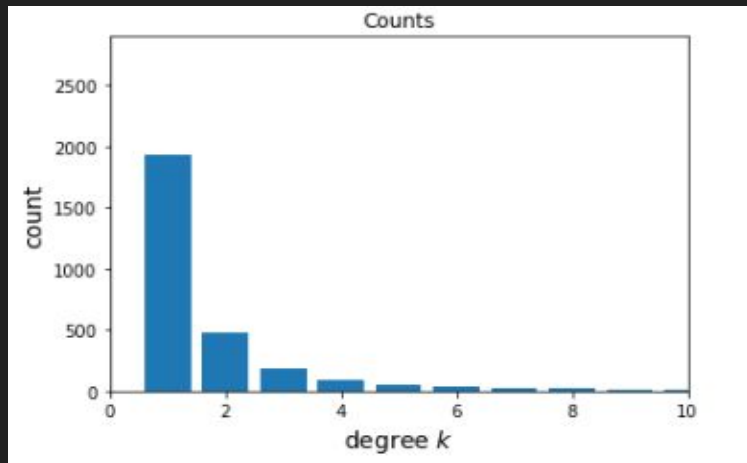
Degree Distributions and Figures for Facebook Network



Degree Distributions and Figures for Erdős–Rényi Network



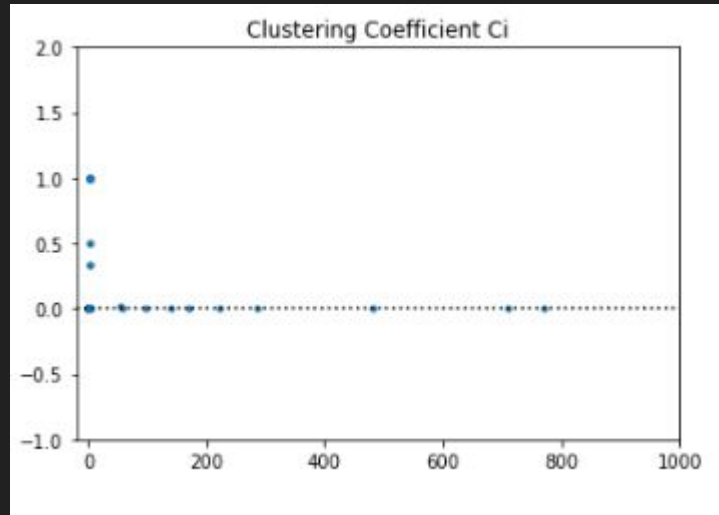
Degree Distributions and Figures for Barabási–Albert Network



Clustering Coefficient C_i

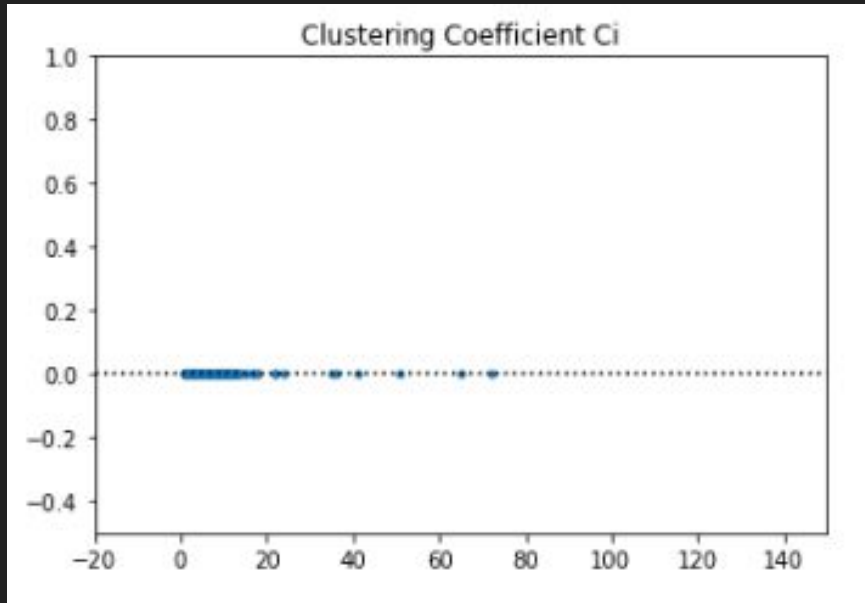
Real Facebook Network

Average Clustering Coefficient $\langle C \rangle$: 0.027247421431211827

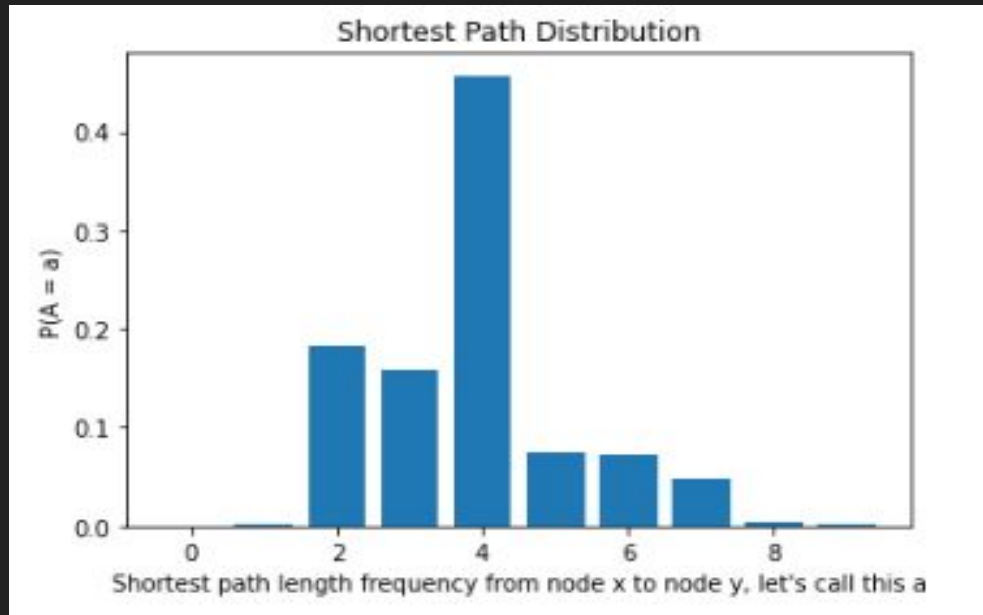


Barabási–Albert Network

Average Clustering Coefficient $\langle C \rangle$: 0.0

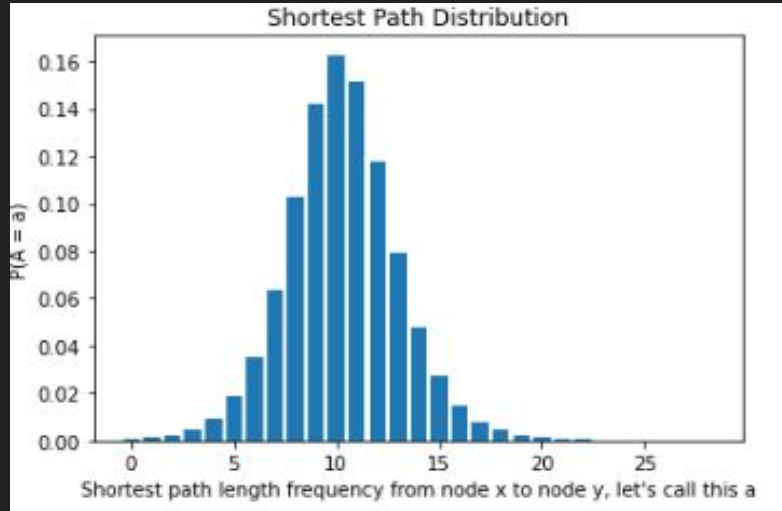


Shortest Path Distribution

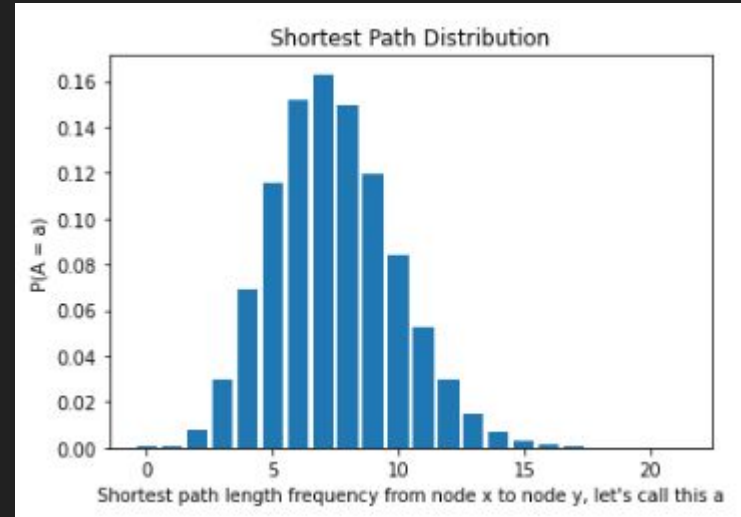


Shortest Path Distribution

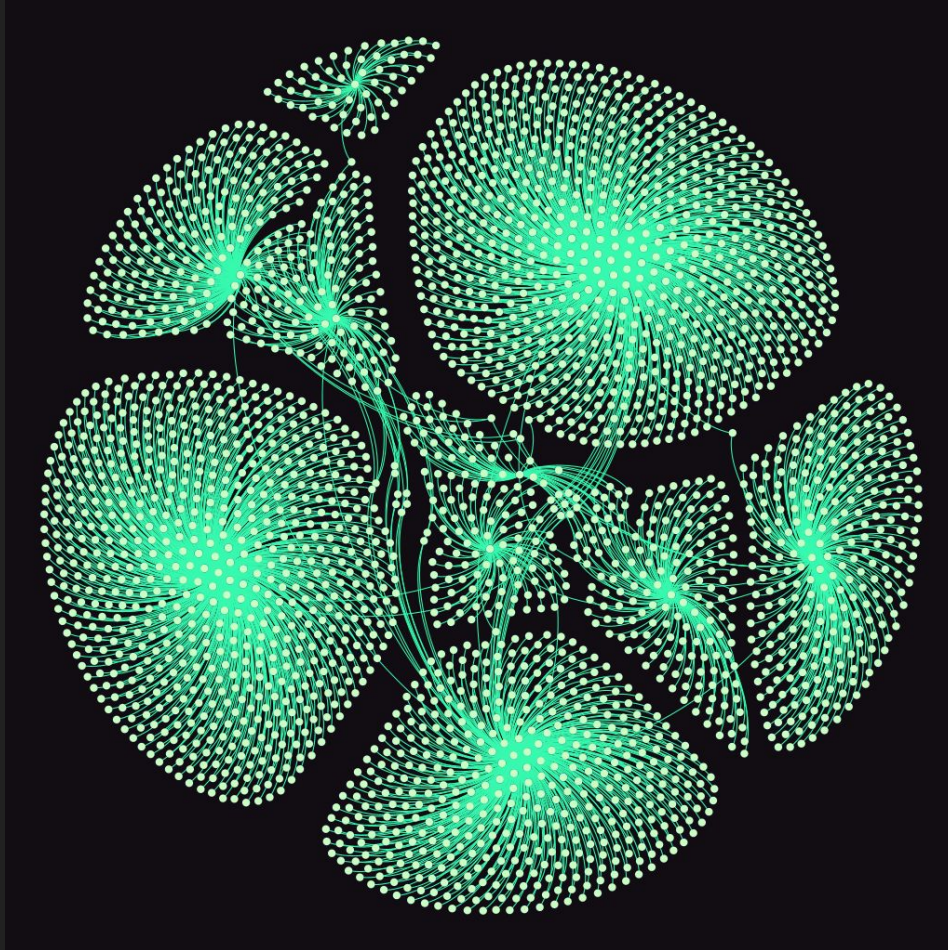
Erdős–Rényi Random Network



Barabási–Albert Random Network



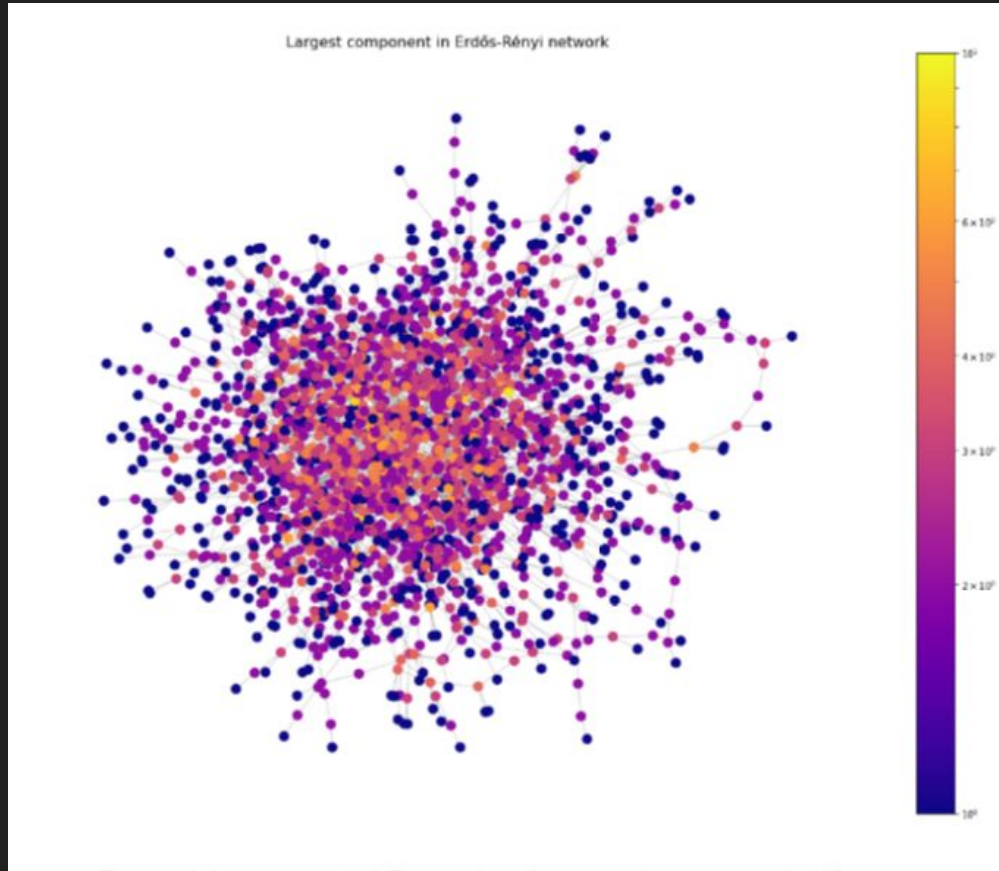
Facebook Network Components



For the Real Network the graph is connected and there is only one connected component

The largest component in ER Network contains 2888 nodes and 2981 edges

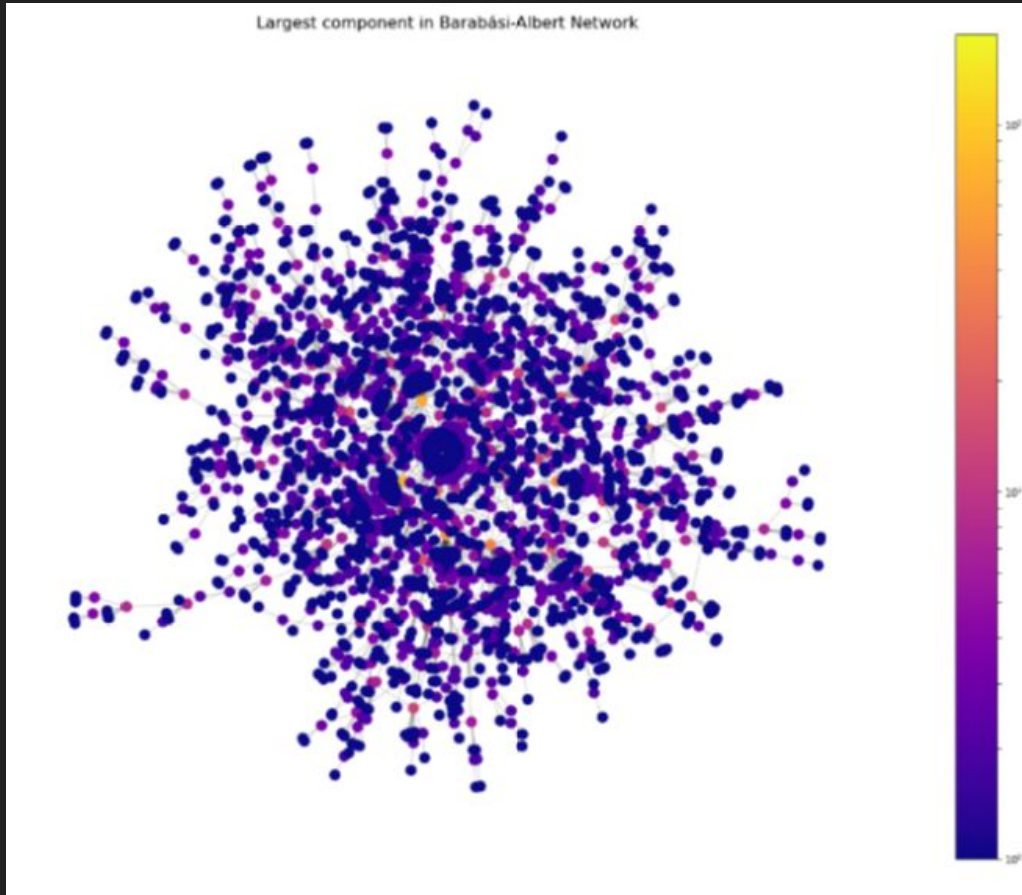
Erdős–Rényi Network Components



The graph is not connected.
The number of connected components is 445

The largest component in ER Network: Graph with 2326 nodes and 2821 edges

Barabási–Albert Network Components



The graph is connected and the number of connected components is 1 (the whole graph)

The largest component has 2888 nodes and 2887 edges as the whole Graph

Density (ρ)

The **Density** for Facebook Network is 0.0007150690793671507

The **Density** for **Erdős–Rényi** Network is 0.0007049943053539268

The **Density** for **Barabási–Albert** Network is 0.0006925207756232687

We calculated the density using `nx.density()` method

Extra Statistics Facebook Network

- Nodes: 2888
- Edges: 2981
- Density: 0.0007150690793671507
- Maximum degree: 769
- Minimum degree: 1
- Average degree: 2
- Assortativity: -0.6682140067239859
- Number of triangles: 273
- Average number of triangles: 0
- Maximum number of triangles: 52
- Average clustering coefficient: 0.027247421431211827
- Fraction of closed triangles: 0.0003593802862141459

Extra Statistics Erdős–Rényi Network

• Nodes:	2888
• Edges:	2981
• Density:	0.0007114709457909993
• Maximum degree:	7
• Minimum degree:	0
• Average degree:	2
• Assortativity:	0.02486429061540356
• Number of triangles:	6
• Average number of triangles:	0
• Maximum number of triangles:	1
• Average clustering coefficient:	0.0003973750164885899
• Fraction of closed triangles:	0.0010133423408208073

Extra Statistics Barabási–Albert Network

- Nodes: 2888
- Edges: 2981
- Density: 0.0006925207756232687
- Maximum degree: 176
- Minimum degree: 1
- Average degree: 1.9993074792243768
- Assortativity: -0.0749340849167783
- Number of triangles: 0
- Average number of triangles: 0
- Maximum number of triangles: 0
- Average clustering coefficient: 0.0
- Fraction of closed triangles: 0

PART III 3a. Community Discovery

- K-clique
- DEMON
- Louvain
- Infomap
- Fast Greedy
- Girvan and Newman

K-clique

A k-clique community is the union of all cliques of size k that can be reached through adjacent (sharing k-1 nodes) k-cliques . We choose $k = 3$

Results:

- The total number of 3-clique communities are 3
- The sizes of the communities are: 13, 52, 24
- The size of the largest community is 52
- The number of nodes that do not belong to any 3-clique community are 2800
- The maximum number of communities a single node belongs to is: 2
- The number of nodes that belong to at least two communities: 1
- Modularity: -0.037554911397365304

Demon (Democratic Estimate of the Modular Organization of a Network)

Demon approaches the community discovery problem through the analysis of simpler structures (ego-networks).

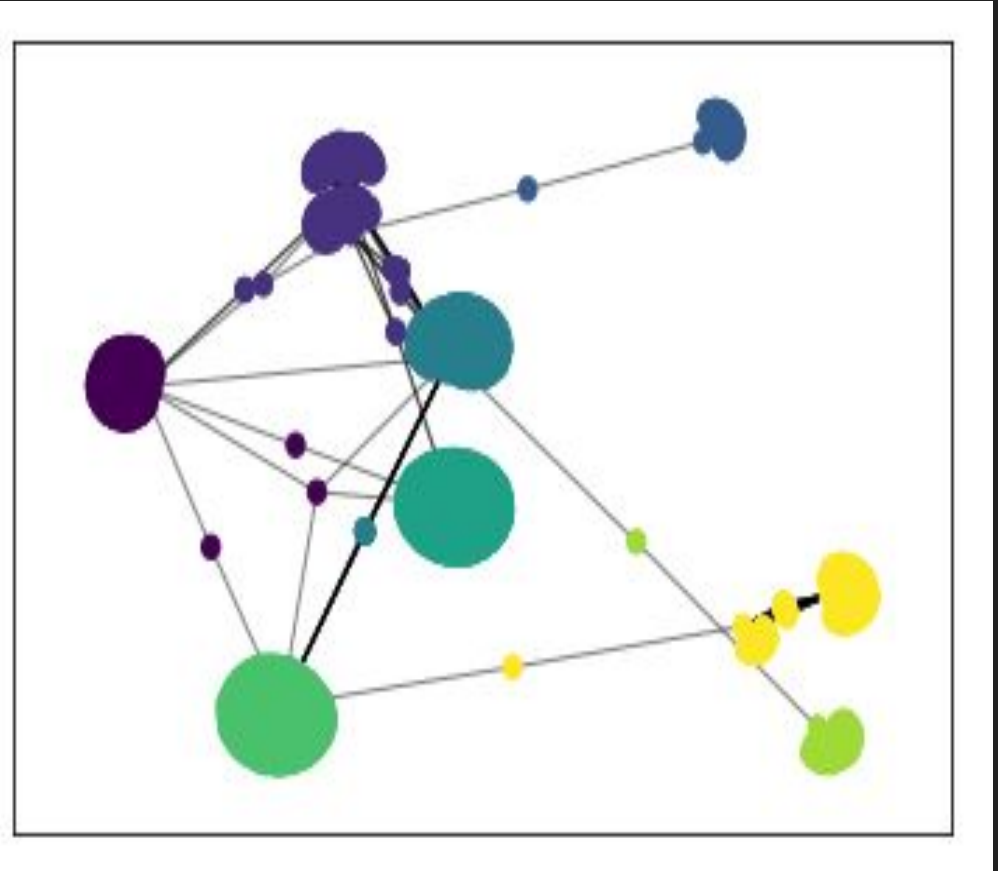
Results:

- The total communities are 3
- The sizes of communities are: 13, 52, 24
- The length of the biggest community is 52
- Modularity -0.03755491139736614
- As we can see the Demon and K-clique have the same partition and modularity and same number of communities

Louvain

Results:

- The number of communities are 8
- The sizes of the communities are: 284, 315, 465, 707, 757, 98, 203, 59
- The length of the biggest community is 757
- Modularity: 0.808687549359893
- We made a color for every different community



Infomap

Results:

- The number of communities are: 3
- The sizes of the communities are: 1523, 993, 372
- The length of the biggest community is 1523
- Modularity: 0.46727152992647863

Fast Greedy

Results:

- The best partition found consists of the following 8 communities with sizes:
59, 98, 203, 707, 313, 757, 465, 286
- The length of the biggest community is 757
- The modularity of this partition is: 0.8087217591092699

Girvan and Newman

Results:

- Best partition found consists of the following 2 communities with sizes: 2180, 708
- The length of the biggest community is 2180
- The modularity of this partition is 0.3612020713540672

PART III 3e Curiosity Driven (Centrality)

- [Degree Centrality](#): a simple centrality measure that counts how many neighbors a node has.
- [Eigenvector Centrality](#): is a measure of the influence of a node in a network.
- [Katz Centrality](#): node is important if it is linked from other important nodes or if it is highly linked
- [Closeness Centrality](#): is based on the mean distance from one node to other nodes.
- [Betweenness Centrality](#): is a measure of centrality in a graph based on shortest paths.

The Statistics from our Graph

- [Degree Centrality:](#)

Minimum Degree Centrality: 0.00034638032559750607

Maximum Degree Centrality: 0.2663664703844822

- [Eigenvector Centrality:](#)

Minimum Eigenvector Centrality: 2.881674339877942

Maximum Eigenvector Centrality: 0.7024818331273985

- [Katz Centrality:](#)

Minimum Katz Centrality: -0.28551528810262417

Maximum Katz Centrality: 0.03607422724740297

- [Closeness Centrality:](#)

Minimum Closeness Centrality: 0.0

Maximum Closeness Centrality: 0.42692312814502775

- [Betweenness Centrality:](#)

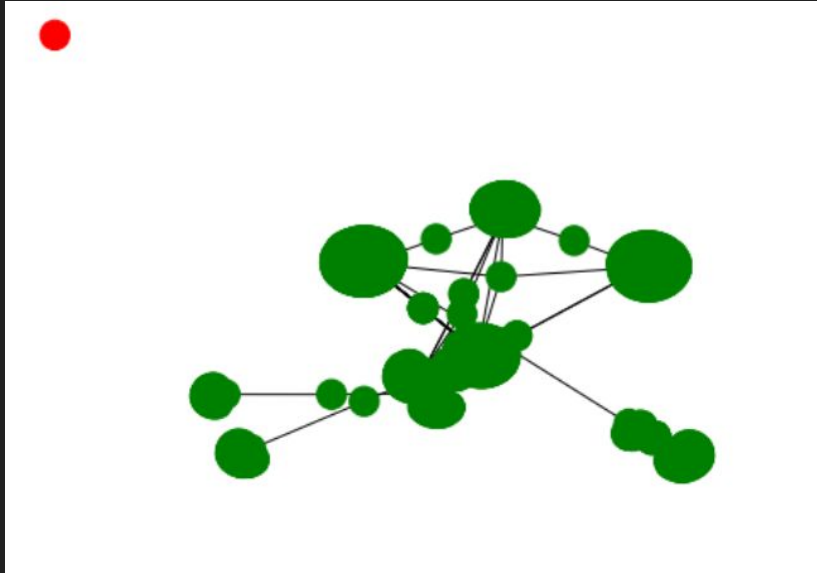
Minimum Betweenness Centrality: 0.0

Maximum Betweenness Centrality: 0.5497065448918781

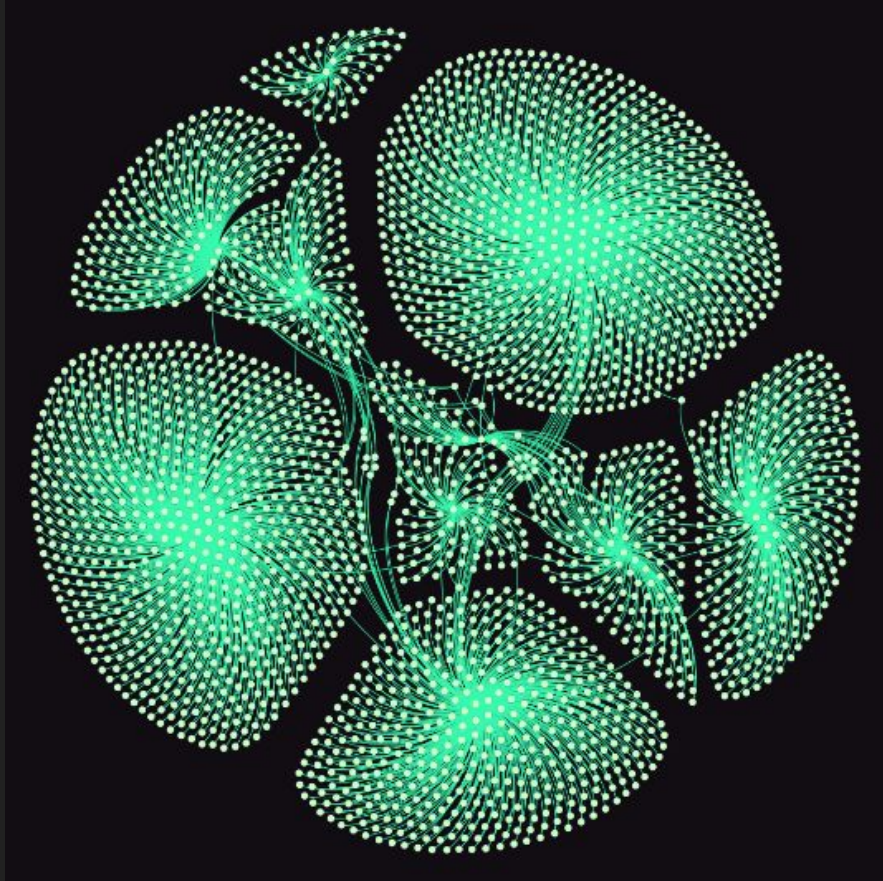
Closeness Centrality

We added an isolated node without any edges in the graph and we found that it's closeness centrality is 0.

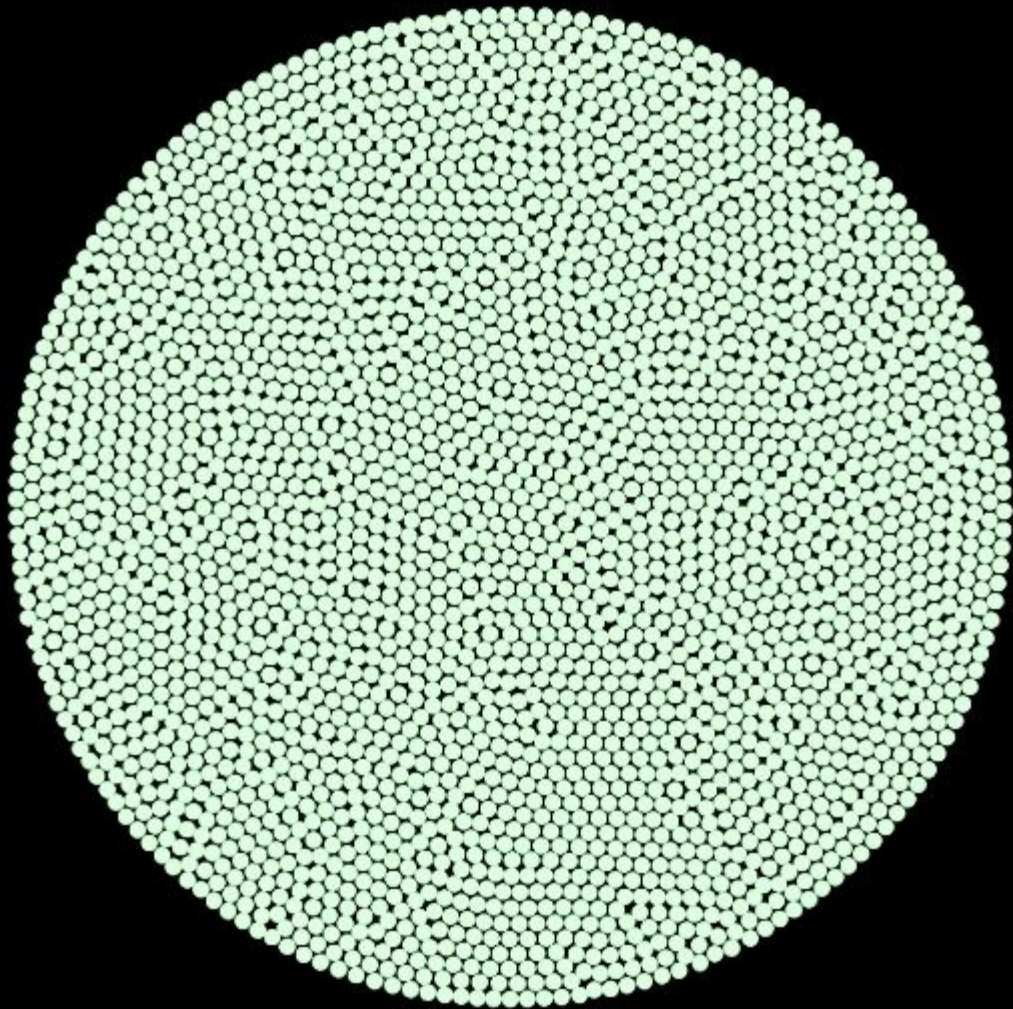
Here is the graph, you can see with red the isolated node and with green the rest of the graph.



Betweenness Centrality



Graph before removing nodes with high betweenness.



**Graph after removing nodes
with high betweenness.**

**If we remove the 21 nodes with
high betweenness, the graph is
not as it used to be.**

Thank you for your attention, any questions?

