# Final Presentation


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# FB-PAGES-FOOD

## (Social Network)

- NUMBER NODES: 620
- NUMBER LINKS: 2102
- TYPE OF NETWORK:
  - Undirected
  - Scale-free network

https://networkrepository.com/fb-pages-food.php




- SIGNIFICANCE & MEANING: Data collected about Facebook pages (November 2017). These datasets represent blue verified Facebook page networks of different categories. Nodes represent the pages and edges are mutual likes among them.

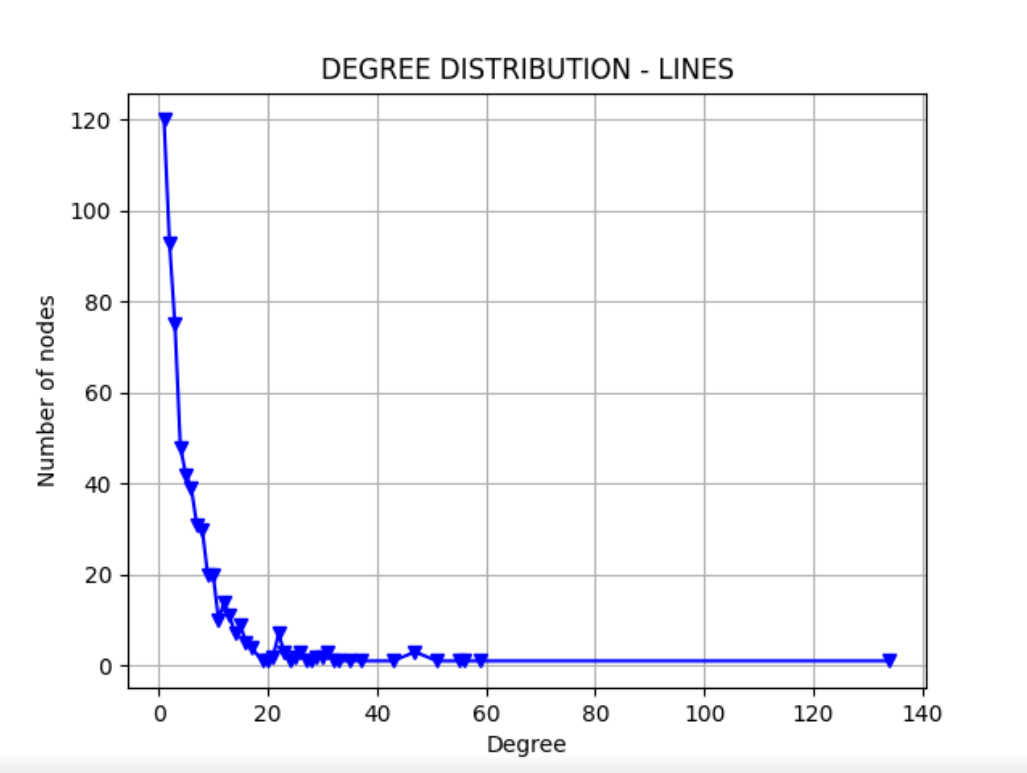
# Network Properties I

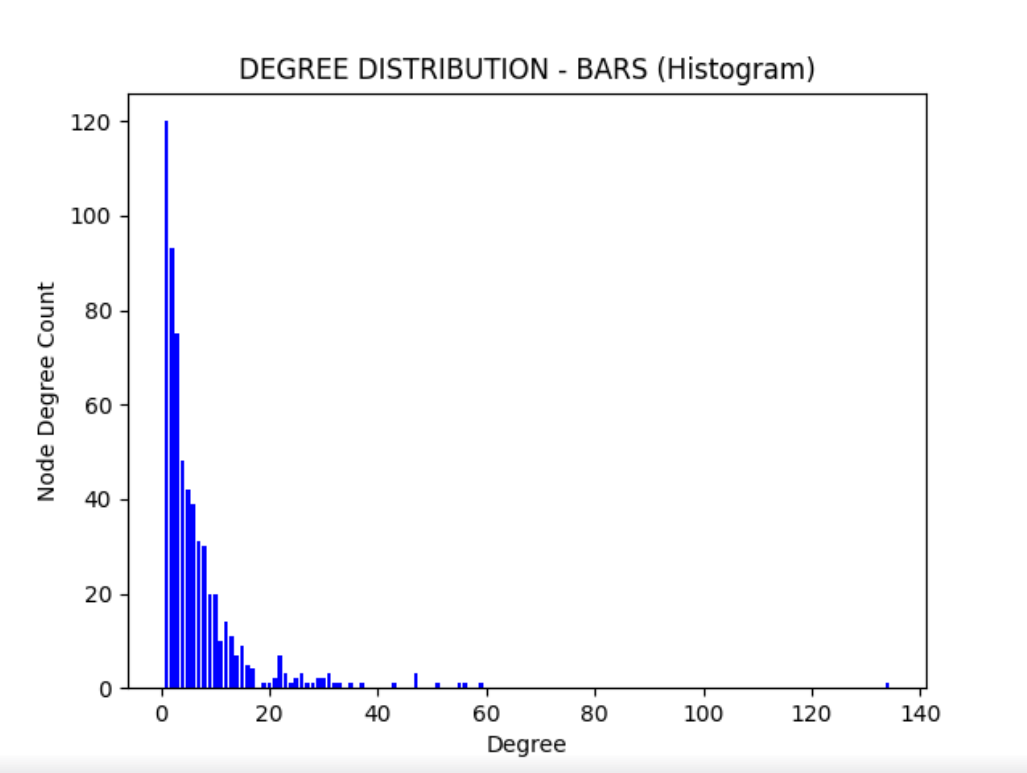
- AVERAGE DEGREE: 6.7806451612903222
- MIN DEGREE: 1
- MAX DEGREE: 134
- DIAMETER: 17
- DENSITY: 0.010954192506123322

# Network Properties II

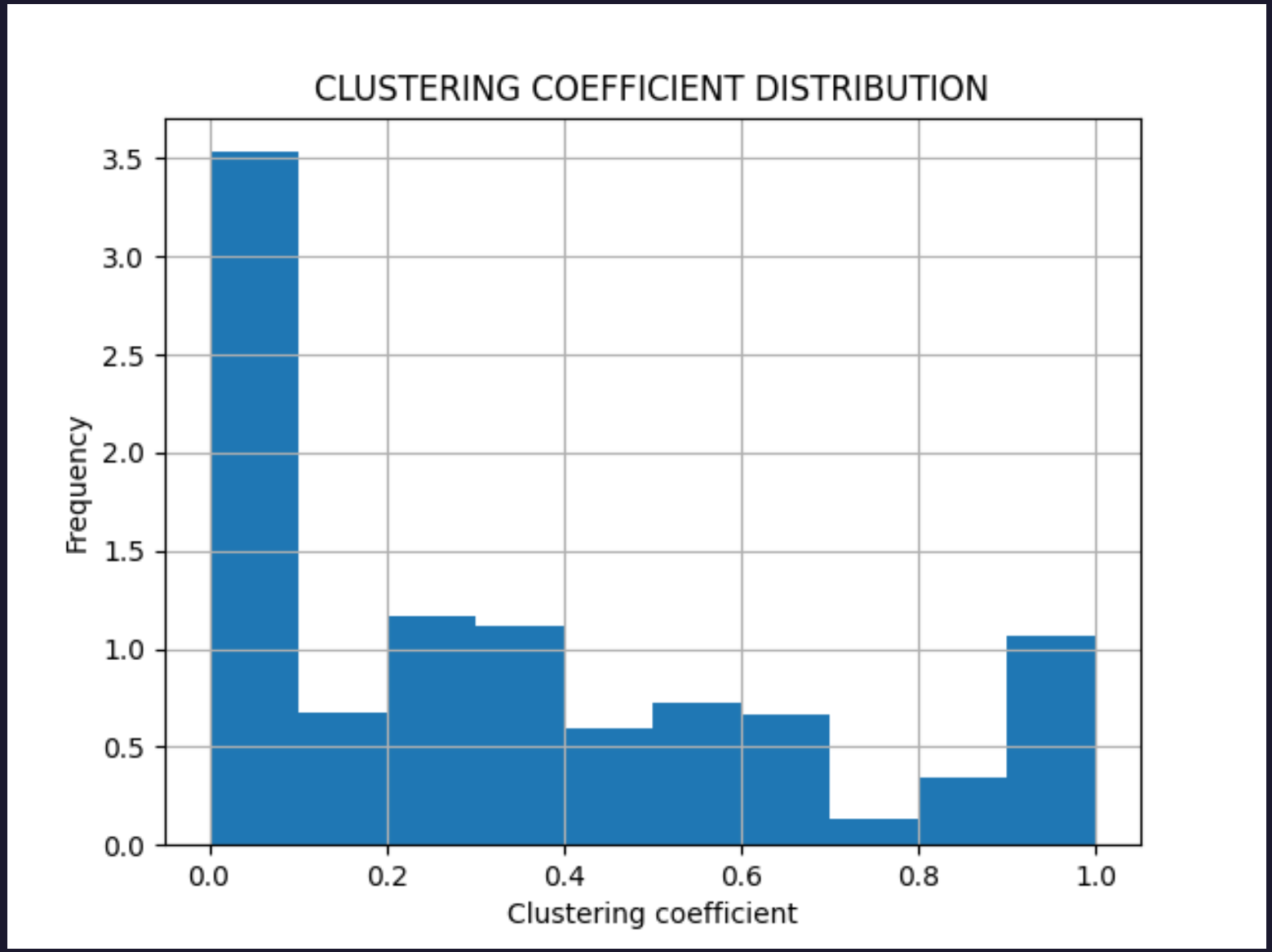
- CONNECTED COMPONENTS: 1
- SIZE LARGEST COMPONENT: 620
- AVERAGE SHORTEST PATH: 5.088696649121893
- AVERAGE CLUSTERING COEFFICIENT: 0.330897026353271

# Degree Distribution



# Clustering Coefficient Distribution



# Most Important Nodes

| Node | Betweenness Centrality |
|---|---|
| 265 | 0.349907666173777 67 |
| 31 | 0.1619605706800918 |
| 518 | 0.14456288292404343 |
| 618 | 0.09327260616363 37 |
| 35 | 0.09141807568331686 |
| 216 | 0.07911166993681 57 |
| 498 | 0.07229884637101391 |
| 101 | 0.05838784338316884 |
| 217 | 0.057229302697032476 |
| 148 | 0.057020665866287595 |

| Node | Closeness Centrality |
|---|---|
| 265 | 0.331370449678800 86 |
| 611 | 0.30283757338551 86 |
| 70 | 0.29816955684007707 |
| 90 | 0.2980259990370727 |
| 56 | 0.2947619047619048 |
| 217 | 0.2923948984411904 |
| 505 | 0.2911571025399811 7 |
| 67 | 0.2908834586466165 |
| 340 | 0.2892523364485981 6 |
| 248 | 0.2884436160298229 4 |

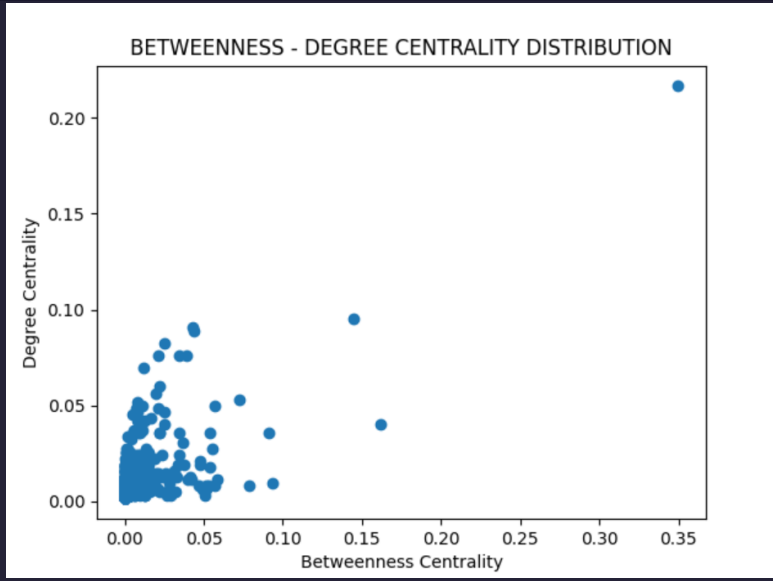
| Node | Degree Centrality |
|---|---|
| 265 | 0.21647819063004847 |
| 518 | 0.095315024232633 29 |
| 67 | 0.09046849757673668 |
| 340 | 0.08885298869143 78 |
| 90 | 0.08239095315024234 |
| 611 | 0.07592891760904685 |
| 56 | 0.07592891760904685 |
| 70 | 0.07592891760904685 |
| 89 | 0.06946688206785137 |
| 288 | 0.05977382875605816 |

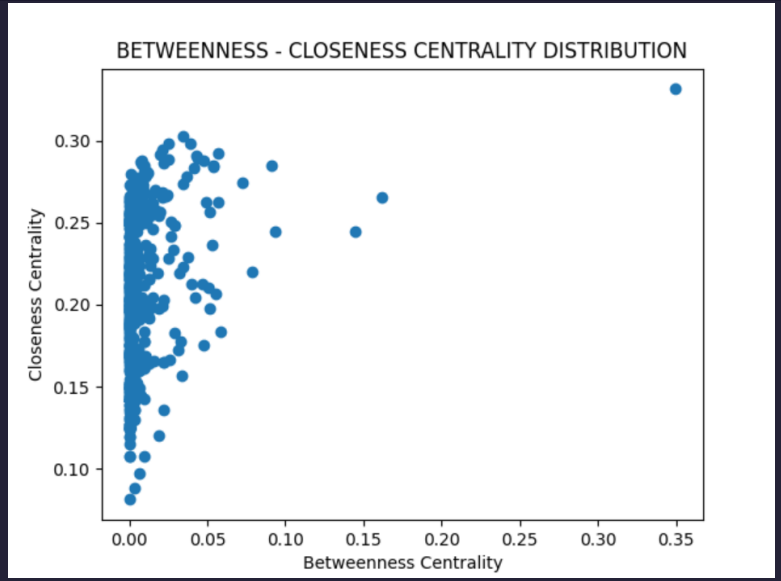
| Node | Eigen Centrality |
|---|---|
| 265 | 0.325752178352679 67 |
| 90 | 0.22124763622497173 |
| 340 | 0.21990111769744997 |
| 67 | 0.20730874642453745 |
| 56 | 0.20600750503290324 |
| 611 | 0.1849390286281483 |
| 89 | 0.1795844430988681 5 |
| 70 | 0.17605019181207024 |
| 317 | 0.161765900423639 4 |
| 505 | 0.15717739346300 85 |

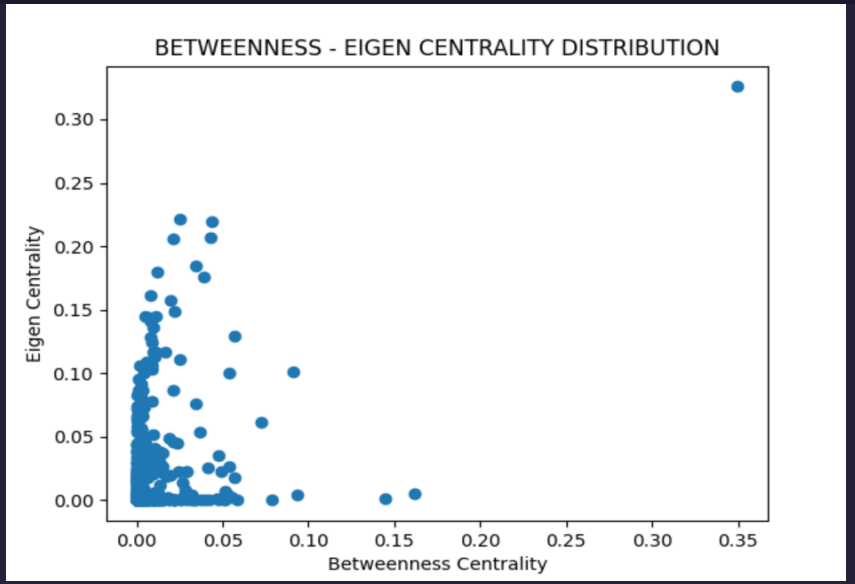
| Node | Degree |
|---|---|
| 265 | 134 |
| 518 | 59 |
| 67 | 56 |
| 340 | 55 |
| 90 | 51 |
| 611 | 47 |
| 56 | 47 |
| 70 | 47 |
| 89 | 43 |
| 288 | 37 |

# Most Important Nodes

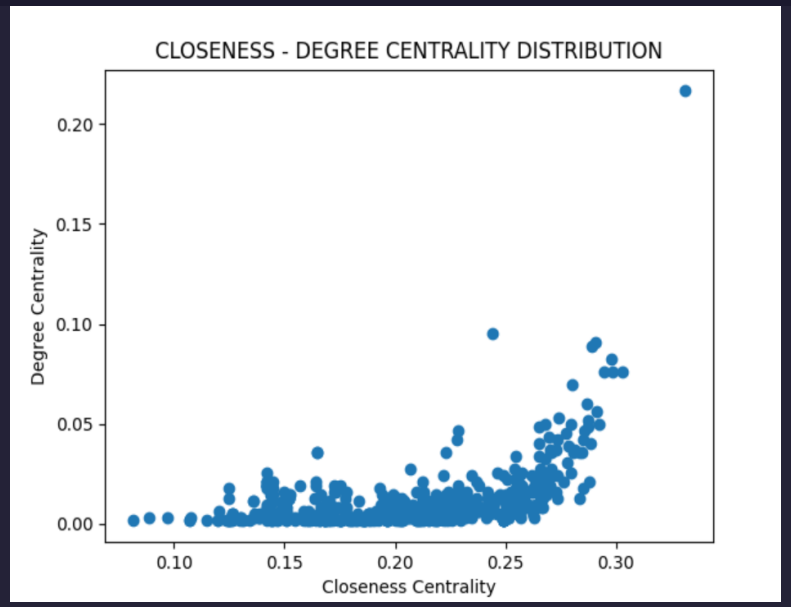
# Comparison between Centrality Distributions

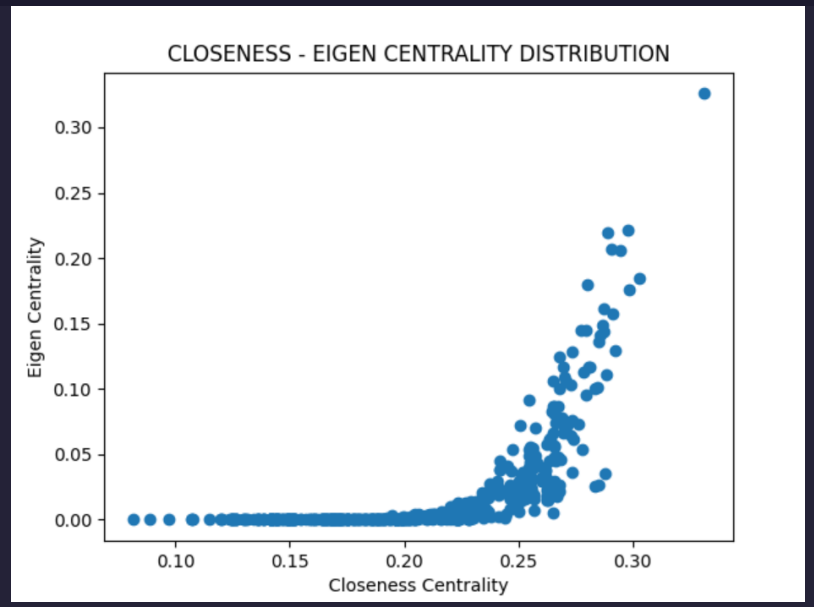


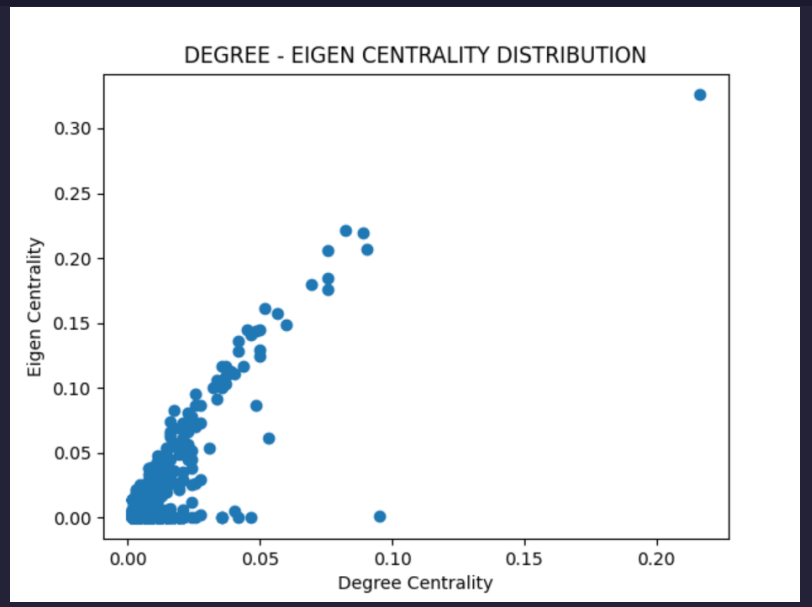



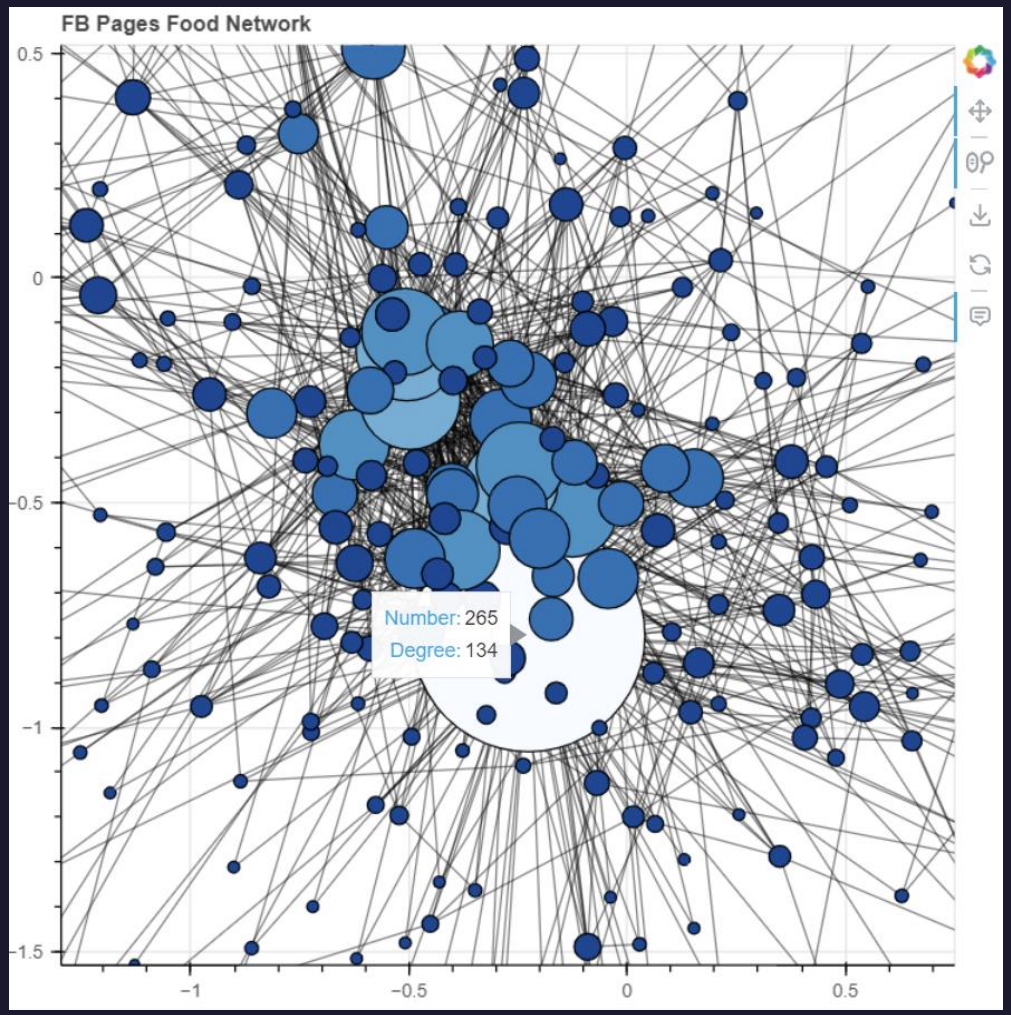
# Comparison between Centrality Distributions

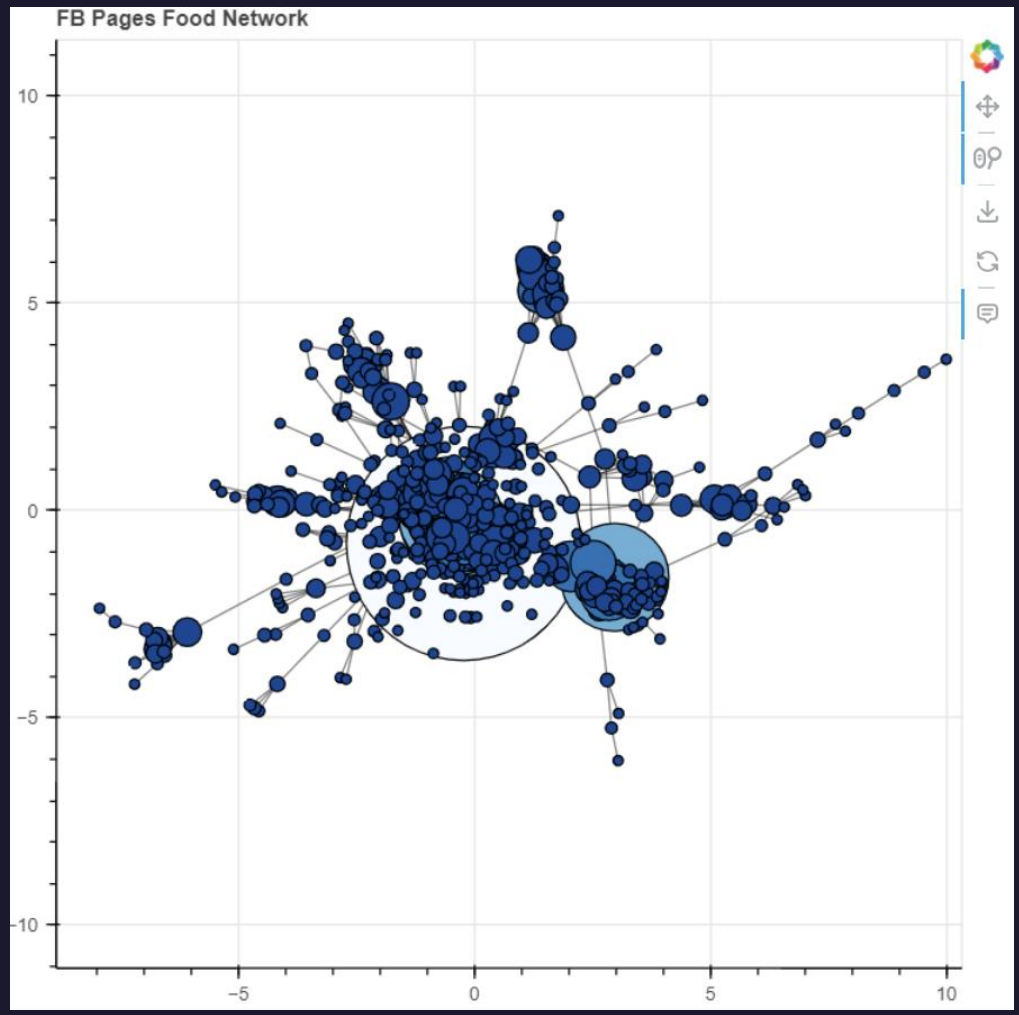


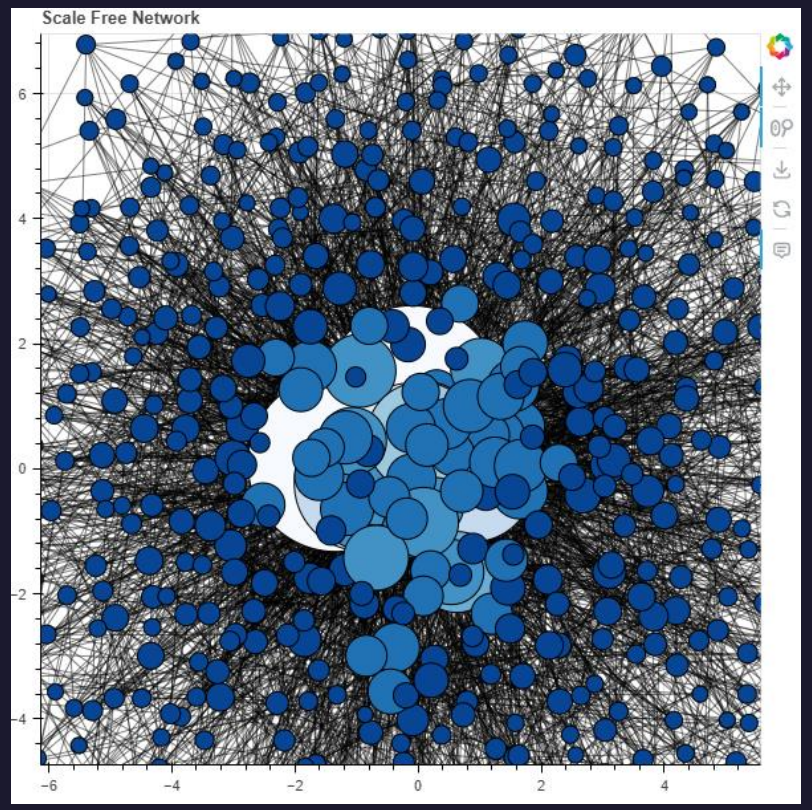



# Visualization of the network

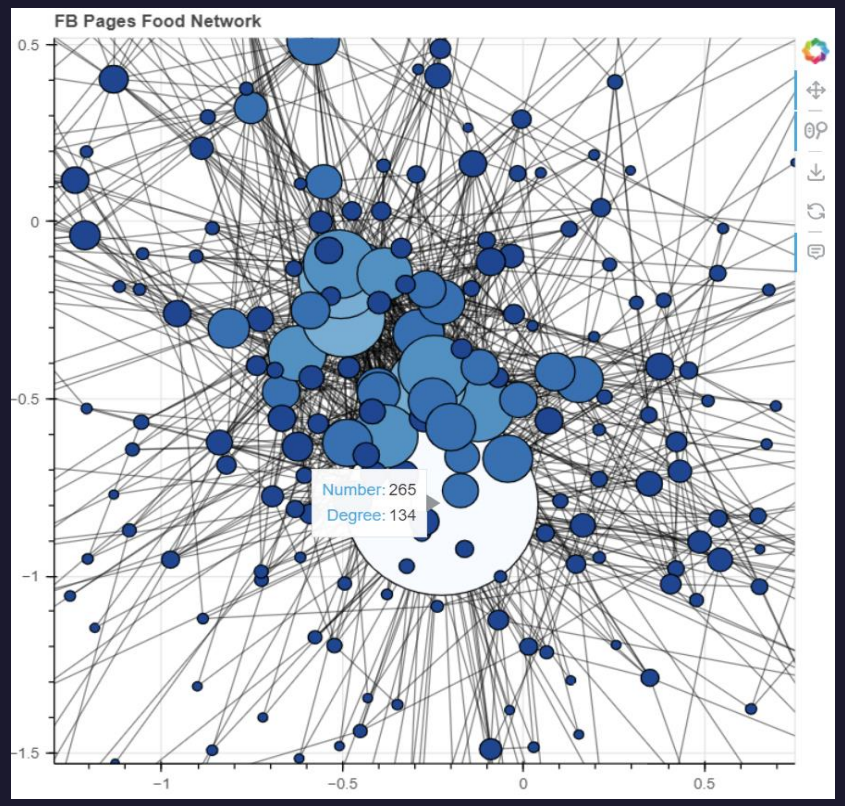


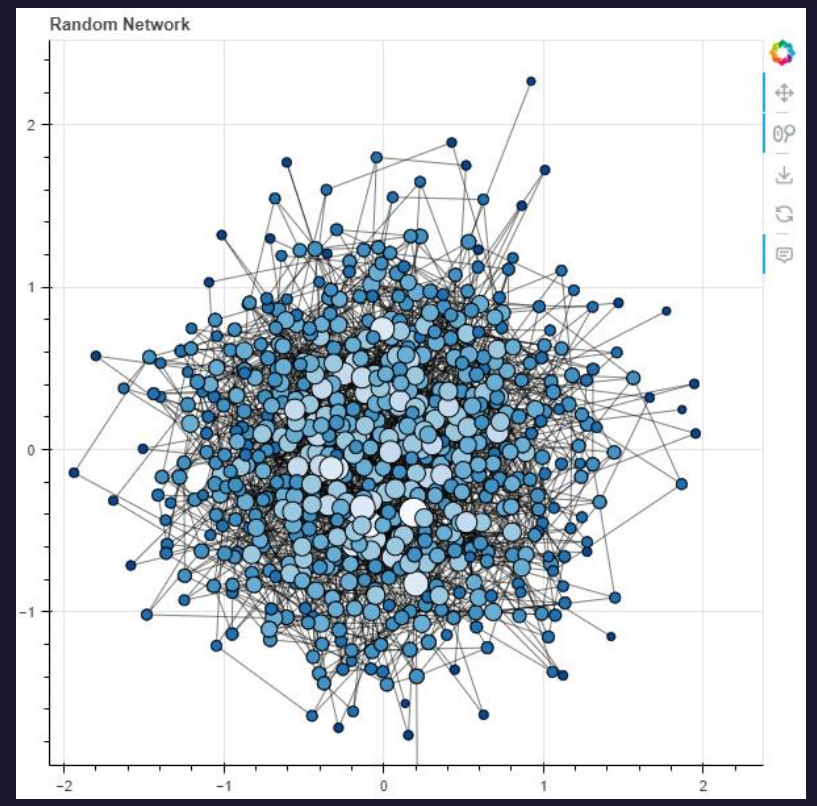
# Scale-free Network VS Random Network




Scale-free Network




Our Network (Scale-free)




Random Network

# Real Data Analysis

## Breast Cancer

https://www.kaggle.com/datasets/uciml/breast-cancer-wisconsin-data

# Background

- ID number
- Diagnosis (M = malignant, B = benign)
- Ten real-valued features are computed for each cell nucleus:
  - a) radius (mean of distances from center to points on the perimeter)
  - b) texture (standard deviation of gray-scale values)
  - c) perimeter
  - d) area
  - e) smoothness (local variation in radius lengths)
  - f) compactness (perimeter^2 / area - 1.0)
  - g) concavity (severity of concave portions of the contour)
  - h) concave points (number of concave portions of the contour)
  - i) symmetry
  - j) fractal dimension ("coastline approximation" - 1)

# BREAST CANCER REAL DATASET

- NUMBER NODES: 545
  - 188 Malignant Nodes
  - 357 Benign Nodes
- NUMBER LINKS: 1848
  - 363 Malignant Links
  - 1485 Benign Links
- TYPE OF NETWORK:
  - Undirected
  - Random network

# Significance & Meaning

- **Nodes:** 545 – biopsy sample
- **Links:** 1848 – (same radius or same texture) and same diagnosis
- **Tumor size:** The radius of a tumor is a measure of its size. Larger tumors may be indicative of more advanced stages of cancer and may require more aggressive treatment.
- **Tumor type:** The texture of a tumor may provide clues as to its type. For example, breast cancer tumors with a smooth texture may be more likely to be benign, while those with a rough or irregular texture may be more likely to be malignant.
- **Tumor grade:** Tumor grade is a measure of how abnormal the cancer cells look under a microscope. The grade of a breast cancer tumor may be related to its texture, as tumors with more irregular and disorganized cells may have a higher grade, indicating a more aggressive cancer.

# Network Properties I

*MALIGNANT COMPONENT*

- **AVERAGE DEGREE:** 3.8617021276595747
- **MIN DEGREE:** 1
- **MAX DEGREE:** 9
- **DIAMETER:** 16
- **DENSITY:** 0.020650813516896l2

*BENIGN COMPONENT*

- **AVERAGE DEGREE:** 8.319327731092438
- **MIN DEGREE:** 1
- **MAX DEGREE:** 20
- **DIAMETER:** 11
- **DENSITY:** 0.023368898121046172

# Network Properties II

*MALIGNANT COMPONENT*

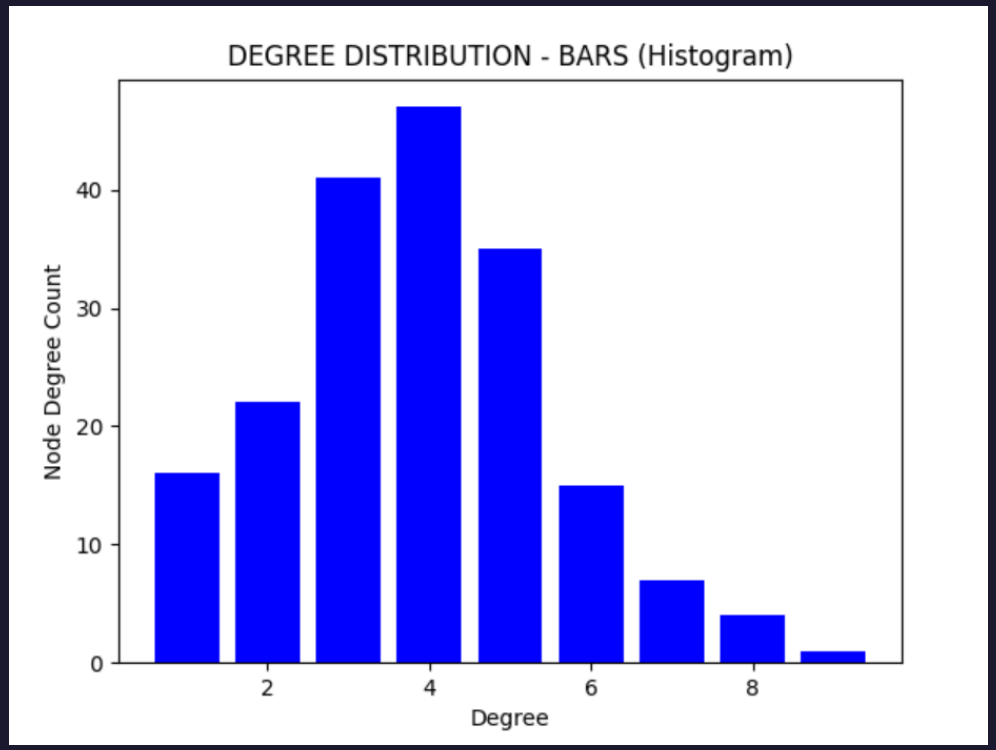
- **CONNECTED COMPONENTS:** 1
- **SIZE LARGEST COMPONENT:** 188
- **AVERAGE SHORTEST PATH:** 6.445158721128683
- **AVERAGE CLUSTERING COEFFICIENT:** 0.5079533941236071

*BENIGN COMPONENT*

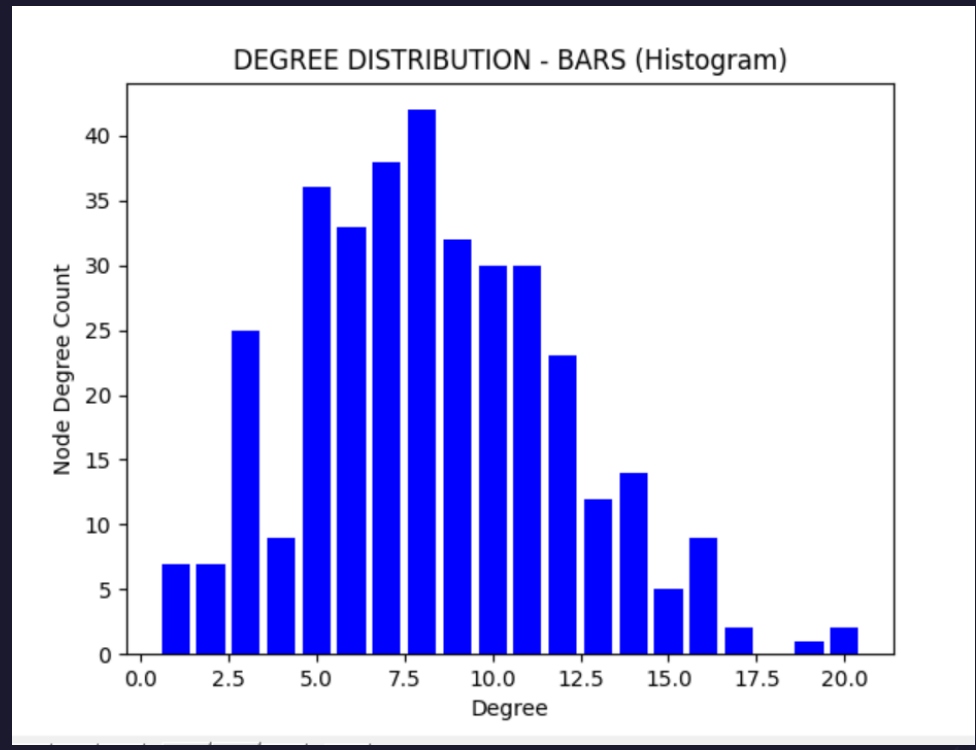
- **CONNECTED COMPONENTS:** 1
- **SIZE LARGEST COMPONENT:** 357
- **AVERAGE SHORTEST PATH:** 3.892770591 3826203
- **AVERAGE CLUSTERING COEFFICIENT:** 0.590091768399129

# Degree Distribution

*MALIGNANT COMPONENT*

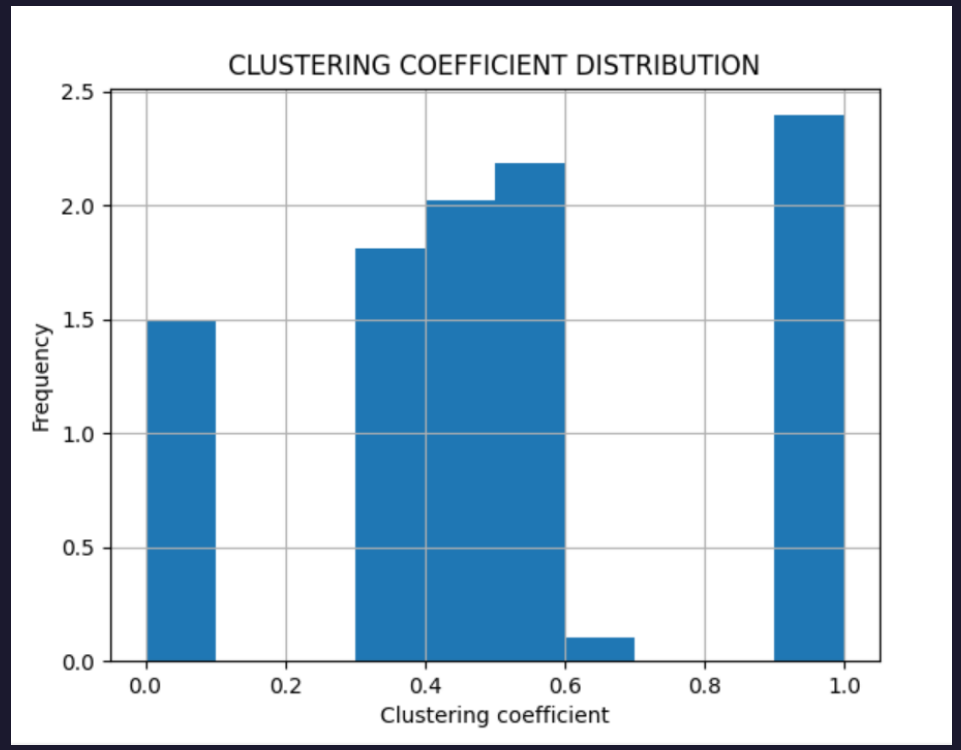



*BENIGN COMPONENT*

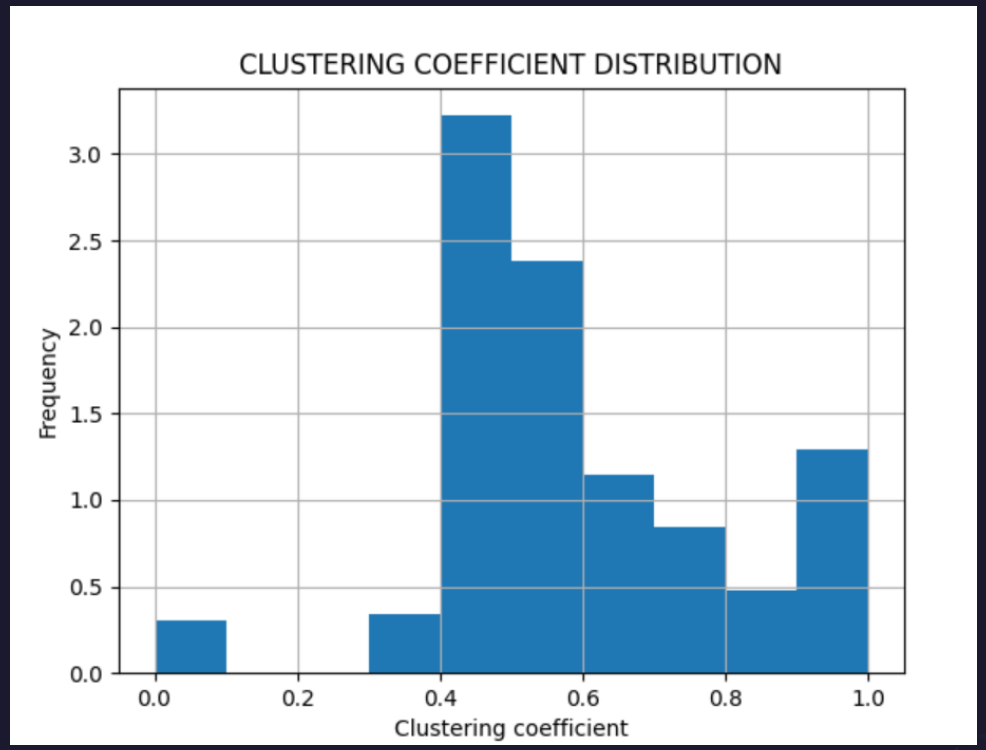


# Clustering Coefficient Distribution

*MALIGNANT COMPONENT*




*BENIGN COMPONENT*



# Most Important Nodes ~ Malignant (M)/ Benign (B)

| Node | Betweenness Centrality |
|---|---|
| M 17 | 0.13563729410719236 |
| M 392 | 0.12527555054724282 |
| M 131 | 0.12468245629363452 |
| M 533 | 0.10643645354702799 |
| M 479 | 0.10536595158813 55 |
| B 518 | 0.04318198290663 68 |
| B 242 | 0.03932031313749861 |
| B 52 | 0.03310856863857 2346 |
| B 51 | 0.03067263449053 5262 |
| B 195 | 0.02935134628929 7035 |

| Node | Closeness Centrality |
|---|---|
| M 392 | 0.19914802981895632 |
| M 141 | 0.19663512092534174 |
| M 509 | 0.19560669456066945 |
| M 17 | 0.19519832985386 22 |
| M 119 | 0.19458896982310095 |
| B 518 | 0.34362934362934362 |
| B 192 | 0.33085501858736 06 |
| B 242 | 0.32811059907834 1 |
| B 52 | 0.32393084622383983 |
| B 284 | 0.32246376811594 2 |

| Node | Degree Centrality |
|---|---|
| M 210 | 0.04812834224598 93 |
| M 392 | 0.04278074866310 16 |
| M 223 | 0.04278074866310 16 |
| M 509 | 0.04278074866310 16 |
| M 94 | 0.04278074866310 16 |
| B 284 | 0.05617977528089 8875 |
| B 518 | 0.05617977528089 8875 |
| B 242 | 0.05337078651685393 |
| B 475 | 0.04775280898876 4044 |
| B 52 | 0.04775280898876 4044 |

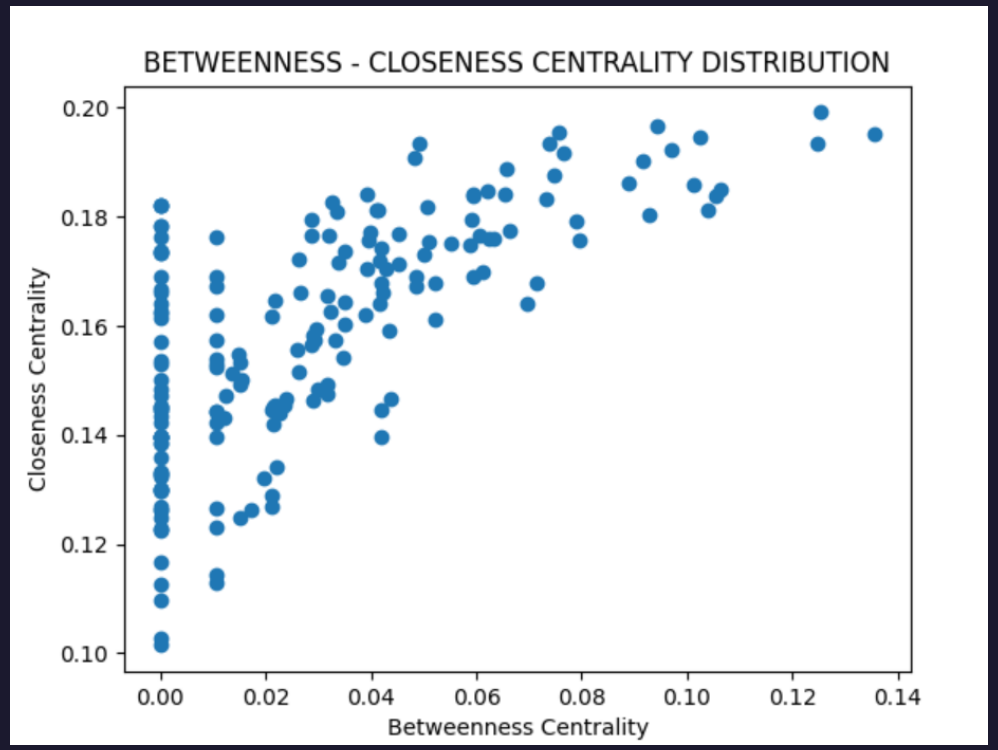
| Node | Eigen Centrality |
|---|---|
| M 509 | 0.39646323746854 12 |
| M 392 | 0.38416461554178566 |
| M 131 | 0.35359840998266 47 |
| M 172 | 0.32415139154232 7 |
| M 259 | 0.32415139154232 7 |
| B 518 | 0.27242963426558 15 |
| B 284 | 0.26260908243040 81 |
| B 247 | 0.24600269758611 75 |
| B 268 | 0.24376262661196624 |
| B 403 | 0.24376262661196624 |

| Node | Degree |
|---|---|
| M 210 | 9 |
| M 392 | 8 |
| M 223 | 8 |
| M 509 | 8 |
| M 94 | 8 |
| B 284 | 20 |
| B 518 | 20 |
| B 242 | 19 |
| B 475 | 17 |
| B 52 | 17 |

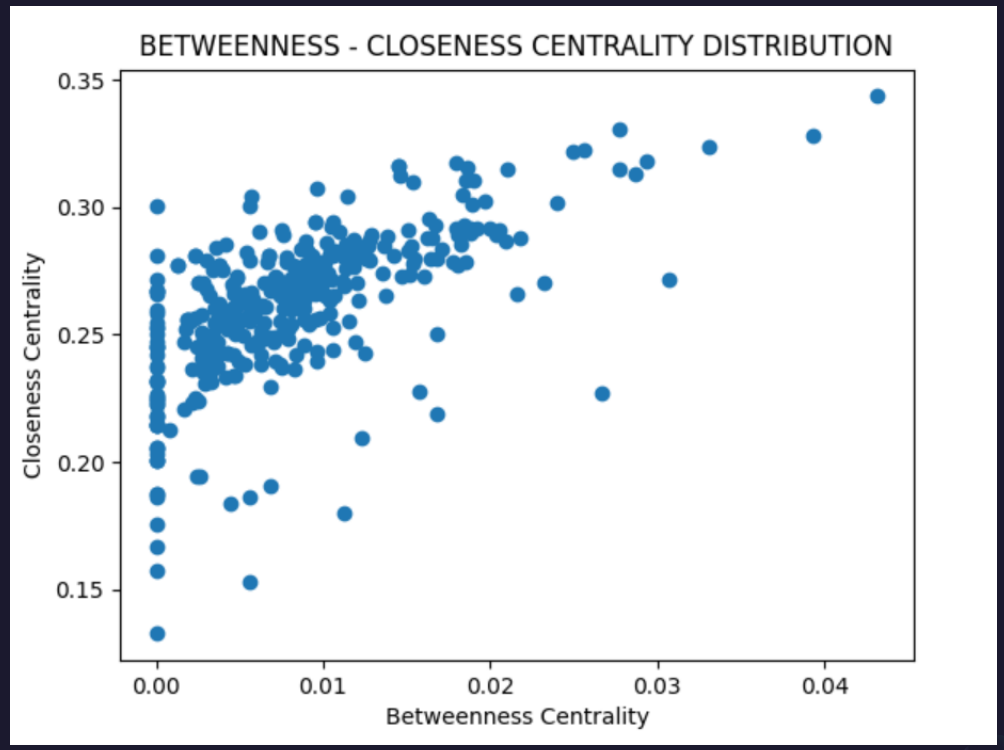
# Most Important Nodes ~ Malignant (M)/ Benign (B)

# Betweenness – Closeness Centrality Distribution

*MALIGNANT COMPONENT*

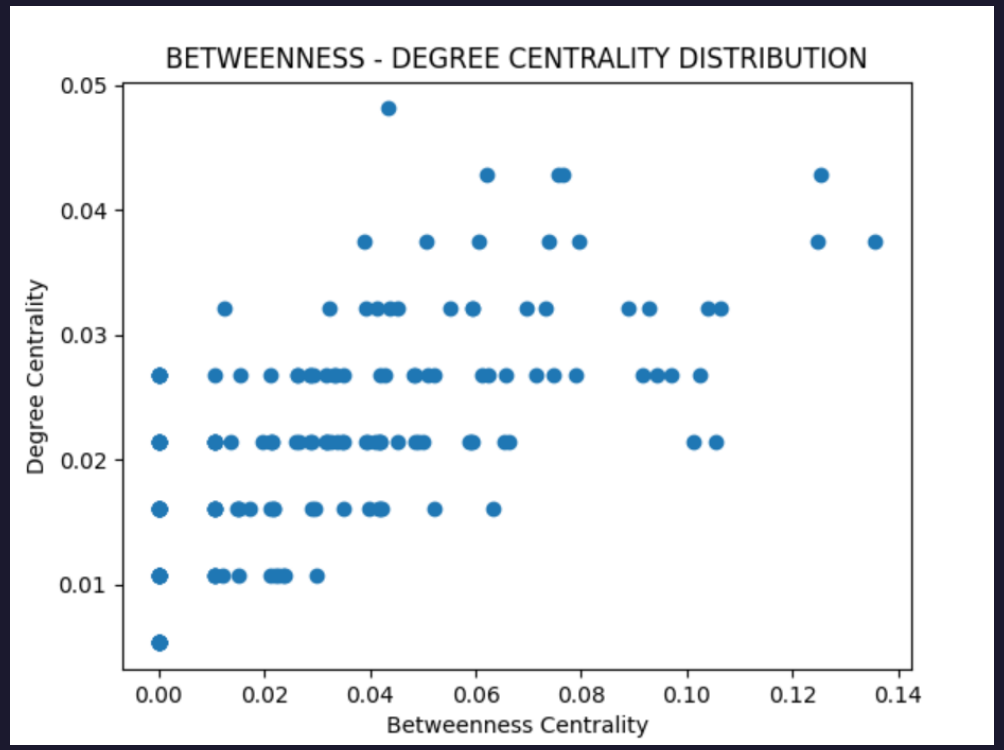



*BENIGN COMPONENT*

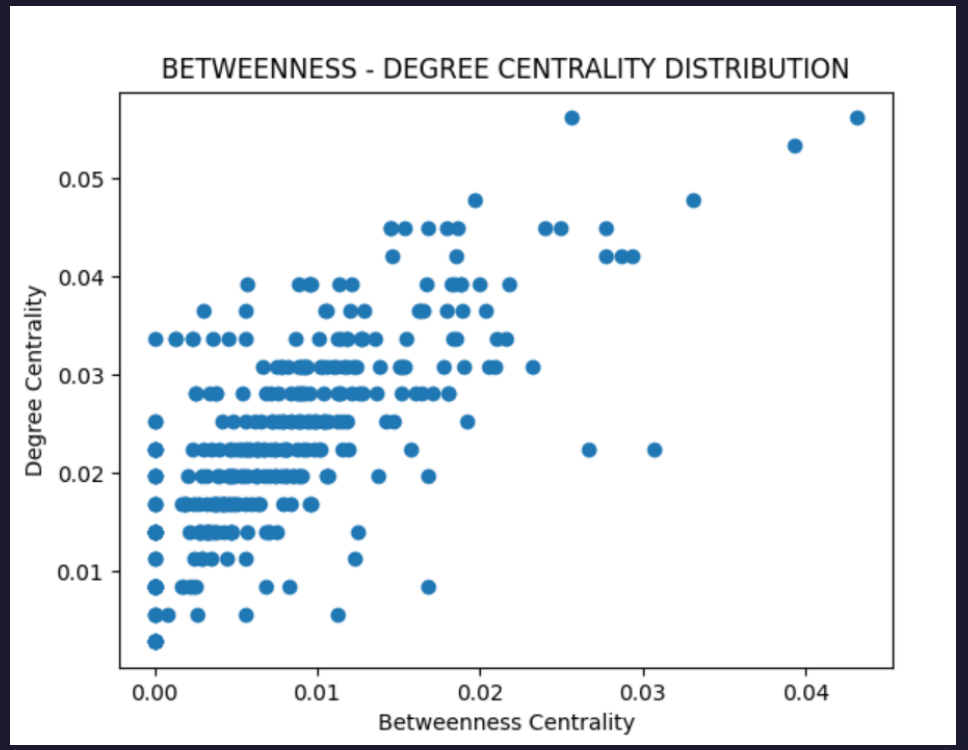


# Betweenness – Degree Centrality Distribution

*MALIGNANT COMPONENT*

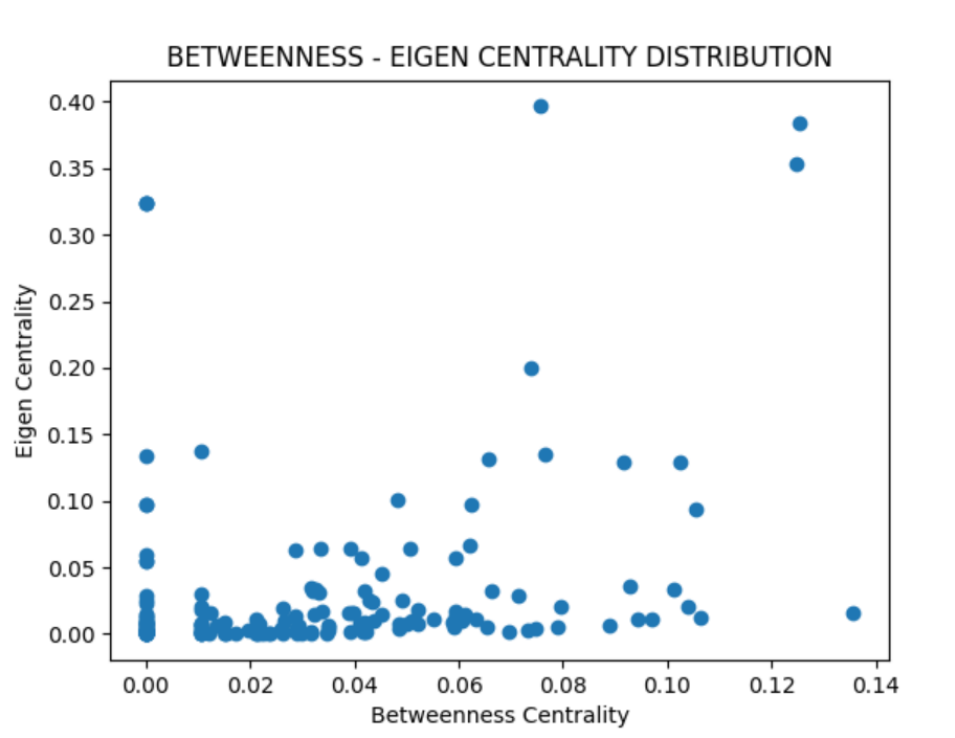



*BENIGN COMPONENT*

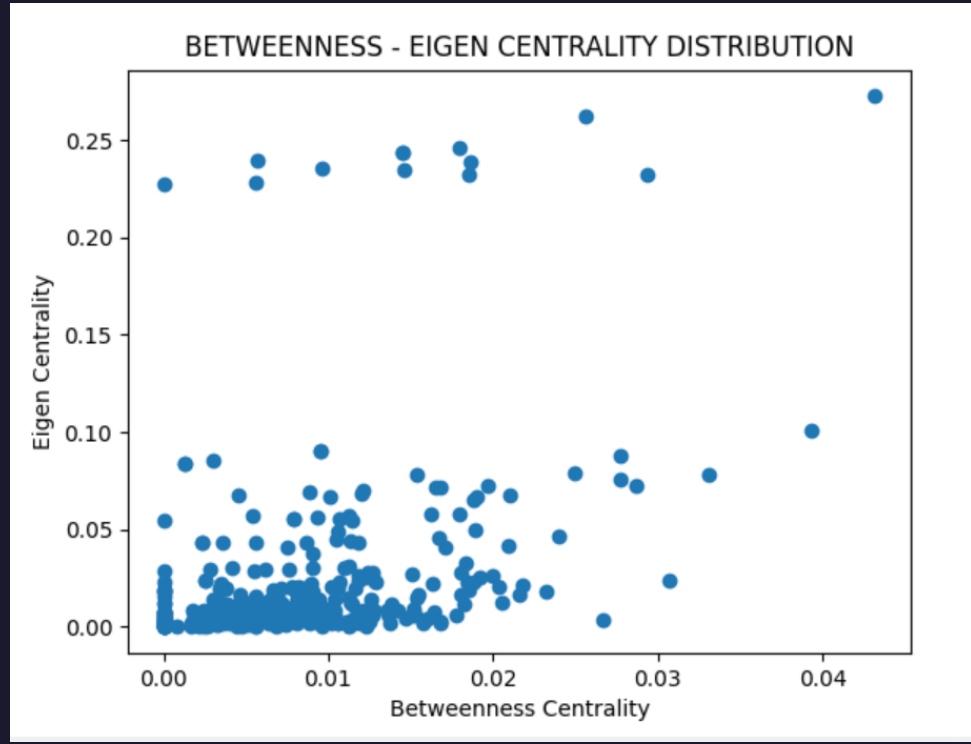


# Betweenness – Eigen Centrality Distribution

*MALIGNANT COMPONENT*

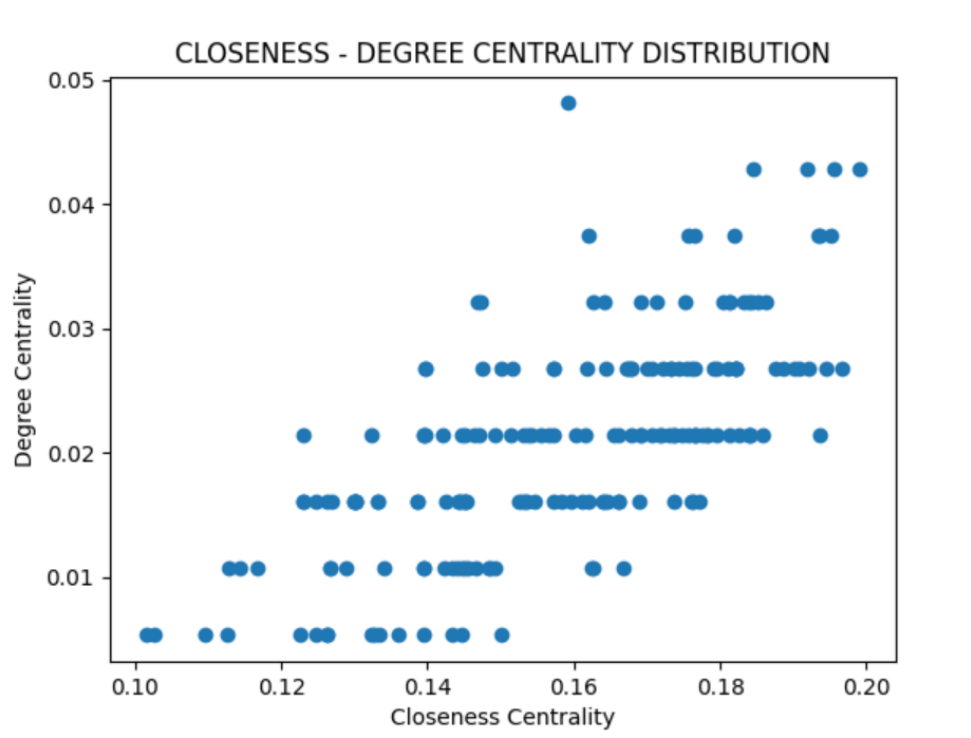



*BENIGN COMPONENT*

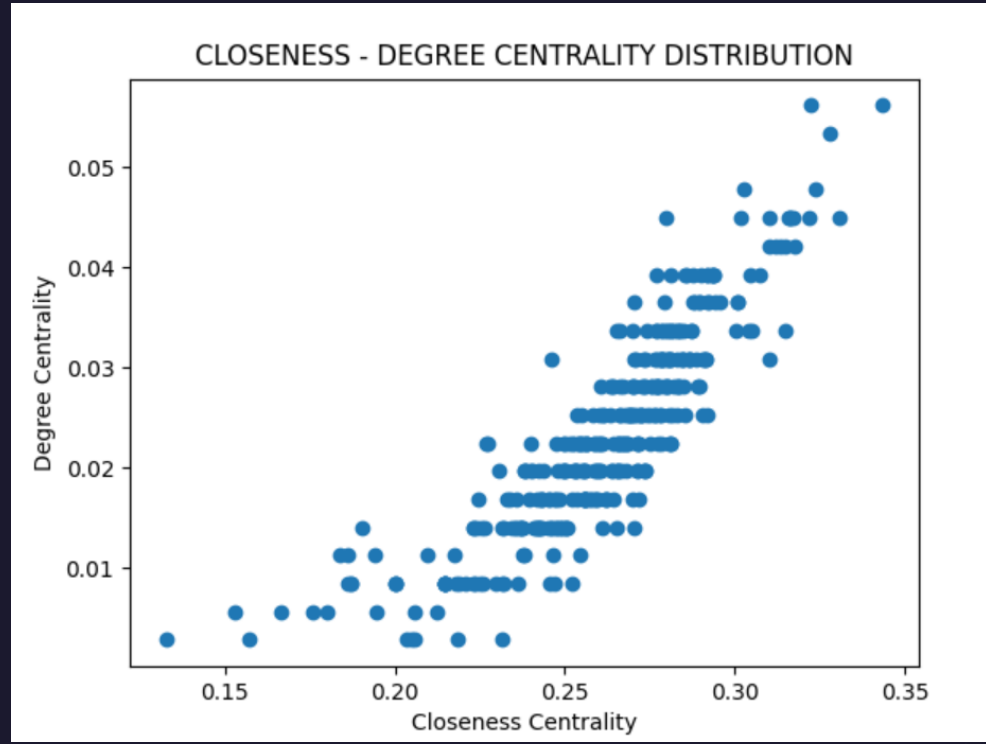


# Closeness – Degree Centrality Distribution

*MALIGNANT COMPONENT*

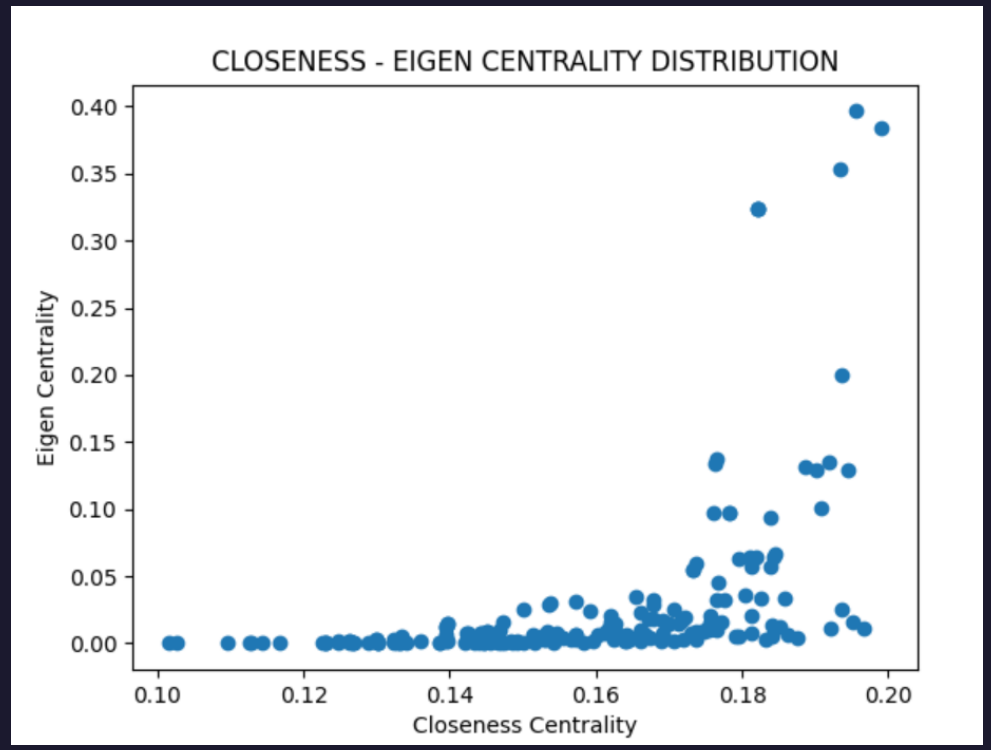



*BENIGN COMPONENT*

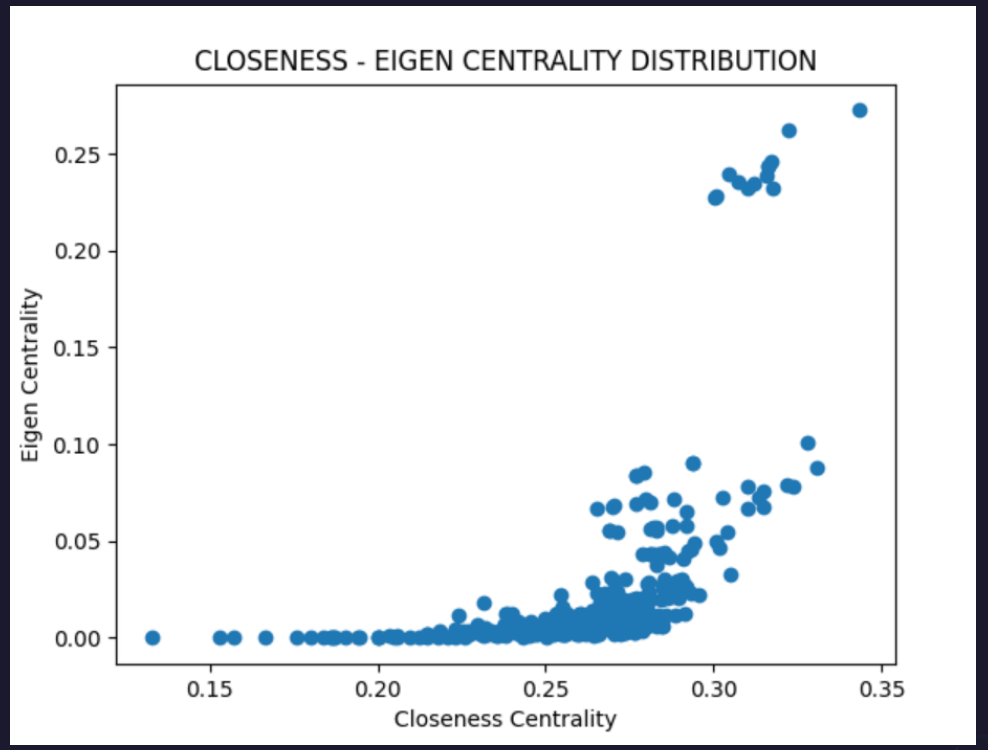


# Closeness – Eigen Centrality Distribution

*MALIGNANT COMPONENT*

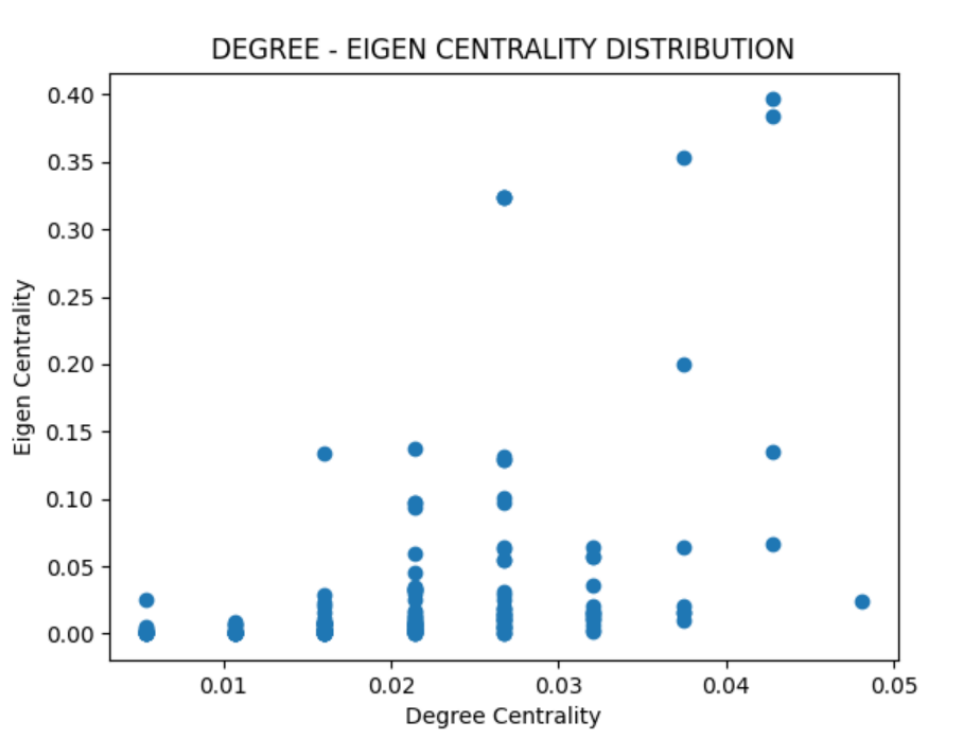



*BENIGN COMPONENT*

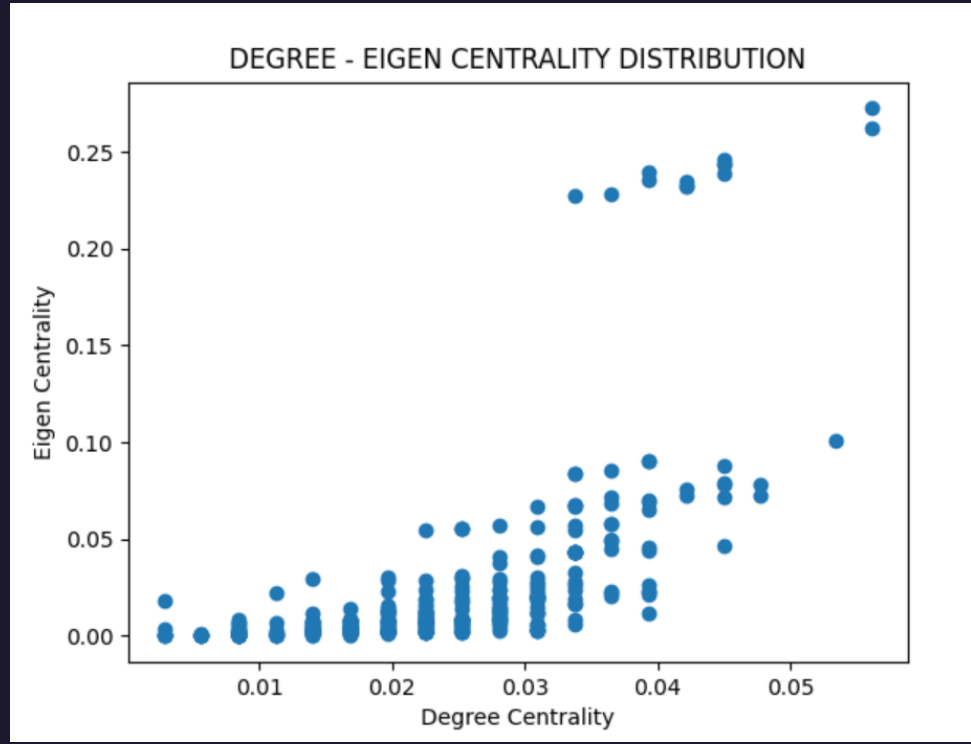


# Degree – Eigen Centrality Distribution

*MALIGNANT COMPONENT*

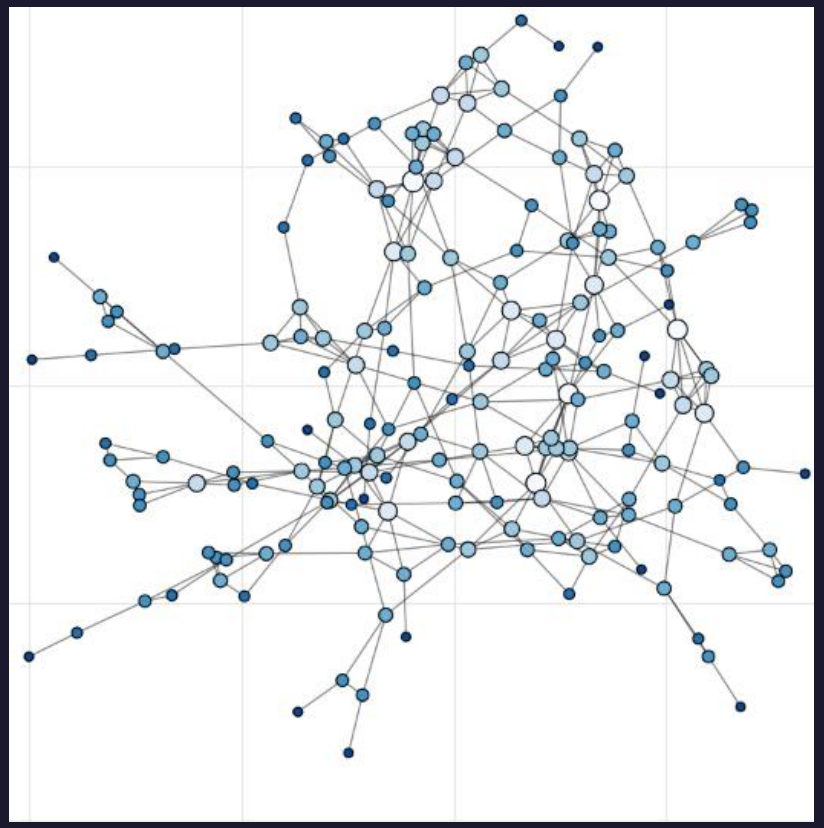



*BENIGN COMPONENT*

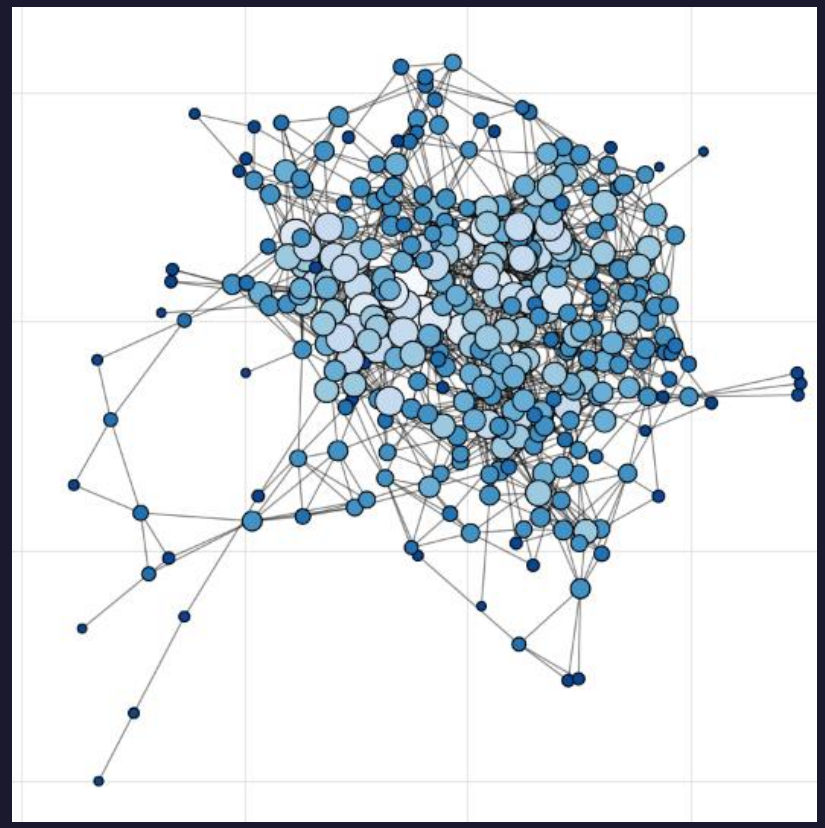


# Visualization of the Networks

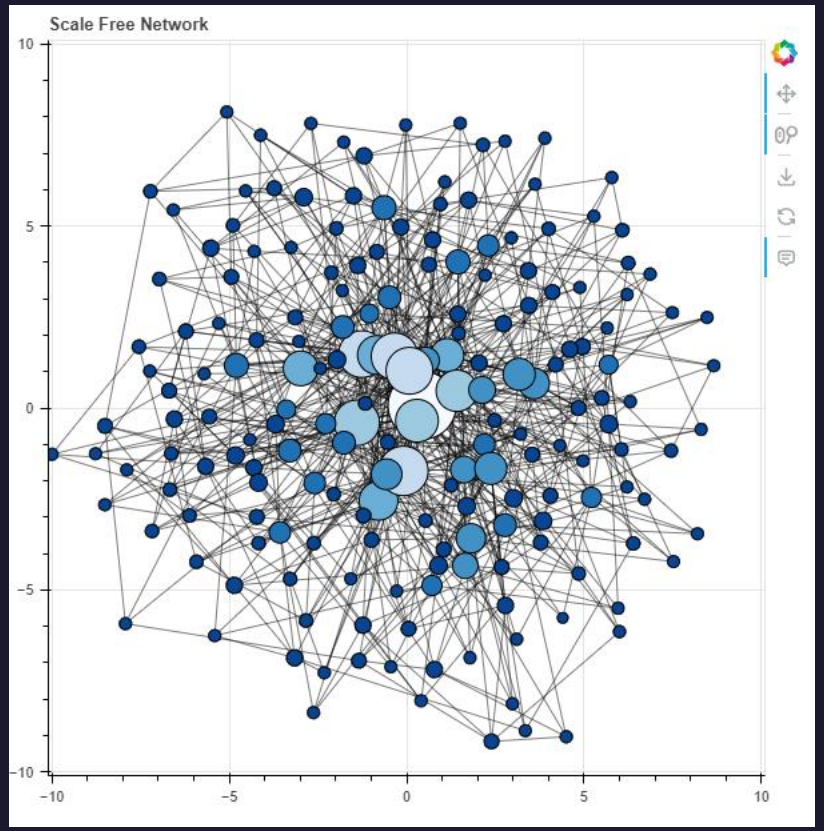
*MALIGNANT COMPONENT*



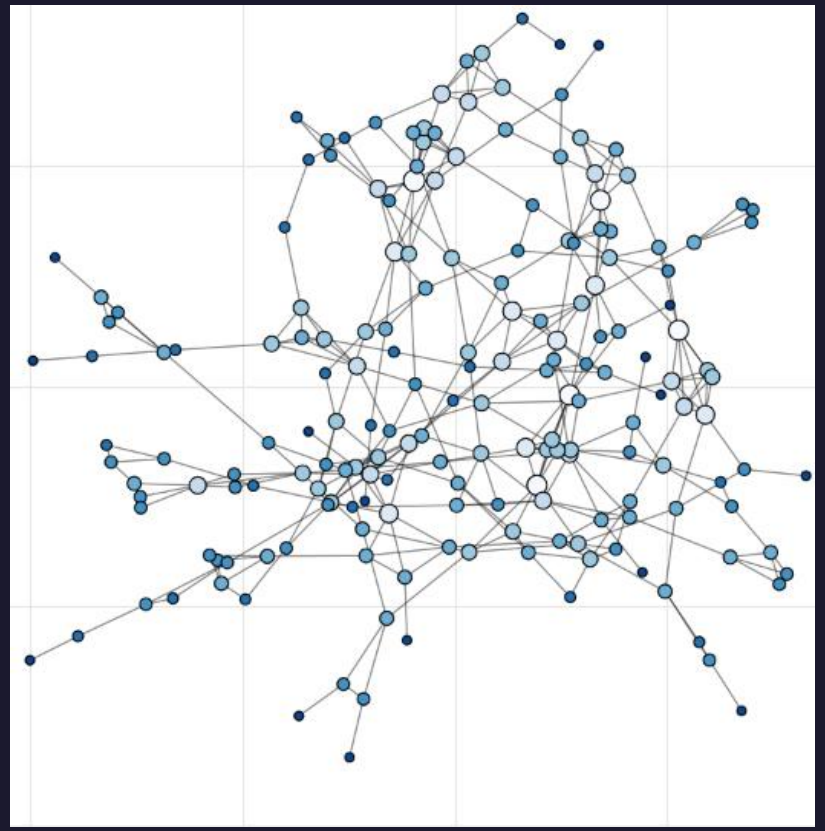
*BENIGN COMPONENT*



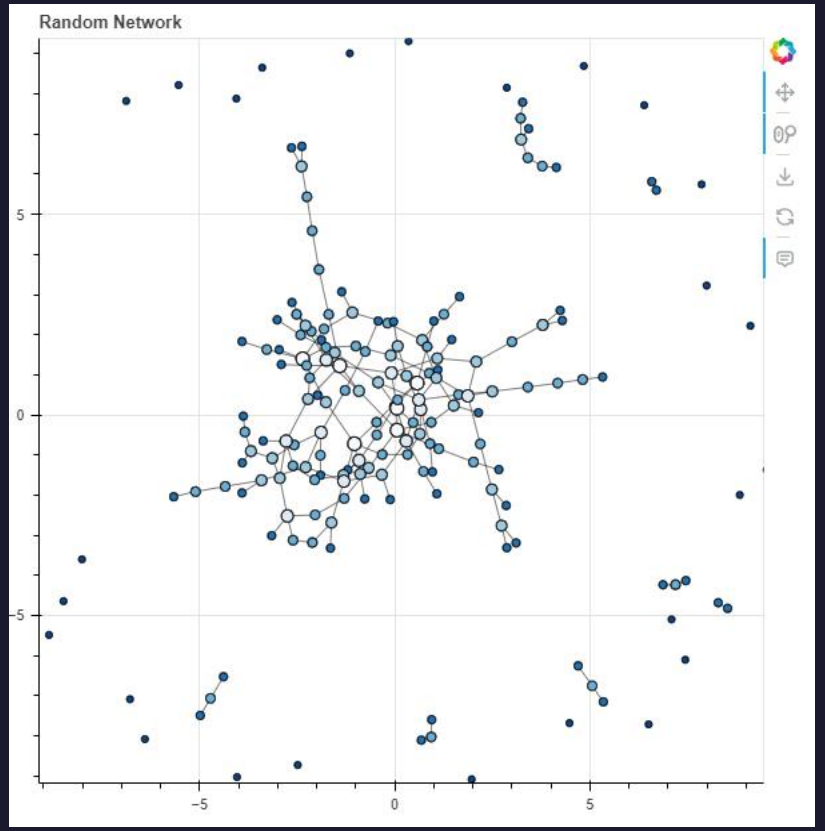
# Scale-free Network VS Random Network




Scale-free Network



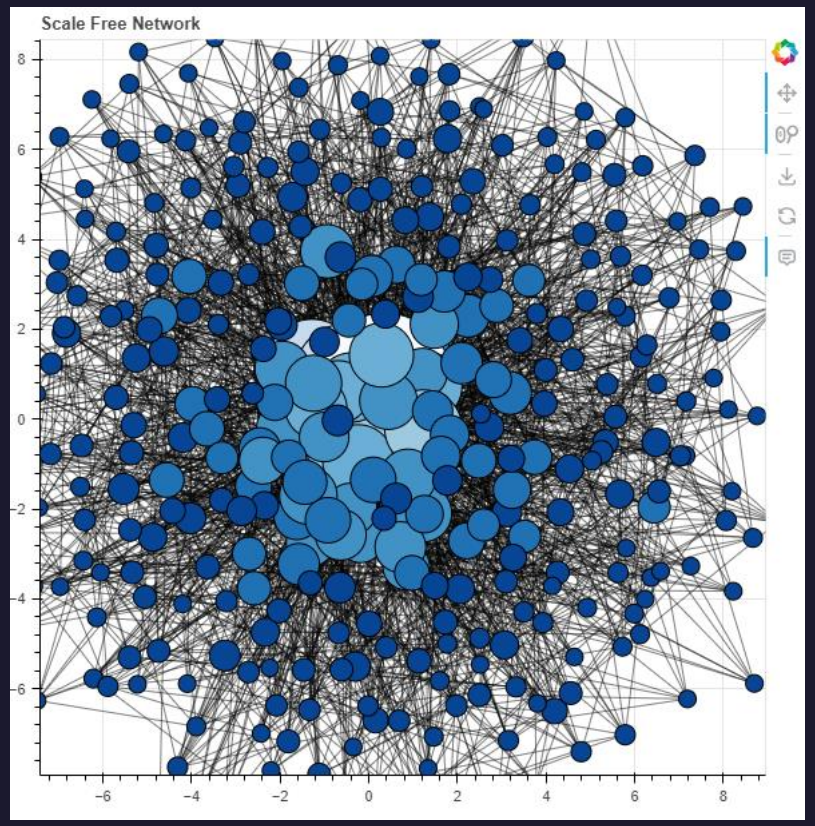
Our Malignant Network (Random)



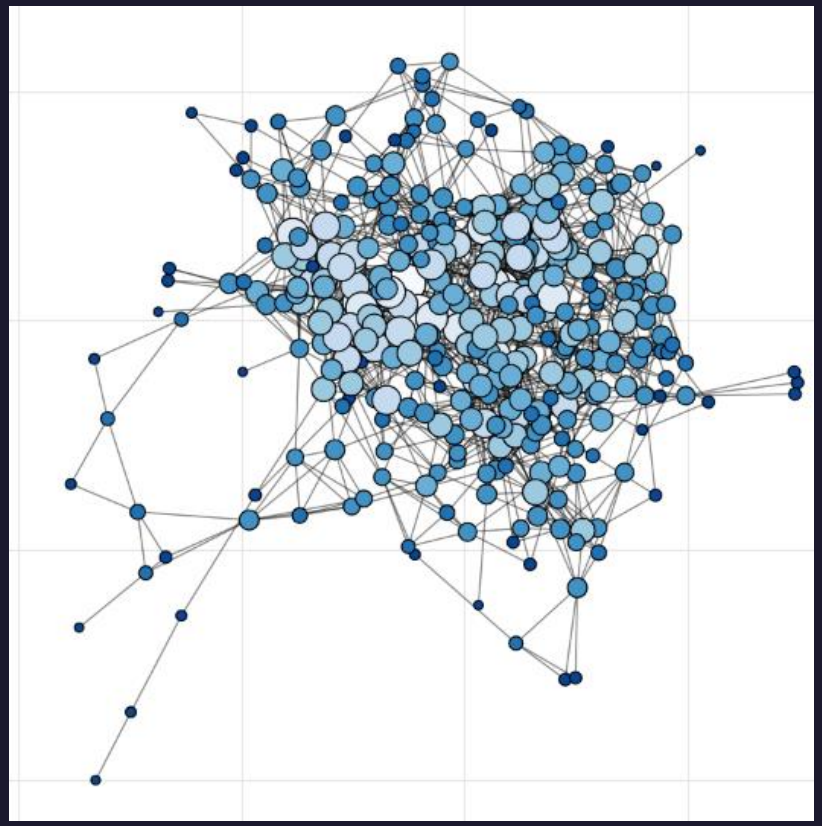

Random Network

# Scale-free Network VS Random Network

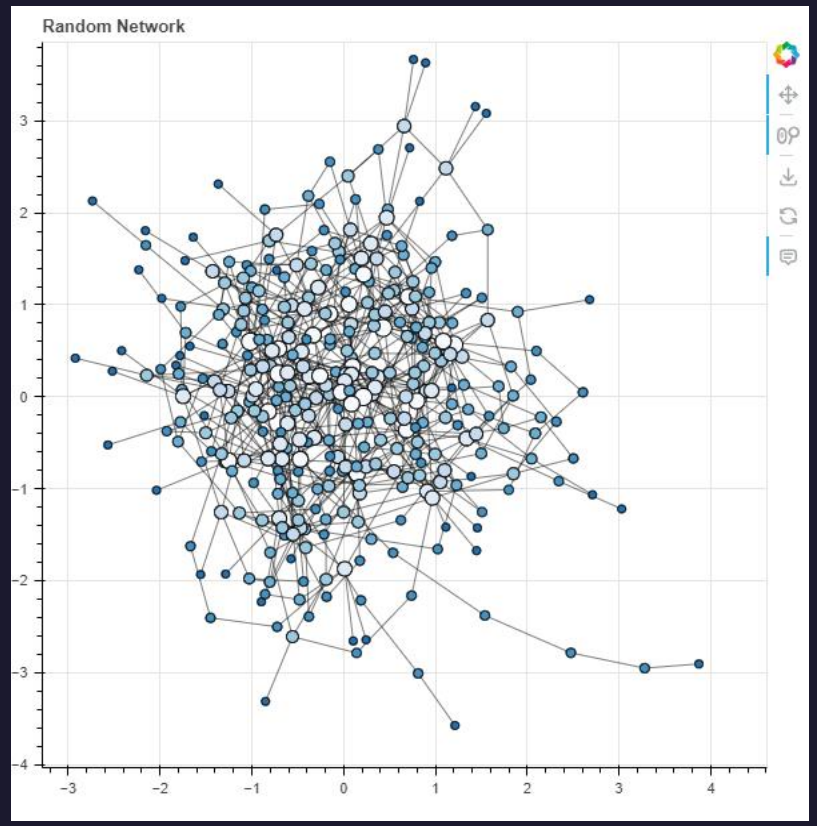
B




Scale-free Network



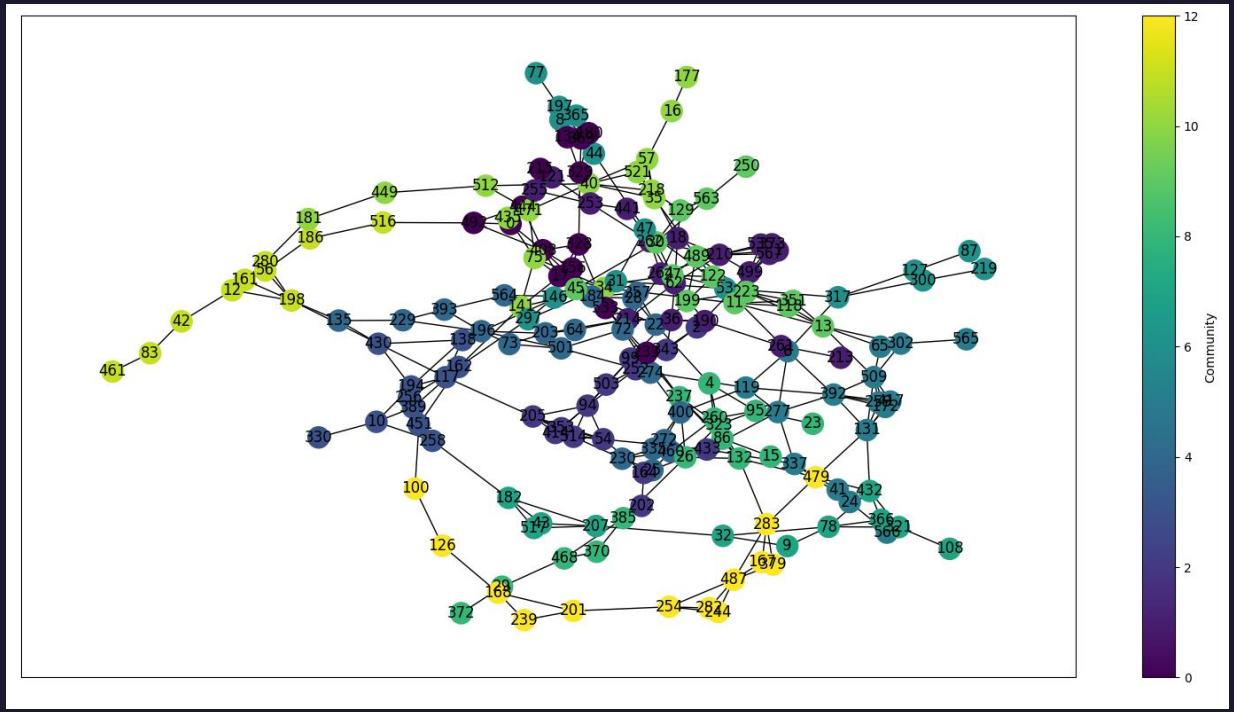
Our Benign Network (Random)



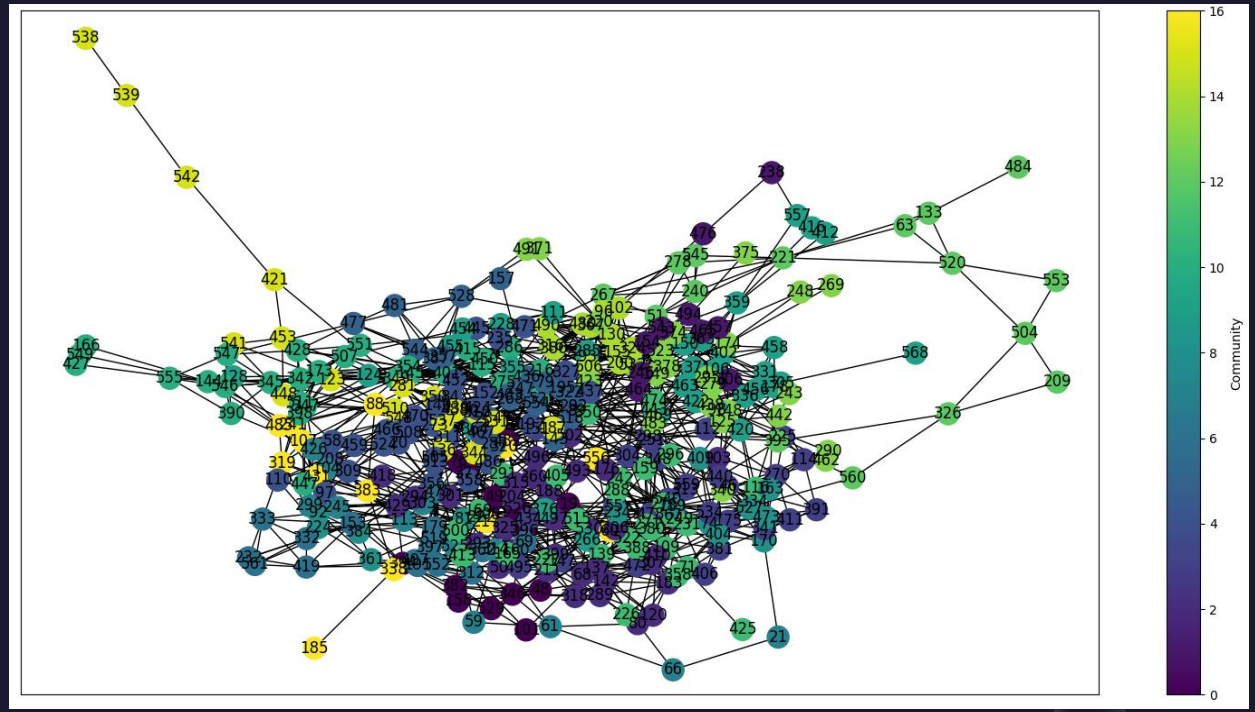

Random Network

# Functional Modules Detection using Louvain Algorithm

## *MALIGNANT COMPONENT*




## *BENIGN COMPONENT*



# Thank You For Your Attention!