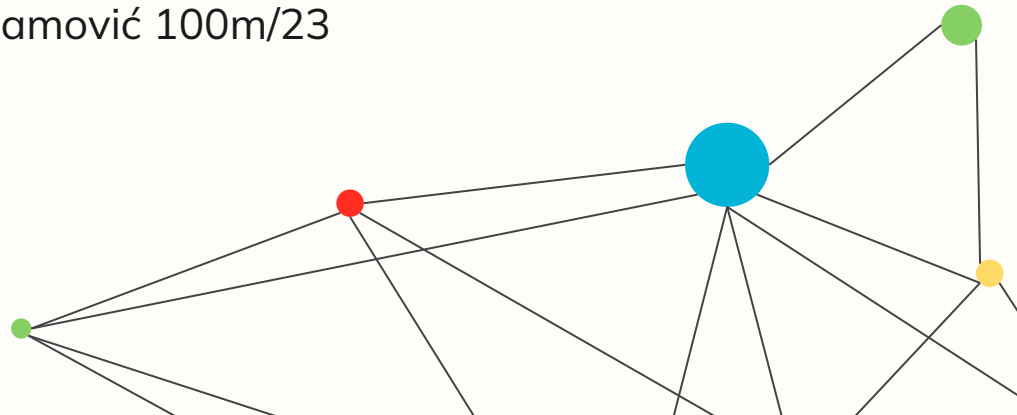




# Barabási–Albert Model

Mila Krstić 85m/23  
Marina Adamović 100m/23





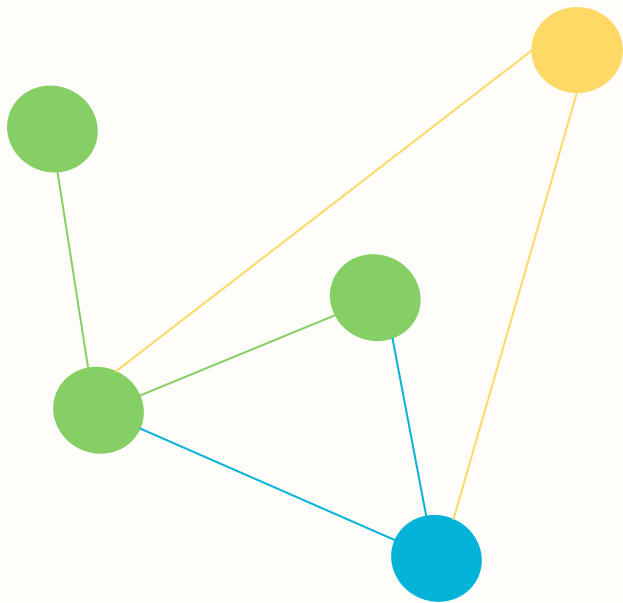
# What is the Barabási–Albert model?



Barabasi-Albert model is an algorithm for generating random **scale-free** networks using a **preferential attachment** mechanism.



# How is the Barabási-Albert model generated?



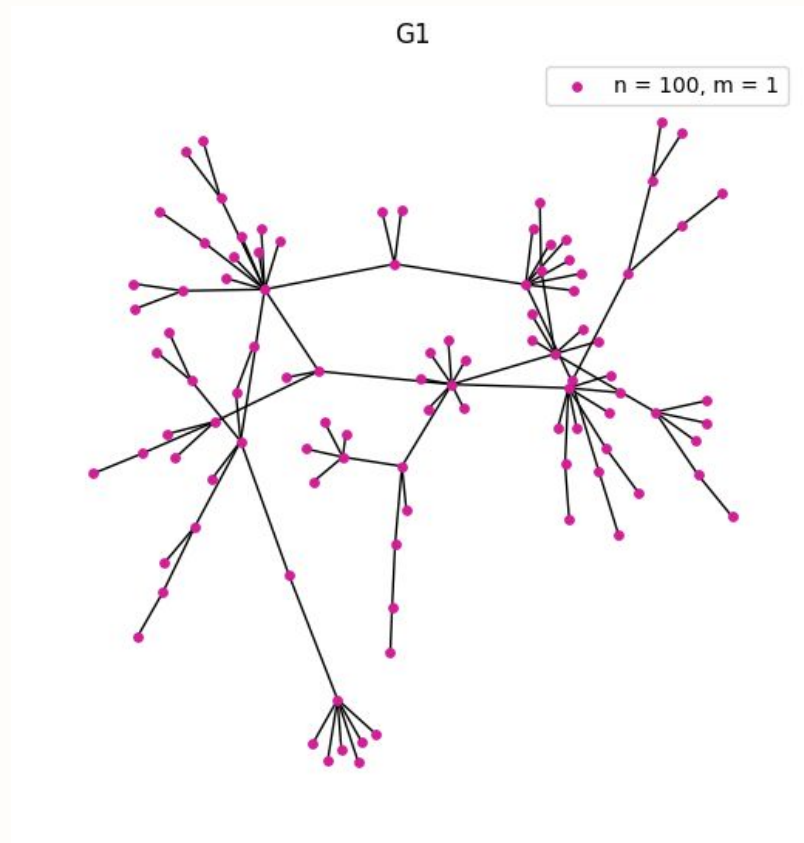


# Phase 1

## Introduction and Model Generation



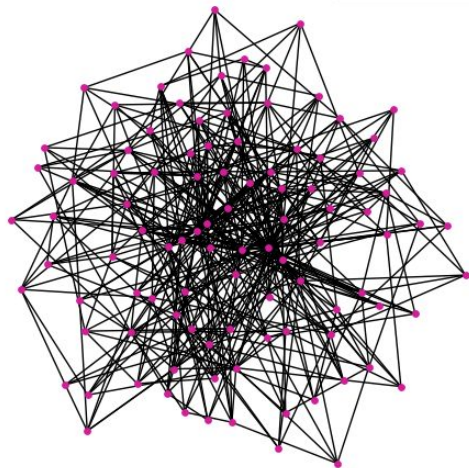
# Task 1.1: Network Generation



# Task 1.1: Network Generation

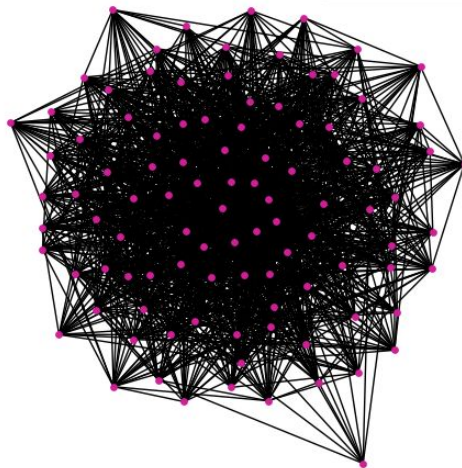
G2

•  $n = 100, m = 5$



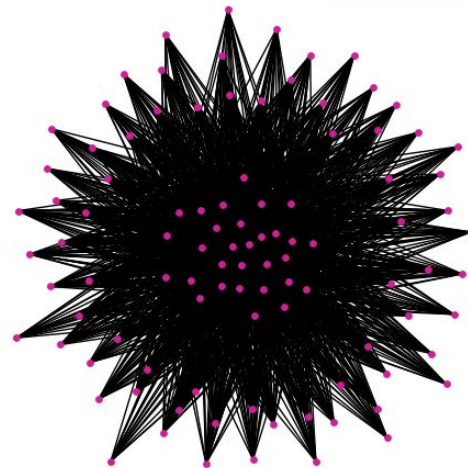
G3

•  $n = 100, m = 20$



G4

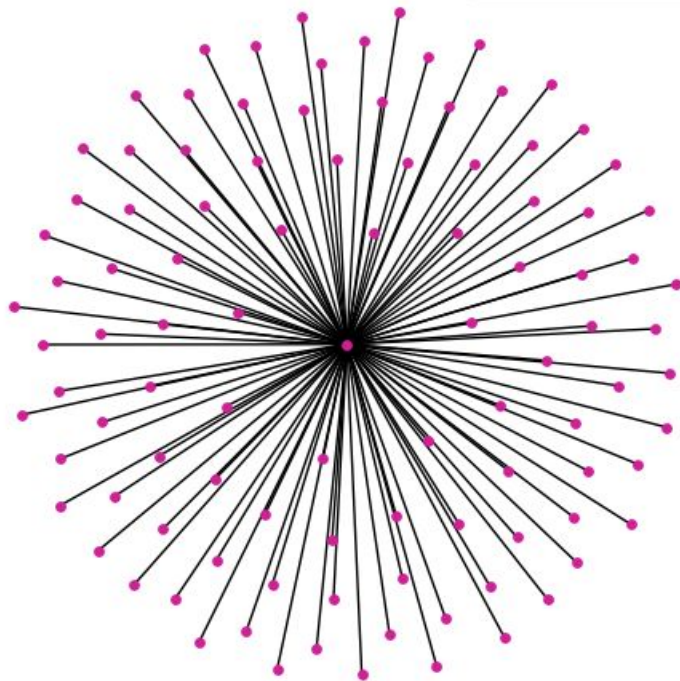
•  $n = 100, m = 70$



# Task 1.1: Network Generation

G5

•  $n = 100, m = 99$





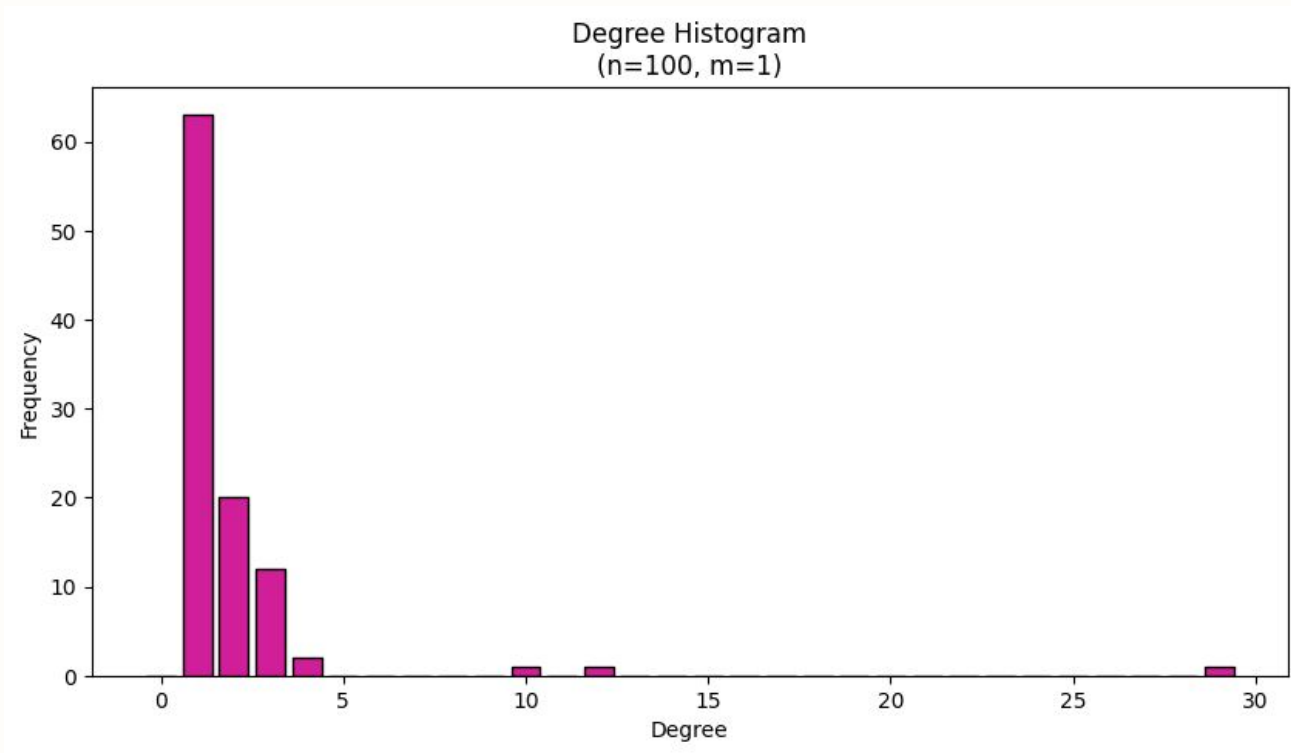
# Phase 2

## Structural Analysis

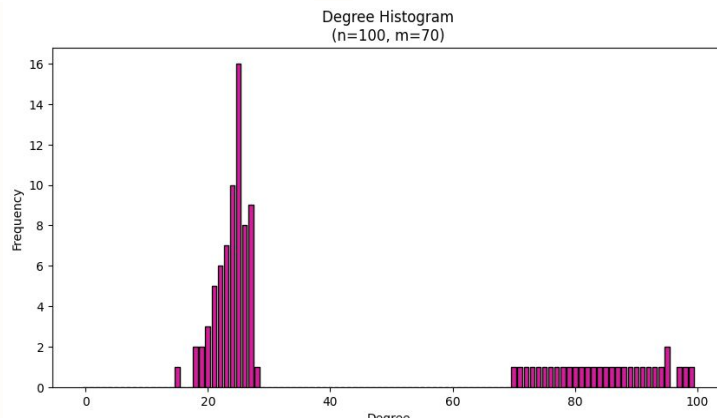
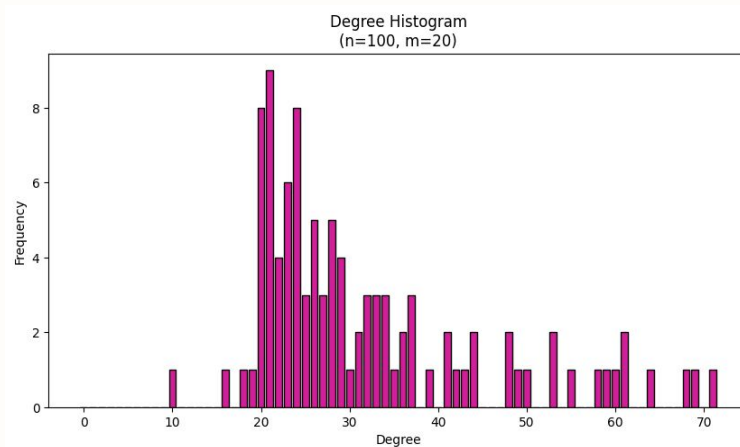
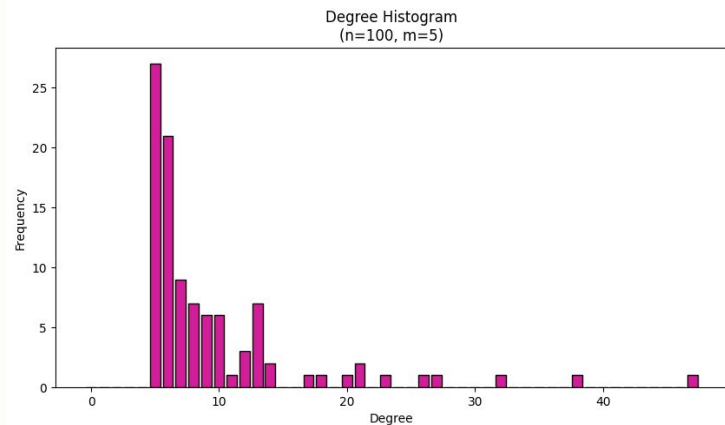




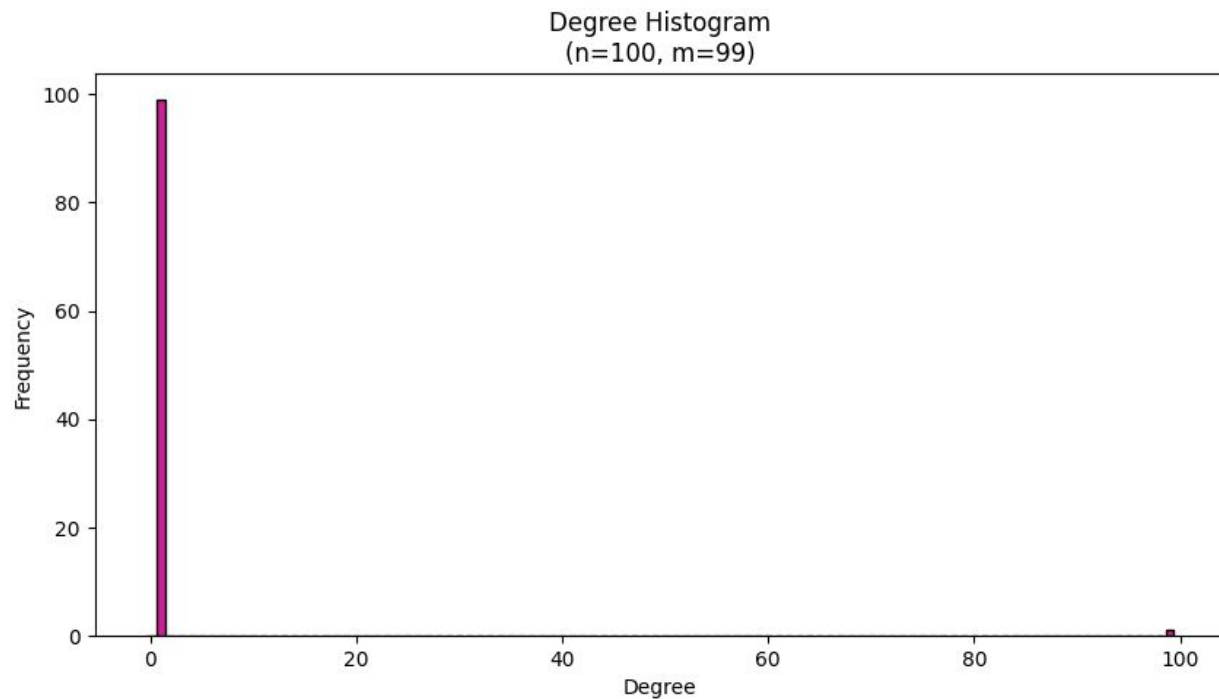
# Task 2.1: Basic Metrics



# Task 2.1: Basic Metrics



# Task 2.1: Basic Metrics



## Task 2.1: Basic Metrics

	m=1	m=5	m=20	m=70	m=99
Average Path Length	5.37	2.22	1.68	1.58	1.98
Global Clustering Coefficient	0	0.15	0.41	0.55	0
Average Clustering Coefficient	0	0.18	0.44	0.84	0

## Task 2.1: Basic Metrics – Closeness Centrality

	m=1	m=5	m=20	m=70	m=99
1st	0.31	0.62	0.81	1	1
2nd	0.3	0.59	0.74	0.99	0.5
3rd	0.28	0.57	0.72	0.98	0.5

## Task 2.1: Basic Metrics – Betweenness Centrality

	m=1	m=5	m=20	m=70	m=99
1st	0.663	0.169	0.040	0.030	0.999
2nd	0.655	0.135	0.037	0.029	0
3rd	0.562	0.097	0.033	0.028	0

## Task 2.1: Basic Metrics – Degree Centrality

	m=1	m=5	m=20	m=70	m=99
1st	0.141	0.384	0.768	1	1
2nd	0.121	0.303	0.657	0.99	0.01
3rd	0.081	0.253	0.616	0.98	0.01

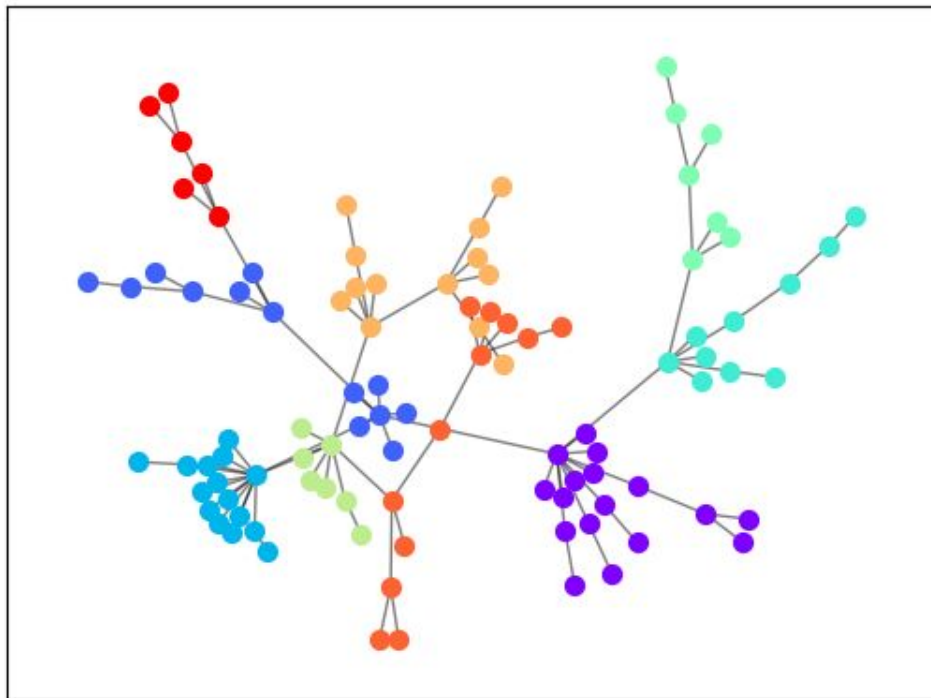
# Task 2.1: Basic Metrics – Eigenvector Centrality

	m=1	m=5	m=20	m=70	m=99
1st	0.679	0.313	0.198	0.168	0.707
2nd	0.173	0.26	0.183	0.166	0.071
3rd	0.169	0.251	0.178	0.165	0.071



# Task 2.2: Community Detection

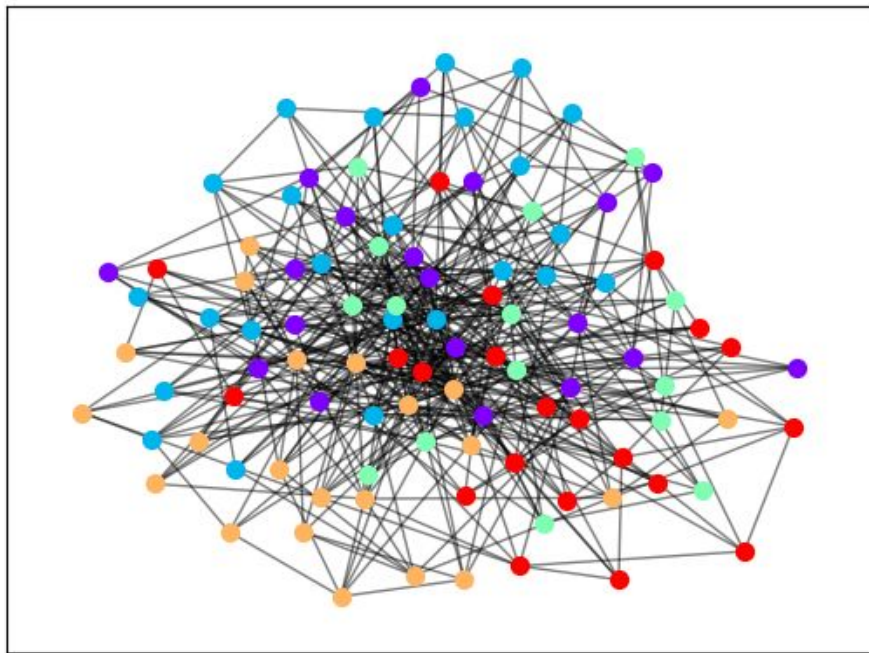
Louvain Communities in G1



- Community 0
- Community 1
- Community 2
- Community 3
- Community 4
- Community 5
- Community 6
- Community 8
- Community 7

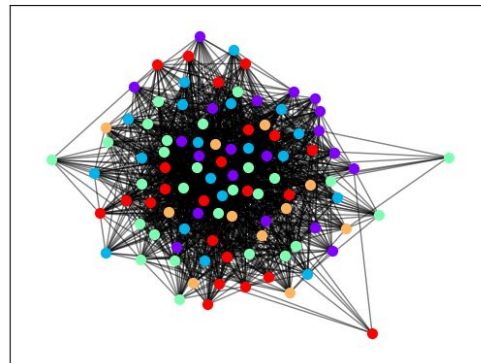
# Task 2.2: Community Detection

Louvain Communities in G2



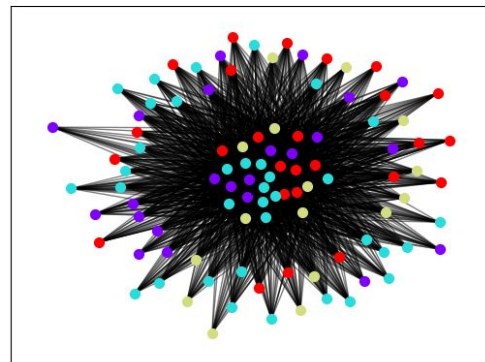
- Community 3
- Community 0
- Community 1
- Community 4
- Community 2

Louvain Communities in G3



- Community 2
- Community 1
- Community 4
- Community 0
- Community 3

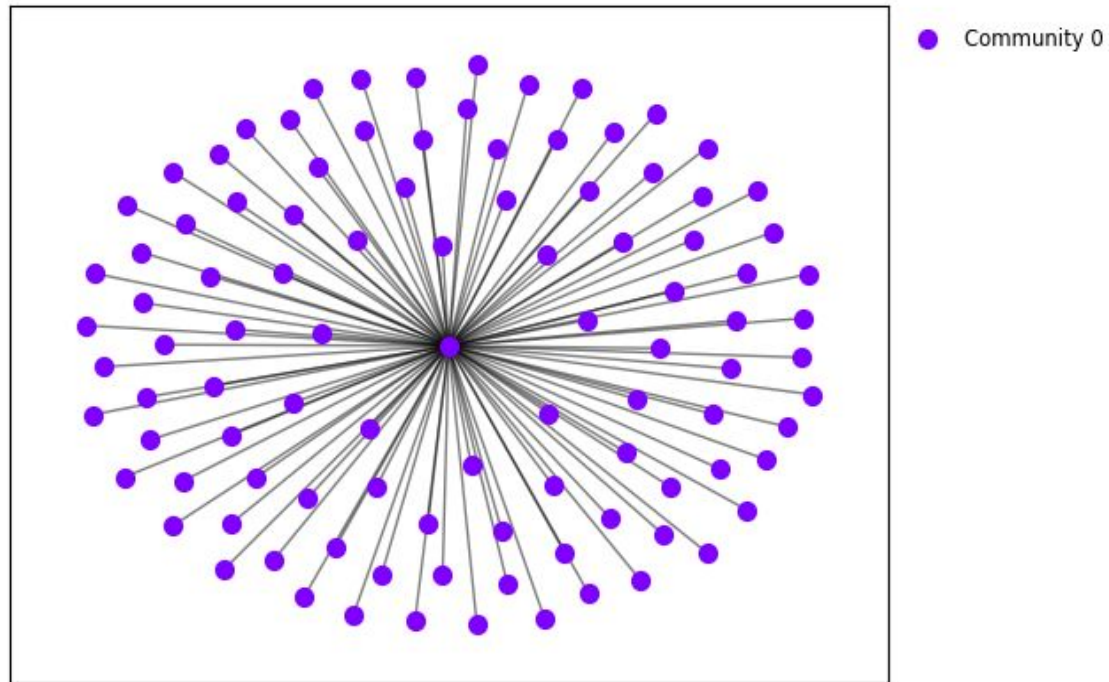
Louvain Communities in G4



- Community 0
- Community 3
- Community 2
- Community 1

# Task 2.2: Community Detection

Louvain Communities in G5





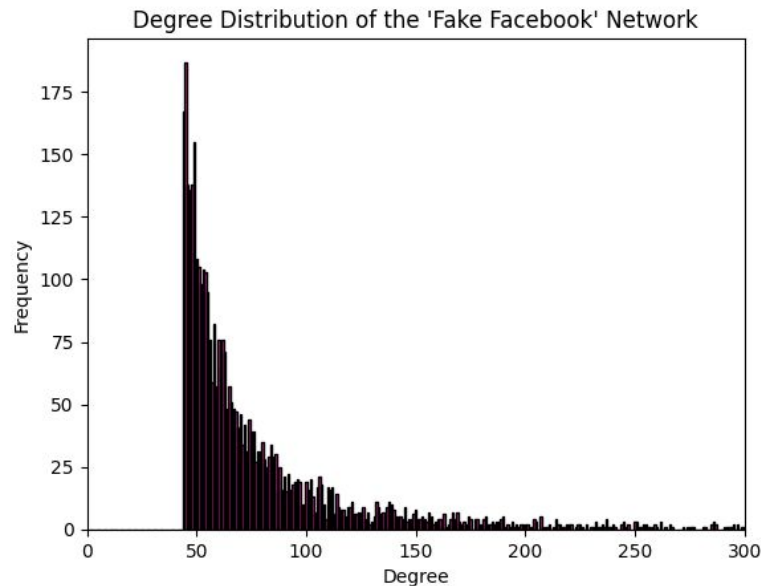
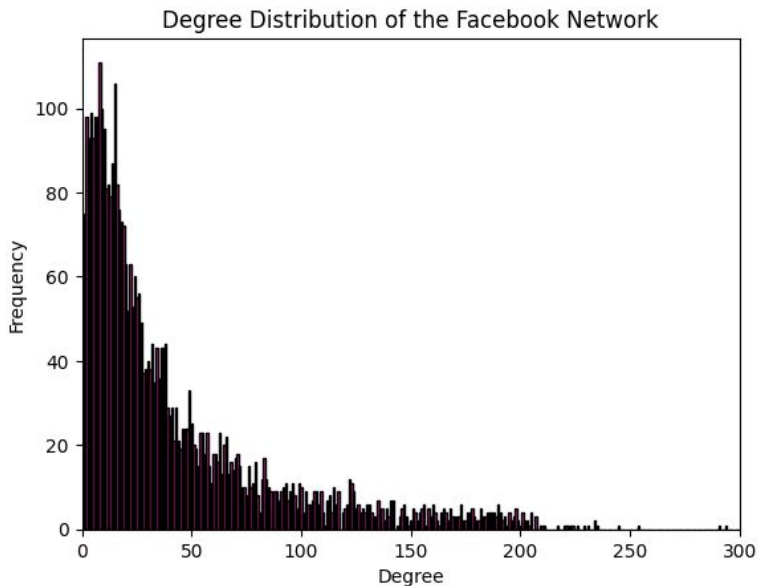
# Phase 3

## Real-World Data Application



# Task 3.1: Comparison with Real-World Networks

- Facebook Network, 4039 nodes
- BA model with the same number of nodes and  $m = 44$  (average connections per user in Facebook network)

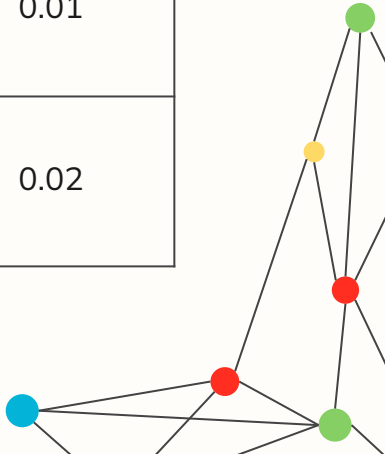




# Task 3.1: Comparison with Real-World Networks

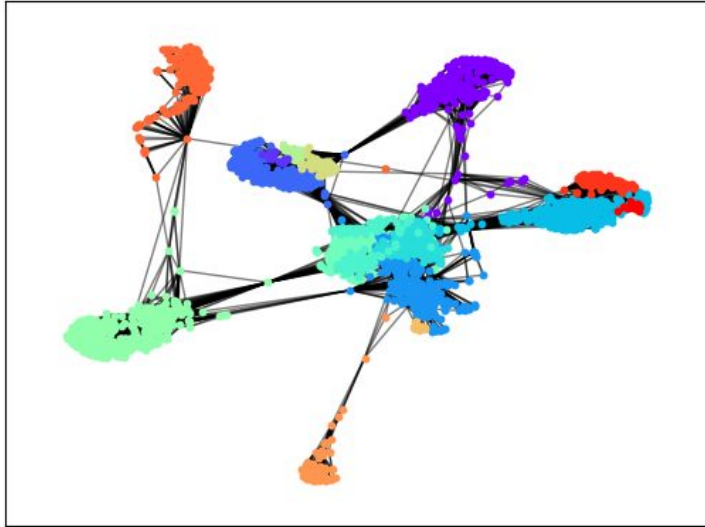


	Average Path Length	Global Clustering Coefficient	Average Clustering Coefficient	Diameter	Density
Facebook Network	3.69	0.52	0.6	8	0.01
BA Model	2.13	0.06	0.06	3	0.02



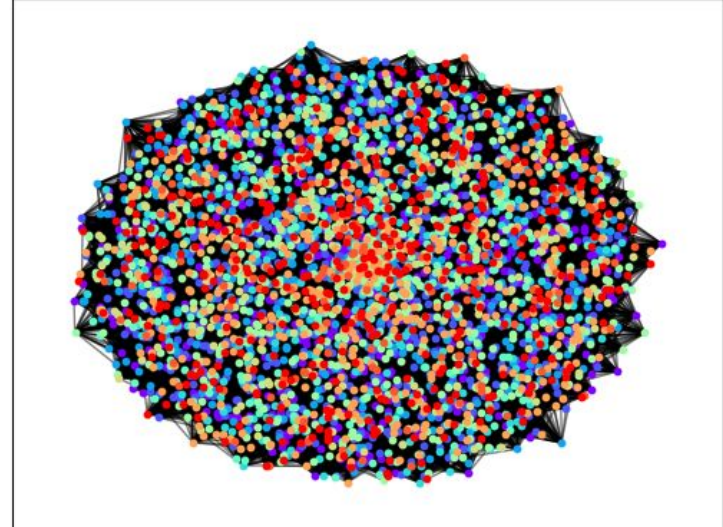
# Task 3.1: Comparison with Real-World Networks

Louvain Communities in F



- Community 0
- Community 7
- Community 2
- Community 3
- Community 4
- Community 5
- Community 6
- Community 8
- Community 9
- Community 10
- Community 11
- Community 12
- Community 13
- Community 14
- Community 15
- Community 1

Louvain Communities in FF



- Community 0
- Community 1
- Community 2
- Community 3
- Community 4
- Community 5
- Community 6
- Community 7
- Community 8
- Community 9



# Phase 4

## Advanced Analysis


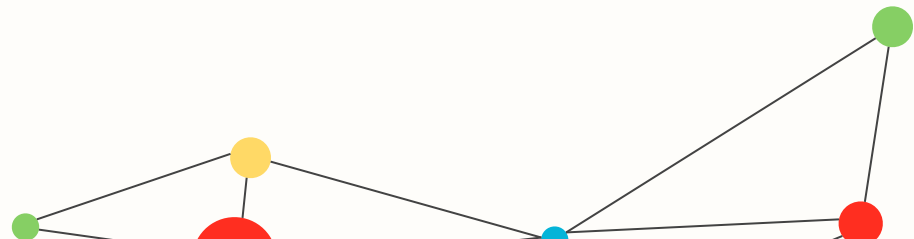




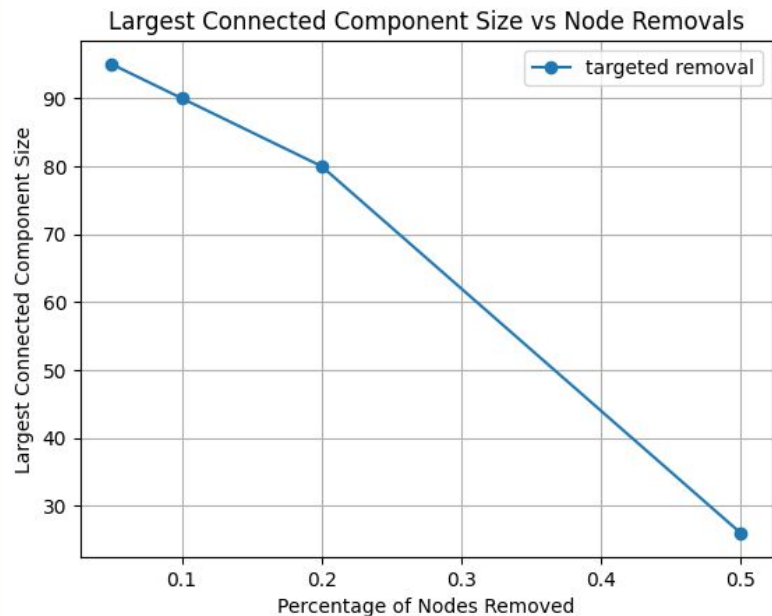
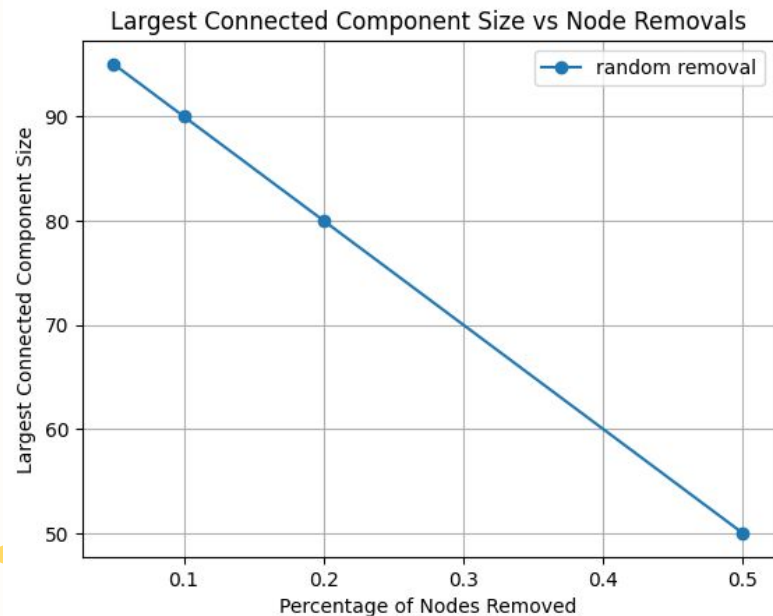


# Task 4.1: Robustness Analysis

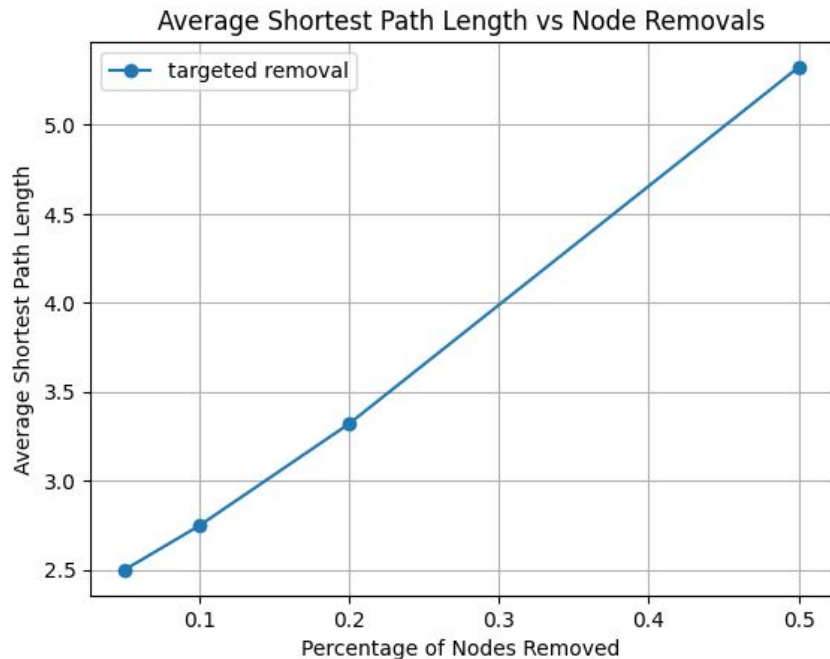
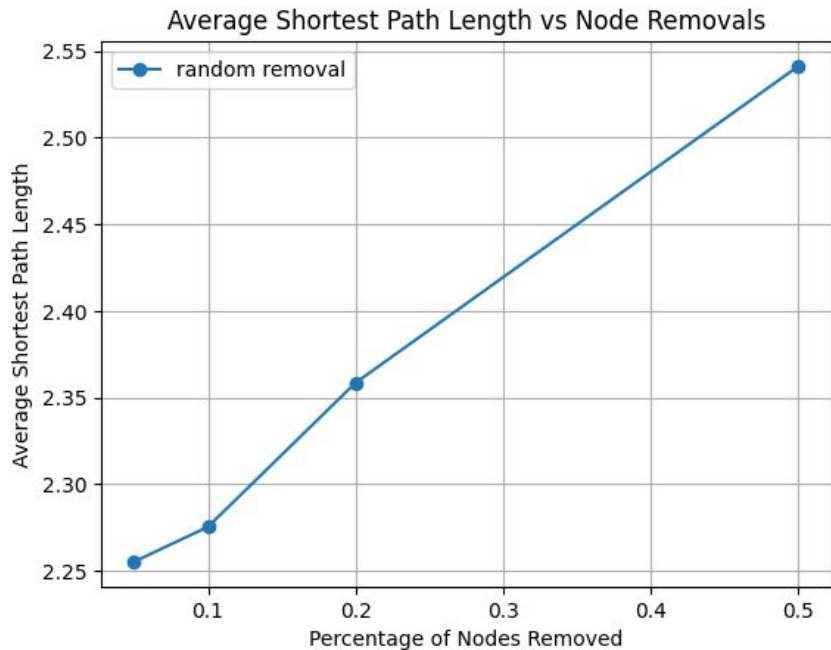
Removal of 5%, 10%, 20% and 50% random and targeted nodes from G2 ( $n=100$ ,  $m=5$ ) and showing the impact on the:

- Largest connected component
  - Average shortest path length
  - Density
- 
- 

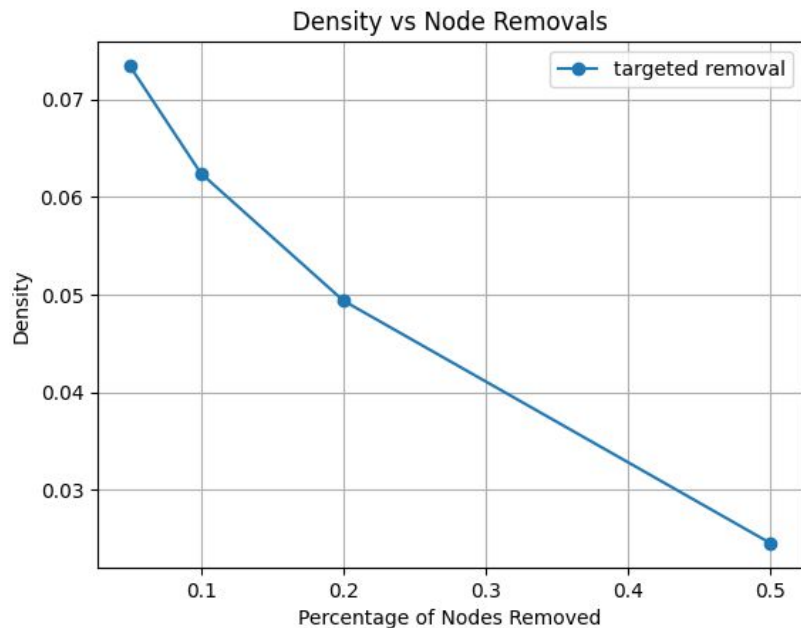
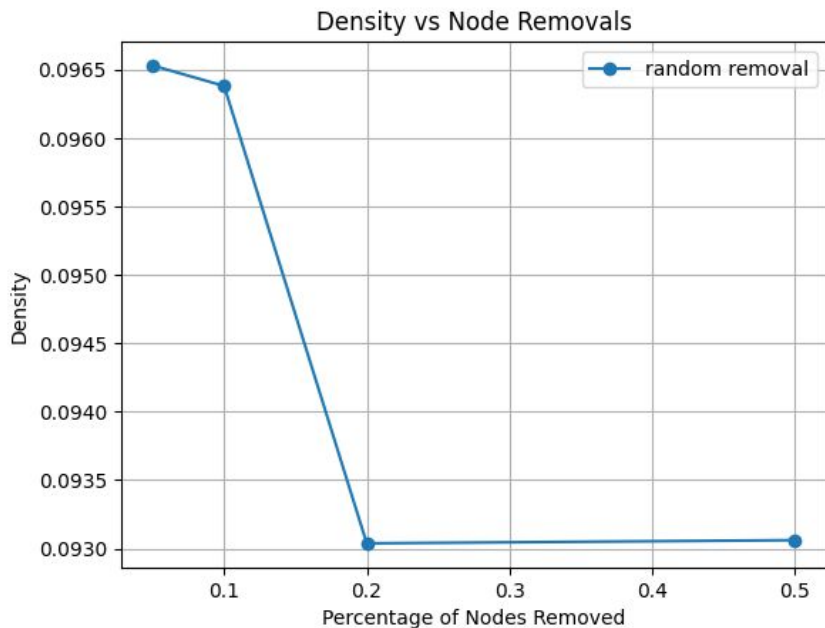
# Task 4.1: Robustness Analysis – LCC



# Task 4.1: Robustness Analysis – ASPL



# Task 4.1: Robustness Analysis – Density





## Task 4.2: Parameter Sensitivity Study

Impact of  $m$  and  $N$  on metrics:

- Average clustering coefficient
- Average shortest path length
- Diameter

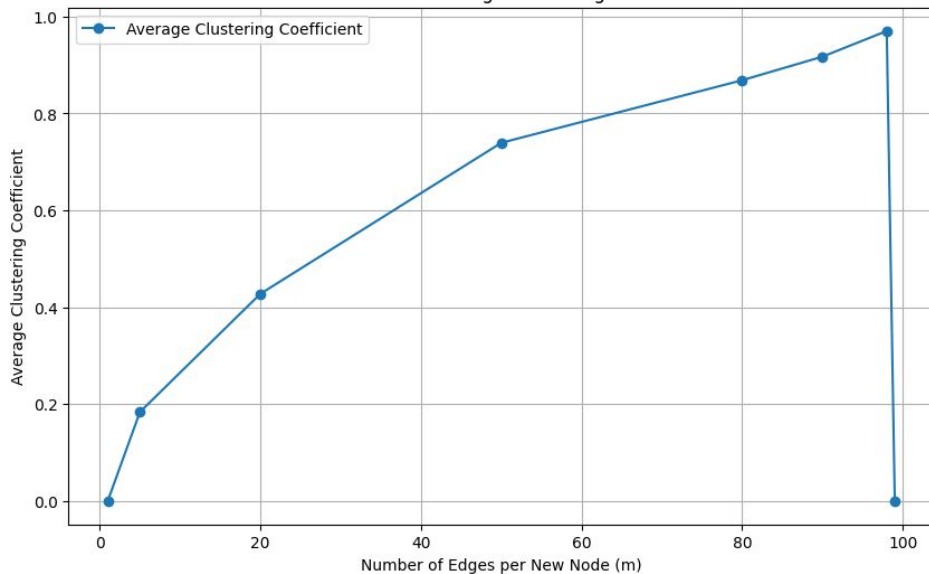
$m\_values = [1, 5, 20, 50, 80, 90, 98, 99]$ ,  $N=100$

$N\_values = [10, 100, 500, 1000, 2000]$ ,  $m=3$

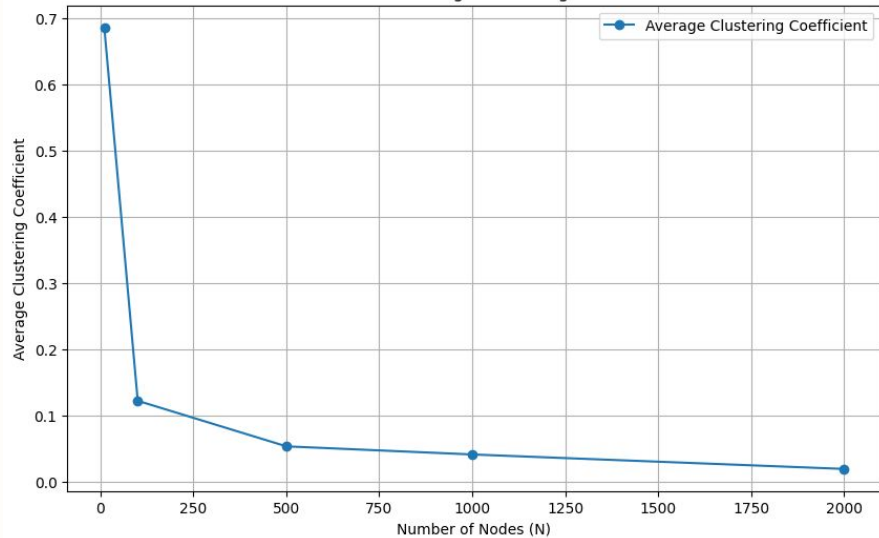


# Task 4.2: Parameter Sensitivity Study – ACC

Effect of  $m$  on Average Clustering Coefficient

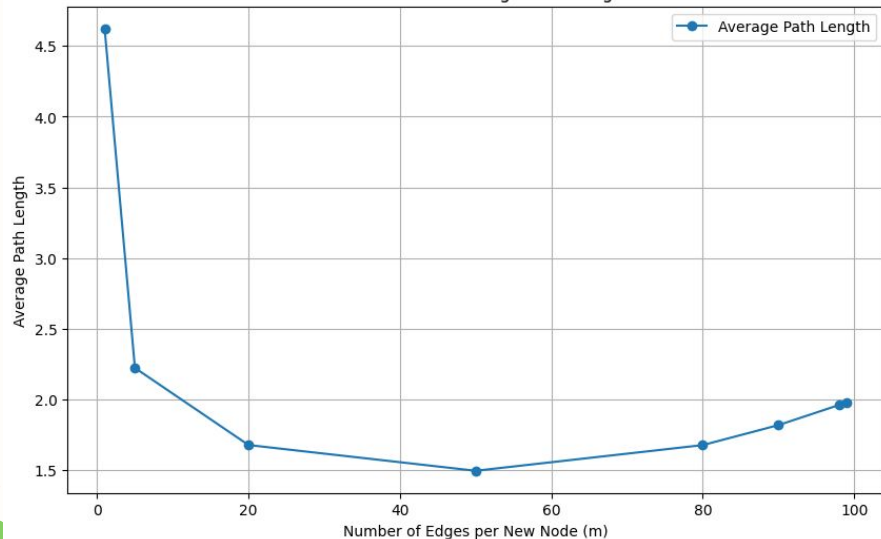


Effect of  $N$  on Average Clustering Coefficient

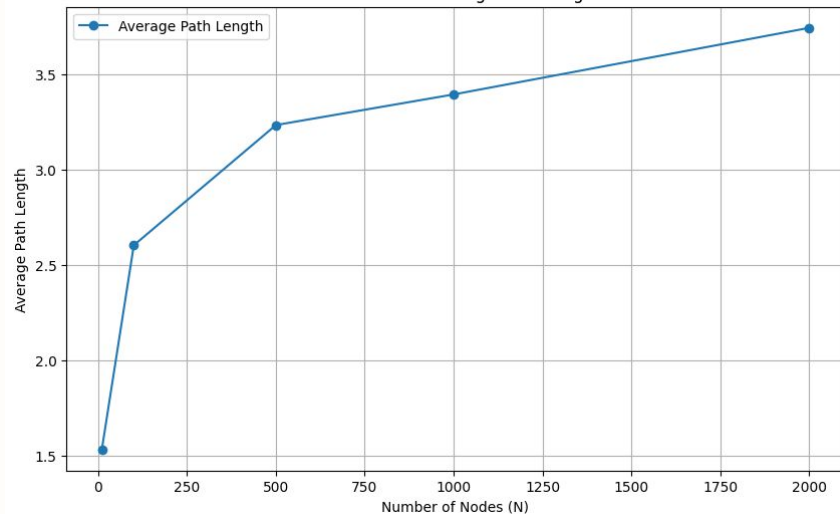


# Task 4.2: Parameter Sensitivity Study – ASPL

Effect of  $m$  on Average Path Length

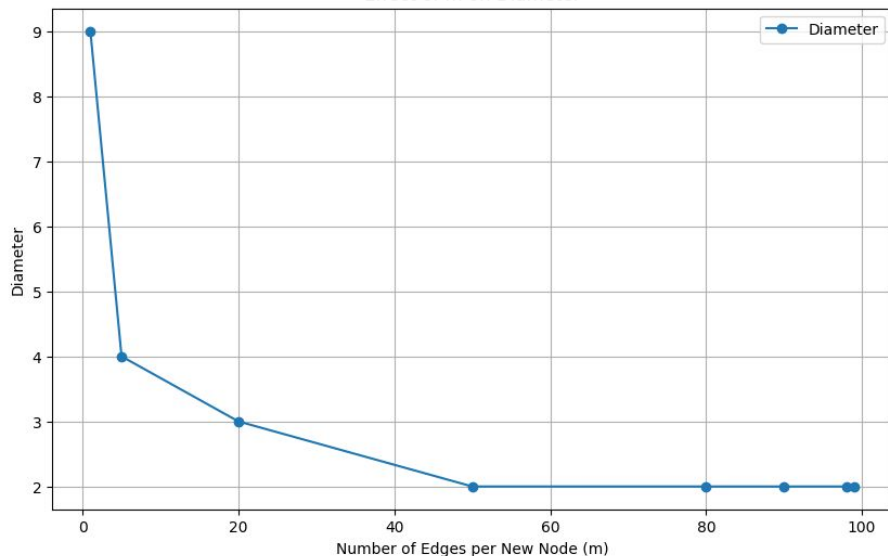


Effect of  $N$  on Average Path Length

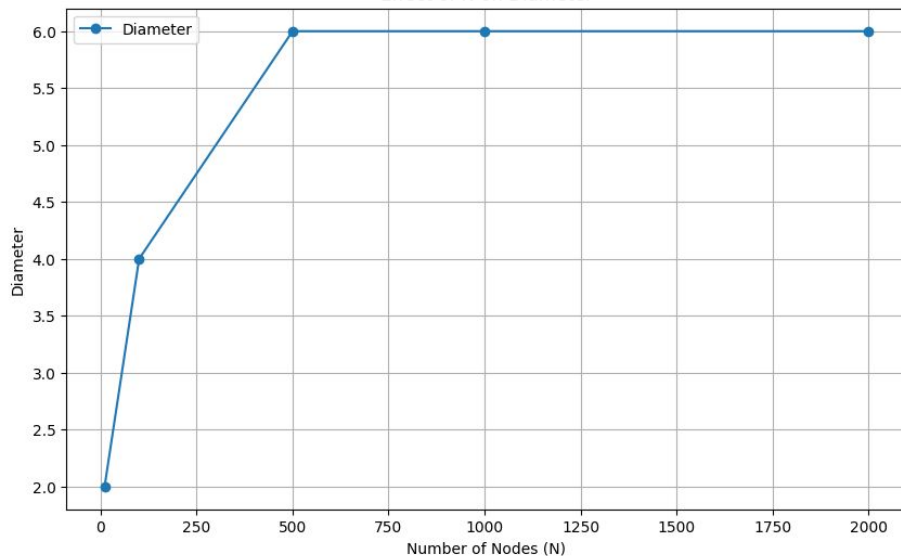


# Task 4.2: Parameter Sensitivity Study – Diameter

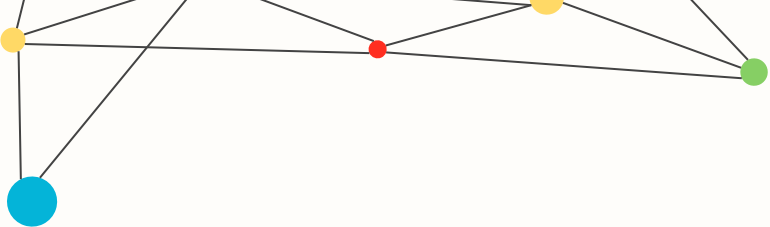
Effect of  $m$  on Diameter



Effect of  $N$  on Diameter







**Thank you for your attention!**

