Universität Zürich[UZH]

UZH Blockchain Center

Blockchain & DLT Research Group

# Communities and Random Networks

*Network Science ’22: Assignment 4*


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# Objectives

1. Explore the community structure of real networks
2. Explore the emergence of giant components in random networks
3. Gain intuition on the small world property of real networks

# A04.1 Community detection

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***Task:*** *For the given networks find the communities using (a) the greedy modularity maximization by Clauset Newman and Moore and (b) the Girvan-Newman algorithm. Assign to each community a color and draw the resulting graph.*

***Task:*** *Randomise each network and compare the number of communities obtained before and after randomisation.*

# A04.1 Hints

- Clauset et al. algorithm is available as `nx.greedy_modularity_communities()`
- Girvan-Newman algorithm is available as `nx.girvan_newman()`
  - Calculate the modularity of all the partition returned by Girvan-Newman algorithm, and draw the graph which corresponding to the largest modularity.
  - Modularity is available as `nx.modularity()`

# A04.1 Datasets provided

**Datasets provided**:

+ Zachary Karate Club: Nodes represent members of the club and Edges represent a tie between two members **[1]**
+ Dolphin social network: Nodes represent dolphins and Edges represent frequent associations observed among a group of 62 individuals **[2]**
+ Jazz collaboration network: Nodes represent jazz musicians and Edges represent collaborations in bands that performed between 1912 and 1940 **[3]**

# A04.1 Datasets provided

**[1]** W. W. Zachary, An information flow model for conflict and fission in small groups, Journal of Anthropological Research, 33 (1977), pp. 452–473
**[2]** D. Lusseau et al., ”The bottlenose dolphin community of Doubtful Sound features a large proportion of long-lasting associations.” Behavioral Ecology and Sociobiology 54(4), 396-405 (2003)
**[3]** P. Gleiser and L. Danon, ”Community Structure in Jazz.” Advances in Complex Systems 6(4), 565-573 (2003).

# A04.2 Random Graphs

# A04.2 Erdos-Renyi random networks

***Task:*** *Generate three Erdos-Renyi networks with* $N = 500$ *nodes and average degree (a)* $\langle k \rangle = 0.3$*, (b)* $\langle k \rangle = 1$ *and (c)* $\langle k \rangle = 2.5$. *Visualize these networks.*

***Task:*** *Generate ER graphs with* $N = 200$ *nodes for different edge creation probabilities* $p \in [0, 1]$ *and:*

1. Plot the average fraction of nodes in the largest connected component $\langle N_G/N \rangle$ as a function of $p$ and mark with a vertical line the critical probability $p_c = 1/N$
2. Plot the average clustering $\langle C \rangle$ as a function of $p$ and give an interpretation of the result

# A04.2 Hints

- Use the `nx.spring_layout( )` for better visualization of the networks
- To plot the average $\langle N_G/N \rangle$ you need to average your results by generating many ($\sim 100$) graphs for each value of $p$
- Use logarithmic spacing for the values of $p$
- In ER graphs for each node the probability that two of its neighbors are connected is the same probability that any other two nodes will be connected and it is equal to $p$

# A04.3 Small-world with high clustering

***Task:*** *Generate many WS small-world networks with $N = 150$ nodes and fixed number of neighbors for each node $2\kappa = 12$. As a function of the rewiring probability $p$, using both linear and logarithmic scale for the $p$-axis:*

1. Plot the average clustering $\langle C(p) \rangle / \langle C(0) \rangle$ and check if it correctly reproduces the analytical result

$$\langle C(p) \rangle \approx \frac{3}{2} \frac{(\kappa - 1)}{2\kappa - 1} (1 - p)^3 \tag{1}$$

2. Plot the average shortest-path length $D(p)/D(0)$

# A04.3 Hints

- `nx.watts_strogatz_graph` generates a WS network
- `nx.average_shortest_path_length(g)` computes $D(p)$

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