UPPSALA UNIVERSITET
DEPARTMENT OF MATHEMATICS
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Modeling Complex Systems (1MA256)
Spring 2023

LAB 3: Networks and random graphs

The deadline for this assignment is May 14th.

Please submit by email, upload to GitHub or any other "box", if the files/data are too large (provide a link). All code should be included. Feel free to submit videos illustrating your results where appropriate, via Studium or uploaded elsewhere such as vimeo or youtube. You may work in groups of size 1-7, and only one group member needs to submit the assignment. State clearly the members of the group.

Task 1:

1) Pick any data set (with a number of vertices not too high) in `http://vlado.fmf.uni-lj.si/pub/networks/data/`.
2) Write a code that reads this data set, and draws the data set as a graph
3) Try to identify different communities visually.
4) After having empirically identified the communities, compute the modularity of this network.

Task 2: Write a code that generates a random Erdös-Rényi graph $G(n,p)$.

1) Verify that for $p < \frac{\ln n}{n}$ the graph $G(n,p)$ is almost surely disconnected: generate many such graphs with some large n, and count how many of them have an isolated component.
2) Verify that for $p > \frac{\ln n}{n}$ the graph $G(n,p)$ is almost surely connected: : generate many such graphs with some large n, and count how many of them have no isolated component.

Task 3: Write code that computes the global clustering coefficient C of $G(n,p)$ (see `https://mathworld.wolfram.com/GlobalClusteringCoefficient.html` for theory).

1) Fix some very large n. Plot expected C of $G(n,p)$ as a function of p. (That is, now that n has been fixed, pick a p, generate many $G(n,p)$'s for that p, and compute the expected value of C. Repeat this for some discretization of $[0,1] \ni p$. In this way, you obtain the plot of the expected value of C as a function of p.)

   Note: There is a theoretical result that says that the expected global clustering coefficient for the Erdös-Rényi model is $C = p + O(n^{-1/2})$. Compare with you graph!