Amsterdam University College

Modelling Real World Problems

Networks: LAB 7 (Graded)

1. **Degree Distributions (8 points)**:
   You can find the files needed for this exercise under `Part I` on Canvas.

   (a) In the folder you downloaded from Canvas you will find two gexf files (`Graph1.gefx` and `Graph2.gefx`) each corresponding to a network. Load these two networks in Gephi. Then use Gephi to determine the degree distributions of these networks. For each graph, take a picture of its degree distribution, classify it, and explain your answer (2 points).

   (b) Compare the topologies of the two networks. In particular, explain how their degree distributions affect their topology. Include pictures of the networks to support your explanation (2 points). [Hint: try to use different layouts to see how you can make the differences between the two topologies more evident.]

   (c) Choose a measure among those we have seen in lecture 6a (you **cannot** use degree centrality). Use Gephi to show how the measure distributes in the network of file `Graph1.gefx` and file `Graph2.gefx` (1 point). Explain how the degree distribution affects this distribution (2 points). Explain how you would test your hypothesis (1 point).

2. **Dynamics (11 points)**:
   You can find the files needed for this exercise under `Part II` on Canvas. The file `engine.py` contains a network version of the SI model. The file `experiments.py` contains a few functions that should allow you to easily run some experiments. These files are a modified version of the files of lab 5 (so the mechanisms used are very similar). In this implementation of the SI model, nodes of groupA are treated as infected individuals, while nodes of groupB are treated as vaccinated individuals.

   In the following exercise you can assume a probability of transmission of 0.5.

(a) Device an experiment to compare the dynamic of the model on a random network (with $p = 1.5/1000$) and on a scale-free network (with parameter $\gamma = 2.5$) both with 1000 nodes. Explain your experiment (2 points). Run you experiment, take pictures of the results and explain what the pictures show (1 point). Then, describe the difference in the dynamics of the two systems (2 points).

(b) Now assume that you want to vaccinate 5 individuals. Device an experiment that is aimed at studying the difference between random vaccination and selective vaccination on random and scale-free networks. Explain your experiment (2 point). Run you experiment, take pictures of the results and explain what the pictures show (1 point). Then, describe the difference in the dynamics of the two selection systems on the two types of graphs (3 points). [Hint: Try to find a way of selecting the 5 individuals that shows how the topology of the network can influence the dynamic of the system.]

3. **Random Graph and Graphs Formation (6 points+2 bonus points)**: You can find the files needed for this exercise under `Part III` on Canvas.

   The file `RandomGraph.py` contains some code to generate a random graph.

   (a) Explain what the code does, which random graph model the code is an implementation of and why, and how it can be seen as an implementation of a graph formation process, i.e., an algorithm that describes how a network is formed (3 points). Explain how this process affects the degree distribution of the final graph (1 point).

   (b) Think of a way of making the graph formation process you just described more realistic. Then explain how this may affect the degree distribution of the final graph (2 points). Bonus (2 points): Implement your modified random graph and run an experiment to show the effect of your modification on the degree distribution of the graph. Include your commented code, the results of your experiment and a short explanation in your answer.

Total points $8 + 11 + 6 = 25 + 2$ bonus points.

The deadline for the LAB is on the 25th of April at 23:59. You can hand in your report via Canvas. You should also send an email with the python file containing all the code you have written for this lab to l.galeotti@uva.nl. Be sure that your code is well commented. Each file you submit should contain the names of the members of your group. Only one member of each group should submit the solution.