Aston University
BIRMINGHAM UK

College of Engineering & Physical Sciences

Assignment Brief

AM41NS – Network Science	Coursework – Part A
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Assignment Brief/ Coursework Content:

- Theoretical and Computational Techniques
- This coursework assesses all learning outcomes on the first part of the module's content. (See *Assessment Rationale* on Module's Specification for more details.)

Descriptive details of Assignment:

- This is an individual work.
- **Justify every answer with all relevant details.** Include and mention explicitly all methods and references (when appropriate), including from every dataset you use. Failure to do so will lead to the loss of marks.
- The coursework should be submitted as one single file: a Jupyter notebook with all solutions and code in the correct order. The filename should be: [*Your_student_number*].ipynb.
- Any additional file will not be considered as part of the submission and will not be marked.
- Code in the format of a Python file instead of a Jupyter notebook will not be considered for marking.
- Your code should be properly commented, with all variables and functions clearly explained.
- The code on your notebook should run without problems or conflicts in any computer. Make sure that the libraries you use have no conflicts with other libraries. In case of doubt, stick to what has been used during the lectures.
- **All cells which do not run will be deleted**, which can have consequences to cells below them. **Therefore, be sure that all cells run without problems.**
- Text and analytical calculations should be presented as ***markdown***. Mathematical formulas should be rendered in LATEX (between $$) or typed and pasted as an image on the notebook.
- Whenever a question asks you to relate quantities to the **nature** of the

network, you should explain how they affect the functioning of the physical system represented by the network. Just describing the values without connection with the physical role of the network is not enough.

- Wherever third-party sources are used, you are obliged to include the appropriate reference. **Failure to do so might lead to a plagiarism process.**
- Analysing a network different from the one you were asked to will imply a penalty of 50% on the marks of the corresponding exercise after marking.
- Use the appropriate technical language taught during the module. Do not invent new terms, unless you carefully and rigorously define them beforehand. Do not use non-technical language to describe mathematical entities as it is not precise enough and prone to ambiguity.

Recommended reading/ online sources:

- Reading list, recorded lectures, lecture slides and any other material on the module's Blackboard page.

Key Dates:

Submission: 15/12/2023, 14:00

Feedback: 19/01/2024

Submission Details:

- Online on Blackboard

Declaration

I declare that I have personally prepared this assignment. The work is my own, carried out personally by me unless otherwise stated and has not been generated using paid for assessment writing services or Artificial Intelligence tools unless specified as a clearly stated approved component of the assessment brief. All sources of information, including quotations, are acknowledged by means of the appropriate citations and references. I declare that this work has not gained credit previously for another module at this or another University, save for permitted elements which formed part of an associated proposal linked directly to this submission. I understand that plagiarism, collusion, copying another student and commissioning (which for the avoidance of doubt includes the use of essay mills and other paid for assessment writing services, as well as unattributed use of work generated by Artificial Intelligence tools) are regarded as offences against the University's Assessment Regulations and may result in formal disciplinary proceedings.

I understand that by submitting this assessment, I declare myself fit to be able to undertake the assessment and accept the outcome of the assessment as valid.

Marking Rubric:

- The whole coursework is worth 50 marks: 40 - content, 10 - presentation
- This coursework is worth 50% of the module's total marks.

Marking Criteria for Presentation

10	Perfect presentation. Readable, well organised, professional looking.
8 - 7	Good presentation. Some issues with organisation and/or format.
6 - 4	Acceptable presentation. Several issues with organisations and/or format. Readability is somewhat compromised.
<4	Below-standards presentation. Too many issues of organisation and/or format. Difficult to read and follow.

General Advice

Presentation is a question of common sense. You should be critical about your work by putting yourself in the place of the marker and question what you would think of your presentation: how many marks would you assign to it if you were a professional educator marking it?

Points to Notice

Some particular mistakes are often repeated. The following non-exhaustive list provides advice on some of the most common points of concern:

- Solutions should be presented in the order they were asked. A different order not only compromises readability, but also shows lack of care.
- Graphs should be of professional standards: all axes should be appropriately labelled, captions should be informative, every annotation should be readable (pay attention to the size of the fonts!) and any provided graph should be referred to in the main text.
- When plotting, be sure that all relevant information is easily visualised. If necessary, change scales and adjust the range of axes.

AM41NS – Network Science

Roberto C. Alamino

Coursework – Part A

1. (20 Marks)

For this exercise, use the network provided on the Blackboard page of this assignment.

Note: when calculating distances, use the giant component if the network is not connected.

a) (1 mark) Extract from the dataset the number of nodes and links.

b) (2 marks) Explain the difference between weakly and strongly connected components and find how many of each the network has.

c) (7 marks) Plot the in and out degree distributions of this network, giving the corresponding average values. Relate your results to the nature of the network.

d) (10 marks) Plot the distributions of the eccentricity and harmonic closeness centralities of the network. Provide their definitions and explain what the difference in the information they provide about the network is. Relate your results to the nature of the network. **Note:** for both centralities, you need to take into consideration the **direction** of the paths in the network.

2. (20 Marks)

Use your student number as a seed when you generate random objects in this exercise.

a) (5 marks) Generate a sequence of Barabasi-Albert networks and plot their average clustering coefficient against the number of nodes. Is this the behaviour of a real network? Explain your reasoning. Explain also what kind of information the clustering coefficient gives about a network. **Note:** you should choose the appropriate parameters (number of nodes, repetitions etc) for your sequence and your plot in order to provide enough information to support your conclusions.

b) (5 marks) Generate 200 Watts-Strogatz networks with 200 nodes and 200 links for each value of the probability of rewiring in the following list $p_d = (\,0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0)$ and plot the change in degree assortativity against the rewiring probability. Each point of your plot needs to be the average value over the 200 generated networks. Analyse what is happening with the assortativity and explain the reason for this result.

c) (6 marks) Ask ChatGPT to list and define the 3 main properties of real networks with whatever prompt you think makes it work better. Explain the differences between its answer and what we learned in our module by providing all details and mathematical definitions. **Note:** you will not receive any marks by copying and pasting ChatGPT's answer. Marks will only be awarded to your analysis of it.

d) (4 marks) Show indication that the degree distribution of the $G(N, L)$ model can be approximated by a Gaussian for large N numerically by working out one example. You have to implement some method to show that it is the case, not derive any analytical equations. The comparison should be made simply by plotting the two distributions in the same figure.