Aston University
BIRMINGHAM UK

College of Engineering & Physical Sciences

Assignment Brief

AM41NS – Network Science	Coursework – Part B
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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 B

For this entire coursework:

- Use your student number as a seed when you generate random objects.
- If your networks are disconnected (in the case of undirected ones) or weakly disconnected (in the case of directed ones), use the (weak) greatest component to work with.

1. (20 Marks)

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

a) (5 marks) Find the best division in communities of your network using both Louvain and the Greedy algorithm. Decide which one is better, explain why and relate the result to the nature of the network.

b) (10 marks) Run the forest fire basic model with $p = f = 0$ on the given network according to the following instructions:

- Generate one initial configuration in which each site has a probability 0.4 of having a tree. You will use this same initial configuration in all your simulations.
- Start the fire on different communities each time according to the best partition of all that you obtained in the previous item (remember that fires can only start on trees, not empty sites).
- Calculate the average number of burnt trees over 50 simulations for each different starting community.

Based on your results, if you only had resources to prevent fire on about 1/3 of the communities, which ones should be prioritised? Explain your reasoning.

c) (5 marks) Consider a new state of the forest fire model represented by a **grey node**. This state does not change. In other words, fire cannot spread to it and trees cannot grow on it. All other rules remain the same. Assuming that grey nodes are randomly distributed on the network, what is the minimum fraction of the network that they have to occupy on average at the start of the fire in order to prevent it from spreading through the whole network? Use f an p as in the previous item and initial configurations where each site has a probability of 0.6 of having a tree.

2. (20 Marks)

Consider the Voter Model as explained in the lectures.

a) (8 marks) Using an asynchronous update rule, present a plot of the number of steps it takes on average for the whole network to reach consensus against the probability of linking p for $G(N, p)$ networks with $N = 50$. In the initial configuration, each voter has the same probability of having one

of the two possible opinions. Analyse your result by relating the time it takes to how the probability of linking defines the connections in the network model used in this exercise.

b) (10 marks) Run the model on a single Barabasi-Albert network with $N = 200$ nodes with synchronous update and initial configuration with every site having the same probability of having one of the two possible opinions. You do not need to average over many generated networks.

Find out what is more efficient to prevent or slow down consensus: random removal of links or simultaneous targeted removal of links based on their betweenness. Try to explain the observed differences in the results by relating them to the differences between the two processes.

c) (2 marks) Ask ChatGPT (with the prompt you find most appropriate) what is the importance of the Max-flow Min-cut Theorem and analyse its answer explaining whether it agrees with what we studied in our lectures and what could be missing on it.