ISyE 3133 Team Project PART A Due: March 12

Submission Instructions

This project is to be completed in teams. For **Part A** of this project, each team should submit (a) a written report, and (b) two Python files. Details of these are given below.

Written Report The written report should briefly present the team's mathematical formulations of the linear programming (LP) models, answering Question 1 and Question 2(c). The report should provide your answers for Question 2(a), 2(b) and Question 3(b). It should also summarize the findings obtained through the use of the Gurobi solver. It is important to note that in the written report, only the mathematical formulation should be provided, not the Python implementation of the model. However, a glossary page, showing the correspondence between the names of variables and parameters in your mathematical model and the names used in the Python code, should be appended to your report. The report should be written to be informative and helpful for Starfleet Command. It should explain your findings in terms a Starfleet office could understand and appreciate, while also providing details of your models and technical approach, so that these could be audited and duplicated by others if needed. The written report is not expected to be more than six pages. **Fewer pages** and **handwritten reports are welcome**. The written report (printed or written on paper) should be given to Dr Boland at the start of her lecture on March 12. Email submission of the written report is not permitted.

Python Files Each team should submit two Python files, one in response to Question 1 and one in response to Question 3(a). Your files should be named

"Name1Name2Name3PartAQ1.py" and "Name1Name2Name3PartAQ3.py",

where "Name1", "Name2" and "Name3" are your team member names (either first, second or a short name are fine, as long as the end result is likely to uniquely identify your team and to make your identities apparent to your class instructor). For example, if your team members are Anh Do, Celia Pacquola and Mark bin Bakar, your first .py file could be "AnhCeliaBakarPartAQ1.py". Submit your Python files by uploading them to Canvas under the assignment named "Team Project Part A". Please delegate only **one** of your team members to submit the files.

Shortly after the release of these project instructions, data sets for a small test problem, as well as the larger data set for which you should present results, will be released on Canvas. **Do not submit a Python code that does not run; any code file submitted must successfully compile and produce output, taking as input the data sets provided in .csv format.**

Below is **Part A** of the project. Part B will be released after Spring Break.

Team Project: Problem Statement

You work for the Starfleet Corps of Engineers. Starfleet has just acquired a new space station, Deep Space Nine, from an alien race called the Cardassians, and you've been tasked with modifying the station's residential district so that it can house its new occupants. While the residential power grid was more than sufficient for the Cardassians, the people moving into the station have different energy requirements, and the grid can't serve all of them. Your job is to satisfy as much of the energy demand as possible.

Your field teams have provided you with the following information on Deep Space Nine's power grid.

Power flows from the main generator for the station through a series of conduits to demand nodes, where it is accessed by residents. Conduits run from one node to another (one, both, or neither end may be a demand node) and have limited capacity. The power can flow in either direction through the conduit, but whichever direction is used, the magnitude of the flow cannot exceed the given capacity. Fortunately, Cardassian conduits (while having a poor capacity) are extremely efficient; the power put into one end is exactly the power that will come out the other end. The chart in Figure 1 shows the conduits and demand nodes for the residential district.

Part A: Linear Programming Models

Starfleet has asked you to formulate, implement and solve a linear programming (LP) model to decide how power should be distributed.

1. Write, implement and solve an LP model that distributes power so as to satisfy the most total demand.

2. There are several groups of residents on the station: Bajorans, Ferengi, humans, Vulcans, Starfleet personnel, Starfleet officers, and visitors. The color coding of the nodes in the network in Figure 1 shows where each group of potential residents is concentrated.

   Clearly, it wouldn't be fair if an optimal solution meant that the Bajorans got no power so that everyone else could get more power on average; and it also wouldn't be fair if an optimal solution sacrificed all of the humans' power so that all of the Ferengis' demand could be fulfilled. Starfleet has asked you to develop a metric to measure how fair a solution.

   (a) State your metric, and illustrate how it works by calculating the value it gives to the solution you found in Question 1, which maximizes the total demand satisfied.

   (b) Discuss at least one possible shortcoming of your metric. Are there solutions that your metric would score highly (would deem to be very fair), but that some

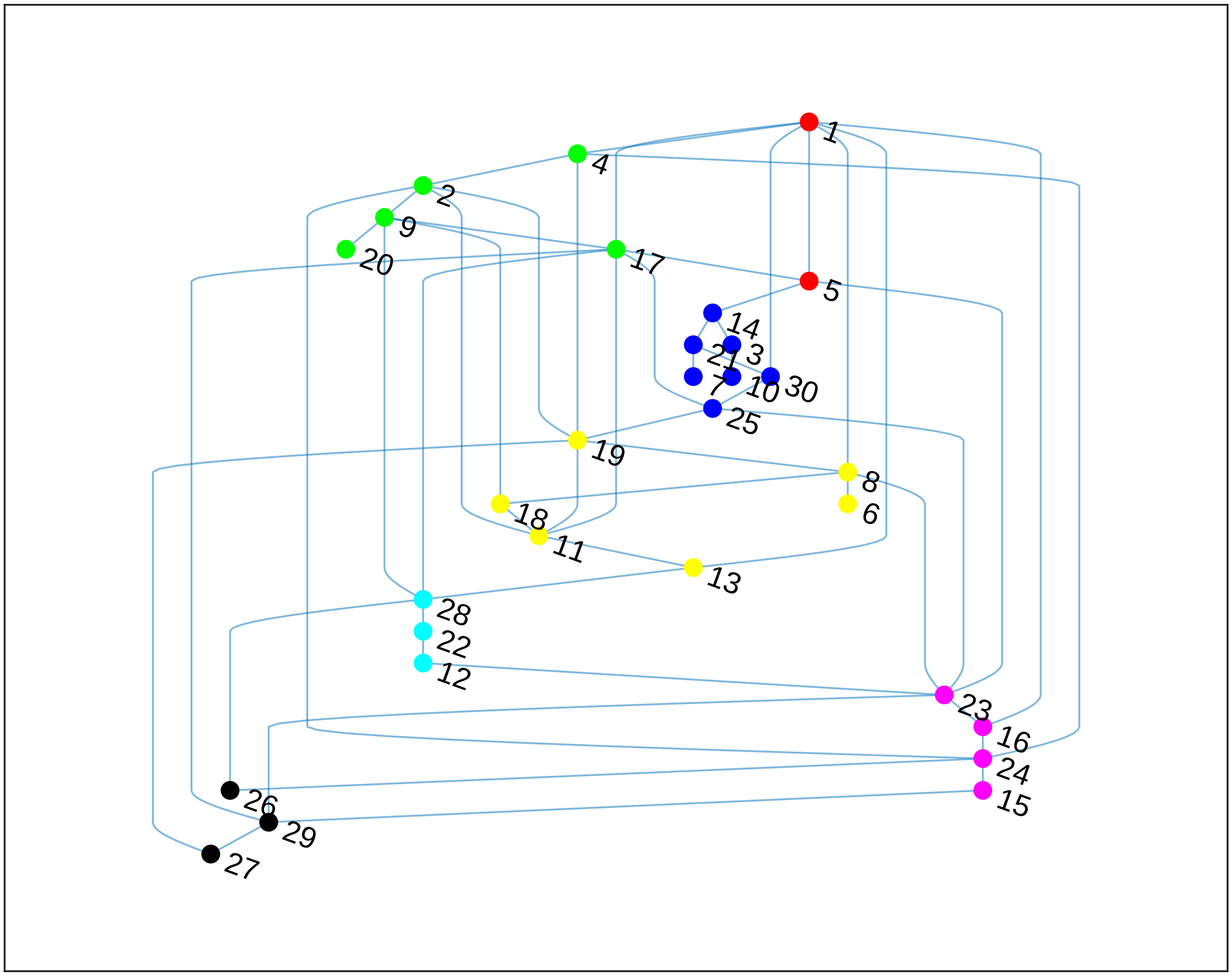

Figure 1: The station residential district power network. It has 30 demand nodes and 54 conduits between pairs of demand nodes. The main generator is located at node 1. There are 7 different groups of residents represented by a color coding of the nodes.

resident groups may reasonably complain is not fair? Might your metric score two different solutions as equally fair, when in fact there are ways in which one is clearly more fair than the other?

(c) Formulate an LP model for deciding how power should be distributed in order to maximize your fairness metric.

3. Starfleet has considered your solution and metric, and has decided that the current solution isn't fair enough.

    (a) Implement the LP model you developed in Question 2(c), and use it to find a solution that maximizes your fairness metric, while still ensuring that the total demand satisfied is at least 95% of the maximum possible, which is what you calculated in Question 1.

    (b) The Starfleet Power Engineering Team likes this new solution, but the Station Harmony Council still feels it isn't fair enough. Both groups want you to generate a complete trade-off curve, showing for wide range of achievable levels of total demand satisfied the greatest level of fairness that can be achieved. Once they see that curve, they can discuss how to compromise, to choose a solution that is fair enough, but still satisfies enough demand.

Part B: Integer Programming Models

Stay tuned!