LP Project

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Min cost flow

Along with max flow there is another problem that can be modeled as an LP with the integrality property called “min cost flow”.

Given a graph $G = (V, E)$, a capacity function $U : E \to \mathbb{N}$, a cost function $C : E \to \mathbb{N}$, and a supply/demand function $S : V \to \mathbb{Z}$, the **min cost flow** problem is the problem of determining an assignment of flow values $x_{i,j}$ for each edge $(i, j) \in E$ such that $\sum_{(i,j)\in E} x_{i,j} \cdot C(i, j)$ is minimized, while obeying the supply/demand and capacity constraints given by S and U.

Min cost flow example

Note the additional data of supply, capacity, and cost that this graph has. One each edge, the cost C is given by the first item of the tuple and the capacity U is given by the second item of the tuple.

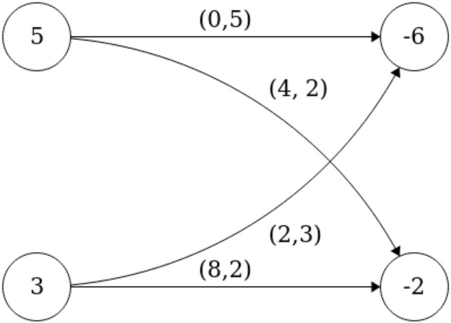

Figure 1: A simple MCF instance

Problem statement

You are in charge of moving products from one set of US cities to another set of US cities. (All of these cities will have their own airports.) However, you are only allowed to use preexisting shipping routes.

You are given a list of trips that can be taken between US airports. Each trip will have a capacity (in pounds) that the route can transfer, based on the largest amount that was transferred in a one month period, over the 9 months from January 2025 to September 2025. There is also a distance associated with each trip, given in miles. Lastly, you will be given the amounts of inventory that you have in each starting city, along with the amount of inventory that you need to send to each destination. (These amounts will tie out.)

Your job is to determine how to move the inventory to the destinations as efficiently as possible.

Data (sample)

Here is some sample data (most important columns, first 5 rows):

source	target	capacity	dist	...	src_city	dst_city
AAF	OCF	3450	173	...	Apalachicola	Ocala
AAF	SUA	3450	341	...	Apalachicola	Stuart
ABE	ACK	3450	285	...	Allentown	Nantucket
ABE	ACY	46051	94	...	Allentown	Atlantic City
ABE	AFW	3.813e+06	1318	...	Allentown	Fort Worth

Latitude and longitude for both source and target cities are also included if you want to plot your route.

Requirements

- You should model this as a min cost flow problem
- You should use OR-Tools with linear programming (not integer programming or any other solving method)
- You should submit a Jupyter notebook (.ipynb format)
- You should give the constraints as part of your submission, in the Markdown cells of the notebook
- I should not need to run your file on my end, it should have all the outputs “pre-run” and included in your file
- You should use Python in the Jupyter notebook, not R or Julia or any other language

Additional notes

- You will all get different problem instances (different source nodes/inventory amounts/sink nodes)
- Your problem instances should all be feasible, so if you get that they are infeasible you probably have an issue with your constraints
- You will be given a CSV that includes all the data you need (as given above)
- You may want to use pandas to read and process the CSV

Submission/grading

Submit your Jupyter notebook file to Brightspace.

Grading:

- 25% MCF formulation
- 25% description of how problem was mapped to MCF
- 40% OR-Tools implementation
- 10% correct solution

AI tools/external resources reminder

Use whatever resources you feel comfortable with.

There are no restrictions.