Module 07 – Maximal Flow

Exploratory Data Analysis

In this section, you should perform some data analysis on the data provided to you. Please format your findings in a visually pleasing way and please be sure to include these cuts:

- *Make a visual graph of your data like what we saw for the sample problem*
    - https://excalidraw.com
    - https://mermaid.live
    - https://dreampuf.github.io/GraphvizOnline
    - Powerpoint/Word

Model Formulation

Write the formulation of the model into here prior to implementing it in your Excel model. Be explicit with the definition of the decision variables, objective function, and constraints.

MAX: *X_70*

Subject to:

+X_70 - X_01 - X_02 - X_03 = 0
+X_01 - X_14 = 0
+X_02 - X_24 = 0
+X_03 - X_34 = 0
+X_14 + X_24 + X_34 - X_45 = 0
+X_45 - X_56 - X_57 = 0
+X_56 - X_67 = 0
+X_67 + X_57 - X_70 = 0

with the following bounds on the decision variables:

0 <= X_01 <= 369 0 <= X_14 <= 193 0 <= X_45 <= 151
0 <= X_02 <= 389 0 <= X_24 <= 81 0 <= X_56 <= 99
0 <= X_03 <= 138 0 <= X_34 <= 111 0 <= X_57 <= 222
0 <= X_67 <= 365 0 <= X_70 <= 9999

Model Optimized for Maximal Flow

Implement your formulation into Excel and be sure to make it neat. This section should include:

- *A screenshot of your optimized final model (formatted nicely, of course)*
- *A text explanation of what your model is recommending, especially any identified bottlenecks*
- *Update your graph from the EDA section to bold/color the links being used (and show how much is going through that link)*

Between the source node (Butter Rum Reef) to the sink node (Starburst Starlit Skies), the optimal model yields a maximum flow of 385 units. The network distributes flow over several channels, guaranteeing that each link maintains its capacity and that each node has a balanced inlet and outflow. Nineteen units connect Node 0 to Node 1 to Node 5, eighty-one units connect Node 0 to Node 2 to Node 4, and 111 units connect Node 0 to Node 3 to Node 6. These are the principal pathways. After that, these flows pass via Nodes 4, 5, and 6 in the direction of Node 7.

The system has been shown to have multiple bottlenecks. The connections between Nodes 6 and 7 (210 units), 3 and 6 (111 units), and 4 and 7 (81 units) are all completely saturated. These are the network's most important restrictions, preventing additional traffic. The flow graph should be changed to improve clarity. Use gray to indicate unused paths, blue to indicate active links that aren't at full capacity, and red to indicate saturated linkages. To properly demonstrate consumption, each link should additionally show the flow over its capacity (for example, "111/111").

Model with Stipulation Alternative:

In the optimized model, intermediary nodes balance input and outflow, with Node 0 sending out 385 units and Node 7 receiving all 385. Although the system functions well, the overall flow is constrained by a few crucial linkages.

Where links are completely saturated, bottlenecks form. These comprise connections between Nodes 0 and 1, 1 and 5, 3 and 6, 4 and 7, and 6 and 7. These edges limit additional growth in the overall flow because they are at capacity.
Nodes 0 to 2 (81/389) and Nodes 5 to 7 (94/151) are two examples of unused linkages. Although some routes have additional capacity, downstream constraints prevent them from carrying more flow. Additionally, nodes like Node 2 that receive flow through these links are not used to their full potential.

Saturated linkages should be colored red, underutilized links should be blue, and nodes should be marked red if they are underutilized or green if they are completely exploited.

More capacity is required on critical bottleneck edges, particularly between Nodes 6 and 7, in order to maximize flow. This would increase the network's overall output by allowing underutilized pathways to contribute more.

				Max Flow->	385	

Units of Flow	Links To		From		Upper Bound
193	0	Butter Rum Reef	1	Choco Volcano	369
81	0	Butter Rum Reef	2	Chocolate River Rapids	389
111	0	Butter Rum Reef	3	Frosted Fluff Fields	138
193	1	Choco Volcano	5	Molasses Marsh	193
81	2	Chocolate River Rapi	4	Frozen Fudge Fjords	81
0	3	Frosted Fluff Fields	1	Choco Volcano	199
0	3	Frosted Fluff Fields	2	Chocolate River Rapids	106
111	3	Frosted Fluff Fields	6	Sprinkle Street	111
81	4	Frozen Fudge Fjords	7	Starburst Starlit Skies	322
0	4	Frozen Fudge Fjords	5	Molasses Marsh	151
94	5	Molasses Marsh	7	Starburst Starlit Skies	222
99	5	Molasses Marsh	6	Sprinkle Street	99
210	6	Sprinkle Street	7	Starburst Starlit Skies	365
385	7	Starburst Starlit Skie	0	Butter Rum Reef	9999

	Nodes	Inflow	Outflow	Net Flow	Supply / Demand
0	Butter Rum Reef	385	385	0	0
1	Choco Volcano	193	193	0	0
2	Chocolate River Rapids	81	81	0	0
3	Frosted Fluff Fields	111	111	0	0
4	Frozen Fudge Fjords	81	81	0	0
5	Molasses Marsh	193	193	0	0
6	Sprinkle Street	210	210	0	0
7	Starburst Starlit Skies	385	385	0	0