ISyE 3133 Team Project

Part A: Due March 12, 2020

Parts B and C: Due April 16, 2020

Introduction

You are in charge of developing an optimization solution for a large online retailer. The retailer sells K types of products. These products are stored in N warehouses spread around the country. Each warehouse has limited stock of products available. These are given in Warehouses.csv.

We want to satisfy M customer orders. Each order may consist of varying quantities of different products. For now, you can assume that products are infinitely divisible. For instance, all of the following are valid orders:

- Order 1 requires 3 units of Product 1.

- Order 2 requires 5 units of Product 2 and 5 units of Product 3

- Order 3 requires 1.5 unit of Product 1

The orders are given in Orders.csv.

Sending products from the warehouse to the customer has a cost. The cost is proportional to both the distance between the warehouse and the customer and the total weight of the items sent. The costs of sending one pound from a warehouse to satisfy a order are given in DeliveryCost.csv. Per unit weight of the products is given in ProductWeight.csv.

Your goal is to assign customer orders to warehouses so that you satisfy all the orders while minimizing fulfillment costs.

Part A (50 pts)

Question 1 (20 pts)

Formulate a Linear Programming model to solve this problem. Your submitted model **must** be typed.

Clearly specify your choice parameters and variables. Explain your choice of the objective function. Explain your constraints.

Question 2 (20 pts)

Implement your model in Gurobi/Python. Your program **must** read the data from the given files. Hard-coded data will be (severely) penalized. In your submission, this script should be named ModelA.py.

Explain your data structures. Explain how different parts of your code correspond to different parts of your formulation, i.e. explain which parts of the code generate the variables, objective function, and each constraint.

Question 3 (5 pts)

Solve your model. What is the objective value of your solution? What does it mean in words?

What is the optimal solution, i.e. which orders are satisfied from which warehouse? What quantities of different items have been sent? In your write up, summarize your solution in a human readable format, e.g. a table.

Question 4 (5 pts)

Notice that all orders in the data require whole quantities of products. In practice, the products are not infinitely divisible. Suppose we were to impose this restriction (you do not have to implement it or change the formulation yet). Would the optimal solution change?

If your answer is yes, would the optimal objective value be higher, lower or stay the same? Why?

If your answer is no, why not?

Part B (20 pts)

Question 5 (5 pts)

Now assume that products are not infinitely divisible and can only be sold in whole quantities. Furthermore, sending a package from a warehouse to a customer incurs a fixed cost in addition to the weight based cost. Fixed costs are given in FixedCosts.csv. How would you change your formulation to reflect the new assumptions? You can either write out the new formulation or specify what you had to add and which parts of the old formulation had to be changed and how. Is your new formulation an LP or IP?

Question 6 (10 pts)

Implement the changes to your model in Question 5 in Gurobi/Python. In your submission, this script should be named ModelB.py.

As in Question 2, make sure you explain any new lines of code you have added.

Question 7 (5 pts)

Solve your model. What is the objective value of your solution? What does it mean in words? How does it compare to the solution of Question 3?

What is the optimal solution, i.e. which orders are satisfied from which warehouse? What quantities of different items have been sent? In your write up, summarize your solution in a human readable format, e.g. a table.

Part C (30 pts)

Question 8 (15 pts)

Often businesses have to take into account considerations beyond just the cost. In our case, due to trade regulations, our warehouses and customer orders have been assigned to one of the four regions. These assignments are given in WarehouseRegions.csv and OrderRegions.csv. Orders from one region should be fulfilled by warehouses from the same region until the supplies last. Afterwards, they can be fulfilled from any region.

For instance, suppose Region 1 has only one Warehouse, say Warehouse 1. This warehouse holds 5 units of Product 1. Suppose further, there is only one order coming from Region 1, say Order 1. Order 1 requires 7 units of Product 1. With the new regional constraints, we have to send 5 units of Product 1 from Warehouse 1 to Order 1. We can satisfy the remaining demand of 2 units form any warehouse. Notice that this constraint takes precedence over any cost considerations, i.e. we have to send 5 units from Warehouse 1 even if it is cheaper to satisfy the order from another warehouse.

Write the model for the updated problem. Explain any additional parameters, variables, and constraints you had to introduce. The new formulation should include the changes you have made in Question 5. You don't have to explain these again.

Question 9 (10 pts)

Implement your new model in Gurobi/Python. In your submission, this script should be named ModelC.py.

As in Question 2, make sure you explain any new lines of code you have added.

Question 10 (5 pts)

Solve your model. What is the objective value of your solution? What does it mean in words? How does it compare to the solution of Question 8?

What is the optimal solution, i.e. which orders are satisfied from which warehouse? What quantities of different items have been sent? In your write up, summarize your solution in a human readable format, e.g. a table.