IE 400: Principles of Engineering Management Project

Spring 2021-2022

Assume you moved to a new neighborhood for your job. Since you are not familiar with new neighborhood, you want to allocate your budget for your expenses in order not to encounter any monetary issues. You thought that grocery shopping expenses could be diminished by choosing the best prices at markets. You make a plan throughout the week and decide to go shopping every Sunday. You start with checking your inventory, and identifying the needs that must be satisfied. For instance, if you have a shortage in oil for cooking, then you add oil into your shopping list.

Once all needs are identified, you search for possible products that can be purchased to meet each need in the list. Your scope for the search is bounded by the local markets in your neighbourhood. Currently, there are 4 markets in the neighbourhood (market A, B, C, D). For any product alternative, you compare the prices over markets and note the cheapest one.

The third step is to focus on your shopping plan in detail. In order to do that you should decide the following:

- Which markets you will go and in which sequence you will visit them.
- How many packages (or bottles etc.) for each product you will purchase from each market you go.

All these decisions must be made together in a single model (not step by step).

Let $K = 1, ..., |K|$ be the set of markets, $N = 1, ..., |N|$ be the set of needs and $I = 1, ..., |I|$ be the set of products. Each product has a unit cost (C_i) and gives a certain level of satisfaction (S_i), which is a representation of your

prosperity.

For this week's shopping plan, you identified 4 types of needs ("beverages", "carbohydrate meals", "cheese" and "breakfast products"). As you search for the product alternatives, you create a list of products which summarizes unit price (C_i), unit satisfaction (S_i), amount of product in one packet (A_i), the need that the product satisfies (each product contributes to the satisfaction of demand in one need) and the market with the lowest price.

In order to answer these questions, you have some assumptions to consider, which are as follows.

- Throughout the shopping (starting from leaving the house and ending at arriving the house) you must travel at most (T) meters distance in total. (Let d_{kl} be the distance between locations k and l.)
- The needs on the shopping list are crucial. Thus, you must meet these needs. The demand for each need (D_n) is provided to you.
- You allocate a budget for your weekly grocery shopping expenses. The allocated budget (B) is strict, so the shopping expenses cannot exceed this predetermined budget.
- At the end of the shopping, spared money from your budget gives satisfaction as you can use it on other needs.(You gain E units of satisfaction per 1 TL of spared money)

a) Considering all the assumptions and given data, try to achieve **maximum satisfaction** from your shopping plan. Model this problem as an LP/IP problem, write down the decision variables, parameters, objective function, and constraints explicitly.
Hint 1: You can define new parameters combining the information given.
Hint 2: Make sure that if you arrive in a market, you also leave it.

b) Solve the problem using a mathematical optimization solver (e.g., Gurobi, CPLEX, XPRESS, etc.)

c) In Market **k**, stocks of product **i** is limited and it is bundled with, product **j**. In other words, if you buy product **i**, then you must buy product

j as well. However the reverse is not necessary. Make the necessary changes in your model in part (a) to maximize your satisfaction.

d) Now, assume that you do not like products **i** and **j** together. Therefore, you cannot buy both product **i** and product **j** together (you may buy one of these though). Make the necessary changes in your model in part (a) to maximize your satisfaction.

e) Now, assume you travel with an average speed of 5 m/min. Currently, you are at home and you should turn back to your initial position within a duration **Td**, which includes the time spent in each market, and the time spent traveling. The time spent in each market as follows.

Market	**A**	**B**	**C**	**D**
Time Spent	35 min	45 min	55 min	40 min

Model this problem as an LP/IP problem to maximize the satisfaction. Write down the decision variables, parameters, objective function, and constraints explicitly. Then, solve the problem using an mathematical optimization solver.

Note: You can find the list of products and all parameters described by notations in **data.xlsx** file. (Each group will be assigned to a different data set, and the assignment will be announced later).

Instructions

Please read the following instructions carefully:

(1) Formulate the models in each part separately.

(2) You can solve the models using any appropriate solver (Gurobi, CPLEX, XPRESS, etc.)

(3) Prepare a written document including your precise mathematical models. Explain your objective values, constraints, decision variables and parameters explicitly.

(4) Submit your report (including members full names and ID's) as well as your CPLEX model (or your choice of solver) and all of your codes as a .zip file to busra.bayrak@bilkent.edu.tr. The name of the .zip file should be your group number (Do not add names, ID's etc. to the file name).

(5) There will be a presentation session where you will be asked questions about your models and the project.