LT-OR 2021-2022 Exercises for training Van-Dat CUNG

Exercise 1: Towards an optimized distribution network

The M2 company has several factories, they produce several products, but to start, we can consider without loss of generality that they produce **only one product and over one time period**. The company wants to set up an optimized distribution network to deliver its clients. For this, the products are sent from factories to clients, either directly or through one hub. There is **at most** one hub between a client and a factory. A priori, any factory can deliver any client or hub, and any hub can deliver any client.

The company wants to optimize the costs over the network but keeps the control on the number of opened hubs equal to K.

Besides, the company wants to control the activities of the opened hubs as well. Each opened hub should deliver at most $\lceil SC/K \rceil$ clients, where SC is the total number of clients. Each client is served by at most one hub.

For this, you manage to get the following information:

- Set of factories $f \in F$ with their production P_f, $|F| = SF$;
- Set of clients $c \in C$ with their demand D_c, $|C| = SC$;
- Set of possible hubs $h \in H$, $|H| = SH$;
- C_{fc}^{fix}, C_{fc}^{var} are respectively fixed and variable transport costs between a factory f and a client c;
- C_{fh}^{fix}, C_{fh}^{var} are respectively fixed and variable transport costs between a factory f and a hub h;
- C_{hc}^{fix}, C_{hc}^{var} are respectively fixed and variable transport costs between a hub h and a client c;
- O_h^{fix} is the fixed opening cost of hub h;
- K is a parameter giving the number of opened hubs, in practice, $K \ll SH \ll SC$.

Question 1: Draw the M2 distribution network and put the aforementioned data on the related elements of the network.

Question 2: Which type of problem is now addressed by M2?

a) K-median problem
b) K-center problem
c) Uncapacitated Facility Location problem
d) Service Network Design problem
e) Vehicle Routing problem
f) Location-Routing problem
g) Inventory-Location problem
h) Production-Location problem

Question 3: Give an MILP to help the company to set up the network which optimizes all the fixed and variable transport costs.

Question 4: Extend the MILP given in your answer to Question 3 to handle as well the possibility to have **more than one hub** between a client and a factory. Please do mention explicitly additional assumptions if it is necessary.

Exercise 2: Routing for bread distribution

An E-bakery must delivery everyday bags of bread from the shop in Donges (D) to the clients who are located in the following cities: Andard (A), Carquefou (C), Guérande (G), Monnières (M), Pannecé (P), Trélazé (T). After analyzing the needs of the clients and for the sake of simplicity, we consider the logistics unit as the bag of bread.
A study over a map gives the following symmetrical distance matrix expressed in km between the cities:

Distance Dij (km)	Donges (D)	Andard (A)	Carquefou (C)	Guérande (G)	Monnières (M)	Pannecé (P)	Trélazé (T)
Donges (D)	999	148	55	32	70	73	140
Andard (A)	148	999	93	180	99	72	12
Carquefou (C)	55	93	999	85	20	28	83
Guérande (G)	32	180	85	999	100	99	174
Monnières (M)	70	99	20	100	999	49	85
Pannecé (P)	73	72	28	99	49	999	73
Trélazé (T)	140	12	83	174	85	73	999

Demand qi (m3)	5	6	3	17	15	13

On this basis, the demands of the cities are expressed are as given above.

The E-bakery must satisfy all the daily demands. For this purpose, the supermarket has a small vehicle, with a capacity C=20 boxes of food. The vehicle departs from Donges and returns to Donges, in particular when reloads are needed. The client demands are **NOT SPLITTABLE, i.e. one client is delivered only one time for its demand**.

Question 1: How many tours are at least necessary to deliver all the clients? Give your methodology to justify your answer.

Question 2: Assess the total distance run by the vehicle if every cities are served independently and directly from Donges, **i.e. the vehicle departs from Donges and must return to Donges after serving one and only one city (star tours).**

Now vehicle routings are allowed and several clients can be served in the same route.

Question 3: On using the nearest neighbor heuristic algorithm given for the Traveling Salesman Problem (TSP), build and give a good (optimizing the distance costs) solution “by hand” along with its tours and its total distance. Beware to respect the capacity constraint of the vehicle.

Question 4: Set up an MILP to model this distribution problem. This MILP should be able to give an optimal solution regarding the total distance of the tours when the number of tours is given.

Now E-bakery considers that it is not interesting to have its shop located in Donges and decides to close the shop in Donges. You are asked to help E-bakery to find new locations among the clients’ cities to setup new shops.
Question 5: Give a global approach to handle this request.