Introduction

The company RoboMarkt specializes in installing and servicing automatic grocery stores that sell goods in remote areas of a sparsely populated country, where traditional stores are anti-economical. These automatic stores ("stores" from now on) sell food and beverages as well as house goods such as toiletries and books. A feasibility study identifies a new remote area where these stores can be installed. The region has n small villages, whose coordinates in kilometers are described by parameters `Cx` and `Cy`. Despite their remoteness, these villages are well-connected to one another so that the traveling distance between each village can be approximated by their Euclidean distance.

Installation

RoboMarkt wants to install a store in one or more of the villages in $N = \{1, 2, \ldots, n\}$ and needs your help deciding where. Not all villages gave permission to install such stores. Whether or not it is possible to build a store at village i is described by parameter `usable[i]`. All considered, the cost of building a mini-market at house i is `Dc[i]`. The company wants to plan the construction of stores so that each village is at most `maxdist` kilometers away from an open store but two open stores must be at least `mindist` km away from each other.

Maintenance

The main branch of the company for the region is based at location (village) 0. For reasons of company image, a store should always be built at location 0. All installed stores must be refilled on Monday each week, even if they were not used much. The company branch plans to hire truck drivers (each with their respective truck) to refill the stores every Monday, planning the routes so that all stores are visited by a truck that is stationed at location 0, which also functions as a warehouse for the entire area. The store at location 0 does not need to be refilled by a truck, since it is located at the main branch.

Each truck must be assigned a route that starts and ends at location 0, and which you must find. A single truck has the capacity to and visits up to `maxstores` stores (excluding the store at location 0). The company has arranged to hire each driver+truck for a fixed fee of `Fc`. In addition to the driver fee, the company also pays an additional fee of `Vc` per kilometer driven by a truck, to account for both the time of the driver and the cost of the petrol used.

Note that `Fc` and `Vc` are considered throughout the whole lifetime of the shops as is `Dc`: opening a shop at location i costs `Dc[i]` when amortized in the next 15 years, and similarly `Fc` is the cost of a truck+driver over the next 15 years and `Vc` is the proportional cost (per kilometer) over the next 15 years.

Problem

The company wants to know where it should install these stores and with what routes every truck should serve them so that the total cost (building plus maintenance costs) is minimized.

Project

For all the instances found online for this project, provide a Python file that solves the above problem by using the modeling capabilities you have learned in class. If you use a Jupyter notebook, remember to save it to Python format by choosing the "Download as→Python" option from the menu.

The data can be imported with the following command (all parameters mentioned above should be imported):

```
from robomarkt_data import Fc, capacity, ...
```

Modeling the above problem is nontrivial: routing each truck through a subset of shops requires that each truck departs from location 0, visits a subset of shops, and then returns to location 0. Coupled with the installation constraints, the problem can be quite difficult both for you to model and for the computer to solve.

Rules

Using Webeep, when your solution is ready you can submit it on Webeep. Only one submission for each group is requested. The file name should be `XYZ_YZX_ZXY.py`, where XYZ, YZX, and ZXY are the person ID of each group member. At the beginning of the Python file there should be a comment section with the full name of all group members, like the following:

```
# Authors:
# Name1 Surname1
# Name2 Surname2
# Name3 Surname3
```

The final output of the script should be a list of all open facilities and, for each truck, its path through the shops, like in the following example:

```
Shops: 0 4 19 21 44 50 51 58 79
Path 1: 0 44 19 21 0
Path 2: 0 50 4 51 0
Path 3: 0 58 79 0
```

You can work by yourself or in a group, but groups can have at most three people. You and your group **must** work autonomously: the submission of your group must be the sole work of the group and not of other people. See the Politecnico's code of conduct.