VRP Challenge

Difficulty level: advanced

Keywords

- Mathematical modelling

- Mixed Integer Linear Programming

- Excel Solver

- Heuristic algorithms

- Exact algorithms

Introduction

The supermarket chain *SuperAmazingMarket* has decided to launch a new service: home delivery of groceries.

Each customer who requests the service, located in the province of Brescia, must be given a certain number of shopping bags containing the requested goods.

Each supermarket participating in the service, also located within the province, have some small, medium, and large capacity vehicles available for delivery: the small capacity vehicle can carry at most 30 shopping bags, the medium vehicle can carry at most 50, while the large one at most 70.

Each day, each vehicle will load the goods from the supermarket in which it is located, and set off to make deliveries. Each vehicle can stay on the road for a maximum of 3 hours, from departure until it returns to the same supermarket from which it started.

During the journey, each vehicle can pass (even more than once) next to customers, without necessarily serving them, and next to the supermarkets, including its own (but without stocking up on other bags).

Once back at its supermarket, the vehicle will no longer be able to leave. It is expected that each courier (who will drive the vehicle and deliver the shopping) will cost the company 50 €/day. Also, it will take about 1 minute to bring a pair of bags from the vehicle to the customer's home. During the actual delivery phase, the vehicle will be shut down. Finally, it has been estimated that the fuel for the vehicles will cost 0.07 €/minute.

The company *SuperAmazingMarket* asks for your help in trying to spend as little as possible, by establishing:

- which vehicles from each supermarket will make the deliveries;

- which path each of these vehicles must follow;

- which customers each of these vehicles should serve.

In particular, the company is interested in solving the problem on three hypothetical different scenarios, characterized by:

- a different number of customers to serve;

- a different number of supermarkets;

- a different number of vehicles available and their allocation to the various supermarkets.

In each scenario, it is also provided how many shopping bags each customer must receive and which roads the vehicles can travel.

All this information is summarized in three different text files, one for each scenario, attached to this document (i.e., the files `instance-demo.txt`, `instance-1.txt`, and `instance-2.txt`). Hereafter follows an example instance:

```
CLIENTI: 20         Customers
SUPERMERCATI: 2     Supermarkets
VEICOLI: 4          Vehicles

ID-DOMANDA :  ID-DEMAND (related to supermarkets and customers)
1 0 // supermercato 1                                          The first rows of the "ID-DEMAND" section always refer to
2 0 // supermercato 2                                          the supermarkets, characterized by a demand equal to 0.
3 9 // cliente con ID 3 che richiede 9 borse della spesa       The following rows assign a progressive number to each
4 2 // cliente con ID 4 che richiede 2 borse della spesa       customer and indicate how many shopping bags each
5 8 // cliente con ID 5 che richiede 8 borse della spesa       customer asks for.
...

NODO1-NODO2-TEMPO :  NODE1-NODE2-TIME (travelling times)
1 3 20 //per percorrere il tratto stradale che collega il punto 1 al punto 3 servono 20 minuti
1 4 26 //per percorrere il tratto stradale che collega il punto 1 al punto 3 servono 26 minuti
1 10 38
1 11 28
2 8 71                                                  Arcs not appearing in the "NODE1-NODE2-TIME" section
3 6 18                                                  CANNOT be travelled.
3 9 37
...

ID-CAPACITA-SUPERMERCATO :  ID-CAPACITY-SUPERMARKET (related to vehicles)
1 30 1 //il veicolo 1 ha una capacità di trasporto di 30 borse ed è assegnato al supermercato 1
2 50 1 //il veicolo 2 ha una capacità di trasporto di 50 borse ed è assegnato al supermercato 1
3 70 2 //il veicolo 3 ha una capacità di trasporto di 70 borse ed è assegnato al supermercato 2
         The vehicle with ID 3 has a capacity of 70 shopping bags and it is assigned to the supermarket with ID 2
...
```

Instructions

You are five experienced Operations Research teams looking for job opportunities. You have read the problem of the company *SuperAmazingMarket* and you know that only the group who proposes the best solutions will be hired.

To solve the problem, you are free to use any type of digital technology and to make the most of all the operations-research knowledge you have acquired during these years (e.g., mathematical modelling, developing ad hoc algorithms or variants of those you know).

The results are due to be exposed to the executive directors of the company in about a month.

Each team will have twenty minutes for their presentation, in which they will have to explain in detail the methodology developed, and how this was applied to solve the hypothetical scenarios provided by the company. However, to be sure that you are working in the meantime, the company:

- would like to have, within the first two weeks:

  - at least one feasible solution of two instances (i.e., for each instance, the value of the objective function, the vehicle routes and, for each customer, which vehicle serves it);

  - the explanation, in general terms, of the methodology provisionally adopted, which is potentially applicable also to other instances not available to you;

- keeps up to date a shared sheet, in which each team can see who has obtained the best solutions so far, for each of the three instances.

To update their solutions, each team must contact the company, sending the new solutions found, together with the explanation or pseudocode of the method used (or the improvements introduced by the last update).

Warning:

- receiving only the new solutions, without an explanation attached, **will not be enough** to update the shared sheet;

- each team will have access to the shared sheet only **after the first solution submitted**.

For the first two weeks, the company also keeps a contact center active (i.e., `gabriella.colajanni@unict.it` / `alessandro.gobbi@unibs.it` / `alice.raffaele@univr.it`), to request information and clarifications regarding the problem, its characteristics, or the objectives of the project. The response is guaranteed within 48 hours since the request.