Tutorial 5: CVRPTW

The *Capacitated Vehicle Routing Problem with Time Windows* is a variant of the TSP:

- n bars must be supplied with organic grape juice by k delivery persons using a cargo bike of maximal capacity c.
- Each bar i must get q_i juice packs between t_i^s and t_i^e (time window), the delivery having a duration of d_i (the delivery must be finished before t_i^e).
- If the same person delivers bars i and j, t_{ij} is the minimum travel time between the end of the delivery of i and the beginning of the one of j (or vice versa, the transition time matrix being symmetrical).
- Each round starts with the first delivery and ends with the last one (i.e. the time to go from and to the juice depot is not taken into account).

An instance is provided in file `cvrptw.txt` where are specified:

- the number of bars n, of delivery persons k and the maximal capacity of each bike c on the first line;
- for each bar: the duration of the delivery d_i, the quantity of juice q_i and the time window (t_i^s and t_i^e);
- the transition time matrix t (of size $n \times n$).

1. Define the decision variables: for each bar, which person delivers and at what time.
2. With reifications, post constraints that forbid a bike rider to make several deliveries simultaneously (taking the transition times into account).
3. Define new variables to represent the juice loads of each bike and constrain them, using reifications to represent that person j delivers bar i:

$$\forall j, \sum_i (p_i = j) \times q_i \leq c$$

4. Optimize the solution by minimizing the end time of the last delivery:

```
[...]
7 bt
cost 16 in 0.004s:
task 0 done by 0: 10 --> 12
task 1 done by 1: 8 --> 9
task 2 done by 0: 13 --> 16
task 3 done by 2: 9 --> 11
task 4 done by 2: 11 --> 13
task 5 done by 1: 15 --> 16
task 6 done by 1: 11 --> 15
task 7 done by 2: 13 --> 15
load: tech 0:79 tech 1:91 tech 2:82
8 bt
Proof in 0.004s
```