LINGI2365 : Constraint Programming

Assignment 5 :

Project

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1 Objective and practical details

The goal of the project is for you to make use of your knowledge and imagination to solve a difficult optimization problem.

You should respect the following constraints

- Deadline : **Friday 9 May 2014 2pm**.
- This assignment is **mandatory**.
- This assignment must be completed **by groups of two** (the same groups as in the previous assignments).

Modalities

- A **hardcopy of your report** must be turned in (box in front of the INGI secretary) before 2pm on May 9th.
- Submit your files, **code and report pdf**, on iCampus in a zip (or tar.gz) with the name **tp1_gXY** where **XY** is your group number.
- In case of problems, write to `f.aubry@uclouvain.be`.

2 The Vehicle Routing Problem with time windows

Problem Description

Assume we have a set of customers I=$\{1...n\}$ that need to be serviced from one central depot (0). We also have a matrix giving us the distance between each pair of customers and between customers and the depot. The distance from i to j (d_{ij}) is the same as the distance from j to i (d_{ji}). The distances respect the triangle inequality ($d_{ij} + d_{jk} \geq d_{ik}$). Note that the time it takes to travel from i to j corresponds to the distance from i to j. With each customer i ($i = 1...n$) are associated:

- its demand q_i
- the time it takes to perform service s_i
- the start of i's time window e_i
- the end of i's time window l_i

With the depot 0 are associated

- the start of its time window e_0
- the end of its time window l_0

Feasible solution

You are given a fleet of K vehicles each having capacity Q. A feasible solution to this problem corresponds to finding a set of at most K routes such that:

- each customer i ($i = 1...n$) is visited once
- the sum of the demands of the customers visited by a vehicle $\leq Q$
- service at customer i ($i = 1...n$) starts not earlier than e_i and not later than l_i
- vehicles leave the depot at time 0 and do not return to the depot later than l_0

Note that vehicles are allowed to arrive at customer i earlier than e_i, but they must wait until e_i before starting service.

Optimizing the VRPTW

The goal is to minimize the number of routes and then to minimize the total distance. This is a lexicographic objective function, the first objective is more important than the second one.

3 The Project

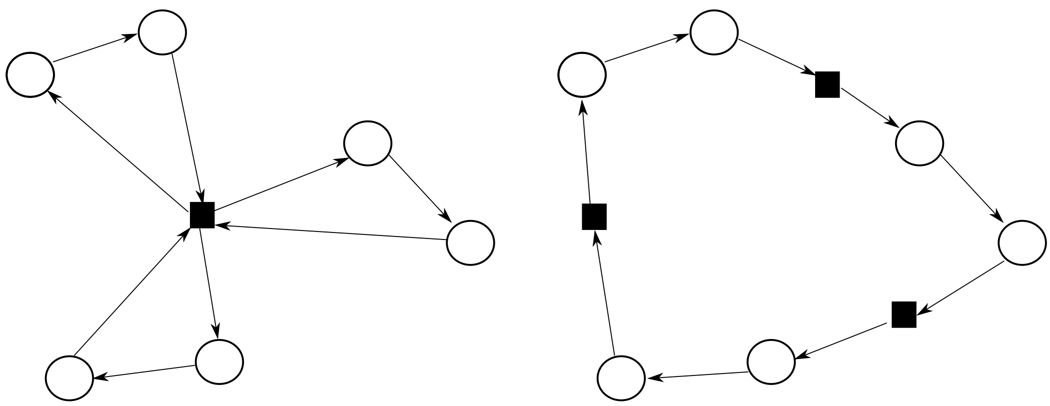
You are given a basic model minimizing the distance and a very basic search.
We ask you to:

1. Understand the model we provide you
2. Design and implement one optimization procedure for **each** of the objectives. The procedure should of course be as adpated as possible to the given objective (for example adapted variable and value ordering heuristics).
3. Test **all your procedures** on the provided benchmark instances.

For your optimization procedures you may use any techniques (basic CP, Dichotomic search, Hybridization of CP with other techniques,...) you've seen in the course or you can imagine. Your procedures must however make use of Constraint Programming techniques in some way or another. You are free to work with the provided model or to modify it in any way you see fit.

The model

Note that the model we provide you with uses a giant tour representation. This means that we duplicate the depot, such as to have one depot per route and link the different depots via the routes.



(a) Classical representation (b) Giant tour representation

Figure 1: Representations of vehicle routing problem

Testing your procedures

The instances we provide you with are part of the standard benchmark instances for the Vehicle Routing Problem with Time Windows. Note that you will possibly not be able to prove the global optimality of your solutions for the provided benchmark instances. The results you indicate should be the best value found after a time limit of **120 CPU sec**. The best known results for these benchmark instances are available under http://www.sintef.no/Projectweb/TOP/VRPTW/Solomon-benchmark/100-customers/. These are tough problems, don't be disappointed if you do not reach competitive results. Remember that we ask you to test **all** your optimization procedures on those instances.

Report

In the report you must:

- explain the provided model (how are the constraints enforced, what do the global constraints used do, what do the decision variables represent, ...)
- explain how you adapt the model to minimize the number of routes
- explain each of your optimization procedures in detail (what, why and how)
- indicate and analyze your test results

Scoring

The scores for this assignment will be based on:

- your understanding and explanation of the models (3)
- the originality, efficiency and conformance of your optimization procedures (7)
- the correctness of your implementation of your optimization procedures (3)
- the correctness and preciseness with which you explain your optimization procedures in the report (4)
- the analysis of your test results in the report (3)