Combinatorial Optimization Contest 2016: Cocontest

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February 24, 2016

1 Cocontest 2016 Problem

This year, we will solve *The Capaciated Facility Location Problem* for the *The Coconut Craftwork, Inc.* company. The Coconut Craftwork, Inc. is producing a large number of coconuts, that needs to be stored and delivered to target customers. Customers are located at different geographical places and each of them demands the coconuts. In order to supply them, you need to build a set of supply facilities.

You have a number of available options where to build a facility. However, building a facility costs some fixed amount of money that vary across different locations and at each location potential facility has different supply capability. Building a set of facilities is just one part. The other part is that you need to keep in mind locations of your customers. Therefore, you will decide on which customer is served by which facility. This defines a supply route, where trucks with coconuts are going. Their fuel consumption is roughly estimated as the distance between the customer and the facility that supplies him.

Your goal is to design the whole coconut supply network as cheaply as possible.

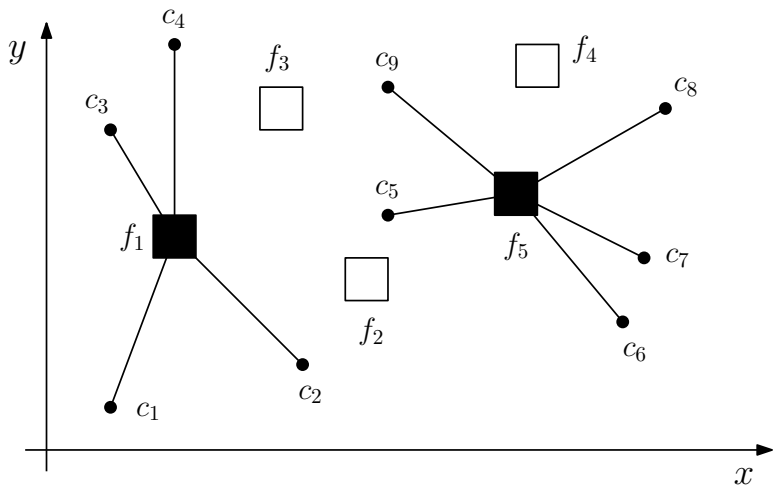

Figure 1: An example of a solution to the problem. From five available facility locations f_1 and f_5 were built and customers $c_1, \ldots, c_9$ were assigned to them.

1.1 Formal description

Given the set of facilities $\mathcal{F}$ and the set of customers $\mathcal{C}$ the goal is to assign each customer $c \in \mathcal{C}$ to the exactly one facility $f \in \mathcal{F}'$, where $\mathcal{F}' \subseteq \mathcal{F}$ such that every $f \in \mathcal{F}'$ will be constructed for

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the given fixed cost $p_f \in \mathbb{N}$. The capacity $cap_f \in \mathbb{N}$ of every facility $f \in \mathcal{F}'$ won't be exceeded by demands $d_c \in \mathbb{N}$ of associated customers. Each customer $c \in \mathcal{C}$ that is served by the facility $f \in \mathcal{F}'$ contributes to the objective by value $\sqrt{(f_x - c_x)^2 + (f_y - c_y)^2}$, where $[f_x, f_y] \in \mathbb{R}^2$ is the location of facility $f \in \mathcal{F}'$ and $[c_x, c_y] \in \mathbb{R}^2$ is the location of customer $c \in \mathcal{C}$. Therefore, the goal is to find a subset of facilities to be built $\mathcal{F}' \subseteq \mathcal{F}$ and an assignment $T : \mathcal{C} \mapsto \mathcal{F}'$ that minimizes objective, i.e.

$$\min_{\mathcal{F}' \subseteq \mathcal{F}} \sum_{f \in \mathcal{F}'} p_f + \sum_{c \in \mathcal{C}} \sum_{f \in \mathcal{F}' | f = T(c)} \sqrt{(f_x - c_x)^2 + (f_y - c_y)^2} \tag{1}$$

such that

$$\forall f \in \mathcal{F}' : \sum_{c \in \mathcal{C} | T(c) = f} d_c \leq cap_f \tag{2}$$

i.e., the capacity of every facility is not exceeded by the total amount of supply demands of associated customers.

2 Submissions & Leaderboard

The central page for the contest is located at `https://cocontest-1225.appspot.com/`, where you can login using your FELId credential. There you find a set of problem instances that your algorithm shall solve.

We are interested in the quality of solutions only (i.e. objective value), not the running time of your algorithm. Therefore, you are allowed to use all the computational power you can get in order to solve larger problems. Alternatively, you can invest more time into the design of your algorithm to find better solutions with comparably less computational effort. The choice is up to you. Furthermore, all of the problem instances do not have to be solved by a single algorithm. Designing multiple algorithms for various sets of instances is highly recommended. Remember, the ultimate goal is to find the best solutions with available resources!

You will upload your solutions to the online system. Submissions will be checked for the feasibility and for the claimed objective value. Based on the objective value for each solved problem instance you will be ranked. The ranking is based on *average instance rank*. That is, the final rank is given as arithmetical average of ranking for each instance based on the objective value. At instances where you don't provide any feasible solution you will be ranked as the last one. We provide you also a basic code solving the problem that you can run for yourself and try to improve it.

The contest will be open from 24.02.2016 00:00:00 to 23.05.2016 00:00:00. A week before the contest ends, the public leaderboard will be frozen, but the system will still accept solutions. The winners will be announced at the last lecture.

The timeline of the contest is following:

- 24.02.2016, 00:00:00 *Contest open*
- 16.05.2016, 00:00:00 *Leaderboard freeze*
- 23.05.2016, 00:00:00 *Contest end*
- 24.05.2016 *Winners announcement at KO lecture*

2.1 Format description

The input for each instance consists of $1 + |\mathcal{F}| + |\mathcal{C}|$ lines. The first line contains two positive integers, $|\mathcal{F}|$ and $|\mathcal{C}|$. Following $|\mathcal{F}|$ lines contain description of available facilities. Every line for

a single facility consists of 2 positive integers denoting setup cost p_f and capacity cap_f followed by 2 doubles, f_x, f_y denoting its geographical location. The remaining $|\mathcal{C}|$ lines stand for each single customer. The line consists of 1 positive integer denoting customer's supply demand d_c and 2 doubles denoting its location c_x, c_y.

The output consists of $1 + |\mathcal{F}'|$ lines. The first line contains a double number standing for the objective value of the solution. In following lines, each line contains an integer denoting the index of the facility that was constructed followed by indices of customers that are served by this facility. Moreover, we ensure that every given problem instance is feasible. All of the double numbers are represented in base format (i.e. 14.24 instead of $1.424e1$).

The example of the input instance `fl_3_1.txt` containing 3 available facility locations and 4 customers is following:

```
3 4
100 100 1065.0 1065.0
100 100 1062.0 1062.0
100 500 0.0 0.0
50 1397.0 1397.0
50 1398.0 1398.0
75 1399.0 1399.0
75 586.0 586.0
```

An example of the output file may look like as follows:

```
2545.77113705
0 0 1
1 2
2 3
```

It denotes the solution, where three facilities were built. The facility 0 serves customers 0 and 1 and the facility 1 serves customer 2 and facility 2 serves customer 3. The solution's objective value 2545.7711. You can try for yourself to copy and paste the solution into the Cocontest upload system at `https://cocontest-1225.appspot.com/` and you will see that solution is accepted.

3 Prize

We will award top participants by a scholarship. The prize pool is 12.000 CZK. The scholarship is sponsored by the ACM UPE Czech Alpha Chapter [1], Honor Society for Computing and Information Disciplines.

Moreover, the top 3 contestants will receive 3 extra points for the final exam of RM35KO class.

[1] `http://upe.cvut.cz/`

4 Contest Rules

- every participant must be a student enrolled to RM35KO class during 2016 summer term
- usage of single-purpose problem-specific solvers is prohibited (i.e. a MILP solver is allowed, but somebody's else code for solving The Capaciated Facility Location Problem is not)
- every participant is required to write its own code and instance solutions cannot be shared with others however, sharing ideas and other discussion about the problem is encouraged
- organizers reserve a right to disqualify a participant based on serious suspicion that provided solutions are not produced by participant's own algorithm
- source codes are required to be submitted after the competition ends