Exercises with AMPL

Antonio Mucherino

Laboratorie d'Informatique, École Polytechnique

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Buying metro tickets

One day, before going out, I thought:

> *"I have to take the metro, and I have no tickets, but I have several coins that I can use for buying a* **carnet** *of tickets".*

Then, I went to the metro station with all my coins. I selected the *carnet* of tickets I wanted from the machine, and I started to put my coins inside, starting from the smallest ones, in order to get rid of as many coins as I could:

> *"This is a very good way to recicle my coins!"*

I was thinking while proudly I was grabbing coins from my bag.

But I was about to discover something **very bad**!

Buying metro tickets

You cannot use more than 20 coins per transaction.
Transation cancelled.

WHAT? I thought. My entusiasm faded out!
I had inserted no more than 5 euros so far, because I was chosing all the smallest coins, while I had to pay **11.40 euros** in total!
The machine started to give me back all the coins, and, during that tragic moment, my mind was looking for a solution.

- Solution 1: I may mainly use 1 or 2 euro coins.

- But, in this way, I would not use many coins.

- Solution 2: I may ask my friend AMPL to help me.

"I need to run back home and write a precise requist!"

The request

What is my problem exactly?

- I want to get rid of as many coins as possible.

- The sum of the values of all the used coins must be the *carnet* price (11.40 euros).

- The total number of coins cannot be more than 20.

- I can only use the coins that I actually have.

- I need to tell my friend how many coins I have for each given value.

The mathematical model

Parameters

- N, integer, the number of coin values
- *totValue*, real, the price to be paid
- C, vector of length N, the values of the different coins
- nC, vector of length N, the number of coins available for a given value

Variables

- x_i, integer, indicates how many coins are used for a given value

The mathematical model

Objective function

- "*I want to get rid of as many coins as possible*"

$$\max \sum_{i=1}^{N} x_i$$

Constraints

- "*The total sum must be 11.40*" $\displaystyle\sum_{i=1}^{N} C_i \times x_i = totValue$

- "*The total number of coins is limited to 20*" $\displaystyle\sum_{i=1}^{N} x_i \leq 20$

- "*I can't use coins I don't have*" $\forall i \in \{1, 2, \ldots, n\} \quad x_i \leq nC_i$

carnet.mod

The .mod file contains the model of the problem to be solved:

```
# carnet.mod

param N integer;
param totValue;
param C {1..N};
param nC {1..N};
var x {1..N} integer, >= 0;

maximize numCoins : sum{i in 1..N} x[i];

subject to carnet_price : sum{i in 1..N} C[i] * x[i] = totValue;

subject to overall_limit : sum{i in 1..N} x[i] <= 20;

subject to limit {i in 1..N} : x[i] <= nC[i];
```

carnet.dat

The .dat file contains the data of the problem to be solved:

```
# carnet.dat

param N := 6;
param totValue := 11.40;

param : C nC :=
1 0.05 6
2 0.10 8
3 0.20 4
4 0.50 4
5 1.00 7
6 2.00 5
;
```

carnet.run

The .run file refers to the other two text files
(the model and the data),
sets the solver to be used,
and displays the final result.

```
# carnet.run

model carnet.mod;
data carnet.dat;
option solver cplex;

solve;

display numCoins;
display sum{i in 1..N} C[i] * x[i];
display x;
```

Calling AMPL

```
[antonio.mucherino@ferrari ~/ampl]$ cat carnet.run | ampl
ILOG AMPL 10.100, licensed to "ecolepolytechnique-palaiseau".
AMPL Version 20060626 (Linux 2.6.9-5.ELsmp)
ILOG CPLEX 10.100, licensed to "ecolepolytechnique-palaiseau", options: e m b q use=8
CPLEX 10.1.0: optimal integer solution; objective 20
4 MIP simplex iterations
0 branch-and-bound nodes
numCoins = 20

sum{i in 1 .. N} C[i]*x[i] = 11.4

x [*] :=
1  6
2  3
3  4
4  0
5  4
6  3
;

[antonio.mucherino@ferrari ~/ampl]$
```

The proposed exercises can be downloaded from:

www.antoniomucherino.it