EPFL
ENAC INTER TRANSP-OR
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Decision-aid Methodologies in Transportation
Spring 2014

Graded Assignment: Optimization

For this assignment you should work in the groups you have been assigned to. You can find the groups on the course website.

Frequently, banks send out vehicles to their branches to collect cash left by depositors. You work in the logistics department of a small bank which, on a particular day, needs to collect cash from 15 of its branches. Table 1 lists the 15 branches (c1 to c15). For each branch, it gives the amount of cash to be collected, the duration of the collection operation (in minutes), and the time interval $[\lambda, \mu]$ (in terms of time of the day) within which the cash can be collected. Table 2, moreover, provides the complete distance matrix in kilometers between the bank vault (v0) and the 15 bank branches (c1-c15).

Your vehicle fleet consists of 3 identical vehicles, which are assumed to travel at a constant speed of 60 km/h.

Your task is to construct the vehicle tours with the objective of minimizing the total length and duration, with equal weights, of the complete tour schedule.

The following constraints are imposed:

1. The amount of cash carried by a vehicle is limited to CHF 600'000.
2. Each branch should be visited exactly once by one vehicle.
3. The collection at each branch should begin and complete within the specified time interval $[\lambda, \mu]$. If the vehicle arrives at a branch before λ it must wait until λ to start the operation. However, the collection operation cannot continue after μ. To give an example, take branch c2. The operation at this branch can start at 12:00. If the vehicle arrives at 11:00, it should wait for 1 hour before starting collection. Given that the duration of the operation is 30m, if the vehicle arrives between 12:00 and 15:30, it can start collecting immediately, so there will be no waiting. Finally, the branch must be visited by one of the vehicles at 15:30 at the latest so that the service does not continue after 16:00.
4. All tours should start and finish at the bank vault, denoted by v0 in Table 2.
5. All tours should start and finish in the interval [8:00, 18:00]. In other words, all used vehicles can leave the vault at 8:00 at the earliest and should return to the vault at 18:00 at the latest.

Hint: *(1) You may want to duplicate the bank vault into "origin vault" and "destination vault" for the sake of modeling. They will have a distance of 0 km between each other, the same distance* *to, and the same distance from any other point. (2) Your model should determine how many (maybe all, maybe not all) of the available vehicles should be used.*

Derliverables

Please send your work by e-mail (one per group) to the teaching assistant Iliya Markov (iliya.markov@epfl.ch). The e-mail should have the subject line *assignment 2, decision-aid methodologies, group [number]* and needs to include:

- A CPLEX project, which implements a mixed integer linear model and includes the problem data. The project should be appropriately commented and should run successfully. Please attach your project as a zip archive, including the .mod file, the .dat file and all the configuration files.
- A short report of 2 to 3 pages, which includes (1) the problem summary, (2) the mathematical model that you implemented (in mathematical notation, not a copy-paste of your CPLEX code), with explanations on objective, constraints, parameters and decision variables, and (3) the following results: (3a) length and (3b) duration of the complete tour schedule, and (3c) the sequence of branches visited in each tour.

Due date: 16 May, 2014 by midnight

Grading scale: 120pt

- CPLEX project: 100pt
  - Parameters, sets and decision variables well defined: 10pt
  - Objective as described in bold above: 10pt
  - Basic routing constraints: 20pt
  - Time related constraints: 30pt
  - Correctly formatted data file: 10pt
  - Appropriate comments: 10pt
  - Runs successfully: 10pt
- Report (as described above): 20pt

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Table 1: Service specifications for branches

Branch	Amount of cash to collect	Collection duration (in minutes)	λ (o'clock)	μ (o'clock)
c1	CHF 110'000	30m	12:00	16:00
c2	CHF 150'000	30m	12:00	16:00
c3	CHF 130'000	30m	12:00	16:00
c4	CHF 80'000	30m	14:00	16:00
c5	CHF 90'000	30m	9:00	12:00
c6	CHF 90'000	30m	9:00	12:00
c7	CHF 80'000	30m	9:00	12:00
c8	CHF 80'000	30m	11:00	14:00
c9	CHF 100'000	30m	11:00	14:00
c10	CHF 110'000	30m	11:00	14:00
c11	CHF 100'000	30m	14:00	16:00
c12	CHF 50'000	30m	14:00	16:00
c13	CHF 90'000	30m	15:00	18:00
c14	CHF 100'000	30m	15:00	18:00
c15	CHF 100'000	30m	16:00	18:00

Table 2: Distance matrix (in km)

	v0	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15
v0	0	31	77	67	18	14	51	73	73	27	79	66	20	47	54	11
c1	31	0	109	94	32	18	81	102	105	55	87	89	46	70	76	21
c2	77	109	0	39	86	91	31	21	11	64	99	73	70	56	59	87
c3	67	94	39	0	83	77	23	19	46	69	61	96	71	26	24	73
c4	18	32	86	83	0	22	64	86	80	25	97	57	17	65	72	23
c5	14	18	91	77	22	0	63	85	87	40	79	77	32	54	61	4
c6	51	81	31	23	64	63	0	22	32	47	73	73	50	27	32	59
c7	73	102	21	19	86	85	22	0	30	67	80	86	72	40	41	81
c8	73	105	11	46	80	87	32	30	0	56	104	63	64	59	63	84
c9	27	55	64	69	25	40	47	67	56	0	99	39	9	57	65	38
c10	79	87	99	61	97	79	73	80	104	99	0	137	96	47	41	76
c11	66	89	73	96	57	77	73	86	63	39	137	0	46	92	99	76
c12	20	46	70	71	17	32	50	72	64	9	96	46	0	57	65	31
c13	47	70	56	26	65	54	27	40	59	57	47	92	57	0	8	51
c14	54	76	59	24	72	61	32	41	63	65	41	99	65	8	0	57
c15	11	21	87	73	23	4	59	81	84	38	76	76	31	51	57	0