1 Beasley OR Library multidimensional knapsack problems

Beasley OR library contains a set multidimensional knapsack test problems (http://people.brunel.ac.uk/ mastjjb/jeb/info.html).

There are 9 groups of problems with numbers of constraints m set to $5, 10, 30$, and the number of variables n set to $100, 250, 500$. Each group contains 30 problems, giving a total of 270 problems. Data are as described in Chu and Beasley (1998).

Coefficients $a_{i,j}$ are integers drawn at random but uniformly from the interval (0, 1000) [1].

For each $m - n$ combination, the right-hand side coefficients b_i are defined as follows:

$$b_i = \alpha \sum_{j}^{n} a_{i,j}$$

where α is a tightness ratio where α is $0.25, 0.50, 0.75$ for the first ten, for the next ten, and for the remaining ten problems, respectively.

The objective function coefficients c_j are integers correlated to $a_{i,j}$ and generated as follows:

$$c_j = \lfloor 500 q_j + \frac{1}{m} \sum_{i=1}^{m} \rfloor, \quad j = 1, ..., n,$$

where q_j is a real number drawn from the continuous uniform generator U(0, 1) and $\lfloor \cdot \rfloor$ denotes rounding down to the nearest integer.

To solve the problems Chu and Beasley used CPLEX version 4.0 on Silicon Graphics Indigo workstation (R4000, 100 MHz, 48 MB memory). The solving process was stopped whenever tree memory usage exceeded 42 MB or after 1800 CPU seconds.

Chu and Beasley were able to solve all problems from $(5-100)$, $(5-250)$ and $(10-100)$ groups to optimality. For all the remaining problems from $(5-500)$, $(10-250)$, $(10-500)$, $300-100)$, $(300-250)$, $(300-500)$ groups no optimal solution was obtained because the solving precesses reached one of the limits

[1] According to Chu and Beasley description. Actually, the data contain coefficients higher than 1000 but less than 1200.

mentioned above. For each problem the optimal or the incumbent (i.e. the best feasible solution) solution and the corresponding objective values were recorded.

2 Solving Beasley OR Library multidimensional knapsack problems on the NEOS platform

We decided to investigate the contemporary (as by 2016) effectiveness of MLIP packages. Our choice was CPLEX because it is renown as an effective and robust optimizer for MILP problems. Morever, it is accessible free of charge via NEOS platform (https://neos-server.org/neos/solvers/lp:CPLEX/LP.html). Running optimization problems on a open access platform ensures perfect result reproducibility. At the time of numerical experiments the platform run CPLEX version 12.6.2.0. With NEOS, jobs are terminated whenever time limit 8 hours of CPU or memory limit 3 Gb is reached. However, as NEOS when reaching one of those limits provides no output log, we put the memory limit to 2.048 Gb [2].

To prepare input data for CPLEX we converted all the 270 knapsack problems to the LP format. We made the converted problems publicly available via the web [3].

With CPLEX running on NEOS we were able to solve to optimality almost all problems from (5, 500) group, a few problems from (10, 250) and no problem from (10, 500) group. No attempt was made to solve problems from (30,100), (30, 250), (30, 500) group. The Table 1 summarizes the results. Numbers in parentheses denote early termination, on the NEOS platform in all cases an early termination was because of memory limit. The gap, as provided by CPLEX, is calculated as

$$\text{gap} = \frac{\text{current MIP best bound - objective function value for incumbent}}{\text{objective function value for incumbent}}$$

[2] Adviced by the NEOS support team, in all CPLEX runs we used the following CPLEX parameter settings: set workmem 128, set mip strategy file 2, set mip limits treememory 2048.

[3] http://www.ibspan.waw.pl/~kaliszew/main_page.html

Problem		CPLEX (Chu & Beasley)			CPLEX (NEOS)				
m, n	α	Av. sol. time (sec.)	Av. no. nodes	Av. gap. (%)	Av. sol. time (sec.)	Av. sol. time (ticks)	Av. no. nodes	Av. gap (%)	No. opt.
5, 500	0.25	(981.6)	64398	0.99	351.0	53924.7	9368662	0.01	10
	0.50	(1048.0)	72744	0.45	(181.5)	26629.6	4714172	0.01	9
	0.75	(1129.8)	80101	0.32	66.5	6889.8	1443435	0.01	10
10, 250	0.25	(1006.2)	69545	4.80	(362.3)	53153.3	8618316	0.12	3
	0.50	(1054.7)	78502	5.41	(423.3)	678234.5	9532148	0.07	1
	0.75	(1195.2)	81475	1.85	(331.5)	53503.0	7864490	0.02	9
10, 500	0.25	(1738.2)	68723	4.88	(260.9)	47926.7	4676405	0.15	0
	0.50	(1651.2)	68929	5.50	(227.9)	48963.5	4820390	0.07	0
	0.75	(1795.0)	68492	2.33	(174.5)	48307.5	5289940	0.04	0

Table 1: Comparison of results reported by Chu and Beasley and results of NEOS CPLEX runs.

In each case, when one is not able to solve a problem to optimality, one is left with an absolute upper bound on the optimal (here: maximal) objective function value, namely

$$\text{optimal objective function value} \leq \text{current MIP best bound}\,. \qquad (1)$$

References

[1] Chu PC, Beasley JE. A genetic algorithm for the multidimensional knapsack problem. Journal of Heuristics 1998; 4: 63-86.