

Amazing Results with ODH | CPLEX

Optimization Direct Inc.

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MIPLIB 2017 Open-v7 Models

- Public collection of 286 models to which an optimal solution has not been proven
- 257 models are known to have a feasible solution
- No solution found to 29 models
- ODH|CPLEX run for *2 hours* with *default* settings
 - except one model which required integrality tolerance of $1e-6$
- Proves optimality on 15 models (5 to zero optimality gap)
- Finds better solutions than the 'best known' in 2 hours to 126 (49%) of them
- Finds solutions to 5 models where no solution found before



Better Solutions: 8 Threads, 2 hrs

- Better solutions on 39%, matched on 19%
- 'Top Ten':

time is time to beat best known solution in seconds

Model	Best known	ODH Soln	Diff	Gap	Time
rmine25	-2553.479	-10831.51	324.2%	240%	2792
rmine21	-2645.005	-10500.37	297.0%	1.70%	2613
mining	531134254.8	-793124325	249.3%	16.25%	512
eva1aprime6x6opt	-3.04087066	-6.764053	122.4%	6795%	84
lr1dr12vc10v70b-t360	8892940.708	1196600.61	86.5%	17.70%	137
fastxgemm-n3r23s5t6	27087	6087	77.5%	98.62%	901
neos-4292145-piako	112705.8	37302	66.9%	58.38%	300
allcolor58	3378	1403	58.5%	97.01%	516
allcolor10	159	67	57.9%	91.04%	92
neos-5273874-yomtsa	128.7594515	54.889718	57.4%	100%	809



Better Solutions: 16 Threads, 2 hrs

- Better solutions on 45%, matched on 20%
- 'Top Ten':

time is time to beat best known solution in seconds

Model	Best known	ODH Soln	Diff	Gap	Time
lr1dr12vc10v70b-t360	8892940.7	1166516.6	86.9%	15.59%	1
neos-3754224-navua	2094267.6	280713.6	86.6%	80.01%	3836
fastxgemm-n3r23s5t6	27087	6087	77.5%	98.62%	35
fastxgemm-n3r22s4t6	21084	6087	71.1%	98.62%	628
neos-4292145-piako	112705.8	33063.0	70.7%	53.06%	287
allcolor58	3378	1157	65.7%	96.37%	68
allcolor10	159	63	60.4%	90.48%	25
graphdraw-grafo2	230722.5	95024.5	58.8%	62.22%	957
fastxgemm-n3r21s3t6	21084	9084	56.9%	99.08%	269
neos-4230265-orari	187078.4	86663.0	53.7%	53.72%	503



Optimal Solutions: 8 Threads, 2 hrs

Proved optimality on 13 models: 4 completed search ('zero tolerance')

Model	Best known	ODH Soln	Diff	Gap	Time
graph20-80-1rand	-6	-6	0.00%	0.00%	7165
neos-4335793-snake	43	27	37.2%	0.00%	4510
neos-954925	-237.769	-237.769	0.0%	0.00%	2391
breastcancer-regularized	35.71	35.77	-0.15%	0.00%	9
snp-06-004-052	1869531920	1869538126	0.0%	0.00%	474
neos-4290317-perth	3017386	3017333	0.0%	0.01%	5900
neos-3068746-nene	61910284	61910284	0.0%	0.01%	3420
gmut-76-40	-14169443	-14168137	0.0%	0.01%	141
minutedispatchstrategy	3109.9	3109.9	0.0%	0.01%	5545
gmut-76-50	-14171398	-14170547	0.0%	0.01%	1491
snp-10-004-052	5906642866	5906784484	0.0%	0.00%	1168
supportcase31	-3720089	-3719727	-0.01%	0.01%	107
neos-4647032-veleka	27214.48	27215.63	0.0%	0.01%	441

Optimal Solutions: 16 Threads, 2 hrs

Proved optimality on 15 models: 5 completed search ('zero tolerance')

Model	Best known	ODH Soln	Diff	Gap	Time
graph20-80-1rand	-6	-6	0.0%	0.00%	6790
neos-4335793-snake	43	27	37.2%	0.00%	3553
neos-5273874-yomtsa	128.7594515	71.034717	44.8%	0.00%	1615
cmflsp50-24-10-4	58988866.75	58988866.75	0.0%	0.01%	5808
breastcancer-regularized	35.71	35.77	-0.15%	0.00%	9
supportcase31	-3720089.081	-3719946.779	0.0%	0.00%	200
snp-10-004-052	5906642866	5906855975	0.0%	0.00%	2149
triptim8	2566.069	2566.078	0.0%	0.00%	6343
snp-06-004-052	1869531920	1869536526	0.0%	0.00%	542
gmut-76-40	-14169441.78	-14168131.27	0.0%	0.01%	167
neos-954925	-237.7688889	-237.753333	0.0%	0.01%	11
gmut-76-50	-14171397.83	-14170484.74	0.0%	0.01%	2482
neos-4647032-veleka	27214.4801	27215.6252	0.0%	0.01%	486
minutedispatchstrategy	3109.903478	3109.903478	0.0%	0.01%	1146
neos-3068746-nene	61910283.69	61910283.69	0.0%	0.01%	797

Useable Solutions: 8 Threads, 2 hrs

Useable results on *at least 7* models where none available before:

- ODH gives gap < 5%
- previous gap > 5%

Model	Best known	ODH Soln	Diff	Gap
neos-4335793-snake	43	27	37.2%	0.00%
adult-regularized	7022.95	10.16	99.9%	0.01%
pizza27i	773290	701882	9.2%	1.24%
rmine21	-2645.00	-10500.37	297%	1.70%
lr1dr04vc05v17a-t360	416992.41	255588.98	38.7%	3.04%
fhnw-binschedule0	16642	16188	2.7%	3.37%
bppc6-06	212	210	0.9%	4.29%



Useable Solutions: 16 Threads, 2 hrs

Useable results on *at least 10* models where none available before:

- ODH gives gap < 5%
- previous gap > 5%

Model	Best known	ODH Soln	Diff	Gap
neos-4335793-snake	43	27	37.2%	0.0%
neos-5273874-yomtsa	128.7594515	71.034717	44.8%	0.0%
adult-regularized	7022.953543	27.164393	99.6%	0.0%
tpl-tub-ss16	256344	150755	41.2%	0.2%
pizza27i	773290	701882	9.2%	1.2%
neos-4531126-vouga	544045.0658	525053.6089	3.5%	2.4%
lr1dr04vc05v17a-t360	416992.4113	254971.5945	38.9%	2.8%
fhnw-binschedule0	16642	16128	3.1%	3.0%
bppc6-06	212	210	0.9%	4.3%
z26	-1101	-1184	7.5%	4.8%



New Solutions: 8 Threads, 2 hrs

Gets solutions to 5 models of 29 where no solution found before

Model	ODH Soln	Gap
kosova1	2027	100.00%
neos-3740487-motru	164.4692	7.49%
neos-4535459-waipa	26192754	100.00%
neos-4545615-waita	8879	59.18%
neos-5189128-totara	35987269	98.69%



New Solutions: 16 Threads, 2 hrs

Gets solutions to 4 models of 29 where no solution found before

Model	ODH Soln	Gap
kosova1	526	100.00%
neos-4545615-waita	7624	52.45%
neos-3740487-motru	164.4692	7.49%
neos-4535459-waipa	26192754	100.00%



16 Threads vs. 8 Threads, 2 hours

- Compare 16 and 8 threads on the same models
- 16 threads on 24 core Xeon E5-2690v3 3GHz
- 8 threads on 4 core i7-4790K 4GHz
- 2 hours' run time

	16 Threads		8 Threads	
Better	116	45.1%	101	39.3%
Match	51	19.8%	48	18.7%
Worse	90	35.0%	108	42.0%
Total	257		257	

Conclusions

- MIPLIB 2017 has 286 open models
 - 257 are known to have a solution
 - no solution has been found to 29 models
- ODH | CPLEX can find better solutions than previously known to 49% of the models known to have a solution *in only 2 hours with default settings*
- ODH | CPLEX can find solutions to 5 models where no solution previously found *in only 2 hours with default settings*
- Parallel solution methods best way of exploiting modern hardware



Benchmarking and Evaluation

- If you think that ODHeuristics and/or ODH | CPLEX might work for you:
- send us your difficult matrices and we will send you the results
- request an evaluation copy