Submitted to *INFORMS Journal on Computing*

A Machine Learning-Based Approximation of Strong Branching Supplemental material

Alejandro Marcos Alvarez, Quentin Louveaux, Louis Wehenkel
Université de Liège, Department of EE&CS,
Sart-Tilman B28, Liège, Belgium, {amarcos,q.louveaux,l.wehenkel}@ulg.ac.be

---

These appendices constitute the supplemental material of the paper entitled *A Machine Learning-Based Approximation of Strong Branching* made available to the reader.

Appendix A: About ExtraTrees parameters

As mentioned in Section 3.2 of the main document, the performances of the ExtraTrees are very robust with respect to the choice of their parameters. The ExtraTrees actually have three parameters: N, which is the number of trees in the method, k, which is the number of features evaluated at each node during the creation of the trees, and $n_{\min}$, which is the number of learning samples contained in a node below which that node becomes a leaf. The number of trees is set to the default value of $N = 100$ in our experiments. The parameter k, which represents the number of features that are considered for the creation of the next node in the ExtraTrees, is also set to a default value of $k = |\phi|$. The exact understanding of these parameters is beyond the scope of this appendix, and we refer the reader to (Geurts et al. 2006) for a deeper explanation.

Tables 1, 2, 3 and 4 compare the influence of the parameter $n_{\min}$ on the performance of the method. The experiments are the same as those shown in Section 5.3 of the main document. The main observation that can be made from those tables is that the parameter $n_{\min}$ influences the computational time, but not the accuracy of the taken decisions. Indeed, the greater the $n_{\min}$, the faster the method. This behavior was expected, as a large $n_{\min}$ produces smaller trees, generally yielding a reduced computational time required to take a branching decision. On the other hand, the third column of the tables 1 and 4, and the sixth column of the table 2, all of which correspond to the gap closed after the node limit has been reached, show that

Table 1 **Results for the problems of BPEQ_test, BPSC_test and MKNSC_test.**

	Node limit (10^5 nodes)			Time limit (10 min.)		
	S/T	Cl. Gap	Time (s)	S/T	Cl. Gap	Nodes
Learned - $n_{\min} = 1$	0/150	0.62	72.23	16/150	0.81	104,090
Learned - $n_{\min} = 5$	0/150	0.62	63.28	19/150	0.82	114,389
Learned - $n_{\min} = 10$	0/150	0.62	61.91	21/150	0.83	122,038
Learned - $n_{\min} = 20$	0/150	0.62	54.23	23/150	0.84	131,994

Table 2 **Results for the MIPLIB problems. Node limit = 10^5 nodes.**

	Solved by all methods			Not solved by at least one method			
	S/T	Nodes	Time (s)	S/T	Cl. Gap	Nodes	Time (s)
Learned - $n_{\min} = 1$	9/44	1,436	3.42	11/44	0.63	8,084	110.70
Learned - $n_{\min} = 5$	9/44	1,229	3.25	10/44	0.62	8,176	103.34
Learned - $n_{\min} = 10$	9/44	1,437	5.45	10/44	0.63	8,083	84.75
Learned - $n_{\min} = 20$	9/44	1,194	2.73	10/44	0.62	8,073	162.87

Table 3 **Results for the MIPLIB problems. Time limit = 10 min.**

	Solved by all methods			Not solved by at least one method			
	S/T	Nodes	Time (s)	S/T	Cl. Gap	Nodes	Time (s)
Learned - $n_{\min} = 1$	19/44	13,887	36.19	5/44	0.64	112,810	510.72
Learned - $n_{\min} = 5$	19/44	15,310	38.46	5/44	0.64	116,493	525.46
Learned - $n_{\min} = 10$	19/44	14,647	37.42	7/44	0.65	124,346	499.55
Learned - $n_{\min} = 20$	19/44	14,008	34.12	5/44	0.63	130,081	512.72

Table 4 **Results for the problems from BPSC_test. Comparison between the strategy learned on the entire dataset and the strategy learned only from BPSC_train examples.**

	Node limit (10^5 nodes)			Time limit (10 min.)		
	S/T	Cl. Gap	Time (s)	S/T	Cl. Gap	Nodes
Learned - $n_{\min} = 1$	0/50	0.47	76.20	0/50	0.63	83,938
Learned - $n_{\min} = 5$	0/50	0.47	67.31	0/50	0.64	94,826
Learned - $n_{\min} = 10$	0/50	0.47	68.58	0/50	0.65	102,941
Learned - $n_{\min} = 20$	0/50	0.48	56.36	0/50	0.67	112,918
Learned - $n_{\min} = 1$ - BPSC only	0/50	0.51	90.69	0/50	0.67	77,174
Learned - $n_{\min} = 5$ - BPSC only	0/50	0.51	79.53	0/50	0.67	82,535
Learned - $n_{\min} = 10$ - BPSC only	0/50	0.51	72.79	0/50	0.68	92,586
Learned - $n_{\min} = 20$ - BPSC only	0/50	0.51	60.54	0/50	0.70	109,066

the accuracy of the taken decision is not influenced by $n_{\min}$ in the range of tested values. These observations illustrate that the method is actually robust to the choice of $n_{\min}$.

Besides the experiments included in this appendix, further work should focus on a more detailed study of the influence of the different parameters of the ExtraTrees on the performance of the optimization procedure.

Table 5 List of problems from MIPLIB3 and MIPLIB2003.

10teams	aflow30a	aflow40b	air03	air04	air05	cap6000	dcmulti
egout	fiber	fixnet6	harp2	khb05250	l152lav	lseu	mas74
mas76	misc03	misc06	misc07	mitre	mod008	mod010	mod011
modglob	nw04	opt1217	p0033	p0201	p0282	p0548	p2756
pk1	pp08a	pp08aCUTS	qiu	rentacar	rgn	set1ch	stein27
stein45	tr12-30	vpm1	vpm2				

Table 6 Updated list of problems from MIPLIB3 and MIPLIB2003. This list contains the problems from Table 5 that are solved to optimality with each branching heuristic in less than five days.

aflow30a	air03	air04	air05	cap6000	dcmulti
egout	khb05250	l152lav	lseu	mas76	misc03
misc06	misc07	mitre	mod008	mod010	mod011
nw04	p0033	p0201	pk1	pp08aCUTS	qiu
rentacar	rgn	stein27	stein45	vpm1	vpm2

Appendix B: Detailed experimental results

This appendix contains the detailed experimental results for the MIPLIB problems used in our experiments. Averaging the following results over all problems gives the aggregated results shown in the main paper. The detailed results are given in Tables 7 through 20.

The first set of tables, i.e., Tables 7 through 14, reports the results for the MIPLIB problems contained in Table 5 when limits are set either on the number of nodes or on the time spent. The B&B version that is used for these experiments is pure, i.e., no cuts nor heuristics are used.

The second set of tables, i.e., Tables 15 through 20, reports the optimization results for the problems contained in Table 6. These problems are obtained by keeping from the initial list the problems that are solved within a 5 days time limit with all considered branching strategies. Tables 15 through 20 then report the optimization results with no time (or node) limit on the second list of MIPLIB problems. Additionally, the second half of these tables contain the results when CPLEX's cuts and heuristics are used in the course of the optimization. The first half still corresponds to the pure version of B&B.

Table 7 Detailed results for the MIPLIB problems (1/4). Node limit = 10^5 nodes.

	Problem names	10teams	aflow30a	aflow40b	air03	air04	air05	cap6000	dcmulti	egout	fiber	fixnet6
	LP Obj.	917	983.17	1,005.66	338,864	55,535.40	25,877.60	-2,450,000	183,976	149.59	156,083	1,200.88
	True Obj.	924	1,158	1,170	340,160	56,100	26,374	-2,450,000	188,182	568.10	405,935	3,983
	Fin. by all	0	0	0	1	0	0	0	0	0	0	0
Method												
Random	Fin.	4	5	5	0	4	4	5	5	4	5	5
	Obj.	917	1,051.18	1,043.31	340,160	55,946.50	26,234.50	-2,450,000	187,298	562.60	189,746	1,573.11
	Nodes	10,000	10,000	10,000	25	10,000	10,000	10,000	10,000	10,000	10,000	10,000
	Time	364.40	9.35	44.47	1.45	2,219.56	1,173.48	30.70	5.61	1.12	5.39	4
	Cl. Gap	0	0.39	0.23	1	0.68	0.72	0.41	0.79	0.99	0.13	0.13
MIB	Fin.	4	5	5	0	4	5	5	0	0	5	5
	Obj.	920	1,059.97	1,038.70	340,160	55,980.80	26,270.30	-2,450,000	188,182	568.10	184,391	2,004.30
	Nodes	10,000	10,000	10,000	7	10,000	10,000	10,000	9,493	7,015	10,000	10,000
	Time	251.55	10.44	46.41	0.60	5,965.28	1,516.76	29.02	4.44	0.79	5.91	4.12
	Cl. Gap	0.43	0.44	0.20	1	0.74	0.79	0.41	1	1	0.11	0.29
NCB	Fin.	0	5	5	0	0	0	5	0	0	5	5
	Obj.	924	1,117.99	1,099.12	340,160	56,137	26,374	-2,450,000	188,182	568.10	359,328	2,528.38
	Nodes	1,453	10,000	10,000	3	131	215	10,000	1,065	5,713	10,000	10,000
	Time	456.18	98.16	354.31	2.04	1,146.13	772.90	147.50	2.99	1.94	52.82	74.06
	Cl. Gap	1	0.77	0.58	1	1	1	0.44	1	1	0.81	0.48
FSB	Fin.	0	5	5	0	0	0	5	0	0	5	5
	Obj.	924	1,120.14	1,099.87	340,160	56,137	26,400	-2,450,000	188,182	568	362,329	2,482.51
	Nodes	259	10,000	10,000	3	111	177	10,000	927	4,730	10,000	10,000
	Time	1,215.41	217.34	979.50	2.75	3,249.42	3,840	159	4.83	2.16	267.72	246.11
	Cl. Gap	1	0.78	0.58	1	1	1	0.44	1	1	0.83	0.46
RB	Fin.	5	5	5	0	0	0	5	0	0	5	5
	Obj.	917	1,103.69	1,089.99	340,160	56,137	26,374	-2,450,000	188,182	568.10	287,517	2,322.90
	Nodes	10,000	10,000	10,000	3	3,601	1,489	10,000	1,013	9,143	10,000	10,000
	Time	1,200.43	37.74	136.16	0.53	2,786.84	1,461.74	118	1.79	2.37	18.77	18.36
	Cl. Gap	0	0.69	0.52	1	1	1	0.44	1	1	0.53	0.40
Learned	Fin.	0	5	5	0	0	4	5	0	0	5	5
	Obj.	924	1,064.88	1,039.41	340,160	56,137	26,284.40	-2,450,000	188,182	568.10	313,565	2,239.68
	Nodes	1,739	10,000	10,000	3	3,833	10,000	10,000	1,565	3,007	10,000	10,000
	Time	108.16	57.10	146.12	0.48	1,648.75	2,237.31	45.80	2.76	1.31	42.17	61.90
	Cl. Gap	1	0.47	0.21	1	1	0.82	0.44	1	1	0.63	0.37

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 8 Detailed results for the MIPLIB problems (2/4). Node limit = 10^5 nodes.

	Problem names	harp2	khb05250	l152lav	lseu	mas74	mas76	misc03	misc06	misc07	mitre	mod008
	LP Obj.	-74,300,000	95,900,000	4,656.36	834.68	10,482.80	38,893.90	1,910	12,841.70	1,415	114,741	290.93
	True Obj.	-73,900,000	107,000,000	4,722	1,120	11,801.20	40,005.10	3,360	12,850.90	2,810	115,155	307
	Fin. by all	0	0	0	0	0	0	1	1	0	0	0
Method												
Random	Fin.	5	4	4	5	5	5	0	0	4	5	4
	Obj.	-74,300,000	107,000,000	4,700.21	1,005.77	10,860.40	39,280.80	3,360	12,851.10	2,294.29	115,094	305.69
	Nodes	10,000	10,000	10,000	10,000	10,000	10,000	1,179	527	10,000	10,000	10,000
	Time	16.92	6.17	32.30	1.10	3.37	3.04	0.51	0.69	10.44	182.61	1.50
	Cl. Gap	0.16	0.98	0.67	0.60	0.29	0.35	1	1.02	0.63	0.85	0.92
MIB	Fin.	5	0	4	5	5	5	0	0	4	0	0
	Obj.	-74,300,000	107,000,000	4,705.10	1,062.44	10,877	39,301.10	3,360	12,850.90	2,574.11	115,155	307
	Nodes	10,000	7,477	10,000	10,000	10,000	10,000	629	551	10,000	986	9,091
	Time	15.67	4.95	35.04	1.11	3.42	3.08	0.32	0.76	9	30.06	1.49
	Cl. Gap	0.14	1	0.74	0.80	0.30	0.37	1	1	0.83	1	1
NCB	Fin.	5	0	0	4	5	5	0	0	4	0	0
	Obj.	-74,100,000	107,000,000	4,722	1,093.29	11,041.20	39,371.80	3,360	12,850.90	2,487.50	115,155	307
	Nodes	10,000	1,527	213	10,000	10,000	10,000	579	56	10,000	617	4,605
	Time	95.59	4.76	4.53	5.16	28.23	23.72	2.65	0.58	152.62	49.18	2.85
	Cl. Gap	0.63	1	1	0.91	0.42	0.43	1	1	0.77	1	1
FSB	Fin.	5	0	0	5	5	5	0	0	4	0	0
	Obj.	-74,100,000	107,000,000	4,722	1,088.06	11,041.80	39,410.90	3,360	12,850.90	2,537.50	115,000	307
	Nodes	10,000	1,502	238	10,000	10,000	10,000	371	55	10,000	709	3,333
	Time	336	7.27	47.67	8.37	44.55	35.20	2.78	1.20	378.26	139	1.77
	Cl. Gap	0.65	1	1	0.89	0.42	0.47	1	1	0.80	1	1
RB	Fin.	5	0	0	4	5	5	0	0	4	0	0
	Obj.	-74,100,000	107,000,000	4,722	1,095.03	11,008	39,368	3,360	12,850.90	2,668.33	115,155	307
	Nodes	10,000	1,685	611	10,000	10,000	10,000	641	62	10,000	1,900	2,927
	Time	43.14	2.21	6.71	2.68	9.43	8.12	1.89	0.54	48.44	130.35	1.24
	Cl. Gap	0.56	1	1	0.91	0.40	0.43	1	1	0.90	1	1
Learned	Fin.	5	0	0	4	5	5	0	0	5	0	0
	Obj.	-74,100,000	107,000,000	4,722	1,083.23	10,914.30	39,321	3,360	12,850.90	2,410	115,155	307
	Nodes	10,000	5,790	1,061	10,000	10,000	10,000	1,865	161	10,000	470	6,365
	Time	59.84	8.29	8.77	6.90	21.87	16.38	2.29	0.53	35.01	26.31	3.81
	Cl. Gap	0.41	1	1	0.87	0.33	0.38	1	1	0.71	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 9 Detailed results for the MIPLIB problems (3/4). Node limit = 10^5 nodes.

	Problem names	mod010	mod011	modglob	nw04	opt1217	p0033	p0201	p0282	p0548	p2756	pk1
	LP Obj.	6,532.08	-62,100,000	20,400,000	16,310.70	-20.02	2,520.57	6,875	176,868	429.68	2,698.95	0
	True Obj.	6,548	-54,600,000	20,700,000	16,862	-16	3,089	7,615	258,411	8,691	3,124	11
	Fin. by all	0	0	0	1	0	1	1	0	0	0	0
Method												
Random	Fin.	4	5	5	0	5	0	0	5	5	5	5
	Obj.	6,543	-57,400,000	20,500,000	16,862	-20.02	3,089	7,615	184,159	1,422.30	2,713.04	2.38
	Nodes	10,000	10,000	10,000	259	10,000	4,859	649	10,000	10,000	10,000	10,000
	Time	21.46	67.20	3.31	10.80	6.83	0.31	0.45	2.36	4.10	12.33	2.72
	Cl. Gap	0.69	0.62	0.33	1	0	1	1	0.09	0.12	0.03	0.22
MIB	Fin.	0	5	5	0	5	0	0	5	5	5	5
	Obj.	6,548	-55,700,000	20,600,000	16,862	-20.02	3,089	7,615	181,564	512.38	2,702.63	3.05
	Nodes	532	10,000	10,000	1,737	10,000	6,265	4,747	10,000	10,000	10,000	10,000
	Time	3.74	77.08	3.34	45.13	6.82	0.35	2.37	2.56	3.16	9.92	2.66
	Cl. Gap	1	0.84	0.57	1	0	1	1	0.06	0.01	0.01	0.28
NCB	Fin.	0	5	5	0	5	0	0	0	5	5	5
	Obj.	6,548	-55,000,000	20,600,000	16,862	-19.80	3,089	7,615	258,411	8,678.53	2,925.78	4.79
	Nodes	96	10,000	10,000	355	10,000	745	173	624	10,000	10,000	10,000
	Time	2.47	2,764.36	24.84	62.49	17	0.10	1.16	1.12	24.01	142.83	33.08
	Cl. Gap	1	0.94	0.66	1	0.06	1	1	1	1	0.53	0.44
FSB	Fin.	0	5	5	0	5	0	0	0	0	5	5
	Obj.	6,548	-55,000,000	20,600,000	16,862	-19.77	3,089	7,615	258,411	8,690	2,942.55	4.54
	Nodes	31	10,000	10,000	233	10,000	363	186	502	8,920	10,000	10,000
	Time	3.33	3,815.40	63.53	82.35	150.78	0.07	3.71	1.29	24.80	483.98	53.50
	Cl. Gap	1	0.94	0.70	1	0.06	1	1	1	1	0.57	0.41
RB	Fin.	0	5	5	0	5	0	0	0	5	5	5
	Obj.	6,548	-55,300,000	20,600,000	16,862	-19.92	3,089	7,615	258,411	4,881.29	2,715.33	4.07
	Nodes	83	10,000	10,000	1,201	10,000	1,150	359	767	10,000	10,000	10,000
	Time	3.26	991.97	9.07	116.97	16.27	0.15	1.51	0.97	20.97	64.81	9.59
	Cl. Gap	1	0.90	0.58	1	0.03	1	1	1	0.54	0.04	0.37
Learned	Fin.	0	5	5	0	5	0	0	0	5	5	5
	Obj.	6,548	-55,900,000	20,600,000	16,862	-19.98	3,090	7,615	258,411	8,640.78	2,721.47	2.96
	Nodes	123	10,000	10,000	235	10,000	291	612	8,614	10,000	10,000	10,000
	Time	1.58	127.51	22.36	10.80	39.96	0.07	1.78	7.55	23.56	110.99	17.70
	Cl. Gap	1	0.83	0.45	1	0.01	1	1	1	0.99	0.05	0.27

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 10 Detailed results for the MIPLIB problems (4/4). Node limit = 10^5 nodes.

	Problem names	pp08a	pp08aCUTS	qiu	rentacar	rgn	set1ch	stein27	stein45	tr12-30	vpm1	vpm2
	LP Obj.	2,748.35	5,480.61	-931.64	28,800,000	48.80	32,007.70	13	22	14,210.40	15.42	9.89
	True Obj.	7,350	7,350	-132.87	30,400,000	82.20	54,537.80	18	30	131,000	20	13.75
	Fin. by all	0	0	0	1	1	0	1	0	0	0	0
Method												
Random	Fin.	5	5	5	0	0	5	0	5	5	5	5
	Obj.	4,270.24	6,265.34	-350.96	30,400,000	82.20	36,346.60	18	27.50	21,683.40	16.63	11.33
	Nodes	10,000	10,000	10,000	41	5,947	10,000	4,283	10,000	10,000	10,000	10,000
	Time	1.77	4.44	97.92	4.54	0.83	3.73	0.60	3.99	4.40	2.48	3.01
	Cl. Gap	0.33	0.42	0.73	1	1	0.19	1	0.69	0.06	0.27	0.37
MIB	Fin.	5	5	5	0	0	5	0	5	5	5	5
	Obj.	4,601.49	6,269.34	-344.50	30,400,000	82.20	35,370.60	18	27.33	23,785.10	16.97	11.32
	Nodes	10,000	10,000	10,000	26	4,147	10,000	4,681	10,000	10,000	10,000	10,000
	Time	1.77	5.07	88.89	3.48	0.58	3.87	0.64	3.75	4.73	2.58	3.17
	Cl. Gap	0.40	0.42	0.74	1	1	0.15	1	0.67	0.08	0.34	0.37
NCB	Fin.	5	5	5	0	0	5	0	5	5	5	5
	Obj.	5,078.04	6,729.63	-156.37	30,400,000	82.20	39,908.60	18	27.50	26,409.90	18.23	12.53
	Nodes	10,000	10,000	10,000	26	2,735	10,000	3,240	10,000	10,000	10,000	10,000
	Time	18.01	58.62	1,403.40	24.52	1.03	37.06	1.77	47.48	50.81	10.54	36.48
	Cl. Gap	0.51	0.67	0.97	1	1	0.35	1	0.69	0.10	0.61	0.69
FSB	Fin.	5	5	5	0	0	5	0	5	5	5	5
	Obj.	5,174.11	6,697.22	-216.31	30,400,000	82.20	40,156.80	18	28.07	27,009.20	18.05	12.50
	Nodes	10,000	10,000	10,000	26	2,849	10,000	2,141	10,000	10,000	10,000	10,000
	Time	73.86	199.13	3,404.77	32.19	1.74	592	3.51	181.32	1,724.58	28.28	66.18
	Cl. Gap	0.53	0.65	0.90	1	1	0.36	1	0.76	0.11	0.57	0.67
RB	Fin.	5	5	4	0	0	5	0	5	5	5	5
	Obj.	4,659.35	6,567.33	-143.30	30,400,000	82.20	40,319	18	27.50	26,487	17.78	11.89
	Nodes	10,000	10,000	10,000	21	2,701	10,000	3,980	10,000	10,000	10,000	10,000
	Time	6.23	15.49	436.22	18.23	0.77	9.60	1.41	21.27	13.61	5.67	19
	Cl. Gap	0.42	0.58	0.99	1	1	0.37	1	0.69	0.11	0.52	0.52
Learned	Fin.	5	5	5	0	0	5	0	5	5	5	5
	Obj.	4,730.36	6,490.81	-279.63	30,400,000	82.20	39,600	18	27.50	24,065.90	16.95	11.35
	Nodes	10,000	10,000	10,000	36	3,401	10,000	4,140	10,000	10,000	10,000	10,000
	Time	42.04	51.12	152.68	4.32	1.20	120	3.13	31.06	366.50	16.07	31.62
	Cl. Gap	0.43	0.54	0.82	1	1	0.34	1	0.69	0.08	0.33	0.38

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 11 Detailed results for the MIPLIB problems (1/4). Time limit = 600 seconds.

	Problem names	10teams	aflow30a	aflow40b	air03	air04	air05	cap6000	dcmulti	egout	fiber	fixnet6
	LP Obj.	917	983.17	1,005.66	338,864	55,535.40	25,877.60	-2,451,540	183,976	149.59	156,083	1,200.88
	True Obj.	924	1,158	1,168	340,160	56,137	26,374	-2,451,200	188,182	568.10	405,935	3,983
	Fin. by all	0	0	0	1	0	0	1	1	1	0	0
Method												
Random	Fin.	4	5	5	0	5	4	0	0	0	5	5
	Obj.	917	1,105.30	1,061.77	340,160	55,798.10	26,181.90	-2,451,380	188,182	568.10	217,681	1,837.57
	Nodes	20,337	603,128	141,714	25	762	3,742	81,127	87,985	11,855	1,076,478	1,304,269
	Time	600.01	600.01	600.01	1.45	600.02	600.02	263.52	46.17	1.31	600.01	600.01
	Cl. Gap	0	0.70	0.35	1	0.44	0.61	0.47	1	1	0.25	0.23
MIB	Fin.	4	5	5	0	5	5	0	0	0	5	5
	Obj.	920.27	1,114.89	1,057.98	340,160	55,849.90	26,221	-2,451,340	188,182	568.10	216,400	2,481.05
	Nodes	28,721	565,662	133,573	7	872	3,877	22,637	9,493	7,015	966,294	1,250,501
	Time	600.01	600.01	600.01	0.60	600.10	600.02	64.25	4.48	0.80	600.01	600.01
	Cl. Gap	0.47	0.75	0.32	1	0.52	0.69	0.59	1	1	0.24	0.46
NCB	Fin.	0	5	4	0	5	5	0	0	0	0	5
	Obj.	924	1,103.67	1,141.45	340,160	55,787.30	26,285.90	-2,451,340	188,182	568.10	405,935	2,766.69
	Nodes	1,453	16,178	52,727	3	12	104	17,214	1,065	5,713	88,143	69,931
	Time	456.95	600.01	600.01	2.04	600.06	600.01	261.12	3.04	1.99	275.17	600.01
	Cl. Gap	1	0.69	0.84	1	0.42	0.82	0.59	1	1	1	0.56
FSB	Fin.	5	4	5	0	5	5	0	0	0	4	5
	Obj.	923	1,135.33	1,095.06	340,160	55,632.60	26,139.10	-2,451,340	188,182	568.10	380,621	2,593.05
	Nodes	102	27,814	6,023	3	6	23	15,732	927	4,725	24,604	25,867
	Time	600.10	600.01	600.01	2.76	600.18	600.16	254.21	4.87	2.23	600.01	600.01
	Cl. Gap	0.86	0.87	0.55	1	0.16	0.53	0.59	1	1	0.90	0.50
RB	Fin.	5	4	5	0	5	5	0	0	0	4	5
	Obj.	917	1,149.05	1,102.58	340,160	55,823.60	26,227.20	-2,451,340	188,182	568.10	382,623	2,773.55
	Nodes	4,018	147,308	44,452	3	247	612	18,989	1,013	9,143	289,900	343,403
	Time	600.01	600.01	600.01	0.52	600.03	600.02	225.13	1.80	2.39	600.01	600.01
	Cl. Gap	0	0.95	0.60	1	0.48	0.70	0.59	1	1	0.91	0.57
Learned	Fin.	0	5	5	0	5	5	0	0	0	5	5
	Obj.	924	1,104.13	1,046.45	340,160	55,992.20	26,224.70	-2,451,380	188,182	568.10	372,086	2,411.64
	Nodes	1,739	120,872	43,281	3	553	2,083	66,587	1,565	3,007	150,084	104,029
	Time	108.28	600.01	600.01	0.49	600.01	600.01	314.71	2.74	1.31	600.01	600.01
	Cl. Gap	1	0.69	0.25	1	0.76	0.70	0.47	1	1	0.86	0.44

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 12 Detailed results for the MIPLIB problems (2/4). Time limit = 600 seconds.

	Problem names	harp2	khb05250	l152lav	lseu	mas74	mas76	misc03	misc06	misc07	mitre	mod008
	LP Obj.	-74,325,200	95,919,500	4,656.36	834.68	10,482.80	38,893.90	1,910	12,841.70	1,415	114,741	290.93
	True Obj.	-73,899,300	106,940,000	4,722	1,120	11,801.20	40,005.10	3,360	12,850.90	2,810	115,155	307
	Fin. by all	0	1	1	1	0	0	1	1	1	0	1
Method												
Random	Fin.	5	0	0	0	5	4	0	0	0	5	0
	Obj.	-74,231,300	106,940,000	4,722	1,120	11,227.40	39,899.60	3,360	12,851.10	2,810	115,131	307
	Nodes	219,404	11,555	57,281	112,035	1,092,445	1,662,754	1,179	527	82,081	63,300	10,307
	Time	600.03	7.15	107.70	10.23	600.01	600.01	0.52	0.70	53.43	600.01	1.54
	Cl. Gap	0.22	1	1	1	0.56	0.91	1	1.02	1	0.94	1
MIB	Fin.	5	0	0	0	5	4	0	0	0	0	0
	Obj.	-74,236,200	106,940,000	4,722	1,120	11,245.90	39,888.20	3,360	12,850.90	2,810	115,155	307
	Nodes	260,188	7,477	42,037	52,413	1,046,064	1,230,909	629	551	24,005	986	9,091
	Time	600.03	4.96	96.91	6.10	600.01	600.01	0.33	0.77	15.88	30.04	1.51
	Cl. Gap	0.21	1	1	1	0.58	0.89	1	1	1	1	1
NCB	Fin.	5	0	0	0	5	4	0	0	0	0	0
	Obj.	-74,019,800	106,940,000	4,722	1,120	11,349.60	39,784.90	3,360	12,850.90	2,810	115,155	307
	Nodes	52,988	1,527	213	18,533	171,360	234,705	579	56	32,873	617	4,605
	Time	600.01	4.79	4.57	7.24	600.01	600.01	2.71	0.59	254.98	49.25	2.91
	Cl. Gap	0.72	1	1	1	0.66	0.80	1	1	1	1	1
FSB	Fin.	5	0	0	0	5	4	0	0	0	0	0
	Obj.	-74,040,700	106,940,000	4,722	1,120	11,310.80	39,786.60	3,360	12,850.90	2,810	115,155	307
	Nodes	17,259	1,502	238	24,957	132,769	178,936	371	55	25,551	709	3,333
	Time	600.02	7.40	48.17	16.65	600.01	600.01	2.83	1.22	591.65	139.18	1.81
	Cl. Gap	0.67	1	1	1	0.63	0.80	1	1	1	1	1
RB	Fin.	5	0	0	0	5	0	0	0	0	0	0
	Obj.	-74,034,800	106,940,000	4,722	1,120	11,481.90	40,005.10	3,360	12,850.90	2,810	115,155	307
	Nodes	115,774	1,685	611	16,933	547,986	621,181	641	62	19,179	1,900	2,927
	Time	600.03	2.24	6.76	3.99	600.01	496.77	1.92	0.53	59.87	130.55	1.25
	Cl. Gap	0.68	1	1	1	0.76	1	1	1	1	1	1
Learned	Fin.	5	0	0	0	5	4	0	0	0	0	0
	Obj.	-74,115,700	106,940,000	4,722	1,120	11,230.50	39,753	3,360	12,850.90	2,810	115,155	307
	Nodes	90,166	5,790	1,061	23,707	301,782	403,888	1,865	161	97,197	470	6,365
	Time	600.01	8.24	8.66	11.39	600.01	600.01	2.24	0.53	174.27	26.21	3.59
	Cl. Gap	0.49	1	1	1	0.57	0.77	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 13 Detailed results for the MIPLIB problems (3/4). Time limit = 600 seconds.

	Problem names	mod010	mod011	modglob	nw04	opt1217	p0033	p0201	p0282	p0548	p2756	pk1
	LP Obj.	6,532.08	-62,122,000	20,430,900	16,310.70	-20.02	2,520.57	6,875	176,868	429.68	2,698.95	0
	True Obj.	6,548	-54,558,500	20,740,500	16,862	-16	3,089	7,615	258,411	8,691	3,124	11
	Fin. by all	1	0	0	1	0	1	1	0	0	0	0
Method												
Random	Fin.	0	5	5	0	5	0	0	5	5	5	4
	Obj.	6,548	-55,956,000	20,607,600	16,862	-20.02	3,089	7,615	192,124	2,085.24	2,733.15	10.92
	Nodes	27,055	82,469	1,293,324	259	687,665	4,859	649	1,712,728	1,285,332	529,728	1,346,758
	Time	47.98	600.01	600.01	10.81	600.01	0.32	0.45	600.01	600.01	600.01	600.01
	Cl. Gap	1	0.82	0.57	1	0	1	1	0.19	0.20	0.08	0.99
MIB	Fin.	0	0	5	0	5	0	0	5	5	5	0
	Obj.	6,548	-54,558,500	20,706,800	16,862	-20.02	3,089	7,615	184,470	524.95	2,705.50	11
	Nodes	532	49,533	989,483	1,737	670,264	6,265	4,747	1,504,144	1,121,079	634,588	927,663
	Time	3.76	419.22	600.01	44.77	600.01	0.37	2.43	600.01	600.01	600.01	382.10
	Cl. Gap	1	1	0.89	1	0	1	1	0.09	0.01	0.02	1
NCB	Fin.	0	5	5	0	5	0	0	0	0	5	5
	Obj.	6,548	-56,157,900	20,682,800	16,862	-19.65	3,089	7,615	258,411	8,691	2,984.96	9.95
	Nodes	96	2,518	176,901	355	260,272	745	173	624	18,782	34,910	151,768
	Time	2.50	600.05	600.01	62.35	600.01	0.12	1.17	1.14	42.31	600.01	600.01
	Cl. Gap	1	0.79	0.81	1	0.09	1	1	1	1	0.67	0.90
FSB	Fin.	0	5	5	0	5	0	0	0	0	5	5
	Obj.	6,548	-56,661,700	20,686,000	16,862	-19.66	3,089	7,615	258,411	8,691	2,950.75	9.23
	Nodes	31	1,260	101,090	233	38,913	363	186	502	8,920	12,364	125,603
	Time	3.36	600.03	600.01	82.23	600.01	0.07	3.78	1.31	25.15	600.01	600.01
	Cl. Gap	1	0.72	0.82	1	0.09	1	1	1	1	0.59	0.84
RB	Fin.	0	5	5	0	5	0	0	0	0	5	0
	Obj.	6,548	-55,719,100	20,686,900	16,862	-19.76	3,089	7,615	258,411	8,691	2,763.77	11
	Nodes	83	6,180	493,119	1,201	389,380	1,145	359	767	145,693	92,008	366,151
	Time	3.27	600.06	600.01	117.90	600.01	0.15	1.52	0.97	174.10	600.01	358.78
	Cl. Gap	1	0.85	0.83	1	0.07	1	1	1	1	0.15	1
Learned	Fin.	0	0	5	0	5	0	0	0	0	5	5
	Obj.	6,548	-54,558,500	20,600,400	16,862	-19.93	3,089	7,615	258,411	8,691	2,728.89	8.60
	Nodes	123	46,907	259,394	235	135,183	291	612	8,614	86,603	53,100	362,383
	Time	1.59	564.95	600.01	10.68	600.01	0.07	1.73	7.56	110.72	600.01	600.01
	Cl. Gap	1	1	0.55	1	0.02	1	1	1	1	0.07	0.78

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 14 Detailed results for the MIPLIB problems (4/4). Time limit = 600 seconds.

	Problem names	pp08a	pp08aCUTS	qiu	rentacar	rgn	set1ch	stein27	stein45	tr12-30	vpm1	vpm2
	LP Obj.	2,748.35	5,480.61	-931.64	28,806,100	48.80	32,007.70	13	22	14,210.40	15.42	9.89
	True Obj.	7,350	7,350	-132.87	30,356,800	82.20	54,537.80	18	30	130,596	20	13.75
	Fin. by all	0	0	0	1	1	0	1	1	0	0	0
Method												
Random	Fin.	5	5	4	0	0	5	0	0	5	5	5
	Obj.	5,198.76	6,756.75	-226.26	30,356,800	82.20	37,522.60	18	30	24,059.40	18.25	12.60
	Nodes	1,725,290	1,103,681	74,246	41	5,947	1,351,176	4,283	63,115	1,251,955	1,608,231	1,455,001
	Time	600.01	600.01	600.01	4.54	0.85	600.01	0.60	20.25	600.01	600.01	600.05
	Cl. Gap	0.53	0.68	0.88	1	1	0.24	1	1	0.08	0.62	0.70
MIB	Fin.	5	5	4	0	0	5	0	0	5	5	5
	Obj.	5,625.42	6,817.68	-211.52	30,356,800	82.20	35,814.40	18	30	26,437.20	18.55	12.60
	Nodes	1,525,690	1,001,129	80,056	26	4,147	1,174,846	4,681	86,199	1,049,709	1,563,746	1,331,407
	Time	600.01	600.01	600.01	3.49	0.60	600.01	0.66	26.17	600.02	600.01	600
	Cl. Gap	0.63	0.72	0.90	1	1	0.17	1	1	0.11	0.68	0.70
NCB	Fin.	5	5	5	0	0	5	0	0	5	5	5
	Obj.	5,800.71	6,988.93	-229.11	30,356,800	82.20	41,291.10	18	30	28,983.30	19.25	13.16
	Nodes	223,945	86,240	4,592	26	2,735	122,404	3,239	44,219	120,874	501,139	142,007
	Time	600.01	600.01	600.01	24.52	1.06	600.01	1.80	149.92	600.01	600.01	600
	Cl. Gap	0.66	0.81	0.88	1	1	0.41	1	1	0.13	0.84	0.85
FSB	Fin.	5	5	5	0	0	5	0	0	5	5	5
	Obj.	5,666.07	6,864.18	-399.43	30,356,800	82.20	40,157.30	18	30	25,847.50	19	13.06
	Nodes	87,459	32,806	1,360	26	2,849	10,008	2,141	24,835	3,496	282,230	105,079
	Time	600.01	600.01	600.01	32.21	1.80	600.02	3.61	285.03	600.02	600.01	600.01
	Cl. Gap	0.63	0.74	0.67	1	1	0.36	1	1	0.10	0.78	0.82
RB	Fin.	5	5	0	0	0	5	0	0	5	0	5
	Obj.	5,649.88	7,082.74	-132.87	30,356,800	82.20	42,397.10	18	30	30,376.10	20	12.79
	Nodes	643,995	305,396	14,923	21	2,701	492,097	3,975	50,335	418,805	649,531	299,538
	Time	600.01	600.01	477.28	18.20	0.78	600.01	1.44	70.49	600.01	446.18	600.01
	Cl. Gap	0.63	0.86	1	1	1	0.46	1	1	0.14	1	0.75
Learned	Fin.	5	5	5	0	0	5	0	0	5	5	5
	Obj.	5,318.51	6,828.05	-179.74	30,356,800	82.20	40,650.20	18	30	24,425.10	18.18	12.24
	Nodes	166,483	129,426	47,914	36	3,401	52,779	4,141	50,013	16,200	448,168	219,927
	Time	600.01	600.01	600.01	4.32	1.20	600.01	3.12	97.31	600.03	600.01	600
	Cl. Gap	0.56	0.72	0.94	1	1	0.38	1	1	0.09	0.60	0.61

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 15 Detailed results for the updated list of MIPLIB problems (1/3). Time limit = none.

	Problem names	aflow30a	air03	air04	air05	cap6000	dcmulti	egout	khb05250	l152lav	lseu
	LP Obj.	983.17	338,864	55,535.40	25,877.60	-2,451,540	183,976	149.59	95,919,500	4,656.36	834.68
	True Obj.	1,158	340,160	56,137	26,374	-2,451,200	188,182	568.10	106,940,000	4,722	1,120
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,450,000	188,182	568.10	107,000,000	4,722	1,120
	Nodes	15,800,801	25	130,471	88,241	81,127	87,985	11,855	11,555	57,281	112,035
	Time	19,276.30	1.44	9,228.73	4,613	259.32	45.45	1.27	6.85	106.19	9.82
	Cl. Gap	1	1	1	1	4.53	1	1	1.01	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,340	188,182	568.10	106,940,000	4,722	1,120
	Nodes	7,691,239	7	105,821	66,991	22,637	9,493	7,015	7,477	42,037	52,413
	Time	9,109.39	0.59	14,008.90	5,642.01	63.34	4.44	0.77	4.77	95.61	5.78
	Cl. Gap	1	1	1	1	0.59	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,340	188,182	568.10	106,940,000	4,722	1,120
	Nodes	137,895	3	131	215	17,214	1,065	5,713	1,527	213	18,533
	Time	1,296.89	2.02	1,133.76	768.24	256.47	2.98	1.93	4.71	4.51	6.93
	Cl. Gap	1	1	1	1	0.59	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,340	188,182	568.10	106,940,000	4,722	1,120
	Nodes	118,057	3	111	177	15,732	927	4,725	1,502	238	24,957
	Time	2,073.98	2.73	3,224.13	3,812.73	250.59	4.81	2.13	7.22	47.27	15.98
	Cl. Gap	1	1	1	1	0.59	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,340	188,182	568.10	106,940,000	4,722	1,120
	Nodes	230,038	3	3,601	1,489	18,989	1,013	9,143	1,685	611	16,933
	Time	898.36	0.52	2,760.38	1,449.85	222.89	1.77	2.31	2.17	6.66	3.83
	Cl. Gap	1	1	1	1	0.59	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,380	188,182	568.10	106,940,000	4,722	1,120
	Nodes	2,825,981	3	3,833	65,305	66,587	1,565	3,007	5,790	1,061	23,707
	Time	8,755.66	0.48	1,613.37	5,141.27	310.41	2.30	1.07	7.13	7.88	8.99
	Cl. Gap	1	1	1	1	0.47	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 16 Detailed results for the updated list of MIPLIB problems (2/3). Time limit = none.

	Problem names	mas76	misc03	misc06	misc07	mitre	mod008	mod010	mod011	nw04	p0033
	LP Obj.	38,893.90	1,910	12,841.70	1,415	114,741	290.93	6,532.08	-62,122,000	16,310.70	2,520.57
	True Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,851.10	2,810	115,155	307	6,548	-54,600,000	16,862	3,089
	Nodes	2,306,195	1,179	527	82,081	288,265	10,307	27,055	517,237	259	4,859
	Time	693.85	0.50	0.70	52.66	1,606.37	1.49	47.67	4,072.82	10.63	0.30
	Cl. Gap	1	1	1.02	1	1	1	1	0.99	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	2,097,725	629	551	24,005	986	9,091	532	49,533	1,737	6,265
	Time	760.55	0.32	0.77	15.67	29.70	1.45	3.70	410.90	44.66	0.35
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	783,139	579	56	32,873	617	4,605	96	19,617	355	745
	Time	1,491.35	2.65	0.58	250.44	48.30	2.82	2.47	5,422.18	61.96	0.10
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	597,109	371	55	25,551	709	3,333	31	18,283	233	363
	Time	1,466.68	2.78	1.19	581.55	137.07	1.75	3.28	6,409.24	81.40	0.06
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	621,181	641	62	19,179	1,900	2,927	83	25,873	1,201	1,145
	Time	477.96	1.89	0.53	59.32	128.88	1.22	3.23	2,715.15	116.54	0.13
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	1,722,679	1,865	161	97,197	470	6,365	123	46,907	235	291
	Time	2,232.96	1.90	0.50	153.05	24.88	2.94	1.51	544.07	10.78	0.05
	Cl. Gap	1	1	1	1	1	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 17 Detailed results for the updated list of MIPLIB problems (3/3). Time limit = none.

	Problem names	p0201	pk1	pp08aCUTS	qiu	rentacar	rgn	stein27	stein45	vpm1	vpm2
	LP Obj.	6,875	0	5,480.61	-931.64	28,806,100	48.80	13	22	15.42	9.89
	True Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,400,000	82.20	18	30	20	13.75
	Nodes	649	1,400,487	172,918,239	411,879	41	5,947	4,283	63,115	14,838,614	25,017,647
	Time	0.44	585.92	793,141	2,523.43	4.48	0.81	0.58	19.91	17,681.30	27,319.80
	Cl. Gap	1	1	1	1	1.03	1	1	1	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	4,747	927,663	63,144,303	337,813	26	4,147	4,681	86,199	8,953,981	20,513,193
	Time	2.36	365.08	161,744	2,058.33	3.44	0.56	0.63	25.79	7,629.32	19,579.40
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	173	257,925	1,744,935	16,865	26	2,735	3,239	44,219	621,984	640,044
	Time	1.15	957.74	17,663.10	1,610.02	24.15	1.02	1.76	146.05	735.40	2,188.64
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	186	306,805	1,561,719	49,693	26	2,849	2,141	24,835	465,770	644,925
	Time	3.69	1,041.17	17,645.50	7,136.80	31.84	1.73	3.49	276.55	954.07	2,692.21
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	359	366,151	2,668,423	14,923	21	2,701	3,975	50,335	649,531	4,837,431
	Time	1.49	344.92	4,815.89	476.17	17.96	0.75	1.39	69.08	431.22	11,571.10
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	612	1,545,753	7,272,423	116,593	36	3,401	4,141	50,013	6,606,414	10,639,147
	Time	1.43	2,187.65	22,281.40	1,074.32	4.26	1.01	2.42	76.64	10,218.50	36,031.50
	Cl. Gap	1	1	1	1	1	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 18 Detailed results for the updated list of MIPLIB problems (1/3). Time limit = none and CPLEX's cuts and heuristics applied.

	Problem names	aflow30a	air03	air04	air05	cap6000	dcmulti	egout	khb05250	l152lav	lseu
	LP Obj.	983.17	338,864	55,535.40	25,877.60	-2,451,540	183,976	149.59	95,919,500	4,656.36	834.68
	True Obj.	1,158	340,160	56,137	26,374	-2,451,200	188,182	568.10	106,940,000	4,722	1,120
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,450,000	188,188	568.10	107,000,000	4,722	1,120
	Nodes	58,369	0	50,847	29,149	180	641	3	5	45,433	185
	Time	256.88	0.59	3,956.43	1,839.59	4.06	1.58	0.01	0.41	324.38	0.13
	Cl. Gap	1	1	1	1	4.53	1	1	1.01	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,350	188,188	568.10	106,940,000	4,722	1,120
	Nodes	35,205	0	46,139	38,793	60	125	3	3	29,545	97
	Time	203.06	0.60	4,403.65	2,607.30	1.30	0.71	0.01	0.42	227.48	0.11
	Cl. Gap	1	1	1	1	0.56	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,350	188,182	568.10	106,940,000	4,722	1,120
	Nodes	115,987	0	365	487	20	8,135	7	9	187	223
	Time	2,043.61	0.59	3,488.17	1,844.01	0.87	33.28	0.02	0.46	4.74	0.22
	Cl. Gap	1	1	1	1	0.56	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,180	188,186	568.10	106,940,000	4,722	1,120
	Nodes	31,323	0	231	211	49	40	7	5	169	133
	Time	1,158.81	0.60	10,229.90	3,941.68	1.53	0.77	0.02	0.42	18.73	0.27
	Cl. Gap	1	1	1	1	1.06	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,350	188,187	568.10	106,940,000	4,722	1,120
	Nodes	84,014	0	336,711	78,761	20	429	7	7	459	99
	Time	590.75	0.59	57,934.10	17,733.40	0.93	1.67	0.02	0.45	6.45	0.15
	Cl. Gap	1	1	1	1	0.56	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	1,158	340,160	56,137	26,374	-2,451,350	188,195	568.10	106,940,000	4,722	1,120
	Nodes	42,389	0	553	5,785	20	111	5	7	799	75
	Time	296.91	0.60	237.80	969.80	0.74	0.87	0.02	0.44	7.27	0.17
	Closed gap	1	1	1	1	0.56	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 19 Detailed results for the updated list of MIPLIB problems (2/3). Time limit = none and CPLEX's cuts and heuristics applied.

	Problem names	mas76	misc03	misc06	misc07	mitre	mod008	mod010	mod011	nw04	p0033
	LP Obj.	38,893.90	1,910	12,841.70	1,415	114,741	290.93	6,532.08	-62,122,000	16,310.70	2,520.57
	True Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,600,000	16,862	3,089
	Nodes	2,869,383	1,009	7	55,815	15	1,589	1,505	58,297	255	1
	Time	1,004.72	0.93	0.55	48.61	4.33	0.47	3.96	3,726.60	46.53	0.01
	Cl. Gap	1	1	1	1	1	1	1	0.99	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	1,742,607	279	11	13,707	29	1,537	39	4,027	337	1
	Time	518.99	0.47	0.56	13.28	4.27	0.47	0.65	333.87	51.31	0.01
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	400,115	455	7	26,769	20	783	13	160,639	39	1
	Time	311.09	1.99	0.59	222.85	4.26	0.47	0.64	34,024.60	34.68	0.01
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	355,507	301	7	17,299	20	423	11	19,789	55	1
	Time	394.68	3.60	0.61	410.78	4.44	0.52	0.91	6,564.28	47.72	0.01
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	561,667	305	9	19,231	15	1,755	115	64,870	1,213	1
	Time	188.54	1.02	0.61	61.48	4.30	0.78	1.24	7,436.06	143.11	0.01
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	40,005.10	3,360	12,850.90	2,810	115,155	307	6,548	-54,558,500	16,862	3,089
	Nodes	564,679	1,979	9	110,751	10	993	99	5,064	55	1
	Time	307.45	3.43	0.56	212.24	4.05	0.67	1.03	541.92	34.02	0.01
	Closed gap	1	1	1	1	1	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

Table 20 Detailed results for the updated list of MIPLIB problems (3/3). Time limit = none and CPLEX's cuts and heuristics applied.

	Problem names	p0201	pk1	pp08aCUTS	qiu	rentacar	rgn	stein27	stein45	vpm1	vpm2
	LP Obj.	6,875	0	5,480.61	-931.64	28,806,100	48.80	13	22	15.42	9.89
	True Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Fin. by all	1	1	1	1	1	1	1	1	1	1
Method											
Random	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,400,000	82.20	18	30	20	13.75
	Nodes	40	861,991	4,965	462,433	9	2,605	4,499	61,825	0	5,869
	Time	0.73	265	8.08	3,565.69	12.75	0.60	0.78	22.17	0.02	4.95
	Cl. Gap	1	1	1	1	1.03	1	1	1	1	1
MIB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	57	892,187	5,157	265,859	7	2,233	4,633	82,377	0	5,721
	Time	0.83	272.01	7.98	1,999.22	12.93	0.51	0.80	27.61	0.01	5.15
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
NCB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	67	243,581	12,497	12,541	7	3,007	3,499	39,787	0	5,781
	Time	1.31	430.17	68.16	913.26	14.27	1.80	1.79	90.07	0.01	14.19
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
FSB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	67	284,851	7,523	27,779	7	1,489	2,153	24,949	0	3,847
	Time	2.60	651.97	70.38	3,074.14	14.23	0.82	3.46	244.19	0.02	18.59
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
RB	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	113	308,491	9,515	26,277	11	2,271	4,231	53,623	0	3,197
	Time	1.13	153.21	22.80	745.02	14.98	0.83	1.58	58.58	0.01	4.18
	Cl. Gap	1	1	1	1	1	1	1	1	1	1
Learned	Fin.	0	0	0	0	0	0	0	0	0	0
	Obj.	7,615	11	7,350	-132.87	30,356,800	82.20	18	30	20	13.75
	Nodes	43	897,129	3,131	25,065	7	1,619	4,449	54,541	0	10,207
	Time	0.88	651.99	8.18	363.04	13.03	0.65	2.78	69.59	0.01	18.03
	Closed gap	1	1	1	1	1	1	1	1	1	1

The row 'Cl. Gap' refers to the gap closed at the end of the optimization whether it achieved optimality or not. The row 'Fin. by all' indicates whether all methods were able to solve this problem to optimality. For each method, the 'Fin.' rows indicate the termination status of the optimization: 0 for optimality, 1 for unfeasibility, 2 for unboundedness, 3 for unfeasibility or unboundedness, 4 for another stopping criterion with a feasible solution found, and 5 for another stopping criterion with no feasible solution found.

References

Geurts, P., D. Ernst, L. Wehenkel. 2006. Extremely randomized trees. *Machine learning* **63** 3–42.