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Measuring the impact of branching rules for mixed-integer programming

Gerald Gamrath*, Christoph Schubert†

Abstract

Branching rules are an integral component of the branch-and-bound algorithm typically used to solve mixed-integer programs and subject to intense research. Different approaches for branching are typically compared based on the solving time as well as the size of the branch-and-bound tree needed to prove optimality. The latter, however, has some flaws when it comes to sophisticated branching rules that do not only try to take a good branching decision, but have additional side-effects. We propose a new measure for the quality of a branching rule that distinguishes tree size reductions obtained by better branching decisions from those obtained by such side-effects. It is evaluated for common branching rules providing new insights in the importance of strong branching.

Keywords: mixed-integer programming, branch-and-bound, branching rule, strong branching

1 Introduction

All state-of-the-art solvers for mixed-integer programs (MIPs) are based on the linear programming (LP) based branch-and-bound method [9]. One of the key components of the algorithm is the *branching rule*, which splits the current problem into two or more disjoint sub-problems. How this is done can have a large impact on the solving process and has been subject to intensive research over the last decades, see [4, 7, 1, 6] among many others. When new ideas are presented in publications, they are typically evaluated on a set of benchmark instances and compared to other common rules. One of the most common criteria for comparison is the solving time to optimality, complemented by the number of instances solved to optimality within the given time limit.

In this paper, we focus on another measure that is often used to describe the impact of branching rules: the size of the branch-and-bound tree needed to prove optimality. This gives a good estimate of the effectiveness of branching rules, as those are responsible for building the tree. This estimate, however, can be flawed by side-effects of a branching rule that artificially decrease the tree size. An extreme case of such a branching rule would just solve the problem corresponding to the current node as a sub-MIP. Then, it transfers all solutions back and installs the dual bound computed by the sub-MIP as the local dual bound of the current node. If no limits are applied to the sub-MIP solving process, this branching rule would solve every instance at the root node and clearly dominate all other branching rules in this regard! The reader will probably agree that this is an unfair comparison, because this had nothing to do with branching

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and the rule did not even do any branching. However, it is just exaggerating the flaw present in many comparisons of branching rules with inherent side-effects.

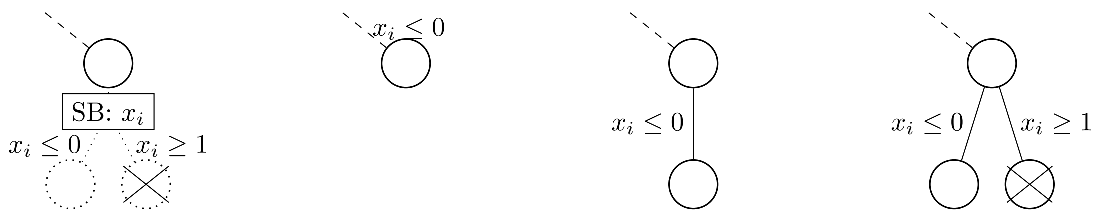
In the next section, we discuss the usefulness of the tree size as a performance indicator for branching and illustrate side-effects of common branching rules. Based on this, we propose the *fair node number*, a new measure for the quality of the decisions taken by a branching rule. Sect. 3 presents an evaluation of some common branching rules, before we close with concluding remarks.

2 Measuring the Impact of Branching Rules

When evaluating new features of a MIP solver, important insights can be achieved by complementing the solving time with another criterion that is tailored more to the algorithmic change being investigated. In the case of branching rules, the canonical candidate for this is the number of branch-and-bound nodes needed to solve an instance to optimality. This is a direct indicator for the quality of the branching decisions taken, which build the tree and naturally aim at keeping it small. The node number has several positive attributes in this context. It allows to measure the potential of a branching rule even with a first prototype that is not necessarily implemented very efficiently. This allows to evaluate research ideas at an early stage and might motivate further investigation of ideas that show some potential without already reducing the solving time. From a practical viewpoint, it is not depending on reliable time measurements, which allows to run multiple experiments in parallel on the same machine. Finally, the tree size reduction may become more important than sequentially measured running times when switching to a massive parallel environment, where distributing nodes of the tree causes a message passing overhead. Summing up, there is a strong incentive to use the size of the branch-and-bound tree created by a branching rule as a measure for its performance in addition to the solving time.

When comparing node numbers between different branching rules, we must only take into account instances solved to optimality within the time limit by all of the rules. Otherwise, final node numbers are unknown and cannot be compared. If a solver timed out, a smaller node count might be an indicator for better decisions creating a smaller tree but could as well point to a slowdown caused by the branching rule, resulting in a larger solving time with a similar or even higher node count.

Many publications follow this approach. However, side-effects of branching rules are often disregarded, but can have a huge impact, see the motivation in the introduction. In common branching rules, side-effects are often encountered when the branching rule uses some form of



(a) Strong branching on variable x_i. (b) Bound added to current node. (c) Only feasible child node created. (d) Both child nodes created.

Figure 1: Strong branching proves infeasibility of a potential child node (a) and three different ways to apply this information in branching.

strong branching (SB) [7]. SB evaluates a potential branching decision by solving an auxiliary LP for each of the potential child nodes. In the first place, this provides very reliable predictions of the dual bounds improvement in both child nodes, which most branching rules try to predict and maximize. However, there are more potential implications which are not directly related to the final branching decision. First, if SB on a variable detects that both auxiliary LPs are infeasible, infeasibility of the current node can be deduced and the node is just cut off without any branching. Analogously, if exactly one of the two auxiliary LPs is infeasible, this node does not need to be investigated by the branch-and-bound algorithm anymore. The way this information is exploited differs among solvers, see Fig. 1. Some solvers will just branch on the variable but omit the infeasible child node as illustrated in Fig. 1c. Others just add the branching bound change of the feasible child directly to the current node and iterate the processing of that node, cf. Fig. 1b. Clearly, this leads to inconsistencies between solvers when evaluating the impact of branching rules and "hides" nodes from the evaluation that could not have been omitted by a branching rule that just returns the best branching variable. Other side-effects exceeding the pure branching decision include the knowledge of dual bounds for both child nodes created by branching as well as an improved dual bound for the current node based on the minimum of the dual bounds of any pair of SB LPs. This information might be used to discard them later in case a better primal solution was found. We also get better estimates for the best primal solution contained in the sub-trees rooted at the child nodes and more accurate pseudo-costs—history information about the dual bound improvement after branching on a variable [4]. Finally, conflict constraints can be extracted from infeasible SB LPs [2]. All this introduces a bias towards SB based branching rules, because it decreases the number of nodes reported by the solver additionally to the effect of better branching decisions.

This motivates us to propose a new measure to cover the quality of the branching decision better: the *fair node number*. It is based on the notion of a *branching oracle*, which, given the current LP solution, does nothing else than returning a variable to branch on. The valuable information that one or both of the two potential child nodes for a branching candidate are infeasible can then only be returned indirectly by selecting this variable for branching. This branching adds two nodes to the branch-and-bound tree to obtain the same information otherwise learned directly from SB, as the node(s) will be found infeasible when being processed, cf. Fig. 1d. If all compared branching rules can be interpreted as such an oracle, they are on a level field and their branch-and-bound nodes allow for a fair comparison. There are two means to reach this fair comparison for other branching rules. First, node numbers should be adjusted by mimicking that two branch-and-bound nodes were created for every cutoff or domain change identified. This means that the number of nodes is increased by two for each SB cutoff and by one or two for each domain change identified by SB, depending on whether the solver already created one child node in such a case or directly applied the reduction at the current node (see Fig. 1).

Other algorithmic features that cause side-effects, e.g., conflict analysis for infeasible SB children, should be disabled if possible. This typically includes providing the optimal objective value as an upper bound at the beginning of the solving process and disabling primal heuristics, cf. [6]. By this, the variability introduced by finding solutions at a different point of time is removed, while focusing on the main task of branching rules, which is improving the dual bound and proving optimality. This helps to reduce most side-effects. Since the upper bound is already optimal, improved dual bounds obtained by SB for child nodes as well as the current node either directly cause a reduction that will lead to an adjusted node count or will never allow to prune that node. They might influence node selection, as do the changed estimates, but due to the optimum being known upfront, the tree size is not influenced by the node selection, except for rare side-effects of the selection. Finally, pseudo costs are updated as a part of the branching rule and used later for branching. However, they also have other uses which might cause side-effects,

Settings	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
MIB	134.77	10957.54	10957.54	0.00	0.00
PCB	45.37	3192.05	3192.05	0.00	0.00
FSB	80.86	203.44	1301.82	534.50	85.15
FSBDP	82.40	190.97	1287.02	535.19	90.61
RB	37.58	993.94	1748.13	167.21	21.60
HB	34.20	857.97	1582.86	156.40	25.97

Table 1: Aggregated results over the 156 instances solved by all branching rules.

e.g., in primal heuristics and node selection. Since these main other applications are disabled or without effect due to the installed upper bound, the side-effects should be negligible.

3 Computational results

We performed computational experiments to evaluate common branching rules implemented in SCIP [2] with respect to time, node count, and fair node number. All regarded rules perform variable branching, i.e. create the sub-problems by splitting the domain of an integer variable with fractional value in the current LP solution into two disjoint parts. However, the methodology could as well be applied to general constraint branching, an active field of research that did not make it into state-of-the-art rules for general MIP so far. All computations were performed on a cluster of 2.5 GHz Intel Xeon E5-2670v2 CPUs with 64 GB main memory, running only one job per node at a time. We used the MMMC test set consisting of all benchmark instances from the last three MIPLIB [8] versions as well as the COR@L test set [5]. As suggested in the previous section, we installed the optimal objective value as an upper bound upfront and disabled primal heuristics as well as conflict analysis for temporary SB children. We restrict the comparison to the 156 instances that needed some branching to be solved and were solved by all branching rules within the time limit of 8 hours.

Table 1 summarizes the results, detailed instance-wise results can be found in Appendix A. For each branching rule, we list the average solving time to optimality, the number of nodes reported by SCIP and the fair node number introduced in the previous section, as well as the number of domain reductions and cutoffs which are needed to compute the fair node number. All averages are computed using the shifted geometric mean [2] with a shift of 10.

The first two rows show results for *most infeasible branching* (MIB) and the *pseudo-cost branching rule* [4] (PCB), two rules without any side-effects, so that the fair nodes equal the number of nodes reported by SCIP. While MIB selects an integer variable with fractional part of the solution value closest to 0.5, PCB uses pseudo-costs to predict the lower bounds obtained in both child nodes and chooses a variable which maximizes the lower bound improvements. This helps to decrease both time and nodes by a factor of about three.

More accurate, but also more expensive, is *full strong branching* (FSB) which applies SB at every node for each fractional variable. The node reduction by a factor of 15 is in line with experiments in the literature [1]. However, we now see that this is largely caused by side-effects: SB proves infeasibility for more than every third node, and identifies on average 2.5 bound changes per node. Thus, the fair node number is more than six times higher than the node count. This means that the better branching decisions reduce the tree size by “only” 59 % compared to PCB. The side-effects, on the other hand, further reduce the node number by another 84 %. Full strong branching with domain propagation [6] (FSBDP) improves SB predictions by applying domain propagation techniques during SB. This mainly identifies more domain changes and cutoffs per node, so that a node decrease of 5 % diminishes to about 1 % in the fair node number.

The *reliability pseudo-cost branching rule* [1] (RB) is a combination of PCB and SB and uses SB only a few times on each variable to obtain reliable predictions. This reduces the average solving time significantly while increasing the number of reported nodes by a factor of almost five compared to FSB. However, this is mainly due to fewer SB calls which result in fewer domain reductions and cutoffs being identified. Consequently, the difference to FSB is smaller in the fair node number, where reliability branching needs only 34 % more nodes.

Finally, *hybrid branching* [3] extends reliability branching by using additional statistics about infeasible nodes and domain changes inferred by domain propagation as tie breakers. The implementation we used also makes use of SBDP as well as statistical methods to filter out unpromising candidates. All this together gives the fastest variant and a fair node number that is only 23 % higher than that of FSBDP, the branching rule performing best with respect to this criterion. This proves how important it is to support early branching decisions by SB, while using pseudo costs later does not deteriorate the quality of branching decisions very much anymore but just generates fewer side-effects.

4 Conclusions

We presented the *fair node number*, a new measure for the quality of a branching rule. It distinguishes between the quality of the branching decisions themselves and additional reductions learned, e.g., by strong branching. Both help to reduce the tree size, but investigating those effects individually can provide valuable insights. The fair node number, which focuses on the former effect, can be read from the statistics of SCIP if a few parameters are adjusted. It can be used to fairly assess the potential of branching rules with different side-effects. Thereby, it does not replace other measures like the branch-and-bound tree size reported by the solver or the solving time, but rather complements them, allowing for a better analysis of the impact of branching rules.

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A Computational Results per Instance

This appendix presents the instance-wise results of our experiments. Table 2 shows the same information as Table 1 for each individual instance (see the first column).

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
22433	MIB	1.1	22	22	0	0
	PCB	1.1	22	22	0	0
	FSB	1.4	6	26	10	0
	FSBDP	1.4	6	26	10	0
	RB	1.8	2	10	3	1
	HB	1.8	2	10	3	1
23588	MIB	3.2	3796	3796	0	0
	PCB	1.7	1450	1450	0	0
	FSB	4.2	64	578	226	31
	FSBDP	4.5	60	556	218	30
	RB	2.0	440	794	162	15
	HB	2.1	334	748	187	20
30n20b8	MIB	81.9	5	5	0	0
	PCB	79.7	5	5	0	0
	FSB	2736.6	3	1107	552	0
	FSBDP	1498.1	1	237	118	0
	RB	217.2	47	81	17	0
	HB	150.5	15	15	0	0
Test3	MIB	5.2	9	9	0	0
	PCB	5.2	9	9	0	0
	FSB	5.2	3	9	2	1
	FSBDP	5.2	3	9	2	1
	RB	5.1	2	12	5	0
	HB	5.2	2	12	5	0
aflow30a	MIB	34.8	37804	37804	0	0
	PCB	8.1	5196	5196	0	0
	FSB	20.3	282	3398	1444	114
	FSBDP	21.5	248	3298	1405	120
	RB	8.3	2086	3314	595	19
	HB	8.1	1552	2916	646	36
air04	MIB	1333.5	94470	94470	0	0
	PCB	18.6	643	643	0	0
	FSB	34.1	12	106	47	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSBDP	31.3	12	92	40	0
	RB	33.3	9	101	43	3
	HB	25.1	7	129	58	3
air05	MIB	174.6	19008	19008	0	0
	PCB	17.9	1123	1123	0	0
	FSB	55.4	6	260	125	2
	FSBDP	53.2	6	266	128	2
	RB	21.4	56	192	64	4
	HB	21.2	44	154	51	4
aligninq	MIB	22.0	9482	9482	0	0
	PCB	3.8	1210	1210	0	0
	FSB	25.0	22	368	164	9
	FSBDP	26.0	22	364	161	10
	RB	7.7	204	734	256	9
	HB	8.3	288	928	311	9
app1-2	MIB	2731.8	17472	17472	0	0
	PCB	1771.9	11370	11370	0	0
	FSB	3040.5	25	1579	766	11
	FSBDP	3736.7	25	1337	645	11
	RB	940.6	27	2263	1116	2
	HB	921.9	35	2305	1131	4
ash608gpia-3col	MIB	8.7	17	17	0	0
	PCB	9.3	73	73	0	0
	FSB	226.8	7	45	15	4
	FSBDP	262.0	7	47	16	4
	RB	26.9	33	199	73	10
	HB	13.3	12	36	9	3
bc	MIB	6358.8	390237	390237	0	0
	PCB	1595.2	93087	93087	0	0
	FSB	2124.9	1209	36485	17040	598
	FSBDP	2454.0	1199	36465	17034	599
	RB	3067.3	144125	190699	22747	540
	HB	3680.0	190941	231753	19236	1170
bc1	MIB	156.5	10733	10733	0	0
	PCB	111.3	9261	9261	0	0
	FSB	75.7	413	3747	1598	69
	FSBDP	91.0	425	3723	1578	71
	RB	119.7	5751	9791	1935	85
	HB	182.0	8959	13471	2132	124
bell3a	MIB	5.1	24978	24978	0	0
	PCB	5.2	24516	24516	0	0
	FSB	4.5	20862	24354	1416	330
	FSBDP	4.7	20882	24438	1450	328
	RB	5.0	22518	24894	1039	149
	HB	6.1	21653	24029	1045	143

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
bell5	MIB	0.5	2341	2341	0	0
	PCB	0.5	1132	1132	0	0
	FSB	0.5	951	1151	61	39
	FSBDP	0.5	994	1192	60	39
	RB	0.5	1101	1177	11	27
	HB	0.5	1147	1225	13	26
bienst1	MIB	141.1	16116	16116	0	0
	PCB	92.8	21698	21698	0	0
	FSB	161.9	1201	4867	1326	507
	FSBDP	84.3	1071	4367	1219	429
	RB	122.2	23910	24214	136	16
	HB	63.7	11965	12823	294	135
bienst2	MIB	1532.6	576607	576607	0	0
	PCB	318.6	172279	172279	0	0
	FSB	775.2	21389	87275	23267	9676
	FSBDP	757.0	20773	85711	22986	9483
	RB	459.1	219380	219954	223	64
	HB	264.7	157612	158116	192	60
binkar10_1	MIB	2555.1	2176030	2176030	0	0
	PCB	291.1	234632	234632	0	0
	FSB	976.1	26310	183374	68566	9966
	FSBDP	1022.1	22204	166482	61815	10324
	RB	222.4	190387	201877	5495	250
	HB	208.7	164946	170748	2549	352
blend2	MIB	0.6	1460	1460	0	0
	PCB	0.5	948	948	0	0
	FSB	0.5	112	310	92	7
	FSBDP	0.5	109	393	129	13
	RB	0.5	189	301	49	7
	HB	0.5	376	628	105	21
cap6000	MIB	1.5	3438	3438	0	0
	PCB	1.3	2486	2486	0	0
	FSB	1.2	578	1494	387	71
	FSBDP	1.3	534	1500	404	79
	RB	1.1	1164	1412	109	15
	HB	1.3	1205	1461	111	17
dano3_3	MIB	48.3	14	14	0	0
	PCB	47.9	14	14	0	0
	FSB	51.6	2	18	7	1
	FSBDP	51.9	2	18	7	1
	RB	58.4	6	28	10	1
	HB	56.2	6	22	7	1
dano3_4	MIB	82.6	27	27	0	0
	PCB	81.2	27	27	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSB	96.8	3	31	14	0
	FSBDP	90.8	3	37	16	1
	RB	87.1	7	41	17	0
	HB	87.7	7	41	17	0
danoint	MIB	7110.0	2767144	2767144	0	0
	PCB	4068.2	1546508	1546508	0	0
	FSB	12712.2	83622	462144	150940	38321
	FSBDP	11774.0	80724	460686	151363	38618
	RB	3386.4	1281353	1284489	1138	430
	HB	3815.0	1439125	1439609	120	122
dcmulti	MIB	0.7	745	745	0	0
	PCB	0.5	267	267	0	0
	FSB	0.5	26	86	27	3
	FSBDP	0.6	24	86	27	4
	RB	0.6	32	100	33	1
	HB	0.7	30	104	33	4
eil33-2	MIB	19.9	7048	7048	0	0
	PCB	22.8	8930	8930	0	0
	FSB	161.9	262	8690	4083	131
	FSBDP	93.2	296	8606	4007	148
	RB	43.4	7870	10648	1342	47
	HB	36.5	532	10320	4761	133
eilB101	MIB	332.8	24984	24984	0	0
	PCB	217.9	18226	18226	0	0
	FSB	1203.4	6	1700	845	2
	FSBDP	660.5	4	1648	821	1
	RB	252.5	10136	13126	1451	44
	HB	272.2	11658	18978	3595	65
fast0507	MIB	24337.4	635346	635346	0	0
	PCB	224.3	3742	3742	0	0
	FSB	1469.5	26	2028	988	13
	FSBDP	1923.9	24	2228	1090	12
	RB	113.3	580	804	100	12
	HB	115.9	524	770	108	15
fiber	MIB	0.8	227	227	0	0
	PCB	0.8	246	246	0	0
	FSB	0.9	7	21	7	0
	FSBDP	0.9	6	18	6	0
	RB	0.8	4	22	9	0
	HB	1.0	7	45	19	0
fixnet6	MIB	38.0	61573	61573	0	0
	PCB	1.4	653	653	0	0
	FSB	1.2	7	45	16	3
	FSBDP	1.3	7	43	15	3
	RB	1.7	11	75	29	3

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	HB	1.6	13	73	27	3
flugpl	MIB	0.5	7	7	0	0
	PCB	0.5	7	7	0	0
	FSB	0.5	7	7	0	0
	FSBDP	0.5	7	13	1	2
	RB	0.5	7	7	0	0
	HB	0.5	3	5	0	1
gesa2	MIB	0.5	7	7	0	0
	PCB	0.5	7	7	0	0
	FSB	0.5	3	5	1	0
	FSBDP	0.5	3	5	1	0
	RB	0.5	2	12	5	0
	HB	0.5	2	12	5	0
gesa2-o	MIB	0.7	50	50	0	0
	PCB	0.7	24	24	0	0
	FSB	0.6	4	20	8	0
	FSBDP	0.7	4	20	7	1
	RB	0.6	4	34	15	0
	HB	0.7	4	24	10	0
gesa3	MIB	0.5	31	31	0	0
	PCB	0.5	29	29	0	0
	FSB	0.6	7	39	13	3
	FSBDP	0.7	7	39	13	3
	RB	0.6	8	62	24	3
	HB	0.7	7	65	28	1
gesa3_o	MIB	0.6	27	27	0	0
	PCB	0.6	27	27	0	0
	FSB	0.7	9	29	8	2
	FSBDP	0.8	9	29	8	2
	RB	0.8	9	51	20	1
	HB	0.8	7	41	15	2
iis-100-0-cov	MIB	808.2	126883	126883	0	0
	PCB	1180.6	187347	187347	0	0
	FSB	7708.8	10075	54041	17135	4848
	FSBDP	7877.2	9969	53529	16934	4846
	RB	563.3	82997	83847	355	70
	HB	550.0	83095	83741	101	222
iis-pima-cov	MIB	638.8	36201	36201	0	0
	PCB	188.2	9331	9331	0	0
	FSB	4027.5	1087	12895	5361	543
	FSBDP	4103.6	1083	12965	5400	541
	RB	227.0	6781	8881	987	63
	HB	197.0	7147	8465	650	9
khb05250	MIB	0.5	10	10	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	PCB	0.5	10	10	0	0
	FSB	0.5	5	11	3	0
	FSBDP	0.5	5	11	3	0
	RB	0.5	3	19	8	0
	HB	0.5	3	19	8	0
l152lav	MIB	5.4	5902	5902	0	0
	PCB	2.6	2447	2447	0	0
	FSB	1.4	15	195	83	7
	FSBDP	1.7	15	177	74	7
	RB	1.0	17	203	87	6
	HB	1.2	21	237	99	9
lseu	MIB	0.5	922	922	0	0
	PCB	0.5	624	624	0	0
	FSB	0.5	99	449	159	16
	FSBDP	0.5	90	464	162	25
	RB	0.5	333	575	104	17
	HB	0.5	310	506	83	15
map18	MIB	4111.5	25695	25695	0	0
	PCB	236.3	947	947	0	0
	FSB	868.0	87	519	192	24
	FSBDP	882.3	81	545	210	22
	RB	159.1	369	535	81	2
	HB	154.4	347	497	74	1
map20	MIB	2947.0	21343	21343	0	0
	PCB	157.7	759	759	0	0
	FSB	776.2	77	557	214	26
	FSBDP	781.7	69	513	196	26
	RB	151.3	409	583	84	3
	HB	170.8	481	673	86	10
mas74	MIB	11248.7	65864319	65864319	0	0
	PCB	880.8	5567107	5567107	0	0
	FSB	1033.9	533504	3204248	1097922	237450
	FSBDP	1371.5	512964	3177912	1093299	239175
	RB	464.8	2929591	2967491	17237	1713
	HB	495.3	2984512	3018176	15215	1617
mas76	MIB	180.8	1372216	1372216	0	0
	PCB	59.0	426490	426490	0	0
	FSB	117.0	86160	481426	161794	35839
	FSBDP	160.1	83072	480520	161259	37465
	RB	63.1	451560	456364	2031	371
	HB	70.7	503531	508295	2038	344
mcf2	MIB	6963.4	2711113	2711113	0	0
	PCB	4602.1	1822685	1822685	0	0
	FSB	11895.4	80279	445351	145814	36722
	FSBDP	11137.3	77817	446269	147074	37152

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	RB	3532.8	1345656	1349342	1374	469
	HB	5141.9	1988357	1988651	70	77
mine-166-5	MIB	972.5	494385	494385	0	0
	PCB	51.1	17891	17891	0	0
	FSB	10.6	139	597	187	42
	FSBDP	9.2	37	243	98	5
	RB	9.6	644	926	129	12
	HB	5.9	227	529	141	10
misc03	MIB	0.5	458	458	0	0
	PCB	0.5	556	556	0	0
	FSB	0.7	59	459	189	11
	FSBDP	0.8	51	509	215	14
	RB	0.6	141	841	335	15
	HB	0.6	75	629	260	17
misc06	MIB	0.5	221	221	0	0
	PCB	0.5	111	111	0	0
	FSB	0.5	13	49	16	2
	FSBDP	0.5	13	49	16	2
	RB	0.5	9	45	14	4
	HB	0.5	11	37	9	4
misc07	MIB	10.3	18560	18560	0	0
	PCB	7.7	13643	13643	0	0
	FSB	50.8	1959	28837	12469	970
	FSBDP	54.4	1907	28281	12235	952
	RB	17.1	27252	30362	1382	173
	HB	20.5	32270	35882	1593	213
mod008	MIB	0.7	536	536	0	0
	PCB	0.6	409	409	0	0
	FSB	0.6	10	54	21	1
	FSBDP	0.7	10	54	21	1
	RB	0.6	7	57	25	0
	HB	0.6	7	53	23	0
mod010	MIB	0.5	2	2	0	0
	PCB	0.5	2	2	0	0
	FSB	0.5	2	4	1	0
	FSBDP	0.5	2	4	1	0
	RB	0.5	2	10	4	0
	HB	0.5	2	12	5	0
mod011	MIB	89.7	1885	1885	0	0
	PCB	87.2	2129	2129	0	0
	FSB	188.2	69	735	301	32
	FSBDP	183.0	67	715	292	32
	RB	81.9	1143	1801	316	13
	HB	85.8	1131	1539	193	11

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
modglob	MIB	0.5	249	249	0	0
	PCB	0.5	247	247	0	0
	FSB	0.5	11	69	25	4
	FSBDP	0.5	9	71	26	5
	RB	0.5	31	91	28	2
	HB	0.5	31	89	28	1
neos-1053591	MIB	2134.1	4754920	4754920	0	0
	PCB	915.3	2287976	2287976	0	0
	FSB	1461.9	140111	538473	146121	53060
	FSBDP	2126.2	201181	756477	193135	84513
	RB	8.7	14037	15557	735	25
	HB	7.4	8924	10512	791	3
neos-1058477	MIB	12.8	4043	4043	0	0
	PCB	11.5	3367	3367	0	0
	FSB	0.9	1	5	2	0
	FSBDP	1.0	1	5	2	0
	RB	0.7	2	6	2	0
	HB	0.8	2	6	2	0
neos-1109824	MIB	2001.2	695781	695781	0	0
	PCB	494.0	147766	147766	0	0
	FSB	135.3	680	8832	3760	316
	FSBDP	174.3	638	8460	3607	304
	RB	152.0	36694	47440	4874	499
	HB	127.4	25719	35933	4663	444
neos-1120495	MIB	3.0	505	505	0	0
	PCB	3.1	457	457	0	0
	FSB	2.8	4	20	8	0
	FSBDP	2.9	4	20	8	0
	RB	2.9	5	41	18	0
	HB	2.9	5	45	18	2
neos-1126860	MIB	675.5	11292	11292	0	0
	PCB	439.1	9784	9784	0	0
	FSB	2145.8	7337	9675	1168	1
	FSBDP	2718.8	2961	9215	1996	1131
	RB	446.7	8154	8184	15	0
	HB	467.7	5405	7073	833	1
neos-1200887	MIB	2136.8	3549185	3549185	0	0
	PCB	61.1	90271	90271	0	0
	FSB	243.0	1873	19195	7786	875
	FSBDP	149.7	1077	12131	5000	527
	RB	25.1	35177	35867	298	47
	HB	24.3	30241	30967	296	67
neos-1208069	MIB	137.7	7936	7936	0	0
	PCB	109.5	1875	1875	0	0
	FSB	55.0	1	135	66	1

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSBDP	37.2	1	129	63	1
	RB	89.5	420	830	198	7
	HB	98.0	291	1293	479	22
neos-1208135	MIB	162.4	1127	1127	0	0
	PCB	331.5	27831	27831	0	0
	FSB	39.9	1	107	52	1
	FSBDP	37.9	1	107	52	1
	RB	341.2	5707	10341	2263	54
	HB	175.1	1664	6986	2626	35
neos-1211578	MIB	287.5	1296645	1296645	0	0
	PCB	44.7	183405	183405	0	0
	FSB	231.9	30183	144963	44004	13386
	FSBDP	251.7	26465	128997	39380	11886
	RB	31.4	118283	119635	566	110
	HB	55.7	220937	222477	270	500
neos-1215259	MIB	25904.5	2749385	2749385	0	0
	PCB	130.4	9935	9935	0	0
	FSB	370.6	69	2493	1182	30
	FSBDP	381.6	71	2709	1286	33
	RB	48.9	1982	2648	303	30
	HB	43.2	1717	2379	297	34
neos-1215891	MIB	7237.9	521141	521141	0	0
	PCB	2224.5	285330	285330	0	0
	FSB	444.8	1	265	131	1
	FSBDP	410.6	1	265	131	1
	RB	9438.8	395756	423450	11977	1870
	HB	643.4	6726	8072	613	60
neos-1228986	MIB	9161.5	45170875	45170875	0	0
	PCB	121.8	512627	512627	0	0
	FSB	236.5	33197	148199	43339	14162
	FSBDP	330.8	36819	169973	50547	16030
	RB	69.0	263185	263753	254	30
	HB	65.0	245269	246115	343	80
neos-1281048	MIB	681.7	558920	558920	0	0
	PCB	5.4	2322	2322	0	0
	FSB	43.2	53	889	391	27
	FSBDP	55.0	69	1055	458	35
	RB	7.4	565	1055	232	13
	HB	8.1	599	1405	386	17
neos-1337489	MIB	287.4	1296645	1296645	0	0
	PCB	44.6	183405	183405	0	0
	FSB	232.2	30183	144963	44004	13386
	FSBDP	251.7	26465	128997	39380	11886
	RB	31.2	118283	119635	566	110
	HB	55.5	220937	222477	270	500

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
neos-1396125	MIB	16881.1	2107670	2107670	0	0
	PCB	558.0	183638	183638	0	0
	FSB	2992.3	4053	30795	11997	1374
	FSBDP	704.0	2777	24423	9526	1297
	RB	140.1	27124	27682	262	17
	HB	156.2	37838	38568	339	26
neos-1420205	MIB	99.7	396531	396531	0	0
	PCB	3.4	9463	9463	0	0
	FSB	46.0	10383	13549	1542	41
	FSBDP	110.0	17043	23013	2852	133
	RB	4.5	11868	12042	84	3
	HB	3.2	7206	7370	82	0
neos-1440447	MIB	2072.1	7253331	7253331	0	0
	PCB	93.7	269267	269267	0	0
	FSB	302.6	22299	132335	44951	10067
	FSBDP	336.3	20057	124461	42784	9418
	RB	65.9	166305	168597	956	190
	HB	43.8	114047	117211	951	631
neos-1445743	MIB	40.0	48	48	0	0
	PCB	39.9	44	44	0	0
	FSB	42.9	4	50	23	0
	FSBDP	41.5	2	34	15	1
	RB	55.5	4	76	36	0
	HB	47.8	3	33	15	0
neos-1445755	MIB	39.3	120	120	0	0
	PCB	39.3	130	130	0	0
	FSB	41.4	6	60	26	1
	FSBDP	41.2	6	60	26	1
	RB	46.2	5	45	20	0
	HB	44.7	4	38	17	0
neos-1445765	MIB	49.2	454	454	0	0
	PCB	45.3	236	236	0	0
	FSB	52.6	8	138	64	1
	FSBDP	51.2	8	138	64	1
	RB	56.9	6	150	70	2
	HB	61.0	6	84	39	0
neos-1480121	MIB	2.1	9255	9255	0	0
	PCB	26.6	140313	140313	0	0
	FSB	3.2	2230	8814	2509	783
	FSBDP	4.5	2166	9346	2613	977
	RB	11.1	44715	60153	4946	2773
	HB	5.4	18151	23259	1302	1252
neos-1489999	MIB	983.5	1204727	1204727	0	0
	PCB	8.2	4383	4383	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSB	27.8	15	613	291	8
	FSBDP	26.6	15	607	288	8
	RB	6.7	75	975	444	6
	HB	3.2	27	221	92	5
neos-1582420	MIB	97.1	18769	18769	0	0
	PCB	34.1	6019	6019	0	0
	FSB	206.7	89	1995	911	42
	FSBDP	210.4	73	1913	885	35
	RB	40.6	3401	5451	987	38
	HB	39.8	2627	4727	999	51
neos-430149	MIB	398.7	603423	603423	0	0
	PCB	156.8	307773	307773	0	0
	FSB	12689.4	772466	4190330	1488700	220232
	FSBDP	19615.1	789263	5709107	2092862	367060
	RB	21.5	30810	31472	306	25
	HB	26.1	36702	37724	505	6
neos-476283	MIB	92.0	3100	3100	0	0
	PCB	53.8	1336	1336	0	0
	FSB	71.5	27	329	143	8
	FSBDP	83.9	15	309	140	7
	RB	67.5	214	646	198	18
	HB	94.0	613	1535	419	42
neos-480878	MIB	2773.1	2071984	2071984	0	0
	PCB	63.3	34584	34584	0	0
	FSB	66.0	1365	4945	1547	243
	FSBDP	78.8	1209	6699	2242	503
	RB	13.0	4198	4386	86	8
	HB	13.5	5391	5693	118	33
neos-501474	MIB	54.8	203669	203669	0	0
	PCB	2.9	9853	9853	0	0
	FSB	0.9	231	1387	465	113
	FSBDP	1.1	233	1433	486	114
	RB	1.1	2001	3129	470	94
	HB	0.9	1139	2227	467	77
neos-504674	MIB	2116.9	1565547	1565547	0	0
	PCB	151.8	99831	99831	0	0
	FSB	235.3	1185	10337	4174	402
	FSBDP	239.8	1073	10059	3984	509
	RB	41.4	27655	28125	208	27
	HB	46.1	27513	28207	290	57
neos-504815	MIB	230.8	250133	250133	0	0
	PCB	16.8	13793	13793	0	0
	FSB	38.3	243	2033	803	92
	FSBDP	47.5	275	2423	945	129
	RB	10.0	6375	6787	201	5

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	HB	9.5	5693	6023	153	12
neos-512201	MIB	409.3	258381	258381	0	0
	PCB	36.7	18895	18895	0	0
	FSB	48.3	121	1641	714	46
	FSBDP	45.3	71	1503	681	35
	RB	22.4	8935	9753	388	21
	HB	22.5	10885	11729	398	24
neos-522351	MIB	0.7	4	4	0	0
	PCB	0.7	4	4	0	0
	FSB	0.7	2	6	1	1
	FSBDP	0.7	2	6	1	1
	RB	0.6	1	3	0	1
	HB	0.6	1	3	0	1
neos-530627	MIB	0.5	3	3	0	0
	PCB	0.5	3	3	0	0
	FSB	0.5	3	3	0	0
	FSBDP	0.5	3	3	0	0
	RB	0.5	3	3	0	0
	HB	0.5	3	3	0	0
neos-538916	MIB	8430.0	10833058	10833058	0	0
	PCB	90.6	78007	78007	0	0
	FSB	214.7	3412	33990	13606	1683
	FSBDP	249.3	3549	33849	13389	1761
	RB	36.4	27820	30400	1127	163
	HB	27.7	19659	21615	810	168
neos-544324	MIB	1370.8	110932	110932	0	0
	PCB	1065.2	88616	88616	0	0
	FSB	103.1	13	2267	1126	1
	FSBDP	103.0	13	2267	1126	1
	RB	1372.6	95478	172138	37986	344
	HB	728.4	45178	71556	13143	46
neos-551991	MIB	451.6	13367	13367	0	0
	PCB	219.5	3649	3649	0	0
	FSB	2241.4	37	7029	3477	19
	FSBDP	2236.7	39	7237	3579	20
	RB	694.0	13305	28513	7586	18
	HB	431.3	8072	19996	5933	29
neos-555694	MIB	0.8	2	2	0	0
	PCB	0.9	2	2	0	0
	FSB	0.8	2	4	1	0
	FSBDP	0.9	2	4	1	0
	RB	1.0	1	3	0	1
	HB	1.2	2	12	5	0
neos-555771	MIB	1.8	2	2	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	PCB	1.8	2	2	0	0
	FSB	1.7	2	6	1	1
	FSBDP	1.8	2	6	1	1
	RB	1.6	1	3	0	1
	HB	1.9	2	12	5	0
neos-570431	MIB	29.4	9487	9487	0	0
	PCB	14.9	3637	3637	0	0
	FSB	186.8	49	5341	2621	25
	FSBDP	193.9	49	5425	2663	25
	RB	36.7	5317	11955	3242	77
	HB	27.2	3045	7907	2373	58
neos-584851	MIB	174.0	18166	18166	0	0
	PCB	35.2	2547	2547	0	0
	FSB	24.3	2	162	80	0
	FSBDP	19.2	2	162	80	0
	RB	37.1	967	1095	61	3
	HB	22.3	111	331	108	2
neos-585192	MIB	1322.6	179800	179800	0	0
	PCB	234.7	24733	24733	0	0
	FSB	19.7	71	401	149	16
	FSBDP	27.9	65	703	300	19
	RB	17.9	927	1639	307	49
	HB	19.8	699	1777	498	41
neos-585467	MIB	13.9	2300	2300	0	0
	PCB	6.9	1071	1071	0	0
	FSB	5.4	24	106	35	6
	FSBDP	5.6	16	178	74	7
	RB	4.1	24	172	65	9
	HB	3.8	24	130	44	9
neos-593853	MIB	768.1	1114089	1114089	0	0
	PCB	11.6	10866	10866	0	0
	FSB	10.5	631	4347	1552	306
	FSBDP	11.1	493	3327	1174	243
	RB	6.1	1535	3989	1129	98
	HB	6.2	1601	3921	1056	104
neos-595904	MIB	1095.5	267241	267241	0	0
	PCB	104.3	23823	23823	0	0
	FSB	130.8	1639	4569	1375	90
	FSBDP	138.6	1547	4749	1469	132
	RB	43.3	460	1182	340	21
	HB	48.4	638	1422	368	24
neos-595905	MIB	2.5	299	299	0	0
	PCB	2.5	237	237	0	0
	FSB	4.2	11	167	73	5
	FSBDP	3.6	5	125	58	2

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	RB	3.9	6	66	29	1
	HB	4.7	8	88	40	0
neos-611838	MIB	121.8	19005	19005	0	0
	PCB	31.3	4339	4339	0	0
	FSB	98.4	209	2397	1011	83
	FSBDP	96.5	177	2393	1032	76
	RB	27.7	3167	3289	60	1
	HB	25.4	2913	3107	94	3
neos-612125	MIB	35.1	3535	3535	0	0
	PCB	14.0	935	935	0	0
	FSB	31.3	55	663	281	23
	FSBDP	30.3	49	659	282	23
	RB	13.0	419	525	52	1
	HB	12.3	429	591	80	1
neos-612143	MIB	64.1	7369	7369	0	0
	PCB	22.2	2541	2541	0	0
	FSB	57.4	119	1335	561	47
	FSBDP	59.1	107	1367	589	41
	RB	26.3	2003	2153	73	2
	HB	26.4	1993	2133	68	2
neos-612162	MIB	99.8	12603	12603	0	0
	PCB	23.5	2635	2635	0	0
	FSB	80.6	161	1997	859	59
	FSBDP	83.2	151	1955	846	56
	RB	27.2	2391	2481	44	1
	HB	26.3	2271	2397	61	2
neos-633273	MIB	1.9	35	35	0	0
	PCB	1.9	35	35	0	0
	FSB	1.8	35	35	0	0
	FSBDP	1.8	35	35	0	0
	RB	1.8	35	35	0	0
	HB	1.9	35	35	0	0
neos-686190	MIB	182.6	41331	41331	0	0
	PCB	84.7	14078	14078	0	0
	FSB	142.8	258	3532	1516	121
	FSBDP	161.0	236	3782	1658	115
	RB	39.3	2399	5145	1320	53
	HB	43.8	2629	4993	1133	49
neos-775946	MIB	3.4	4	4	0	0
	PCB	3.4	4	4	0	0
	FSB	4.1	3	47	22	0
	FSBDP	4.1	3	47	22	0
	RB	4.2	3	31	13	1
	HB	3.9	3	27	11	1

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
neos-785899	MIB	8302.0	5074348	5074348	0	0
	PCB	5.6	1179	1179	0	0
	FSB	9.6	14	200	86	7
	FSBDP	8.3	12	404	190	6
	RB	2.9	4	48	20	2
	HB	3.0	6	56	22	3
neos-801834	MIB	729.3	97316	97316	0	0
	PCB	26.6	1570	1570	0	0
	FSB	491.4	4	494	243	2
	FSBDP	542.7	4	466	229	2
	RB	33.1	222	530	151	3
	HB	38.5	288	412	60	2
neos-803219	MIB	85.6	67973	67973	0	0
	PCB	35.4	27255	27255	0	0
	FSB	42.5	1815	11727	4241	715
	FSBDP	55.0	1669	11651	4251	740
	RB	45.4	33677	35165	645	99
	HB	40.8	29541	31251	736	119
neos-803220	MIB	125.7	90232	90232	0	0
	PCB	74.4	53475	53475	0	0
	FSB	128.3	11366	54640	18489	3148
	FSBDP	182.6	10998	56152	19028	3549
	RB	73.4	50236	51248	434	72
	HB	74.6	50743	51705	403	78
neos-806323	MIB	28.9	13557	13557	0	0
	PCB	29.2	14115	14115	0	0
	FSB	110.2	2309	9775	3559	174
	FSBDP	75.3	1255	6147	2198	248
	RB	31.8	14778	15634	414	14
	HB	22.0	8947	9829	377	64
neos-807639	MIB	28.9	17558	17558	0	0
	PCB	14.7	8602	8602	0	0
	FSB	28.6	1253	4423	1288	297
	FSBDP	33.8	1245	4389	1275	297
	RB	15.7	7349	8097	344	30
	HB	13.4	5632	6254	290	21
neos-807705	MIB	50.5	29021	29021	0	0
	PCB	19.9	10767	10767	0	0
	FSB	52.9	1020	5250	1785	330
	FSBDP	61.5	967	5227	1767	363
	RB	11.7	5323	5473	58	17
	HB	12.1	5189	5401	92	14
neos-808072	MIB	22.1	483	483	0	0
	PCB	55.5	1479	1479	0	0
	FSB	16.6	7	189	90	1

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSBDP	13.6	9	115	53	0
	RB	28.3	67	79	4	2
	HB	29.1	101	111	5	0
neos-810326	MIB	29.3	2447	2447	0	0
	PCB	17.6	1269	1269	0	0
	FSB	72.7	9	379	181	4
	FSBDP	74.9	9	387	185	4
	RB	19.6	124	356	114	2
	HB	20.3	137	335	96	3
neos-820879	MIB	277.2	91426	91426	0	0
	PCB	32.5	4885	4885	0	0
	FSB	45.6	14	574	274	6
	FSBDP	45.2	12	506	242	5
	RB	27.1	271	999	354	10
	HB	26.0	139	923	384	8
neos-829552	MIB	8170.5	28626	28626	0	0
	PCB	652.1	1330	1330	0	0
	FSB	6192.5	13	2169	1077	1
	FSBDP	6123.9	13	2301	1143	1
	RB	383.2	412	554	66	5
	HB	305.7	302	360	26	3
neos-839859	MIB	185.2	48130	48130	0	0
	PCB	48.4	10828	10828	0	0
	FSB	112.8	210	2192	913	78
	FSBDP	241.8	138	1926	830	64
	RB	28.9	2410	3918	711	43
	HB	29.1	1938	3622	788	54
neos-860300	MIB	8.0	2	2	0	0
	PCB	7.8	2	2	0	0
	FSB	7.7	1	3	0	1
	FSBDP	7.5	1	3	0	1
	RB	7.6	1	3	0	1
	HB	7.6	1	3	0	1
neos-863472	MIB	9227.5	15604262	15604262	0	0
	PCB	433.6	710395	710395	0	0
	FSB	1558.0	92720	697914	261838	40759
	FSBDP	1598.3	82146	628118	233566	39420
	RB	262.8	344140	363406	9098	535
	HB	240.4	323038	337174	3774	3294
neos-880324	MIB	0.5	113	113	0	0
	PCB	0.5	78	78	0	0
	FSB	0.5	22	120	41	8
	FSBDP	0.5	24	160	56	12
	RB	0.5	147	311	71	11
	HB	0.5	105	303	76	23

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
neos-892255	MIB	24.2	670	670	0	0
	PCB	50.2	990	990	0	0
	FSB	1008.9	9	585	288	0
	FSBDP	676.5	7	559	276	0
	RB	89.9	716	1162	221	2
	HB	112.6	925	1411	240	3
neos-906865	MIB	160.1	75775	75775	0	0
	PCB	130.8	65522	65522	0	0
	FSB	244.5	8458	66188	25878	2987
	FSBDP	278.3	8399	65559	25610	2970
	RB	118.3	52181	59727	3125	648
	HB	157.4	66160	75578	4357	352
neos-912023	MIB	338.8	87045	87045	0	0
	PCB	1820.0	753947	753947	0	0
	FSB	4755.3	2846	64452	29386	1417
	FSBDP	4827.3	3344	76476	34898	1668
	RB	137.9	32901	34347	625	98
	HB	83.8	15991	17375	507	185
neos-942323	MIB	23.5	22087	22087	0	0
	PCB	1.5	856	856	0	0
	FSB	73.0	335	6019	2677	165
	FSBDP	91.9	398	7362	3283	199
	RB	8.8	3259	4095	381	37
	HB	7.4	1691	3371	744	96
neos-955215	MIB	674.1	3480870	3480870	0	0
	PCB	9.6	34642	34642	0	0
	FSB	6.0	2772	9180	2533	671
	FSBDP	7.6	2684	9290	2620	683
	RB	6.8	21894	22620	326	37
	HB	4.0	12388	13298	147	308
newdano	MIB	18656.0	12836876	12836876	0	0
	PCB	4734.7	5967427	5967427	0	0
	FSB	13315.2	387870	1991588	624481	177378
	FSBDP	12985.9	367248	1933570	609473	173688
	RB	3725.6	4442461	4446105	1537	285
	HB	1811.3	1669909	1672331	958	253
noswot	MIB	1287.6	6229063	6229063	0	0
	PCB	341.5	1520848	1520848	0	0
	FSB	902.6	733399	1458487	297025	65519
	FSBDP	790.9	320840	1228452	352905	100901
	RB	296.9	1248895	1264133	7046	573
	HB	125.3	565551	578899	5593	1081
ns1208400	MIB	2388.0	4776	4776	0	0
	PCB	3818.2	22831	22831	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	FSB	1266.2	2	348	173	0
	FSBDP	862.9	2	344	171	0
	RB	2162.0	2384	7672	2628	16
	HB	2793.7	3034	19740	8273	80
ns1688347	MIB	4.8	101	101	0	0
	PCB	5.0	230	230	0	0
	FSB	7.4	3	69	31	2
	FSBDP	7.0	3	67	30	2
	RB	5.9	3	33	13	2
	HB	10.0	141	1079	449	20
ns1766074	MIB	550.5	978072	978072	0	0
	PCB	572.9	1018506	1018506	0	0
	FSB	458.6	249625	1116399	311616	121771
	FSBDP	879.6	248335	1118219	312393	122549
	RB	571.2	1005437	1008223	877	516
	HB	538.5	1019999	1022957	1025	454
ns1830653	MIB	4899.2	767841	767841	0	0
	PCB	200.5	26092	26092	0	0
	FSB	4822.4	1909	21753	9014	908
	FSBDP	4365.7	1733	20731	8647	852
	RB	451.9	46434	53122	3281	63
	HB	159.3	18423	20335	881	75
nsa	MIB	0.9	211	211	0	0
	PCB	0.9	231	231	0	0
	FSB	1.6	69	167	35	14
	FSBDP	1.8	71	169	36	13
	RB	0.9	175	189	5	2
	HB	1.1	197	203	3	0
nug08	MIB	29.6	8	8	0	0
	PCB	28.6	8	8	0	0
	FSB	45.3	3	15	5	1
	FSBDP	39.7	3	15	5	1
	RB	53.3	4	28	12	0
	HB	21.9	2	14	5	1
nw04	MIB	12.2	935	935	0	0
	PCB	12.6	957	957	0	0
	FSB	10.7	6	84	39	0
	FSBDP	10.7	6	84	39	0
	RB	11.5	6	56	25	0
	HB	10.9	5	47	20	1
p0201	MIB	0.5	435	435	0	0
	PCB	0.5	250	250	0	0
	FSB	0.6	5	139	64	3
	FSBDP	0.7	5	131	60	3
	RB	0.6	9	139	62	3

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	HB	0.7	11	157	68	5
p0282	MIB	0.5	5	5	0	0
	PCB	0.5	5	5	0	0
	FSB	0.5	4	10	3	0
	FSBDP	0.5	4	10	3	0
	RB	0.5	3	23	10	0
	HB	0.5	3	17	7	0
p2756	MIB	0.6	87	87	0	0
	PCB	0.6	63	63	0	0
	FSB	0.6	3	9	2	1
	FSBDP	0.6	4	12	3	1
	RB	0.6	2	12	4	1
	HB	0.6	2	14	5	1
pg	MIB	9.7	1380	1380	0	0
	PCB	8.2	1080	1080	0	0
	FSB	8.3	202	872	312	23
	FSBDP	8.6	208	874	311	22
	RB	7.9	168	736	272	12
	HB	7.8	178	736	267	12
pg5_34	MIB	785.5	322684	322684	0	0
	PCB	710.0	303794	303794	0	0
	FSB	886.8	27180	228974	96888	4009
	FSBDP	937.0	27104	228874	96876	4009
	RB	577.5	184560	231856	23107	541
	HB	607.5	151920	234076	40038	1040
pk1	MIB	172.6	819824	819824	0	0
	PCB	92.3	452725	452725	0	0
	FSB	173.6	51523	358761	130668	22951
	FSBDP	211.7	48555	355139	129978	23314
	RB	66.1	305419	312207	3086	308
	HB	63.6	301322	302682	417	263
pp08a	MIB	1.1	1393	1393	0	0
	PCB	0.6	727	727	0	0
	FSB	0.9	47	353	134	19
	FSBDP	1.0	43	325	121	20
	RB	0.7	189	427	109	10
	HB	0.7	143	343	86	14
pp08aCUTS	MIB	0.8	901	901	0	0
	PCB	0.6	613	613	0	0
	FSB	0.7	35	241	90	13
	FSBDP	0.9	35	291	114	14
	RB	0.6	99	357	123	6
	HB	0.7	87	307	100	10
prod1	MIB	231.8	800247	800247	0	0

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	PCB	21.1	44946	44946	0	0
	FSB	28.9	3284	28356	10988	1548
	FSBDP	36.3	3200	28132	10932	1534
	RB	12.6	23673	24387	276	81
	HB	13.1	23844	24830	300	193
qap10	MIB	69.7	6	6	0	0
	PCB	70.0	6	6	0	0
	FSB	99.9	2	8	2	1
	FSBDP	88.0	2	8	2	1
	RB	90.4	4	14	5	0
	HB	60.6	2	12	5	0
qiu	MIB	275.0	143727	143727	0	0
	PCB	48.3	16157	16157	0	0
	FSB	1236.2	15845	69043	19805	6794
	FSBDP	1290.9	15975	69751	19975	6913
	RB	44.6	13131	13153	10	1
	HB	40.7	12211	12235	12	0
qnet1	MIB	80.3	52955	52955	0	0
	PCB	2.6	636	636	0	0
	FSB	2.2	4	16	6	0
	FSBDP	2.3	5	19	7	0
	RB	2.0	4	8	2	0
	HB	2.4	5	23	9	0
qnet1_o	MIB	1.9	950	950	0	0
	PCB	1.0	53	53	0	0
	FSB	1.5	7	21	6	1
	FSBDP	1.3	4	14	5	0
	RB	0.9	3	23	10	0
	HB	0.9	2	14	5	1
rail507	MIB	19395.2	507052	507052	0	0
	PCB	531.5	8178	8178	0	0
	FSB	1421.2	26	2288	1118	13
	FSBDP	1683.0	26	2348	1148	13
	RB	118.1	574	738	71	11
	HB	111.5	486	690	86	16
ran16x16	MIB	12904.1	14379844	14379844	0	0
	PCB	413.6	438753	438753	0	0
	FSB	640.1	16729	163965	68456	5162
	FSBDP	731.7	16305	162681	66989	6199
	RB	328.3	331013	346753	7546	324
	HB	291.2	297873	311077	6112	490
reblock67	MIB	14351.2	11641257	11641257	0	0
	PCB	830.1	525421	525421	0	0
	FSB	399.3	15270	79888	30065	2244
	FSBDP	326.9	8682	61660	23540	2949

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
	RB	67.8	41430	45976	2240	33
	HB	59.7	31313	35837	2174	88
rentacar	MIB	2.0	16	16	0	0
	PCB	2.0	14	14	0	0
	FSB	2.4	4	30	13	0
	FSBDP	2.4	4	30	13	0
	RB	2.3	4	20	8	0
	HB	2.2	2	18	8	0
rmatr100-p10	MIB	62.5	821	821	0	0
	PCB	67.7	935	935	0	0
	FSB	594.9	91	1497	657	46
	FSBDP	623.8	87	1431	628	44
	RB	106.8	825	1203	184	5
	HB	103.8	745	1053	126	28
rmatr100-p5	MIB	124.5	411	411	0	0
	PCB	126.2	437	437	0	0
	FSB	1260.8	33	927	430	17
	FSBDP	1281.7	33	877	405	17
	RB	198.9	385	785	199	1
	HB	191.6	405	651	111	12
set1ch	MIB	0.5	48	48	0	0
	PCB	0.5	38	38	0	0
	FSB	0.5	5	27	10	1
	FSBDP	0.5	5	27	10	1
	RB	0.5	6	60	25	2
	HB	0.5	6	60	25	2
sp98ir	MIB	767.5	205856	205856	0	0
	PCB	77.3	16898	16898	0	0
	FSB	59.9	100	2250	1027	48
	FSBDP	69.3	104	2364	1080	50
	RB	38.3	4450	7062	1274	32
	HB	33.6	3300	6246	1418	55
stein27	MIB	0.6	4483	4483	0	0
	PCB	0.5	3963	3963	0	0
	FSB	1.4	795	2371	414	374
	FSBDP	2.0	787	2425	432	387
	RB	0.6	4151	4151	0	0
	HB	0.7	3929	4203	24	113
stein45	MIB	13.2	89577	89577	0	0
	PCB	8.2	48861	48861	0	0
	FSB	44.6	7577	28021	6540	3682
	FSBDP	60.3	7527	27675	6434	3640
	RB	8.8	51173	51257	32	10
	HB	8.6	48479	48549	12	23

Instance	Setting	Time (s)	Nodes	Fair Nodes	DomReds	Cutoffs
triptim1	MIB	3071.4	44	44	0	0
	PCB	3505.5	56	56	0	0
	FSB	665.6	2	6	1	1
	FSBDP	665.1	2	6	1	1
	RB	2441.1	34	34	0	0
	HB	681.7	2	4	1	0
vpm2	MIB	0.6	900	900	0	0
	PCB	0.6	1062	1062	0	0
	FSB	0.6	32	182	64	11
	FSBDP	0.7	30	170	58	12
	RB	0.5	102	244	61	10
	HB	0.5	102	234	57	9

Table 2: Results for the 156 instances solved by all branching rules.