TABLE I: All benchmark Information in Primary Variable Number, and Variable and Clause Number under Different Symmetry Breaking Settings.

ID	subjects	primary	var^{NoSB}	clause^{NoSB}	$\text{var}^{AlloySB}$	$\text{clause}^{AlloySB}$	var^{CNFSB}	clause^{CNFSB}	$\text{var}^{ManualSB}$	$\text{clause}^{ManualSB}$
1	alloy/addressBook1g/delUndoesAdd_1.cnf	51	514	1007	790	1469	811	1901	N/A	N/A
2	alloy/addressBook3a/show_1.cnf	92	1807	5073	2178	5711	1906	5371	N/A	N/A
3	alloy/basic-auth/run$1_1.cnf	485	2725	5153	4090	7472	3977	8933	N/A	N/A
4	alloy/chord/FindSuccessorWorks_17.cnf	173	2449	4213	2449	4213	2746	5107	N/A	N/A
5	alloy/chord/FPisActive_9.cnf	173	5069	8970	5069	8970	5267	9560	N/A	N/A
6	alloy/chord/SameFP_10.cnf	167	3910	8570	3910	8570	4108	9159	N/A	N/A
7	alloy/chord/ShowMe1_14.cnf	192	2841	5458	2841	5458	3782	8267	N/A	N/A
8	alloy/chord/ShowMe2_15.cnf	192	3723	6919	3723	6919	4565	9430	N/A	N/A
9	alloy/chord/ShowMeFC_4.cnf	61	744	1153	744	1153	1023	1993	N/A	N/A
10	alloy/chordbugmodel/ShowMe3_4.cnf	496	13586	25243	13586	25243	13883	26098	N/A	N/A
11	alloy/chordbugmodel/ShowMeCorrectSuccessorEg_3.cnf	130	2399	4381	2399	4381	2597	4973	N/A	N/A
12	alloy/chordbugmodel/ShowMeGood_2.cnf	149	3214	5584	3214	5584	3511	6469	N/A	N/A
13	alloy/chordbugmodel/StrongerFindSuccessorWorks_6.cnf	282	4561	8787	4561	8787	4858	9673	N/A	N/A
14	alloy/dijkstra-K-state/TwoPrivileged_2.cnf	143	2654	5300	2654	5300	2753	5581	N/A	N/A
15	alloy/file_system/check$1_1.cnf	127	1532	3106	1532	3106	1730	3702	N/A	N/A
16	alloy/firewire/ElectionHappens_2.cnf	456	12600	23968	12600	23968	12897	24862	N/A	N/A
17	alloy/firewire/Execution_1.cnf	290	6823	12552	6823	12552	7120	13446	N/A	N/A
18	alloy/firewire/OneEventuallyElected_7.cnf	531	16725	31694	16725	31694	17022	32588	N/A	N/A
19	alloy/handshake/P10_1.cnf	200	3988	9584	3988	9584	4168	9386	N/A	N/A
20	alloy/handshake/P12_2.cnf	288	6410	15593	6410	15593	6685	15285	N/A	N/A
21	alloy/handshake/P14_3.cnf	392	9548	23300	9548	23300	9938	22910	N/A	N/A
22	alloy/handshake/P16_4.cnf	512	13534	33107	13534	33107	14059	32627	N/A	N/A
23	alloy/hotel3/NoBadEntry_1.cnf	391	7886	20392	8585	21591	8183	21286	N/A	N/A
24	alloy/javatypes/Show_1.cnf	46	384	620	384	620	522	1037	N/A	N/A
25	alloy/life/interesting_3.cnf	90	3654	11352	3654	11352	3654	10956	N/A	N/A
26	alloy/life/Show_2.cnf	324	27394	92875	27394	92875	27394	90783	N/A	N/A
27	alloy/life/Square_1.cnf	95	4654	13779	4654	13779	4654	13345	N/A	N/A
28	alloy/mediaAssets/CutPaste_2.cnf	120	1640	3662	2266	4730	2135	5153	N/A	N/A
29	alloy/mediaAssets/PasteCut_3.cnf	120	1640	3662	2266	4730	2135	5152	N/A	N/A
30	alloy/messaging/OutOfOrder_2.cnf	496	4513	7007	4513	7007	6145	11905	N/A	N/A
31	alloy/messaging/SomeState_1.cnf	76	609	731	609	731	916	1656	N/A	N/A
32	alloy/opt_spantree/SuccessfulRun_1.cnf	205	4568	8718	4568	8718	4568	8718	N/A	N/A
33	alloy/origin-tracking/check$2_2.cnf	190	3247	6294	4037	7664	3445	6865	N/A	N/A
34	alloy/p300-hotel/NoIntruder_1.cnf	137	3138	6436	3595	7218	3435	7330	N/A	N/A
35	alloy/p303-hotel/NoIntruder_2.cnf	207	5235	11247	5942	12460	5532	12141	N/A	N/A
36	alloy/paragraph-numbering/AddNeverReduces_2.cnf	420	5233	11773	5233	11773	5530	12667	N/A	N/A
37	alloy/peterson/ThreeRun_2.cnf	1038	12338	27266	12338	27266	12437	27564	N/A	N/A
38	alloy/peterson/TwoRun_1.cnf	698	8079	17853	8079	17853	8178	18151	N/A	N/A
39	alloy/philosophers/Liveliness_2.cnf	307	7554	19005	9266	21980	7752	19089	N/A	N/A
40	alloy/philosophers/run$1_1.cnf	120	2242	5543	2910	6691	2440	6003	N/A	N/A
41	alloy/prisoner/run$5_5.cnf	707	8010	24515	8842	25967	8076	22465	N/A	N/A
42	alloy/queens/run$1_1.cnf	2048	22807	70414	29970	82925	22906	66840	N/A	N/A
43	alloy/railway/PolicyWorks_1.cnf	80	956	1566	956	1566	1253	2460	N/A	N/A
44	alloy/railway/TrainsMoveLegal_2.cnf	87	890	1564	890	1564	1301	2803	N/A	N/A
45	alloy/ringlead/SomeLeader_4.cnf	627	9333	16876	9333	16876	9724	17573	N/A	N/A
46	alloy/stable_ringlead/CBadLivenessTrace_5.cnf	137	4746	8476	4746	8476	4905	8804	N/A	N/A
47	alloy/view-backing/zippishOK_1.cnf	1734	93764	291349	93764	291349	93764	289725	N/A	N/A
48	kodkod/alloy/DNACuts/1.cnf	90	4779	188	4802	188	4911	628	N/A	N/A
49	kodkod/alloy/FileSystem/1.cnf	135	1611	3235	2210	4281	1745	3639	N/A	N/A
50	kodkod/alloy/GroupScheduling/1.cnf	285	4158	10669	5508	12991	4158	9397	N/A	N/A
51	kodkod/alloy/Handshake/1.cnf	200	3901	9292	4841	11016	4045	9058	N/A	N/A
52	kodkod/alloy/Lists/1.cnf	180	3122	7626	3644	8528	3277	8021	N/A	N/A
53	kodkod/alloy/Pigeonhole/1.cnf	8188	388755	764957	453358	877429	397566	834629	N/A	N/A
54	kodkod/alloy/ToyLists/1.cnf	138	2004	4760	2562	5724	2202	5311	N/A	N/A

TABLE II: All benchmark Information in Primary Variable Number, and Variable and Clause Number under Different Symmetry Breaking Settings.

ID	subjects	primary	var^{NoSB}	clause^{NoSB}	$\text{var}^{AlloySB}$	$\text{clause}^{AlloySB}$	var^{CNFSB}	clause^{CNFSB}	$\text{var}^{ManualSB}$	$\text{clause}^{ManualSB}$
55	kodkod/csp/BlockedNQueens/1.cnf	200	8615	27337	9328	28554	8714	23990	N/A	N/A
56	kodkod/csp/GraphColoring/1.cnf	120	631	1550	990	2167	932	2457	N/A	N/A
57	kodkod/csp/GraphColoring2/1.cnf	150	1021	1700	1339	2242	1417	2892	N/A	N/A
58	kodkod/csp/LatinSquare/1.cnf	512	73271	12182	77410	19401	73370	12480	N/A	N/A
59	kodkod/csp/NQueens/1.cnf	48	3332	12099	3411	12255	4026	12242	N/A	N/A
60	kodkod/tptp/GEO115/1.cnf	280	2747	3042	4975	6920	5928	12605	N/A	N/A
61	kodkod/tptp/MGT066/1.cnf	1024	7105	11936	8892	15013	7897	14463	N/A	N/A
62	nQueen/3queen_1/NQueensProblem_1.cnf	3072	20969	56705	27113	71033	21167	55370	N/A	N/A
63	nQueen/3queen_2/NQueensProblem_1.cnf	3072	20969	56630	27113	70958	21167	55295	N/A	N/A
64	nQueen/3queen_3/NQueensProblem_1.cnf	3072	20969	56549	27113	70877	21167	55214	N/A	N/A
65	nQueen/3queen_4/NQueensProblem_1.cnf	3072	20969	56462	27113	70790	21167	55127	N/A	N/A
66	nQueen/3queen_5/NQueensProblem_1.cnf	3072	20969	56369	27113	70697	21167	55034	N/A	N/A
67	nQueen/3queen_6/NQueensProblem_1.cnf	3072	20969	56270	27113	70598	21167	54935	N/A	N/A
68	nQueen/3queen_7/NQueensProblem_1.cnf	3072	20969	56165	27113	70493	21167	54830	N/A	N/A
69	nQueen/3queen_8/NQueensProblem_1.cnf	3072	20969	56054	27113	70382	21167	54719	N/A	N/A
70	nQueen/3queen_9/NQueensProblem_1.cnf	3072	20969	55937	27113	70265	21167	54602	N/A	N/A
71	nQueen/3queen_10/NQueensProblem_1.cnf	3072	20969	55814	27113	70142	21167	54479	N/A	N/A
72	nQueen/3queen_11/NQueensProblem_1.cnf	3072	20969	55685	27113	70013	21167	54350	N/A	N/A
73	nQueen/3queen_12/NQueensProblem_1.cnf	3072	20969	55550	27113	69878	21167	54215	N/A	N/A
74	nQueen/nqueen_1/NQueensProblem_1.cnf	1024	3762	7163	3762	7163	3762	7163	N/A	N/A
75	nQueen/nqueen_2/NQueensProblem_1.cnf	2048	11477	30870	14549	38034	11576	29984	N/A	N/A
76	nQueen/nqueen_3/NQueensProblem_1.cnf	3072	20969	56549	27113	70877	21167	55214	N/A	N/A
77	nQueen/nqueen_4/NQueensProblem_1.cnf	4096	33326	89753	42541	111244	33623	87866	N/A	N/A
78	nQueen/nqueen_5/NQueensProblem_1.cnf	5120	48549	130477	60835	159131	48945	127937	N/A	N/A
79	nQueen/nqueen_6/NQueensProblem_1.cnf	6144	66638	178715	81995	214532	67133	175420	N/A	N/A
80	nQueen/nqueen_7/NQueensProblem_1.cnf	7168	87593	234461	106021	277441	88187	230309	N/A	N/A
81	nQueen/nqueen_8/NQueensProblem_1.cnf	8192	111414	297709	132913	347852	112107	292601	N/A	N/A
82	nQueen/nqueen_9/NQueensProblem_1.cnf	9216	138101	368453	162671	425759	138893	362273	N/A	N/A
83	nQueen/nqueen_10/NQueensProblem_1.cnf	10240	167654	446687	195295	511156	168545	439331	N/A	N/A
84	nQueen/nqueen_11_blocked/NQueensProblem_1.cnf	11264	200074	532527	230786	604159	201064	523947	N/A	N/A
85	nQueen/nqueen_11/NQueensProblem_1.cnf	11264	200073	532405	230785	604037	201063	523828	N/A	N/A
86	nQueen/nqueen_12/NQueensProblem_1.cnf	12288	-	-	269141	704396	-	-	N/A	N/A
87	DataStructure/bst-exactly-6-Node/RepOk_1.cnf	191	3632	9140	4169	10062	3731	8594	3778	9863
88	DataStructure/bst-exactly-7-Node/RepOk_1.cnf	234	4935	12538	5627	13728	5034	11802	5126	13633
89	DataStructure/bst-exactly-8-Node/RepOk_1.cnf	425	8899	24275	9818	25859	8999	21883	9141	25854
90	DataStructure/bst-exactly-9-Node/RepOk_1.cnf	492	12051	33698	13101	35508	12150	30880	12350	35951
91	DataStructure/bst-exactly-10-Node/RepOk_1.cnf	387	-	-	13189	34565	-	-	12298	35426
92	DataStructure/bt-exactly-6-Node/RepOk_1.cnf	79	1251	3466	1668	4178	1446	4053	1613	4585
93	DataStructure/bt-exactly-7-Node/RepOk_1.cnf	106	1847	5328	2443	6350	2045	5924	2381	7060
94	DataStructure/bt-exactly-8-Node/RepOk_1.cnf	137	2602	7749	3409	9137	2800	8345	3356	10288
95	DataStructure/bt-exactly-9-Node/RepOk_1.cnf	172	4389	13879	5439	15689	4587	14475	5417	17509
96	DataStructure/bt-exactly-10-Node/RepOk_1.cnf	211	-	-	7141	21049	-	-	7178	23684
97	DataStructure/dllist-exactly-6-Node/RepOk_1.cnf	109	2438	7004	2955	7891	2549	7339	2452	7120
98	DataStructure/dllist-exactly-7-Node/RepOk_1.cnf	141	3625	10784	4341	12016	3738	11125	3641	10940
99	DataStructure/dllist-exactly-8-Node/RepOk_1.cnf	177	5148	15727	5703	16674	5263	16074	5166	15929
100	DataStructure/dllist-exactly-9-Node/RepOk_1.cnf	217	8741	28208	9439	29402	8858	28561	8761	28462
101	DataStructure/dllist-exactly-10-Node/RepOk_1.cnf	261	-	-	12517	39685	-	-	11682	38528
102	DataStructure/rbt-exactly-6-Node/RepOk_1.cnf	203	5375	12991	5952	13983	5564	12478	5521	13780
103	DataStructure/rbt-exactly-7-Node/RepOk_1.cnf	248	7336	17832	8076	19106	7561	17145	7527	19018
104	DataStructure/rbt-exactly-8-Node/RepOk_1.cnf	297	9688	23706	10607	25290	9955	22834	9930	25405
105	DataStructure/rbt-exactly-9-Node/RepOk_1.cnf	510	18694	48290	19808	50212	19045	45562	18993	50696
106	DataStructure/rbt-exactly-10-Node/RepOk_1.cnf	407	-	-	18242	45694	-	-	17279	46619
107	DataStructure/sllist-exactly-6-Node/RepOk_1.cnf	43	992	3039	1209	3401	1091	3337	1006	3155
108	DataStructure/sllist-exactly-7-Node/RepOk_1.cnf	57	1496	4739	1804	5257	1595	5037	1512	4895
109	DataStructure/sllist-exactly-8-Node/RepOk_1.cnf	73	2145	6972	2560	7674	2244	7270	2163	7174
110	DataStructure/sllist-exactly-9-Node/RepOk_1.cnf	91	3803	12888	4341	13802	3902	13186	3823	13142
111	DataStructure/sllist-exactly-10-Node/RepOk_1.cnf	111	-	-	5772	18684	-	-	5117	17842
112	DataStructure/sortedlist-exactly-6-Node/RepOk_1.cnf	139	4930	14157	5467	15079	5029	13189	4944	14273
113	DataStructure/sortedlist-exactly-7-Node/RepOk_1.cnf	169	6430	18598	7122	19788	6529	17419	6446	18754
114	DataStructure/sortedlist-exactly-8-Node/RepOk_1.cnf	201	8173	23826	9036	25312	8272	22436	8191	24028
115	DataStructure/sortedlist-exactly-9-Node/RepOk_1.cnf	235	11023	33054	12073	34864	11122	31453	11043	33308
116	DataStructure/sortedlist-exactly-10-Node/RepOk_1.cnf	271	-	-	14858	43378	-	-	13627	41528

TABLE III: ApproxMC Performance on Alloy benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	No SB Error	Alloy SB Time	Alloy SB Solution	Alloy SB Error	CNF SB Time	CNF SB Solution	CNF SB Error
alloy/addressBook1g/delUndoesAdd_1.cnf	1.72	106496	0.017620303	0.13	640	0.059602649	1.01	30720	0.049789837
alloy/addressBook3a/show_1.cnf	1.74	62464	0.026692965	1.1	2752	0.039667548	1.57	58368	0.034196818
alloy/basic-auth/run$1_1.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chord/FindSuccessorWorks_17.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chord/FPisActive_9.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chord/SameFP_10.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chord/ShowMe1_14.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chord/ShowMe2_15.cnf	676.46	2.88E+018	0.010526316	681.55	2.88E+018	0.010526316	74.75	1.76E+017	-
alloy/chord/ShowMeFC_4.cnf	1.43	11534336	0.05931923	1.41	11534336	0.05931923	0.85	6160384	0.070823241
alloy/chordbugmodel/ShowMe3_4.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chordbugmodel/ShowMeCorrectSuccessorEg_3.cnf	2.01	83886080	0.081219482	2	83886080	0.081219482	1.97	49283072	0.01616861
alloy/chordbugmodel/ShowMeGood_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/chordbugmodel/StrongerFindSuccessorWorks_6.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/dijkstra-K-state/TwoPrivileged_2.cnf	63.79	528482304	0.019059382	63.65	528482304	0.019059382	58.36	276824064	0.011495672
alloy/file_system/check$1_1.cnf	5000	unknown	-	5000	unknown	-	3366.47	2080374784	-
alloy/firewire/ElectionHappens_2.cnf	285.69	966656	-	285.97	966656	-	248	704512	-
alloy/firewire/Execution_1.cnf	861.32	1023410176	-	863.27	1023410176	-	895.4	1023410176	-
alloy/firewire/OneEventuallyElected_7.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/handshake/P10_1.cnf	445.14	47104	0.168253968	443.23	47104	0.168253968	440.14	47104	0.168253968
alloy/handshake/P12_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/handshake/P14_3.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/handshake/P16_4.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/hotel3/NoBadEntry_1.cnf	148.04	129024	0.044289044	1.09	168	0.012048193	43.91	50176	0.096503497
alloy/javatypes/Show_1.cnf	0.57	52224	0.048943015	0.57	52224	0.048943015	0.49	40960	0.102290159
alloy/life/interesting_3.cnf	14.97	12544	0.033163265	14.93	12544	0.033163265	16.71	12544	0.033163265
alloy/life/Show_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/life/Square_1.cnf	3.91	976	0.014553015	3.91	976	0.014553015	4.17	976	0.014553015
alloy/mediaAssets/CutPaste_2.cnf	160	144703488	0.064579782	0.74	137216	0.010575932	29.21	13631488	0.110809079
alloy/mediaAssets/PasteCut_3.cnf	217.9	63963136	0.050068543	0.62	62464	0.029072746	19.72	5767168	0.058489427
alloy/messaging/OutOfOrder_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/messaging/SomeState_1.cnf	0.79	88080384	0.004820892	0.8	88080384	0.004820892	0.78	6684672	0.007849551
alloy/opt_spantree/SuccessfulRun_1.cnf	1.09	213909504	0	1.1	213909504	0	1.08	213909504	0
alloy/origin-tracking/check$2_2.cnf	158.31	2621440	0.046232439	0.38	280	0.014492754	87.31	1310720	0.027496338
alloy/p300-hotel/NoIntruder_1.cnf	1.06	2272	0.051851852	0.02	30	0	0.69	552	0.022222222
alloy/p303-hotel/NoIntruder_2.cnf	6.91	17664	0.108695652	0.04	17	0	2.78	4608	0.019018134
alloy/paragraph-numbering/AddNeverReduces_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/peterson/ThreeRun_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/peterson/TwoRun_1.cnf	6.67	4288	0.102880658	6.67	4288	0.102880658	5.96	2944	0.135802469
alloy/philosophers/Liveliness_2.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-
alloy/philosophers/run$1_1.cnf	5.57	51200	0.0378125	0.95	2432	0.098464318	5.55	50176	0.030054209
alloy/prisoner/run$5_5.cnf	0.77	24576	0.000488281	2.23	12288	0.000488281	1.93	12288	0.000488281
alloy/queens/run$1_1.cnf	5000	unknown	-	2.96	92	0	5000	unknown	-
alloy/railway/PolicyWorks_1.cnf	1.1	499712	0.059502001	1.11	499712	0.059502001	0.91	126976	0.006001134
alloy/railway/TrainsMoveLegal_2.cnf	38.14	3710000000000	0.072254335	38.15	3710000000000	0.072254335	49.97	1340000000000	-
alloy/ringlead/SomeLeader_4.cnf	5000	unknown	-	5000	unknown	-	3948.32	3120000000000	-
alloy/stable_ringlead/CBadLivenessTrace_5.cnf	2.24	5120	0.0125	2.21	5120	0.0125	1.73	2432	0.065789474
alloy/view-backing/zippishOK_1.cnf	5000	unknown	-	5000	unknown	-	5000	unknown	-

TABLE IV: ApproxMC Performance on Kodkod benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	No SB Error	Alloy SB Time	Alloy SB Solution	Alloy SB Error	CNF SB Time	CNF SB Solution	CNF SB Error
kodkod/alloy/DNACuts/1.cnf	1.19	3.52E+13	0	1.19	3.52E+13	0	0.01	44	0
kodkod/alloy/FileSystem/1.cnf	1305.39	5637144576	-	1.65	92160	0.055208333	815.24	3825205248	-
kodkod/alloy/GroupScheduling/1.cnf	5000	unknown	-	218.16	1344	0	5000	unknown	-
kodkod/alloy/Handshake/1.cnf	421.08	47104	0.168253968	1	1	0	463.98	47104	0.168253968
kodkod/alloy/Lists/1.cnf	5000	unknown	-	5.92	434176	0.110702938	5000	unknown	-
kodkod/alloy/Pigeonhole/1.cnf	5000	unknown	-	0.91	1	0	5000	unknown	-
kodkod/alloy/ToyLists/1.cnf	286.22	96468992	0.023035344	1.06	3968	0.092511013	218.35	35651584	0.031141393
kodkod/csp/BlockedNQueens/1.cnf	5000	unknown	-	9.17	352	0.083076923	5000	unknown	-
kodkod/csp/GraphColoring/1.cnf	324.47	54525952	0.07560513	14.59	2228224	0.054920415	17.5	8650752	0.119252813
kodkod/csp/GraphColoring2/1.cnf	5000	unknown	-	5000	unknown	-	3511.95	1.72E+11	-
kodkod/csp/LatinSquare/1.cnf	52	768	0.066666667	0.26	6	0	44.79	368	0.022222222
kodkod/csp/NQueens/1.cnf	2898.4	3670016	-	1.05	92	0	3889.46	425984	-
kodkod/tptp/GEO115/1.cnf	78.91	7.59E+83	-	80.54	1.96E+81	-	5000	unknown	-
kodkod/tptp/MGT066/1.cnf	5000	unknown	-	14.53	335872	0.081462592	5000	unknown	-

TABLE V: ApproxMC Performance on Data Structure Benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	No SB Error	Alloy SB Time	Alloy SB Solution	Alloy SB Error	CNF SB Time	CNF SB Solution	CNF SB Error	Manual SB Time	Manual SB Solution	Manual SB Error
bst-exactly-6-Node/RepOk_1.cnf	1079.16	96256	0.012794613	1.35	128	0.03125	867.87	92160	0.027562216	1.47	140	0.060606061
bst-exactly-7-Node/RepOk_1.cnf	5000	unknown	-	3.31	480	0.118881119	5000	unknown	-	1.84	472	0.1002331
bst-exactly-8-Node/RepOk_1.cnf	5000	unknown	-	18.58	1408	0.015625	5000	unknown	-	5.44	1408	0.015625
bst-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	75.89	4608	0.055121528	5000	unknown	-	13.98	4992	0.026737968
bst-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	-	0	-	5000	unknown	-	0.01	0	-
bt-exactly-6-Node/RepOk_1.cnf	9.08	100352	0.055892256	0.6	416	0.165266106	5.08	62464	0.015047613	0.23	132	0
bt-exactly-7-Node/RepOk_1.cnf	197.8	2129920	0.015136719	3.55	1824	0.023026316	176.68	1638400	0.064844784	0.36	472	0.1002331
bt-exactly-8-Node/RepOk_1.cnf	2177.4	57671680	0.0002442	17.82	9984	0.030248397	1787.7	25165824	0.031370799	0.69	1504	0.051748252
bt-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	105.83	65536	0.081166689	5000	unknown	-	1.25	5120	0.053064582
bt-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	1636.55	368640	0.01182997	5000	unknown	-	3.3	16896	0.005953799
dllist-exactly-6-Node/RepOk_1.cnf	9.31	819200	0.111111111	0.82	1184	0.027777778	6.92	204800	0.059778109	0.21	1024	0
dllist-exactly-7-Node/RepOk_1.cnf	126.81	21495808	0.041269841	2.05	4736	0.072635135	72.47	8781824	-	0.43	4352	0.0625
dllist-exactly-8-Node/RepOk_1.cnf	990.46	587202560	0.125	6.98	22016	0.021802326	724.06	247463936	-	0.62	16128	0.015873016
dllist-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	53.69	102400	-	5000	unknown	-	1.13	70656	0.078125
dllist-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	721.51	483328	-	5000	unknown	-	2.73	278528	0.0625
rbt-exactly-6-Node/RepOk_1.cnf	139.05	15104	0.048888889	0.34	20	0	108.88	12032	0.051932156	0.22	20	0
rbt-exactly-7-Node/RepOk_1.cnf	2439.63	192512	0.091337868	0.84	35	0	1806.55	151552	-	0.36	35	0
rbt-exactly-8-Node/RepOk_1.cnf	5000	unknown	-	4.6	64	0	5000	unknown	-	0.57	64	0
rbt-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	41.93	128	0.049180328	5000	unknown	-	16.05	124	0.016393443
rbt-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	116.56	0	-	5000	unknown	-	0.85	0	-
sllist-exactly-6-Node/RepOk_1.cnf	3.2	736	0.022222222	0.01	7	0	2.72	736	0.022222222	0	1	0
sllist-exactly-7-Node/RepOk_1.cnf	91.1	5376	0.066666667	0.02	12	0	97.96	5376	0.066666667	0	1	0
sllist-exactly-8-Node/RepOk_1.cnf	818.21	45056	0.117460317	0.04	30	0	1037.41	45056	0.117460317	0	1	0
sllist-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	0.14	62	0	5000	unknown	-	0	1	0
sllist-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	5.51	164	0.012345679	5000	unknown	-	0.02	1	0
sortedlist-exactly-6-Node/RepOk_1.cnf	89.6	24064	0.044444444	0.21	62	0	62.27	13312	0.013089802	0.18	32	0
sortedlist-exactly-7-Node/RepOk_1.cnf	1540.12	319488	0.009615385	2.47	160	0.038961039	950.88	184320	0.021028646	0.37	64	0
sortedlist-exactly-8-Node/RepOk_1.cnf	5000	unknown	-	4.69	416	0.034825871	5000	unknown	-	1.84	130	0.015625
sortedlist-exactly-9-Node/RepOk_1.cnf	5000	unknown	-	16.2	1136	0.097584541	5000	unknown	-	2.75	248	0.028225806
sortedlist-exactly-10-Node/RepOk_1.cnf	5000	unknown	-	79.42	2688	0.017113095	5000	unknown	-	4.33	504	0.003984064

TABLE VI: ApproxMC Performance on n-Queen Benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	Alloy SB Time	Alloy SB Solution	CNF SB Time	CNF SB Solution
3queen_1/NqueensProblem_1.cnf	0.02	0	0.01	0	0.02	0
3queen_2/NQueensProblem_1.cnf	0.03	0	0.04	0	0.04	0
3queen_3/NQueensProblem_1.cnf	0.04	0	0.04	0	0.04	0
3queen_4/NQueensProblem_1.cnf	2.55	168	0.11	24	0.17	48
3queen_5/NQueensProblem_1.cnf	3.64	1312	3.58	208	2.1	400
3queen_6/NQueensProblem_1.cnf	18.3	6400	2.61	1040	4.14	1984
3queen_7/NQueensProblem_1.cnf	29.9	24064	4.44	3520	12.28	7296
3queen_8/NQueensProblem_1.cnf	107.56	64512	7.94	9728	30.26	18944
3queen_9/NQueensProblem_1.cnf	368.65	176128	12.78	25088	67.43	51200
3queen_10/NQueensProblem_1.cnf	695.55	335872	26.14	57344	153.16	122880
3queen_11/NQueensProblem_1.cnf	1307.04	688128	45.1	114688	280.15	241664
3queen_12/NQueensProblem_1.cnf	4811.86	1081344	200704	111.76	567.48	417792
nqueen_1/NQueensProblem_1.cnf	0.01	1	0.01	1	0	1
nqueen_2/NQueensProblem_1.cnf	0.01	0	0.02	0	0.02	0
nqueen_3/NQueensProblem_1.cnf	0.04	0	0.04	0	0.04	0
nqueen_4/NQueensProblem_1.cnf	0.42	48	0.09	2	0.15	11
nqueen_5/NQueensProblem_1.cnf	13.37	1184	0.25	10	9.78	208
nqueen_6/NQueensProblem_1.cnf	98.77	2816	0.29	4	77.17	2560
nqueen_7/NQueensProblem_1.cnf	3727.1	208896	1.14	40	1446.4	67584
nqueen_8/NQueensProblem_1.cnf	5000	unknown	13.67	92	5000	unknown
nqueen_9/NQueensProblem_1.cnf	5000	unknown	16.27	304	5000	unknown
nqueen_10/NQueensProblem_1.cnf	5000	unknown	44.97	784	5000	unknown
nqueen_11_blocked/NQueensProblem_1.cnf	5000	unknown	82.11	1120	5000	unknown
nqueen_11/NQueensProblem_1.cnf	5000	unknown	199.77	2752	5000	unknown
nqueen_12/NQueensProblem_1.cnf	5000	unknown	822.14	15360	5000	unknown

TABLE VII: ProjMC Performance on Alloy Benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	Alloy SB Time	Alloy SB Solution	CNF SB Time	CNF SB Solution
alloy/addressBook1g/delUndoesAdd_1.cnf	1.373823	104652	0.040957	604	1.385245	29263
alloy/addressBook3a/show_1.cnf	5.84816	60840	1.010128	2647	7.269054	56438
alloy/basic-auth/run$1_1.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/chord/FindSuccessorWorks_17.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/chord/FPisActive_9.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/chord/SameFP_10.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/chord/ShowMe1_14.cnf	317.103477	3.04E+15	315.609513	3.04E+15	5000	unknown
alloy/chord/ShowMe2_15.cnf	58.150056	2.85E+18	58.341679	2.85E+18	5000	unknown
alloy/chord/ShowMeFC_4.cnf	0.029493	10888442	0.030288	10888442	0.064219	5752942
alloy/chordbugmodel/ShowMe3_4.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/chordbugmodel/ShowMeCorrectSuccessorEg_3.cnf	2.611185	90699264	2.602715	90699264	154.309598	48498912
alloy/chordbugmodel/ShowMeGood_2.cnf	735.771021	6.23E+18	735.608757	6.23E+18	5000	unknown
alloy/chordbugmodel/StrongerFindSuccessorWorks_6.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/dijkstra-K-state/TwoPrivileged_2.cnf	587.731231	518598144	583.400961	518598144	818.330058	273677952
alloy/file_system/check$1_1.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/firewire/ElectionHappens_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/firewire/Execution_1.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/firewire/OneEventuallyElected_7.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/handshake/P10_1.cnf	1368.645696	40320	1365.902548	40320	3626.172726	40320
alloy/handshake/P12_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/handshake/P14_3.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/handshake/P16_4.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/hotel3/NoBadEntry_1.cnf	240.815937	123552	2.097346	166	184.274995	45760
alloy/javatypes/Show_1.cnf	0.408754	54780	0.415171	54780	1.116541	37159
alloy/life/interesting_3.cnf	80.885621	12960	80.823669	12960	77.921775	12960
alloy/life/Show_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/life/Square_1.cnf	4.218213	962	4.225279	962	3.377678	962
alloy/mediaAssets/CutPaste_2.cnf	616.242308	135925452	3.770258	135780	206.440908	12271675
alloy/mediaAssets/PasteCut_3.cnf	491.210215	60913296	3.193336	64280	119.34025	5448489
alloy/messaging/OutOfOrder_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/messaging/SomeState_1.cnf	0.049489	88505010	0.04924	88505010	1.917049	6632609
alloy/opt_spantree/SuccessfulRun_1.cnf	0.702864	213909504	0.690282	213909504	0.673479	213909504
alloy/origin-tracking/check$2_2.cnf	189.062095	2505600	0.191379	276	189.05232	1346760
alloy/p300-hotel/NoIntruder_1.cnf	1.938304	2160	0.052105	30	0.391705	540
alloy/p303-hotel/NoIntruder_2.cnf	32.461941	19584	0.240147	17	10.190272	4522
alloy/paragraph-numbering/AddNeverReduces_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/peterson/ThreeRun_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/peterson/TwoRun_1.cnf	78.229735	3888	77.863812	3888	57.888277	2592
alloy/philosophers/Liveliness_2.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/philosophers/run$1_1.cnf	26.28695	53136	0.979848	2214	22.07414	51684
alloy/prisoner/run$5_5.cnf	1.29782	24588	0.949647	12294	0.307209	12294
alloy/queens/run$1_1.cnf	5000	unknown	3.453271	92	5000	unknown
alloy/railway/PolicyWorks_1.cnf	0.187005	471648	0.18967	471648	0.147073	127738
alloy/railway/TrainsMoveLegal_2.cnf	2734.250715	3.46E+12	2731.438963	3.46E+12		
alloy/ringlead/SomeLeader_4.cnf	5000	unknown	5000	unknown	5000	unknown
alloy/stable_ringlead/CBadLivenessTrace_5.cnf	4.638441	5184	4.53055	5184	4.414321	2592
alloy/view-backing/zippishOK_1.cnf	5000	unknown	5000	unknown	5000	unknown

TABLE VIII: ProjMC Performance on Kodkod Benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	Alloy SB Time	Alloy SB Solution	CNF SB Time	CNF SB Solution
kodkod/alloy/DNACuts/1.cnf	0.007051	3.52E+13	0.00766	3.52E+13	0.013329	44
kodkod/alloy/FileSystem/1.cnf	5000	unknown	3.495476	97248	5000	unknown
kodkod/alloy/GroupScheduling/1.cnf	5000	unknown	238.358967	1344	5000	unknown
kodkod/alloy/Handshake/1.cnf	1969.606439	40320	3.059277	1	3086.041182	40320
kodkod/alloy/Lists/1.cnf	5000	unknown	23.116591	390902	5000	unknown
kodkod/alloy/Pigeonhole/1.cnf	5000	unknown	0.68206	1	5000	unknown
kodkod/alloy/ToyLists/1.cnf	583.369268	94296832	0.891002	3632	523.982152	36761824
kodkod/csp/BlockedNQueens/1.cnf	5000	unknown	3.749441	325	5000	unknown
kodkod/csp/GraphColoring/1.cnf	42.810665	50693280	43.397577	2112220	95.228553	7729042
kodkod/csp/GraphColoring2/1.cnf	5000	unknown	5000	unknown	5000	unknown
kodkod/csp/LatinSquare/1.cnf	49.548002	720	1.406194	6	48.014137	360
kodkod/csp/NQueens/1.cnf	5000	unknown	0.555518	92	5000	unknown
kodkod/tptp/GEO115/1.cnf	5000	unknown	5000	unknown	5000	unknown
kodkod/tptp/MGT066/1.cnf	5000	unknown	936.681628	310572	5000	unknown

TABLE IX: ProjMC Performance on Data Structure Benchmarks under Different Symmetry Breaking Settings.

subjects	No SB Time	No SB Solution	Alloy SB Time	Alloy SB Solution	CNF SB Time	CNF SB Solution	Manual SB Time	Manual SB Solution
bst-exactly-6-Node/RepOk_1.cnf	139.144231	95040	0.350502	132	136.760792	89688	0.424422	132
bst-exactly-7-Node/RepOk_1.cnf	5000	unknown	3.115373	429	5000	unknown	2.02654	429
bst-exactly-8-Node/RepOk_1.cnf	5000	unknown	22.945739	1430	5000	unknown	9.733099	1430
bst-exactly-9-Node/RepOk_1.cnf	5000	unknown	195.920678	4862	5000	unknown	65.969943	4862
bst-exactly-10-Node/RepOk_1.cnf	5000	unknown	0	0	5000	unknown	0	0
bt-exactly-6-Node/RepOk_1.cnf	5.575678	95040	0.100269	357	7.397723	61538	0.031748	132
bt-exactly-7-Node/RepOk_1.cnf	129.25605	2162160	0.703432	1866	184.976535	1538628	0.095038	429
bt-exactly-8-Node/RepOk_1.cnf	3673.890522	57657600	4.948797	10286	3466.195577	25955296	0.342363	1430
bt-exactly-9-Node/RepOk_1.cnf	5000	unknown	40.215615	60616	5000	unknown	1.488686	4862
bt-exactly-10-Node/RepOk_1.cnf	5000	unknown	610.351032	373001	5000	unknown	10.389149	16796
dllist-exactly-6-Node/RepOk_1.cnf	9.512672	737280	0.925232	1152	41.883334	193248	0.009831	1024
dllist-exactly-7-Node/RepOk_1.cnf	69.122924	20643840	14.497965	5080	5000	unknown	0.009311	4096
dllist-exactly-8-Node/RepOk_1.cnf	1765.434646	660602880	115.549873	22496	5000	unknown	0.013257	16384
dllist-exactly-9-Node/RepOk_1.cnf	5000	unknown			5000	unknown	0.012906	65536
dllist-exactly-10-Node/RepOk_1.cnf	5000	unknown	5000	unknown	5000	unknown	0.02988	262144
rbt-exactly-6-Node/RepOk_1.cnf	196.112366	14400	1.339152	20	215.577983	11438	0.548183	20
rbt-exactly-7-Node/RepOk_1.cnf	4137.857859	176400	7.998439	35	5000	unknown	1.576726	35
rbt-exactly-8-Node/RepOk_1.cnf	5000	unknown	49.852873	64	5000	unknown	5.491503	64
rbt-exactly-9-Node/RepOk_1.cnf	5000	unknown	1005.486166	122	5000	unknown	22.484273	122
rbt-exactly-10-Node/RepOk_1.cnf	5000	unknown	0	0	5000	unknown	0	0
sllist-exactly-6-Node/RepOk_1.cnf	0.458154	720	0.014197	7	0.574255	720	0.008449	1
sllist-exactly-7-Node/RepOk_1.cnf	4.901807	5040	0.043722	12	5.87483	5040	0.00749	1
sllist-exactly-8-Node/RepOk_1.cnf	60.091736	40320	0.118694	30	65.634922	40320	0.008031	1
sllist-exactly-9-Node/RepOk_1.cnf	1302.051768	362880	0.440528	62	1306.623466	362880	0.008169	1
sllist-exactly-10-Node/RepOk_1.cnf	-	-	2.82945	162	-	-	0.014764	1
sortedlist-exactly-6-Node/RepOk_1.cnf	254.48917	23040	1.680999	62	188.180552	13140	0.433474	32
sortedlist-exactly-7-Node/RepOk_1.cnf	4518.106749	322560	7.346341	154	3933.05488	188196	1.11685	64
sortedlist-exactly-8-Node/RepOk_1.cnf	5000	unknown	18.240917	402	5000	unknown	2.314642	128
sortedlist-exactly-9-Node/RepOk_1.cnf	5000	unknown	49.678698	1035	5000	unknown	7.847462	255
sortedlist-exactly-10-Node/RepOk_1.cnf	5000	unknown	294.361	2734	5000	unknown	7.610043	502