Appendix A Comparison of MiniSat Clause-Minimization Policies

We ran `MiniSat` 2.0 with three clause-minimization policies: global, local, and none, on the same benchmarks and hardware as reported in the main body of the paper. The CPU times are shown in Table 2. The percentage of the total time taken by `analyze()` (as estimated using statistics gathered with `gprof`) are shown in Table 3. The two tables combined suggest that conflict-clause minimization is a substantial time investment, but it generally more than pays for itself.

Table 2. `MiniSat` 2.0 CPU times (seconds) with various clause-minimization policies.

Benchmark	Global	Local	None
eq.atree.braun.7.unsat	3.39	4.12	4.66
eq.atree.braun.8.unsat	38.34	32.44	31.85
eq.atree.braun.9.unsat	174.71	206.88	229.71
AProVE07-21	1369.26	2721.54	2436.81
AProVE07-02	4204.60	4102.58	4655.85
AProVE07-22	397.68	611.11	663.37
AProVE07-20	753.64	1329.58	1451.19
AProVE07-15	609.09	837.25	730.48
IBM_FV_2004··30···.k15	1394.55	1746.43	1607.03
itox_vc965	0.25	0.25	0.25
dated-5-11-u	726.91	1300.54	2314.70
dated-5-15-u	5031.67	13356.56	17459.43
total-5-11-u	84.71	78.69	89.93
total-5-13-u	206.64	210.57	204.75
dated-10-15-u	97.12	83.13	75.58
dspam_dump_vc973	18202.99	13484.60	1513.55
manol-pipe-c10nidw_s	919.38	1870.41	755.47
TOTAL(17)	34214.88	41976.70	34224.60

The results are difficult to interpret because of one formula, `dspam_dump_vc973`. This formula was solved by the `MiniSat` version in the SAT 2007 competition in 2.6 seconds, and was solved in less than 15 seconds by five other solvers. However, `picosat` required 997 seconds, and three other solvers exceeded the time limit of 10000 seconds.

It *is* the largest formula among our 17 benchmarks (see Appendix B) and was included in the verified-unsatisfiable track because its size was not a barrier for several solvers. According to this formula, conflict-clause minimization is terrible, and the global version is more terrible than the local version.

Here, `MiniSat` 2.0 without conflict-clause minimization took 1514 seconds, which translates to about 757 seconds on the platform used in the SAT 2007 competition. Clearly, some change between versions affected the performance very adversely for this formula. Therefore, we do not consider this formula to be

Table 3. `MiniSat` 2.0 percentage of total time taken by `analyze()` for various clause-minimization policies.

Benchmark	Global	Local	None
eq.atree.braun.7.unsat	27.76	20.74	19.10
eq.atree.braun.8.unsat	22.14	16.33	15.20
eq.atree.braun.9.unsat	15.67	11.54	11.10
AProVE07-21	10.88	16.31	8.69
AProVE07-02	20.52	14.58	15.01
AProVE07-22	16.89	7.07	5.06
AProVE07-20	13.28	8.48	14.67
AProVE07-15	20.99	10.60	6.38
IBM_FV_2004··30···.k15	14.62	12.40	11.04
itox_vc965			
dated-5-11-u	8.45	6.57	6.18
dated-5-15-u	19.77	10.12	5.55
total-5-11-u	13.74	11.82	8.11
total-5-13-u	12.69	6.34	6.34
dated-10-15-u	31.65	8.37	7.00
dspam_dump_vc973	37.88	32.37	14.36
manol-pipe-c10nidw_s	10.04	7.18	5.10
TOTAL(17)	25.64	17.33	8.96

typical. Even with this outlier included, the "Global" policy was still the best in aggregate.

If we look at the other 15 benchmarks (`itox_vc965` may be disregarded as it was solved by unit-clause propagation) we find that the policy "None" took 32711 seconds, "Local" took 28492, a 12% savings, and "Global" took 16012, a 50% savings. "Global" was faster than "None" in 11 cases and slower in 4 cases.

Biere [Bie08] observes that global conflict-clause minimization shortens conflict clauses by 32% on "industrial" SAT problems in `picosat`, and is much more effective than local, but does not appear to save substantial time. Our results on `MiniSat` 2.0 confirm that global is much more effective than local, when measured by time. Much more study is needed to understand the effects of this technique across various solver implementations and benchmarks.

Appendix B Benchmark Statistics

Table 4. Benchmark Statistics.

Benchmark	Best Time	Variables	Clauses
itox_vc965	0.24	115769	338946
dspam_dump_vc973	3	274379	908191
eq.atree.braun.7.unsat	0.80	505	1696
eq.atree.braun.8.unsat	5	684	2300
eq.atree.braun.9.unsat	22	892	3006
AProVE07-02	686	6196	22741
AProVE07-15	46	21104	74257
AProVE07-20	218	7847	73394
AProVE07-21	412	3189	11039
AProVE07-22	81	15589	54263
dated-5-15-u	864	151952	697321
dated-10-15-u	18	193016	885873
dated-5-11-u	161	108786	482639
total-5-11-u	22	156980	696581
total-5-13-u	75	178708	806681
manol-pipe-c10nidw_s	29	404382	1204273
IBM_FV_2004··30···.k15	121	29084	119659
AVERAGE(17)	162.591	98180.1	375462