

An Elite-guided Weighted Simulated Annealing Algorithm for the Clique Partitioning Problem

Anonymous submission

Additional Computational Results

Comparison of EWSA and the State-of-the-Art Algorithms

For each algorithm and each instance, we report the objective value of the best solution *Best* and the average objective value *Avg* on 20 independent runs. We also record the time for finding the best solution in each run, and calculate the average time over 20 runs for each instance. In addition, we use *Hits* to record the number of hitting the best solution over 20 runs. Note that the best objective values marked with * indicate that EWSA improves the previous best known solutions (BKS), while the best objectives among all algorithms are indicated in bold. Table 1, Table 2, and Table 3 show the comparison results of EWSA, FSS (Jovanovic, Sanfilippo, and Voß 2023), and MDMCP (Lu, Zhou, and Hao 2022) on instances of the first category. Then, Table 4 and Table 5 show the comparison results of EWSA, SACC (Gao et al. 2022), FSS, and MDMCP on instances of the second category. The results indicate that there are no significant difference of solutions among EWSA and other algorithms on those instances, which are small in scale and easy to solve, such as the first category instances. While, EWSA significantly outperforms the other algorithms on challenging large instances.

Comparison of EWSA and the variants

Tables 6 and 7 present the comparison results of the best and average objective values for EWSA and variants on 26 instances, respectively. The variants are described as follows:

- **EWSA_w**: disable the weighting strategy in WSA.
- **EWSA_{c1}**: only using *config₁*.
- **EWSA_{c2}**: only using *config₂*.
- **EWSA_{em}**: disable the elite solution preservation mechanism and only keep the historical best solution.
- **EWSA_{pr}**: use adaptive partitioning instead of the partition restriction strategy.

From Tables 6 and 7, we can observe that EWSA outperforms other variants, because EWSA obtains better results with the most number of times in terms of both the average and best objective values.

Instance	Best known	EWSA				FSS				MDMCP			
		Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits
am-100-10	10700	10700	10700.0	8.0	20	10700	10700.0	1.6	20	10700	10700.0	7.7	20
am-100-20	11700	11700	11700.0	8.1	20	11700	11700.0	1.9	20	11700	11700.0	5.1	20
am-100-3	10000	10000	10000.0	7.9	20	10000	10000.0	1.7	20	10000	10000.0	9.9	20
am-125-10	16500	16500	16500.0	12.5	20	16500	16500.0	4.0	20	16500	16500.0	16.5	20
am-125-20	17750	17750	17750.0	11.7	20	17750	17750.0	3.5	20	17750	17750.0	9.5	20
am-125-3	15625	15625	15625.0	12.0	20	15625	15625.0	3.8	20	15625	15625.0	18.2	20
am-150-10	23550	23550	23550.0	16.0	20	23550	23550.0	37.0	20	23550	23550.0	26.1	20
am-150-20	25050	25050	25050.0	16.3	20	25050	25050.0	22.5	20	25050	25050.0	17.9	20
am-150-3	22500	22500	22500.0	16.6	20	22500	22500.0	31.3	20	22500	22500.0	27.7	20
am-25-10	800	800	800.0	1.2	20	800	800.0	0.0	20	800	800.0	0.2	20
am-25-20	1050	1050	1050.0	1.1	20	1050	1050.0	0.0	20	1050	1050.0	0.2	20
am-25-3	625	625	625.0	1.3	20	625	625.0	0.0	20	625	625.0	0.3	20
am-50-10	2850	2850	2850.0	2.7	20	2850	2850.0	0.3	20	2850	2850.0	1.5	20
am-50-20	3350	3350	3350.0	2.6	20	3350	3350.0	0.2	20	3350	3350.0	0.9	20
am-50-3	2500	2500	2500.0	2.7	20	2500	2500.0	0.2	20	2500	2500.0	1.4	20
am-75-10	6150	6150	6150.0	5.1	20	6150	6150.0	0.8	20	6150	6150.0	3.4	20
am-75-20	6900	6900	6900.0	4.8	20	6900	6900.0	0.7	20	6900	6900.0	2.5	20
am-75-3	5625	5625	5625.0	5.0	20	5625	5625.0	0.8	20	5625	5625.0	4.8	20
boc_1	58	58	58.0	1.1	20	58	58.0	0.1	20	58	58.0	0.2	20
boc_10	70	70	70.0	0.9	20	70	70.0	0.1	20	70	70.0	0.1	20
boc_2	61	61	61.0	2.4	20	61	61.0	0.1	20	61	61.0	0.2	20
boc_3	60	60	60.0	0.9	20	60	60.0	0.1	20	60	60.0	0.2	20
boc_4	50	50	50.0	1.1	20	50	50.0	0.1	20	50	50.0	0.2	20
boc_5	72	72	72.0	0.8	20	72	72.0	0.0	20	72	72.0	0.1	20
boc_6	76	76	76.0	0.8	20	76	76.0	0.1	20	76	76.0	0.1	20
boc_7	78	78	78.0	0.8	20	78	78.0	0.1	20	78	78.0	0.1	20
boc_8	61	61	61.0	1.1	20	61	61.0	0.1	20	61	61.0	0.1	20
boc_9	89	89	89.0	0.8	20	89	89.0	0.0	20	89	89.0	0.1	20
boe_91	80	80	80.0	1.3	20	80	80.0	0.2	20	80	80.0	0.2	20
bridges	3867	3867	3867.0	1.8	20	3867	3867.0	0.1	20	3867	3867.0	0.3	20
bur_69	98	98	98.0	0.9	20	98	98.0	0.1	20	98	98.0	0.2	20
bur_75	67	67	66.8	75.5	15	67	67.0	0.4	20	67	67.0	0.3	20
bur_91	72	72	72.0	1.7	20	72	72.0	0.4	20	72	72.0	0.3	20
can_97	157	157	157.0	1.3	20	157	157.0	0.4	20	157	157.0	0.2	20
cars	1501	1501	1501.0	0.8	20	1501	1501.0	0.0	20	1501	1501.0	0.1	20
ce50-20	58	58	58.0	1.4	20	58	58.0	0.2	20	58	58.0	0.3	20
ce50-30	79	79	79.0	1.3	20	79	79.0	0.1	20	79	79.0	0.1	20
ce50-40	105	105	105.0	1.3	20	105	105.0	0.1	20	105	105.0	0.1	20
ce50-50	163	163	163.0	0.8	20	163	163.0	0.1	20	163	163.0	0.1	20
ce50-60	257	257	257.0	0.7	20	257	257.0	0.0	20	257	257.0	0.1	20
ce60-20	73	73	73.0	1.8	20	73	73.0	0.4	20	73	73.0	0.4	20
ce60-40	151	151	151.0	1.5	20	151	151.0	0.1	20	151	151.0	0.1	20
ce60-60	373	373	373.0	0.8	20	373	373.0	0.0	20	373	373.0	0.1	20
ce70-20	93	93	93.0	2.1	20	93	93.0	0.5	20	93	93.0	0.5	20
ce70-60	491	491	491.0	1.0	20	491	491.0	0.0	20	491	491.0	0.0	20
ce80-20	107	107	107.0	2.5	20	107	107.0	0.7	20	107	107.0	0.5	20
ce80-60	657	657	657.0	1.1	20	657	657.0	0.0	20	657	657.0	0.1	20
cetacea	967	967	967.0	0.4	20	967	967.0	0.0	20	967	967.0	0.0	20
cha_86	102	102	102.0	1.0	20	102	102.0	0.1	20	102	102.0	0.1	20
cha_87	347	347	347.0	7.0	20	347	347.0	0.2	20	347	347.0	0.2	20
companies	81802	81802	81802.0	1.6	20	81802	81802.0	0.0	20	81802	81802.0	0.0	20
corr40-1	2191	2191	2191.0	0.7	20	2191	2191.0	0.0	20	2191	2191.0	0.1	20
corr40-10	2301	2301	2301.0	0.8	20	2301	2301.0	0.0	20	2301	2301.0	0.1	20
corr40-2	1852	1852	1852.0	0.7	20	1852	1852.0	0.0	20	1852	1852.0	0.0	20
corr40-3	2310	2310	2310.0	0.9	20	2310	2310.0	0.1	20	2310	2310.0	0.0	20
corr40-4	2084	2084	2084.0	0.7	20	2084	2084.0	0.0	20	2084	2084.0	0.0	20
corr40-5	2245	2245	2245.0	1.0	20	2245	2245.0	0.1	20	2245	2245.0	0.0	20
corr40-6	2516	2516	2516.0	0.8	20	2516	2516.0	0.0	20	2516	2516.0	0.0	20
corr40-7	2294	2294	2294.0	0.8	20	2294	2294.0	0.0	20	2294	2294.0	0.0	20
corr40-8	2184	2184	2184.0	3.0	20	2184	2184.0	0.0	20	2184	2184.0	0.0	20
corr40-9	2129	2129	2129.0	0.7	20	2129	2129.0	0.0	20	2129	2129.0	0.0	20
corr60-1	3678	3678	3678.0	1.0	20	3678	3678.0	0.0	20	3678	3678.0	0.1	20
corr60-10	3570	3570	3570.0	1.1	20	3570	3570.0	0.0	20	3570	3570.0	0.1	20
corr60-2	3445	3445	3445.0	1.0	20	3445	3445.0	0.1	20	3445	3445.0	0.1	20
corr60-3	3595	3595	3595.0	1.0	20	3595	3595.0	0.1	20	3595	3595.0	0.1	20
corr60-4	3565	3565	3565.0	0.9	20	3565	3565.0	0.0	20	3565	3565.0	0.1	20
corr60-5	3313	3313	3313.0	1.2	20	3313	3313.0	0.0	20	3313	3313.0	0.1	20
corr60-6	3295	3295	3295.0	1.1	20	3295	3295.0	0.0	20	3295	3295.0	0.1	20
corr60-7	3506	3506	3506.0	0.7	20	3506	3506.0	0.1	20	3506	3506.0	0.1	20
corr60-8	3540	3540	3540.0	1.1	20	3540	3540.0	0.0	20	3540	3540.0	0.1	20
corr60-9	3372	3372	3372.0	1.0	20	3372	3372.0	0.1	20	3372	3372.0	0.1	20
NoB		71	70			71	71			71	71		

Table 1: Comparison results of EWSA, FSS and MDMCP on 71 instances with proven optimal solutions.

Instance	Best known	EWSA				FSS				MDMCP			
		Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits
CPn45-1	11545	11545	11545.0	1.7	20	11545	11545	0.0	20	11545	11545.0	0.1	20
CPn45-2	12345	12345	12345.0	1.2	20	12345	12345	0.1	20	12345	12345.0	0.3	20
CPn45-3	11880	11880	11880.0	1.2	20	11880	11880	0.1	20	11880	11880.0	0.1	20
CPn45-4	10506	10506	10506.0	3.9	20	10506	10506	0.2	20	10506	10506.0	0.2	20
CPn35-1	7837	7837	7837.0	0.9	20	7837	7837.0	0.1	20	7837	7837.0	0.1	20
CPn35-2	7215	7215	7215.0	0.8	20	7215	7215.0	0.0	20	7215	7215.0	0.1	20
CPn35-3	7633	7633	7633.0	0.6	20	7633	7633.0	0.0	20	7633	7633.0	0.0	20
CPn35-4	7652	7652	7652.0	0.8	20	7652	7652.0	0.0	20	7652	7652.0	0.1	20
gro_80	53	53	53.0	1.1	20	53	53.0	0.1	20	53	53.0	0.1	20
hayes-roth	2800	2800	2800.0	3.3	20	2800	2800.0	1.5	20	2800	2800.0	0.7	20
ira_95	38	38	38.0	0.6	20	38	38.0	0.0	20	38	38.0	0.0	20
kin_80	41	41	41.0	0.9	20	41	41.0	0.1	20	41	41.0	0.1	20
lecturers	14317	14317	14315.9	421.5	6	14316	14311.2	732.4	1	14316	14315.4	562.9	11
lee_97	115	115	115.0	1.9	20	115	115.0	0.1	20	115	115.0	0.1	20
lung-cancer	3472	3472	3472.0	0.5	20	3472	3472.0	0.0	20	3472	3472.0	0.0	20
lymphography	19174	19174	19174.0	3.6	20	19174	19174.0	0.5	20	19174	19174.0	0.2	20
mas_97	41	41	41.0	0.7	20	41	41.0	0.0	20	41	41.0	0.0	20
mcc_72	43	43	43.0	1.0	20	43	43.0	0.0	20	43	43.0	0.1	20
micro	966	966	966.0	0.6	20	966	966.0	0.0	20	966	966.0	0.0	20
mil_91	46	46	46.0	6.7	20	46	46.0	2.3	20	46	46.0	0.3	20
nai_96a	117	117	117.0	1.4	20	117	117.0	0.0	20	117	117.0	0.0	20
nai_96b	93	93	93.0	1.6	20	93	93.0	0.2	20	93	93.0	0.1	20
nai_96c	91	91	91.0	1.4	20	91	91.0	0.2	20	91	91.0	0.1	20
nai_96d	74	74	74.0	1.8	20	74	74.0	0.3	20	74	74.0	0.2	20
neg-c-00	752	752	752.0	0.8	20	752	752.0	0.1	20	752	752.0	0.0	20
neg-c-10	649	649	649.0	0.9	20	649	649.0	0.1	20	649	649.0	0.0	20
neg-c-20	604	604	604.0	0.9	20	604	604.0	0.1	20	604	604.0	0.0	20
neg-c-30	582	582	582.0	0.9	20	582	582.0	0.1	20	582	582.0	0.0	20
neg-c-40	577	577	577.0	0.7	20	577	577.0	0.1	20	577	577.0	0.0	20
neg-c-50	549	549	549.0	0.8	20	549	549.0	0.1	20	549	549.0	0.1	20
neg-c-60	463	463	463.0	0.9	20	463	463.0	0.1	20	463	463.0	0.1	20
neg-c-70	452	452	452.0	0.9	20	452	452.0	0.1	20	452	452.0	0.1	20
neg-c-80	317	317	317.0	0.9	20	317	317.0	0.3	20	317	317.0	0.2	20
neg-s-80	473	473	473.0	1.0	20	473	473.0	0.5	20	473	473.0	0.2	20
primary-tumor	323614	323614	323614.0	5.2	20	323614	323614.0	0.1	20	323614	323614.0	0.2	20
rog_05	60	60	60.0	1.9	20	60	60.0	0.6	20	60	60.0	0.3	20
sei_88	54	54	54.0	0.6	20	54	54.0	0.0	20	54	54.0	0.0	20
soup	4625	4625	4625.0	13.5	20	4625	4625.0	46.2	20	4625	4625.0	16.3	20
soybean-21	3041	3041	3041.0	0.6	20	3041	3041.0	0.0	20	3041	3041.0	0.0	20
soybean-35	14613	14613	14613.0	0.6	20	14613	14613.0	0.0	20	14613	14613.0	0.0	20
soybean-large	316469	316469	316469.0	6.6	20	316469	316469.0	0.3	20	316469	316469.0	0.6	20
sponge	25677	25677	25677.0	1.2	20	25677	25677.0	0.0	20	25677	25677.0	0.0	20
sul_91	46	46	46.0	0.7	20	46	46.0	0.0	20	46	46.0	0.0	20
ta-evaluation	1108	1108	1108.0	3.3	20	1108	1108.0	3.0	20	1108	1108.0	0.8	20
uno	798	798	798.0	0.9	20	798	798.0	0.1	20	798	798.0	0.1	20
uno_1a	12197	12197	12197.0	2.4	20	12197	12197.0	0.3	20	12197	12197.0	0.2	20
uno_1b	11775	11775	11775.0	2.0	20	11775	11775.0	0.0	20	11775	11775.0	0.0	20
uno_2a	72820	72820	72820.0	2.5	20	72820	72820.0	0.0	20	72820	72820.0	0.1	20
uno_2b	71818	71818	71818.0	2.5	20	71818	71818.0	0.0	20	71818	71818.0	0.1	20
uno_3a	73068	73068	73068.0	2.5	20	73068	73068.0	0.0	20	73068	73068.0	0.1	20
uno_3b	72629	72629	72629.0	1.7	20	72629	72629.0	0.0	20	72629	72629.0	0.0	20
wildcats	1304	1304	1304.0	0.5	20	1304	1304.0	0.0	20	1304	1304.0	0.0	20
workers	964	964	964.0	0.6	20	964	964.0	0.0	20	964	964.0	0.0	20
zoo	16948	16948	16948.0	1.5	20	16948	16948.0	0.0	20	16948	16948.0	0.0	20
NoB		54	54			53	53			53	53		

Table 2: Comparison results of EWSA, FSS and MDMCP on 54 instances with proven optimal solutions.

Instance	Best known	EWSA				FSS				MDMCP			
		Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits
bur_73	126	*130	130.0	24.7	20	130	130.0	4.2495	20	130	130.0	2.1	20
ce60-30	100	100	100.0	1.6	20	100	100.0	0.2015	20	100	100.0	0.3	20
ce60-50	200	200	200.0	1.1	20	200	200.0	0.1045	20	200	200.0	0.1	20
ce70-30	128	128	128.0	1.9	20	128	128.0	0.3825	20	128	128.0	0.4	20
ce70-40	177	177	177.0	1.8	20	177	177.0	0.119	20	177	177.0	0.2	20
ce70-50	266	266	266.0	1.4	20	266	266.0	0.2625	20	266	266.0	0.4	20
ce80-30	157	157	157.0	2.2	20	157	157.0	0.385	20	157	157.0	0.2	20
ce80-40	227	227	227.0	1.9	20	227	227.0	0.074	20	227	227.0	0.1	20
ce80-50	325	325	325.0	1.7	20	325	325.0	0.073	20	325	325.0	0.1	20
corr80-1	4724	4724	4724.0	1.3	20	4724	4724.0	0.076	20	4724	4724.0	0.1	20
corr80-2	4667	4667	4667.0	1.5	20	4667	4667.0	0.0965	20	4667	4667.0	0.1	20
corr80-3	4993	4993	4993.0	1.3	20	4993	4993.0	0.03	20	4993	4993.0	0.1	20
corr80-4	4504	4504	4504.0	1.0	20	4504	4504.0	0.112	20	4504	4504.0	0.1	20
corr80-5	5090	5090	5090.0	1.3	20	5090	5090.0	0.0435	20	5090	5090.0	0.1	20
corr80-6	4465	4465	4465.0	1.6	20	4465	4465.0	1.2775	20	4465	4465.0	0.9	20
corr80-7	5088	5088	5088.0	1.3	20	5088	5088.0	0.034	20	5088	5088.0	0.1	20
corr80-8	4757	4757	4757.0	1.4	20	4757	4757.0	0.051	20	4757	4757.0	0.1	20
corr80-9	4430	4430	4430.0	1.2	20	4430	4430.0	0.0425	20	4430	4430.0	0.1	20
corr80-10	5071	5071	5071.0	1.4	20	5071	5071.0	0.2725	20	5071	5071.0	0.1	20
CPn50-1	13562	13562	13562.0	4.4	20	13562	13562.0	0.1865	20	13562	13562.0	0.3	20
CPn50-2	14080	14080	14080.0	2.7	20	14080	14080.0	0.1975	20	14080	14080.0	0.9	20
CPn50-3	13172	13172	13172.0	4.9	20	13172	13172.0	0.244	20	13172	13172.0	0.8	20
CPn50-4	13728	13728	13728.0	4.5	20	13728	13728.0	0.568	20	13728	13728.0	1.8	20
CPn65-1	20028	20028	20028.0	18.2	20	20028	20028.0	0.612	20	20028	20028.0	1.4	20
CPn65-2	20753	20753	20753.0	5.3	20	20753	20753.0	0.147	20	20753	20753.0	0.5	20
CPn65-3	20463	20463	20463.0	3.0	20	20463	20463.0	0.2695	20	20463	20463.0	0.2	20
CPn65-4	20000	*20093	20093.0	11.9	20	20093	20093.0	1.3675	20	20093	20093.0	2.5	20
CPn100-1	37188	*37562	37562.0	15.2	20	37562	37562.0	3.5085	20	37562	37562.0	11.7	20
CPn100-2	37460	*37990	37990.0	13.8	20	37990	37990.0	1.672	20	37990	37990.0	4.3	20
CPn100-3	39766	39766	39766.0	20.0	20	39766	39766.0	5.136	20	39766	39766.0	14.4	20
CPn100-4	38192	38192	38187.6	66.7	19	38192	38192.0	21.043	20	38192	38187.6	58.8	19
kat_97	175	175	175.0	3.4	20	175	175.0	1.386	20	175	175.0	0.5	20
neg-tt-80	592	592	592.0	1.5	20	592	592.0	1.0805	20	592	592.0	0.3	20
Wang250	419	419	419.0	100.7	20	419	418.9	63.22	17	419	419.0	9.3	20
Wang800	1777	*1793	1790.6	544.8	1	1787	1781.0	794.0955	1	1792	1787.3	524.4	1
Wang1150	3236	*3244	3237.7	1473.8	1	3242	3234.1	4208.457	1	3243	3240.1	1922.4	1
NoB		36	34			34	33			34	34		

Table 3: Comparison results of EWSA, FSS and MDMCP on 36 instances without proven optimal solutions.

Instance	Best known	EWSA				SACC				FSS				MDMCP			
		Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits
rand100-100	24296	24296	24296.0	5.1	20	24296	24296.0	0.1	20	24296	24296.0	0.7	20	24296	24296.0	0.4	20
rand100-5	1407	1407	1407.0	2.5	20	1407	1406.4	0.0	19	1407	1407.0	0.3	20	1407	1407.0	0.2	20
rand200-100	74924	74924	74924.0	16.1	20	74924	74924.0	5.9	20	74924	74924.0	17.2	20	74924	74924.0	14.8	20
rand200-5	4079	4079	4079.0	19.5	20	4079	4079.0	5.0	20	4079	4079.0	8.9	20	4079	4079.0	5.7	20
rand300-100	152709	152709	152709.0	9.4	20	152709	152709.0	0.5	20	152709	152709.0	0.4	20	152709	152709.0	0.7	20
rand300-5	7732	7732	7732.0	46.1	20	7732	7732.0	14.9	20	7732	7732.0	41.6	20	7732	7732.0	33.8	20
rand400-100	222757	222757	222757.0	122.3	20	222757	222757.0	65.0	20	222757	222757.0	25.0	20	222757	222757.0	47.9	20
rand400-5	12133	12133	12133.0	81.0	20	12133	12133.0	30.7	20	12133	12133.0	33.0	20	12133	12133.0	70.4	20
rand500-100	309125	309125	309067.0	195.5	16	309125	308914.2	38.2	3	309125	308983.4	104.4	8	309125	308954.5	130.8	5
rand500-5	17127	17127	17127.0	64.9	20	17127	17127.0	45.6	20	17127	17127.0	126.7	20	17127	17126.8	149.0	19
regnier300-50	32164	32164	32164.0	6.8	20	32164	32164.0	0.1	20	32164	32164.0	0.2	20	32164	32164.0	0.5	20
sym300-50	17592	17592	17592.0	69.1	20	17592	17592.0	38.4	20	17592	17592.0	21.6	20	17592	17592.0	17.9	20
zahn300	2504	2504	2504.0	13.7	20	2504	2504.0	2.3	20	2504	2504.0	1.7	20	2504	2504.0	2.6	20
gauss500-100-1	265070	265070	265070.0	94.6	20	265070	265059.9	122.1	19	265070	265070.0	75.1	20	265070	265059.9	140.4	19
gauss500-100-2	269076	269076	269034.4	145.7	15	269076	269067.9	169.8	19	269076	269076.0	49.2	20	269076	269076.0	66.2	20
gauss500-100-3	257700	257700	257645.1	148.0	15	257700	257619.2	221.9	12	257700	257677.6	132.0	18	257700	257659.6	147.4	16
gauss500-100-4	267683	267683	267683.0	88.4	20	267683	267683.0	41.2	20	267683	267683.0	6.5	20	267683	267683.0	33.2	20
gauss500-100-5	271567	271567	271566.1	96.7	19	271567	271567.0	12.1	20	271567	271567.0	4.5	20	271567	271567.0	6.6	20
p500-100-1	308896	308896	308896.0	134.3	20	308896	308895.1	142.9	18	308896	308895.6	125.9	19	308896	308895.6	163.5	19
p500-100-2	310241	310241	310237.1	123.6	19	310241	310233.2	185.8	18	310241	310217.6	167.9	14	310241	310198.1	95.9	9
p500-100-3	310477	310477	310477.0	73.8	20	310477	310477.0	39.1	20	310477	310474.1	113.5	19	310477	310444.6	122.5	9
p500-100-4	309567	309567	309553.5	142.0	19	309567	309567.0	106.5	20	309567	309567.0	142.9	20	309567	309533.3	254.6	10
p500-100-5	309135	309135	309135.0	126.2	20	309135	309135.0	38.5	20	309135	309135.0	20.8	20	309135	309135.0	35.7	20
p500-100-6	310280	310280	310278.7	124.5	19	310280	310280.0	33.8	20	310280	310280.0	18.3	20	310280	310280.0	31.0	20
p500-100-7	310063	310063	310055.7	183.3	17	310063	310063.0	117.2	20	310063	310060.1	61.5	19	310063	310063.0	126.0	20
p500-100-8	303148	303148	303148.0	126.0	20	303148	303148.0	100.1	20	303148	303148.0	85.9	20	303148	303148.0	97.8	20
p500-100-9	305305	305305	305305.0	40.7	20	305305	305305.0	12.8	20	305305	305305.0	7.3	20	305305	305305.0	10.6	20
p500-100-10	314864	314864	314864.0	71.5	20	314864	314864.0	14.1	20	314864	314864.0	11.0	20	314864	314864.0	15.8	20
p500-5-1	17691	17691	17691.0	39.5	20	17691	17691.0	25.1	20	17691	17691.0	30.5	20	17691	17691.0	47.4	20
p500-5-2	17169	17169	17168.7	137.2	18	17169	17169.0	19.5	20	17169	17168.3	165.7	15	17169	17167.5	120.9	10
p500-5-3	16816	16816	16815.7	139.1	17	16816	16815.5	133.7	9	16816	16816.0	193.8	19	16816	16816.0	181.6	19
p500-5-4	16808	16808	16808.0	64.0	20	16808	16808.0	15.4	20	16808	16808.0	27.4	20	16808	16808.0	49.7	20
p500-5-5	16957	16957	16957.0	33.3	20	16957	16957.0	17.0	20	16957	16957.0	28.8	20	16957	16957.0	69.4	20
p500-5-6	16615	16615	16615.0	97.5	20	16615	16615.0	25.6	20	16615	16615.0	44.1	20	16615	16615.0	95.2	20
p500-5-7	16649	16649	16649.0	102.1	20	16649	16649.0	78.6	20	16649	16649.0	77.2	20	16649	16648.6	142.0	16
p500-5-8	16756	16756	16756.0	117.8	20	16756	16756.0	29.6	20	16756	16756.0	52.0	20	16756	16755.7	144.3	18
p500-5-9	16629	16629	16629.0	97.4	20	16629	16629.0	47.1	20	16629	16629.0	43.6	20	16629	16628.5	121.2	19
p500-5-10	17360	17360	17360.0	14.5	20	17360	17360.0	5.2	20	17360	17360.0	2.8	20	17360	17360.0	4.7	20
unif700-100-1	515016	515016	515016.0	201.2	20	515016	515016.0	142.5	20	515016	515016.0	88.7	20	515016	515016.0	272.7	20
unif700-100-2	519441	519441	519441.0	81.1	20	519441	519441.0	152.6	20	519441	519441.0	76.3	20	519441	519441.0	133.9	20
unif700-100-3	512351	512351	512280.7	290.2	18	512351	512310.4	349.1	19	512351	512229.1	379.0	17	512351	511699.1	435.8	4
unif700-100-4	513582	513582	513582.0	161.1	19	513582	513582.0	125.5	20	513582	513499.6	215.9	16	513582	513271.8	493.7	12
unif700-100-5	510585	510585	510483.8	474.3	11	510585	510454.2	341.0	8	510585	510470.4	310.7	9	510585	510391.5	341.7	2
unif800-100-1	639675	639675	639675.0	245.6	20	639675	639675.0	152.9	20	639675	639675.0	201.4	20	639675	639577.7	381.8	13
unif800-100-2	630704	630704	630704.0	489.8	20	630704	630704.0	209.9	20	630704	630703.3	297.5	13	630704	630701.2	466.4	17
unif800-100-3	629375	629375	629124.2	433.7	3	629375	629049.1	459.4	1	629108	629006.4	482.5	6	629108	628911.3	525.6	3
unif800-100-4	624728	624728	624595.1	510.9	14	624728	624366.2	368.2	7	624728	624401.4	399.9	3	624728	624141.6	458.2	1
unif800-100-5	625905	625905	625796.7	436.0	12	625905	625846.2	289.3	16	625905	625905.0	155.1	20	625905	625905.0	216.4	20
NoB		48	37			48	37			47	36			47	29		

Table 4: Comparison results of EWSA, SACC, FSS and MDMCP on 48 instances without proven optimal solutions.

Instance	Best known	EWSA				SACC				FSS				MDMCP			
		Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits	Best	Avg	Time	Hits
p1000-1	885281	885281	885252.2	1019.8	18	885281	885029.5	721.1	5	885016	884826.9	1126.6	3	884970	884732.2	861.8	6
p1000-2	881751	881751	881581.4	782.3	14	881751	881525.8	872.7	14	881751	881487.9	844.2	12	881751	881173.0	1003.6	5
p1000-3	866587	*867008	866178.9	728.4	1	866488	866227.6	916.3	3	866441	866411.3	867.3	16	866441	866330.5	1009.1	10
p1000-4	869374	869374	869345.8	596.6	19	869374	869374.0	464.1	20	869374	869069.3	792.3	12	869374	868645.1	1047.3	5
p1000-5	888960	888960	888819.2	855.9	12	888960	888579.9	924.2	2	888960	888665.1	963.4	5	888960	888520.8	1130.0	1
p1500-1	1619470	1619470	1619424.5	1374.9	3	1619470	1619461.9	1530.4	2	1619470	1619233.3	2067.9	2	1619461	1619135.9	2536.5	1
p1500-2	1649778	1649778	1649773.4	769.4	17	1649778	1649333.2	1539.3	16	1649778	1649768.0	2556.0	10	1649686	1648299.8	2260.7	1
p1500-3	1611197	1611197	1611184.5	952.9	18	1611197	1610649.3	1718.4	11	1611197	1609778.9	1699.8	4	1611197	1610057.9	2678.0	3
p1500-4	1641933	1641933	1641901.5	1540.0	16	1641933	1641724.9	1576.3	16	1641933	1641309.1	1591.4	7	1641933	1641474.2	2466.7	4
p1500-5	1595627	1595627	1595618.6	1198.9	18	1595627	1595627.0	1309.2	20	1595627	1594809.1	1668.3	7	1595627	1594785.7	2618.4	6
p2000-1	2508005	2508005	2507528.6	4500.3	5	2508005	2507580.0	4554.2	3	2507982	2507873.9	6582.7	7	2507239	2506119.2	6247.3	1
p2000-2	2495994	2495994	2494944.7	5439.4	1	2495994	2494752.5	4941.9	1	2494847	2494325.2	6180.2	1	2494710	2493994.8	4852.8	1
p2000-3	2544728	2544728	2543893.3	6273.9	2	2543724	2543164.8	4569.3	3	2543439	2542928.9	7217.3	3	2543214	2542418.4	5636.0	1
p2000-4	2528721	2528721	2528580.0	5042.4	15	2528721	2528048.7	5477.7	8	2528721	2528158.9	7157.2	1	2528618	2527260.8	6116.3	1
p2000-5	2514009	2514009	2513336.9	5079.6	12	2514009	2512017.8	4579.1	2	2513967	2511889.3	7457.3	1	2511126	2510119.9	4645.6	1
new_b2500.1	1064366	1064366	1063760.4	6609.8	2	1064366	1062794.0	5848.9	1	1064062	1062576.2	6742.4	1	1062047	1061062.1	5961.2	1
new_b2500.2	1064428	*1064732	1064363.6	5046.5	1	1064428	1063377.8	5763.8	2	1064343	1063364.2	7746.9	1	1063034	1062147.1	6230.1	1
new_b2500.3	1083209	1083209	1082607.9	5879.8	2	1083209	1082297.1	5638.5	1	1082411	1081980.7	6320.5	1	1082139	1080818.0	5886.8	1
new_b2500.4	1066258	*1066750	1066222.2	5111.9	2	1066258	1065600.6	5552.0	1	1066141	1065444.5	6477.9	1	1065429	1064811.6	4717.7	1
new_b2500.5	1066226	*1066500	1065996.8	5536.1	1	1066226	1065391.8	5276.5	1	1065949	1064948.4	6312.5	1	1065122	1064059.4	5360.1	1
new_b2500.6	1067531	*1068270	1067017.8	5629.4	1	1067531	1066423.0	5875.5	1	1067206	1066279.4	6772.7	1	1067031	1065276.5	6470.6	1
new_b2500.7	1068576	*1068760	1068417.1	5288.7	1	1068324	1067665.9	5829.0	1	1068480	1067669.3	6651.6	1	1067642	1066906.3	4754.8	1
new_b2500.8	1070534	*1070850	1070280.7	5965.5	1	1070534	1070132.1	4884.2	1	1070102	1069430.5	6120.5	1	1069949	1069163.7	5270.8	1
new_b2500.9	1071646	*1071931	1071608.7	5867.0	1	1071447	1070680.9	6026.6	1	1071137	1070579.7	6710.2	1	1071286	1070087.6	4966.8	1
new_b2500.10	1066871	*1067254	1066802.5	5848.6	1	1066871	1066642.8	6269.2	2	1066838	1066182.7	7298.3	1	1066694	1065931.9	6155.9	1
new_p3000.1	3259900	3259900	3258992.6	9354.4	2	3259900	3258066.2	11183.4	6	3259900	3255861.7	14519.9	1	3258688	3255210.4	11664.0	1
new_p3000.2	4102907	*4104060	4101845.5	10291.7	1	4101652	4100589.8	7834.2	1	4102621	4098665.9	14377.2	1	4099687	4097170.9	11821.1	1
new_p3000.3	4122814	*4123241	4121445.2	11409.0	1	4122814	4121662.7	10118.1	6	4122733	4117540.4	13466.8	1	4121343	4117445.9	11897.8	1
new_p3000.4	4588584	4588584	4588540.2	10996.8	5	4588584	4586545.0	10629.6	7	4588238	4584068.1	14755.7	1	4588373	4584604.7	10944.9	1
new_p3000.5	4639266	4639266	4637814.9	11833.7	1	4639266	4632508.0	11996.0	1	4638931	4631150.0	15534.0	1	4638921	4630733.9	9214.1	1
new_p4000.1	5021579	5021579	5018805.1	12235.1	2	5021579	5015852.0	12193.2	1	5018168	5015119.4	13650.2	1	5012722	5009946.5	12538.4	1
new_p4000.2	6381289	*6381936	6379151.0	13413.5	1	6381090	6375097.9	10459.3	2	6381136	6376004.9	13657.2	1	6380297	6371856.0	11458.1	1
new_p4000.3	6388075	*6388234	6387384.1	12300.2	1	6388024	6382777.9	12274.8	1	6387267	6381201.0	16628.9	1	6386998	6381953.1	11480.5	1
new_p4000.4	7130397	*7131146	7126664.0	14328.3	1	7127592	7123288.1	10903.2	1	7129589	7123504.8	16949.4	1	7122672	7116761.1	13821.1	1
new_p4000.5	7048838	*7050732	7045973.4	10897.2	1	7048838	7043396.7	11178.2	1	7047948	7041125.0	14884.9	1	7040927	7036193.8	13172.5	1
new_p5000.1	7011355	*7013489	7009781.8	13196.5	1	7011355	7005544.5	10423.0	1	7011746	7004615.0	15350.1	1	7001781	6996553.5	12682.9	1
new_p5000.2	8850743	*8851575	8844829.1	12438.8	1	8848190	8838727.6	12713.2	1	8844727	8839135.6	16909.7	1	8840084	8830082.2	13792.1	1
new_p5000.3	8978790	*8978921	8976569.4	12587.2	1	8978790	8969701.8	12415.1	1	8973678	8967669.2	15100.4	1	8968616	8961737.9	14464.7	1
new_p5000.4	9957492	*9959907	9956119.9	12843.8	1	9951747	9944681.4	11769.9	1	9958166	9947879.3	16738.8	1	9939475	9931651.9	12794.9	1
new_p5000.5	9845791	*9855134	9848116.1	11825.8	1	9842989	9836746.4	11898.0	1	9851920	9836400.1	16820.5	1	9827427	9821373.6	11608.6	1
new_p6000.1	9218467	*9222250	9216672.0	13675.7	1	9217584	9206922.5	10307.6	1	9217826	9207027.6	16001.7	1	9210854	9200734.1	15552.8	1
new_p6000.2	11733007	*11738114	11729399.5	13278.7	1	11729985	11719095.2	12689.4	1	11732522	11723271.7	15763.2	1	11711600	11702099.9	13268.0	1
new_p6000.3	13058463	*13059413	13053003.5	11906.9	1	13058463	13042774.6	12847.6	1	13052914	13041376.9	15495.6	1	13046195	13029294.6	13637.3	1
new_p7000.1	11638591	*11649618	11641535.9	14868.0	1	11638146	11625022.6	14583.9	1	11634577	11628201.5	18396.2	1	11613191	11604039.0	13495.9	1
new_p7000.2	14699943	*14708026	14699843.7	14327.7	1	14697515	14683896.6	15121.2	1	14695690	14686517.5	16735.0	1	14675940	14666454.1	17528.8	1
new_p7000.3	16408045	*16409389	16400943.9	13997.4	1	16391377	16379753.1	13676.9	1	16395409	16368851.5	17255.3	1	16378525	16357101.8	14884.3	1
NoB		46	40			19	4			10	2			6	0		

Table 5: Comparison results of EWSA, SACC, FSS and MDMCP on 46 instances without proven optimal solutions.

Instance	EWSA		EWSA _w		EWSA _{c1}		EWSA _{c2}		EWSA _{pr}		EWSA _{em}	
	Best	Hits	Best	Hits	Best	Hits	Best	Hits	Best	Hits	Best	Hits
new_b2500.10.txt	1067254	1	1067242	1	1066303	1	1066714	1	1066871	3	1066871	7
new_b2500.2.txt	1064732	1	1064241	2	1063978	1	1064076	1	1064471	1	1064428	2
new_b2500.4.txt	1066750	2	1066147	3	1066262	1	1066092	1	1066764	1	1066764	1
new_b2500.5.txt	1066500	1	1066462	2	1064623	1	1065946	1	1066462	1	1066263	1
new_b2500.6.txt	1068270	1	1067531	1	1065732	1	1067605	1	1068272	1	1068270	1
new_b2500.7.txt	1068760	1	1068656	1	1068164	1	1068544	1	1068845	1	1068700	1
new_b2500.8.txt	1070850	1	1070186	1	1070122	1	1070433	1	1070850	1	1070534	1
new_b2500.9.txt	1071931	1	1071498	1	1070903	1	1071609	1	1071931	3	1071931	1
new_p3000.2.txt	4104060	1	4103668	1	4099077	1	4101913	1	4103668	1	4103925	1
new_p3000.3.txt	4123241	1	4122814	6	4118495	1	4122394	1	4122814	3	4123241	5
new_p4000.2.txt	6381936	1	6382251	1	6368021	1	6378672	1	6382024	1	6382251	1
new_p4000.3.txt	6388234	1	6388234	2	6374234	1	6387212	1	6388224	1	6388234	1
new_p4000.4.txt	7131146	1	7130508	1	7121344	1	7128587	1	7131873	1	7131494	1
new_p4000.5.txt	7050732	1	7050288	1	7038795	1	7049231	1	7048859	1	7050732	1
new_p5000.1.txt	7013489	1	7013284	1	7000146	1	7009870	1	7013338	1	7012330	1
new_p5000.2.txt	8851575	1	8848012	1	8825665	1	8844962	1	8850142	1	8851500	1
new_p5000.3.txt	8978921	1	8978779	1	8952486	1	8976204	1	8978921	2	8978970	1
new_p5000.4.txt	9959907	1	9958166	1	9945895	1	9952725	1	9958289	1	9958745	1
new_p5000.5.txt	9855134	1	9855080	1	9821943	1	9853213	1	9855080	7	9855134	2
new_p6000.1.txt	9222250	1	9224091	1	9196759	1	9215934	1	9223979	1	9223073	1
new_p6000.2.txt	11738114	1	11738244	1	11709300	1	11729599	1	11736295	1	11737119	1
new_p6000.3.txt	13059413	1	13062235	1	13025164	1	13046348	1	13059413	1	13057881	1
new_p7000.1.txt	11649618	1	11641274	1	11610895	1	11641547	1	11645939	1	11648421	1
new_p7000.2.txt	14708026	1	14707214	1	14663142	1	14698056	1	14706918	1	14707001	1
new_p7000.3.txt	16409389	1	16401267	1	16362410	1	16399637	1	16404244	1	16409025	1
p1000-3.txt	867008	1	867008	1	867008	1	867005	1	867008	1	866587	1
NoB	17		5		5		0		6		8	

Table 6: Best solutions over 20 runs and hit times of the variants on 26 instances.

Instance	EWSA		EWSA _w		EWSA _{c1}		EWSA _{c2}		EWSA _{pr}		EWSA _{em}	
	Best	Hits	Best	Hits	Best	Hits	Best	Hits	Best	Hits	Best	Hits
new_b2500.10.txt	1066802.5	5848.6	1066495.6	4638.7	1063376.2	5365.4	1066113.1	4995.2	1066723.6	5936.9	1066728.4	6815.7
new_b2500.2.txt	1064363.6	5046.5	1063578.0	6321.7	1061761.8	5155.7	1063421.0	5001.2	1064261.7	4966.6	1064098.8	6509.4
new_b2500.4.txt	1066222.2	5111.9	1065976.7	4754.2	1064364.3	4652.8	1065392.1	5174.5	1066142.4	4884.5	1065996.9	6328.7
new_b2500.5.txt	1065996.8	5536.1	1065561.0	5585.4	1063199.8	4750.8	1065063.2	4144.9	1065942.8	4866.4	1065587.1	6535.8
new_b2500.6.txt	1067017.8	5629.4	1066704.2	5017.0	1064300.6	4179.0	1066144.0	5662.7	1067239.1	4852.3	1066960.5	7404.8
new_b2500.7.txt	1068417.1	5288.7	1067873.3	5233.2	1066530.5	2599.6	1067638.7	4518.2	1068394.9	5247.8	1068094.7	6112.3
new_b2500.8.txt	1070280.7	5965.5	1069800.2	5006.3	1067633.0	3956.1	1069850.6	4487.2	1070218.3	5536.3	1070203.7	7456.1
new_b2500.9.txt	1071608.7	5867.0	1071036.1	5136.4	1068747.8	5239.4	1071048.0	5520.6	1071739.2	4193.4	1071370.8	7965.3
new_p3000.2.txt	4101845.5	10291.7	4101530.8	9927.4	4094137.3	10241.3	4099612.3	8861.6	4102185.2	10943.7	4101194.0	12517.1
new_p3000.3.txt	4121445.2	11409.0	4120614.1	10648.5	4113122.5	10579.6	4119939.9	7639.7	4121575.1	11052.8	4121900.3	13880.6
new_p4000.2.txt	6379151.0	13413.5	6377610.6	7088.8	6361682.4	10186.4	6375733.8	11088.0	6379977.1	12623.7	6378272.9	15473.4
new_p4000.3.txt	6387384.1	12300.2	6385256.6	11829.3	6365913.3	10267.7	6383927.0	10183.6	6387661.7	10231.0	6387582.6	14317.8
new_p4000.4.txt	7126664.0	14328.3	7124584.7	8797.4	7111428.7	10485.2	7123466.3	12228.0	7127711.0	12829.8	7126149.6	14404.9
new_p4000.5.txt	7045973.4	10897.2	7044088.9	10906.5	7025733.8	12541.5	7041562.1	7072.0	7046294.2	11892.6	7044644.4	14537.3
new_p5000.1.txt	7009781.8	13196.5	7007045.1	9126.9	6986874.3	10766.8	7004540.0	10092.8	7009447.3	11546.0	7008235.6	15889.0
new_p5000.2.txt	8844829.1	12438.8	8840500.9	12032.9	8814156.4	10761.8	8838230.3	9809.3	8844797.6	13605.5	8844855.0	15793.2
new_p5000.3.txt	8976569.4	12587.2	8968857.9	12220.8	8944096.7	10734.1	8970454.1	11221.5	8977885.2	12449.2	8975362.3	14843.0
new_p5000.4.txt	9956119.9	12843.8	9947601.3	13762.1	9923597.3	9567.5	9947424.2	9351.5	9954700.1	12694.3	9954235.8	15308.5
new_p5000.5.txt	9848116.1	11825.8	9838724.4	12110.8	9807020.5	8219.9	9841322.8	9050.5	9849687.7	10522.6	9844384.3	17236.7
new_p6000.1.txt	9216672.0	13675.7	9211299.5	11471.5	9182248.9	11745.5	9210921.7	10279.1	9219075.9	13784.4	9217882.3	15909.3
new_p6000.2.txt	11729399.5	13278.7	11723350.9	11576.4	11691341.5	7898.2	11723260.2	7957.8	11729181.5	12221.8	11728177.9	16469.8
new_p6000.3.txt	13053003.5	11906.9	13046607.8	11675.1	13011883.5	10341.1	13041126.3	9704.1	13050962.0	11814.5	13050293.1	15420.1
new_p7000.1.txt	11641535.9	14868.0	11629841.9	12379.9	11596528.2	11903.5	11630607.5	10526.0	11640833.6	13483.9	11639045.0	13798.0
new_p7000.2.txt	14699843.7	14327.7	14689526.2	12421.7	14638061.7	11209.3	14690571.1	12382.7	14698093.2	14926.1	14697084.0	16007.9
new_p7000.3.txt	16400943.9	13997.4	16383431.5	13850.4	16329493.2	12075.7	16388943.6	8177.4	16388362.9	13547.8	16396970.4	16480.6
p1000-3.txt	866178.9	728.4	866413.8	919.8	865963.1	992.8	866089.7	843.7	866372.0	962.5	866170.2	808.1
NoB	13		1		0		0		10		2	

Table 7: Average behavior of the variants on 26 instances.

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