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Detail Computational Results for the Paper: Neighborhood Combination Search for Single-machine Scheduling with Sequence-dependent Setup Time

Xiao-Lu Liu[1](刘晓路), Hong-Yun Xu[2](徐宏云), Jia-Ming Chen[3](陈嘉铭), Zhou-Xing Su[4](苏宙行), *Member, CCF*, Zhi-Peng Lü[4](吕志鹏), *Member, CCF*, Jun-Wen Ding[4,*](丁俊文), *Member, CCF*

[1] *School of System Engineering, National University of Defense Technology, Changsha 410015, China*

[2] *School of Artificial Intelligence, Jianghan University, Wuhan 430056, China*

[3] *Xi'an Satellite Control Center, Xi'an 710043, China*

[4] *School of Computer Science and Technology, Huazhong University of Science and Technology, Wuhan 430074, China*

E-mail: lxl_sunny_nudt@live.cn; xhy@jhun.edu.cn; chen-jm@aliyun.com; {suzhouxing, zhipeng.lv, junwending}@hust.edu.cn
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Abstract In a local search algorithm, one of its most important features is the definition of its neighborhood which is crucial to the algorithm's performance. In this paper, we present an analysis of neighborhood combination search for solving the single-machine scheduling problem with sequence-dependent setup time with the objective of minimizing total weighted tardiness (SMSWT). We first propose a new neighborhood structure named Block Swap which can be considered as an extension of the previously widely used Block Move neighborhood, and a fast incremental evaluation technique to enhance its evaluation efficiency. Then, we present two kinds of neighborhood combinations of the Block Swap and Block Move neighborhoods, called neighborhood union and token-ring search, and incorporate them into two representative metaheuristic algorithms: iterated local search (ILS_{new}) and hybrid evolutionary algorithm (HEA_{new}) to investigate their performance. Extensive experiments show the competitiveness of the token-ring search combination mechanism of the two neighborhoods. Tested on the 120 public benchmark instances, our HEA_{new} algorithm has a highly competitive performance in solution quality and computational time compared with both the exact algorithms and recent metaheuristics. We have also tested the HEA_{new} algorithm with the selected neighborhood combination search to deal with the 64 public benchmark instances of the single-machine scheduling problem with sequence-dependent setup time. Our HEA_{new} algorithm is able to match the optimal or the best known results for all the 64 instances. In particular, the computational time for reaching the best well-known results for five challenging instances is significantly reduced.

This is a supplementary file to the paper where the detail computational results are provided. Tables 1-3 reports the comparison results of the best solutions obtained by HEA_{new}, ILS_{new}, and the reference algorithms on 40 instances p1-p40, p41-p80, p81-p120 of the SMSWT problem, respectively. Table 4 reports the comparison results of the best solutions obtained by HEA_{new} and the reference algorithms on the 64 instances of the the SMST problem.

Keywords single-machine scheduling, sequence-dependent setup time, neighborhood combination search, token-ring search, hybrid evolutionary algorithm

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*Corresponding Author

Table 1. Comparison of the Best Solutions Obtained by HEA_{new}, ILS_{new}, and the Reference Algorithms on 40 Instances p1-p40 of the SMSWT problem

Instance	OPT	GVNS	ILS	HEA	ILS-$RVND_{SBP}$	GA-VND	IPBVND	ILS_{new}	HEA_{new}
p1	453	**471**	453	453	**459**	**459**	453	453	453
p2	4794	**4878**	4794	4794	**4866**	4794	4794	4794	4794
p3	1390	**1430**	1390	1390	**1414**	1390	1390	1390	1390
p4	5866	**6006**	5866	5866	**5906**	5866	5866	5866	5866
p5	4054	**4114**	**4074**	4054	**4084**	**4074**	**4074**	4054	4054
p6	6592	**6667**	6592	6592	**6607**	6592	6592	6592	6592
p7	3267	**3330**	3267	3267	**3350**	**3271**	3267	3267	3267
p8	100	**108**	100	100	**105**	100	100	100	100
p9	5660	**5751**	5660	5660	**5673**	5660	5660	5660	5660
p10	1740	**1789**	1740	1740	**1768**	1740	**1747**	1740	1740
p11	2785	**2998**	**2830**	**2798**	**2934**	**2854**	**2854**	**2854**	2785
p12	0	0	0	0	0	0	0	0	0
p13	3904	**4068**	**3942**	3904	**4014**	**3942**	**3942**	**3942**	3904
p14	2075	**2260**	**2081**	2075	**2219**	**2138**	**2081**	2075	2075
p15	724	**935**	**775**	724	**896**	**760**	**772**	724	724
p16	3285	**3381**	3285	3285	**3325**	3285	**3301**	3285	3285
p17	0	0	0	0	0	0	0	0	0
p18	767	**845**	767	767	**787**	767	767	767	767
p19	0	0	0	0	0	0	0	0	0
p20	1757	**2053**	1757	1757	**1789**	1757	1757	1757	1757
p21	0	0	0	0	0	0	0	0	0
p22	0	0	0	0	0	0	0	0	0
p23	0	0	0	0	0	0	0	0	0
p24	761	**920**	**773**	761	**1004**	**1025**	**767**	**878**	**1019**
p25	0	0	0	0	0	0	0	0	0
p26	0	0	0	0	0	0	0	0	0
p27	0	0	0	0	0	0	0	0	0
p28	0	0	0	0	0	0	0	0	0
p29	0	0	0	0	0	0	0	0	0
p30	0	0	0	0	0	0	0	0	0
p31	0	0	0	0	0	0	0	0	0
p32	0	0	0	0	0	0	0	0	0
p33	0	0	0	0	0	0	0	0	0
p34	0	0	0	0	0	0	0	0	0
p35	0	0	0	0	0	0	0	0	0
p36	0	0	0	0	0	0	0	0	0
p37	0	**46**	0	0	0	0	0	0	0
p38	0	0	0	0	0	0	0	0	0
p39	0	0	0	0	0	0	0	0	0
p40	0	0	0	0	0	0	0	0	0

Table 2. Comparison of the Best Solutions Obtained by HEA_{new}, ILS_{new}, and the Reference Algorithms on 40 Instances p41-p80 of the SMSWT problem

Instance	OPT	GVNS	ILS	HEA	ILS-RVND_{SBP}	GA-VND	IPBVND	ILS_{new}	HEA_{new}
p41	69102	**69242**	69102	69102	69102	69102	69102	69102	69102
p42	57487	**57511**	57487	57487	57487	57487	57487	57487	57487
p43	145310	145310	145310	145310	145310	145310	145310	145310	145310
p44	35166	**35289**	35166	35166	35166	35166	35166	35166	35166
p45	58935	**59025**	58935	58935	58935	58935	58935	58935	58935
p46	34764	34764	34764	34764	34764	34764	34764	34764	34764
p47	72853	72853	72853	72853	72853	72853	72853	72853	72853
p48	64612	64612	64612	64612	64612	64612	64612	64612	64612
p49	77449	**77833**	77449	77449	77449	77449	77449	77449	77449
p50	31092	**31292**	31092	31092	31092	31092	31092	31092	31092
p51	49208	**49761**	49208	49208	49208	49208	49208	49208	49208
p52	93045	**93106**	93045	93045	93045	93045	93045	93045	93045
p53	84841	84841	84841	84841	84841	84841	84841	84841	84841
p54	118809	**119074**	118809	118809	118809	118809	118809	118809	118809
p55	64315	**65400**	64315	64315	64315	64315	64315	64315	64315
p56	74889	**74940**	74889	74889	74889	74889	74889	74889	74889
p57	63514	**64575**	63514	63514	63514	63514	63514	63514	63514
p58	45322	45322	45322	45322	45322	45322	45322	45322	45322
p59	50999	**51649**	50999	50999	50999	50999	50999	50999	50999
p60	60765	**61755**	60765	60765	60765	60765	60765	60765	60765
p61	75916	75916	75916	75916	75916	75916	75916	75916	75916
p62	44769	44769	44769	44769	44769	44769	44769	44769	44769
p63	75317	75317	75317	75317	75317	75317	75317	75317	75317
p64	92572	92572	92572	92572	92572	92572	92572	92572	92572
p65	126696	126696	126696	126696	126696	126696	126696	126696	126696
p66	59685	59685	59685	59685	59685	59685	59685	59685	59685
p67	29390	29390	29390	29390	29390	29390	29390	29390	29390
p68	22120	22120	22120	22120	22120	22120	22120	22120	22120
p69	71118	71118	71118	71118	71118	71118	71118	71118	71118
p70	75102	75102	75102	75102	75102	75102	75102	75102	75102
p71	145007	145007	145007	145007	145007	145007	145007	145007	145007
p72	43286	43286	43286	43286	43286	43286	43286	43286	43286
p73	28785	28785	28785	28785	28785	28785	28785	28785	28785
p74	29777	**30136**	29777	29777	29777	**30136**	29777	29777	29777
p75	21602	21602	21602	21602	21602	21602	21602	21602	21602
p76	53555	**54024**	53555	53555	53555	53555	53555	53555	53555
p77	31817	31817	**31937**	31817	31817	31817	31817	31817	31817
p78	19462	19462	19462	19462	19462	19462	19462	19462	19462
p79	114999	114999	114999	114999	114999	114999	114999	114999	114999
p80	18157	18157	18157	18157	18157	18157	18157	18157	18157

Table 3. Comparison of the Best Solutions Obtained by HEA_{new}, ILS_{new}, and the Reference Algorithms on 40 Instances p81-p120 of the SMSWT problem

Instance	OPT	GVNS	ILS	HEA	ILS-$RVND_{SBP}$	GA-VND	IPBVND	ILS_{new}	HEA_{new}
p81	383485	383485	383485	383485	383485	383485	383485	383485	383485
p82	409479	409479	409479	409479	409479	409479	409479	409479	409479
p83	458752	458752	458752	458752	458752	458752	458752	458752	458752
p84	329670	329670	329670	329670	329670	329670	329670	329670	329670
p85	554766	554766	554766	554766	554766	**554773**	554766	554766	554766
p86	361417	361417	361417	361417	361417	361417	361417	361417	361417
p87	398551	398551	398551	398551	398551	398551	398551	398551	398551
p88	433186	**433244**	433186	433186	433186	**433244**	433186	433186	433186
p89	410092	410092	410092	410092	410092	410092	410092	410092	410092
p90	401653	401653	401653	401653	401653	401653	401653	401653	401653
p91	339933	339933	339933	339933	339933	339933	339933	339933	339933
p92	361152	361152	361152	361152	361152	361152	361152	361152	361152
p93	403423	**404917**	403423	403423	403423	403423	403423	403423	403423
p94	332941	**332949**	332941	332941	**332949**	332941	332941	332941	332941
p95	516926	**517646**	516926	516926	516926	516926	516926	516926	516926
p96	455448	**457631**	455448	455448	455448	455448	455448	455448	455448
p97	407590	407590	407590	407590	407590	407590	407590	407590	407590
p98	520582	520582	520582	520582	520582	520582	520582	520582	520582
p99	363518	**363977**	363518	363518	363518	363518	363518	363518	363518
p100	431736	**432068**	431736	431736	**432068**	431736	431736	431736	431736
p101	352990	352990	352990	352990	352990	352990	352990	352990	352990
p102	492572	492572	492572	492572	492572	492572	492572	492572	492572
p103	378602	378602	378602	378602	378602	378602	378602	378602	378602
p104	357963	357963	357963	357963	357963	357963	357963	357963	357963
p105	450806	450806	450806	450806	450806	450806	450806	450806	450806
p106	454379	454379	454379	454379	454379	454379	454379	454379	454379
p107	352766	352766	352766	352766	352766	352766	352766	352766	352766
p108	460793	460793	460793	460793	460793	460793	460793	460793	460793
p109	413004	413004	413004	413004	413004	413004	413004	413004	413004
p110	418769	418769	418769	418769	418769	418769	418769	418769	418769
p111	342752	342752	342752	342752	342752	342752	342752	342752	342752
p112	367110	367110	367110	367110	367110	367110	367110	367110	367110
p113	259649	259649	259649	259649	259649	259649	259649	259649	259649
p114	463474	463474	463474	463474	463474	463474	463474	463474	463474
p115	456890	**457189**	456890	456890	456890	**456904**	456890	456890	456890
p116	530601	530601	530601	530601	530601	530601	530601	530601	530601
p117	502840	**503046**	502840	502840	502840	502840	502840	502840	502840
p118	349749	349749	349749	349749	349749	349749	349749	349749	349749
p119	573046	573046	573046	573046	573046	573046	573046	573046	573046
p120	396183	396183	396183	396183	396183	396183	396183	396183	396183

Table 4. Comparison of the Best Solutions Obtained by $\mathrm{HEA}_{\mathrm{new}}$ and the Reference Algorithms on the 64 Instances of the the SMST Problem

Instance	N	OPT	GVNS	HEA	ILS-$\mathrm{RVND}_{\mathrm{SBP}}$	GA-VND	IPBVND	$\mathrm{HEA}_{\mathrm{new}}$
p401	15	90	90	90	90	90	90	90
p402	15	0	0	0	0	0	0	0
p403	15	3418	3418	3418	3418	3418	3418	3418
p404	15	1067	1067	1067	1067	1067	1067	1067
p405	15	0	0	0	0	0	0	0
p406	15	0	0	0	0	0	0	0
p407	15	1861	1861	1861	1861	1861	1861	1861
p408	15	5660	5660	5660	5660	5660	5660	5660
p501	25	261	261	261	261	261	261	261
p502	25	0	0	0	0	0	0	0
p503	25	3497	3497	3497	3497	3497	3497	3497
p504	25	0	0	0	0	0	0	0
p505	25	0	0	0	0	0	0	0
p506	25	0	0	0	0	0	0	0
p507	25	7225	7225	7225	7225	7225	7225	7225
p508	25	1915	1915	1915	1915	1915	1915	1915
p601	35	12	12	12	12	12	12	12
p602	35	0	0	0	0	0	0	0
p603	35	17587	17587	17587	17587	17587	17587	17587
p604	35	19092	19092	19092	19092	19092	19092	19092
p605	35	228	228	228	228	228	228	228
p606	35	0	0	0	0	0	0	0
p607	35	12969	12969	12969	12969	12969	12969	12969
p608	35	4732	4732	4732	4732	4732	4732	4732
p701	45	97	**99**	97	97	**98**	97	97
p702	45	0	0	0	0	0	0	0
p703	45	26506	26506	26506	26506	26506	26506	26506
p704	45	15206	15206	15206	15206	15206	15206	15206
p705	45	200	**202**	200	200	200	200	200
p706	45	0	0	0	0	0	0	0
p707	45	23789	23789	23789	23789	23789	23789	23789
p708	45	22807	22807	22807	22807	22807	22807	22807
p551	55	183	**194**	183	**185**	183	183	183
p552	55	0	0	0	0	0	0	0
p553	55	40498	**40540**	40498	40498	40498	40498	40498
p554	55	14653	14653	14653	14653	14653	14653	14653
p555	55	0	0	0	0	0	0	0
p556	55	0	0	0	0	0	0	0
p557	55	35813	**35830**	35813	**35830**	35813	35813	35813
p558	55	19871	19871	19871	19871	19871	19871	19871
p651	65	247	**264**	247	**259**	247	247	247
p652	65	0	0	0	0	0	0	0
p653	65	57500	**57515**	57500	**57508**	57500	57500	57500
p654	65	34301	34301	34301	34301	34301	34301	34301
p655	65	0	**4**	**2**	**4**	0	**1**	0
p656	65	0	0	0	0	0	0	0
p657	65	54895	54895	54895	54895	54895	54895	54895
p658	65	27114	27114	27114	27114	27114	27114	27114
p751	75	225	**241**	**229**	**237**	**229**	**231**	**237**
p752	75	0	0	0	0	0	0	0
p753	75	77544	**77627**	77544	**77559**	77544	77544	77544
p754	75	35200	**35219**	35200	**35209**	**35203**	35200	35200
p755	75	0	0	0	0	0	0	0
p756	75	0	0	0	0	0	0	0
p757	75	59635	**59716**	59635	**59644**	59635	59635	59635
p758	75	38339	38339	38339	38339	38339	38339	38339
p851	85	360	**402**	**381**	**381**	**369**	**375**	**381**
p852	85	0	0	0	0	0	0	0
p853	85	97497	**97595**	97497	97497	**97522**	97497	97497
p854	85	79042	**79271**	**79086**	**79090**	**79054**	**79086**	79042
p855	85	258	**280**	**270**	**274**	256	**266**	**274**
p856	85	0	0	0	0	0	0	0
p857	85	87011	**87075**	87011	**87064**	87011	87011	87011
p858	85	74739	**74755**	74739	74739	74739	74739	74739
Sum			46	59	51	57	59	61

bold: optimal solution, italic: best known solution.