

This chapter is devoted to showing that our proposed two greedy heuristics perform better than the others and that in terms of the quality of obtained solution

4.1 Data Set

The greedy algorithms were tested on two different classes of benchmark instances [29]. Each instance consists of an undirected, vertex-weighted graph with n vertices and m edges. These instances are grouped, with respect to their number of vertices, into two different classes:

- a) Class SMPI: the class of small and medium problem instances (SMPI) contains 640 instances where n takes values from $\{50, 100, 150, 200, 250\}$.
- b) Class LPI: the class of large problem instances (LPI) consists of 420 instances where n takes values from $\{300, 500, 800, 1000\}$.

The instances of the two classes share the following characteristics:

- 10 problem instances were randomly generated per combination of n and m and results are presented as an average over the objective function values obtained for the 10 instances.
- The weight $w(v)$ of each vertex $v \in V$ is randomly drawn from a uniform distribution, either from the interval $[20, 70]$ (referred to as **Type I**) or from the interval $[1, d(v)^2]$ (referred to as **Type II**), where $d(v)$ is the degree of vertex v .

4 Results

The proposed algorithms were implemented in C++ under Window 7, using Cygwin GCC 4.4 for compiling the software. The experimental results were obtained on a laptop with an Intel i5, 2.5 GHz CPU, and 4 GB of RAM.

Tables 1 and 2 present the numerical results obtained by the two first greedy heuristics (discussed in Section 4.1 in the previous chapter) and their modified versions for the instances of class SMPI. Hereby, Table 1 contains the results for the instances of Type I, whereas Table 2 contains the results concerning the Type II instances.

Remember that class SMPI contains 10 different problem instances for each combination of n and m . The values shown in the tables represent the average results obtained for 10 instances. In general, the structure of Tables 1 and 2 is as follows. The first two columns

indicate the number of vertices (n) and the number of edges (m). Then, for each greedy heuristic there are two columns providing the average solution quality and its corresponding standard deviation respectively. The best results are highlighted in boldface.

In the table below n represent the number of the nodes where m represents the number of connection between the nodes .

Table 1 MWDS greedy heuristic results for SMPI type I.

n	m	$\frac{W(u)}{w(u)}$		$\frac{Wp(u)}{w(u)}$		$\frac{d(u)}{w(u)}$		$\frac{dp(u)}{w(u)}$	
		AVG	SD	AVG	SD	AVG	SD	AVG	SD
50	50	578.3	35.57	565.2	35.38	588	41.48	564.7	26.27
50	100	410.5	36.34	405.1	34.42	407.4	40.17	399	33.87
50	250	197.2	20.42	193.1	17.25	198.8	15.28	196	15.44
50	500	105.5	9.89	105.5	9.89	103.3	11.07	103.3	11.06
50	750	72.9	9.35	72.9	9.35	72	8.65	72	8.65
50	1000	48.1	9.72	46.1	9.03	47.9	9.63	45.9	8.88
100	100	1168	55.6	1137.4	69.87	1176.5	66.9	1136.5	77.22
100	250	676.7	36.96	665.3	32.3	673	33.95	655.9	36.14
100	500	397.3	36.96	395.2	35.35	396.6	36.64	392.9	31.77
100	750	294.9	13.54	292.9	15.93	286.1	21.53	286.1	21.53
100	1000	235.1	7.59	232.9	10.08	234	11.07	229.3	11.98
100	2000	122.3	8.37	120.3	9.9	119.6	10.42	116.4	8.84
150	150	1727.6	84.34	1701.7	82.77	1725.2	74.79	1698.5	95.43
150	250	1340.5	67.32	1327.9	66.11	1353	67.65	1326.8	58.32
150	500	830.4	58.44	810.5	57.52	826	54.08	814.4	51.35
150	750	611.4	41.6	605	37.73	617.5	55.94	613..9	55.71
150	1000	488.7	28.48	486.7	29.22	496.1	22.91	484	21.14
150	2000	271.5	10.18	269.5	11.51	266.5	14.63	268.2	17.29
150	3000	191.1	12.56	191.1	12.59	186.1	13.19	182.7	9.67
200	250	2095.1	75.6	2063.8	64.49	2112.6	70.82	2044.1	57.44
200	500	1380.8	56.27	1364.9	54.26	1403.5	57.88	1375.7	48.05
200	750	1020.5	61.08	1014.4	55.32	1019.1	65.51	1018.9	70.48
200	1000	809.6	27.04	804.9	31.34	813.4	27.04	809	24.31
200	2000	467.5	21	462.6	17.57	473.9	20.67	475	18.46
200	3000	334.8	19.06	334.8	19.06	331.8	16.7	329.9	14.66
250	250	2906	89.12	2810.4	88.37	2931.6	96.5	2820.1	90.115
250	500	2040.9	114.18	2006.1	97.11	2014.6	89.38	1982.1	79.67
250	750	1533.8	72.9	1502.7	69.19	1542.3	61.71	1515.8	47.87
250	1000	1238.8	51.52	1229.4	53.83	1232.4	69.94	1214.2	50.195
250	2000	715.8	29.45	710.7	43.27	706.4	35.81	703.4	39.30

250	3000	500.4	18.72	495.8	14.07	500	20.78	429.9	23.648
250	5000	328.4	13.44	327	15.69	323.6	17.28	322.4	17.709

Table 4.1 – comparison result on SM T1 instance

Table 2

MWDS heuristic comparison for small and medium type 2 instance

N	Edges(M)	$\frac{W(u)}{w(u)}$		$\frac{W(u)+w(u)}{w(u)}$ Prime		$\frac{d(u)}{w(u)}$		$\frac{d(u)}{w(u)} + 1$ Prime	
		AVG	SD	AVG	SD	AVG	SD	AVG	SD
50	50	64.9	7.58	63.2	6.79	65	8.22	62.6	6.85
50	100	100.1	21.11	96.4	20.2	99.4	22.52	93.5	18.54
50	250	165.4	52.33	158	50.82	166.5	47.64	155.8	42.36
50	500	205.5	88.26	198.1	83.93	201.1	75.5	189.4	69.39
50	750	178.1	93.8	173.2	92.19	178.1	93.8	173.2	92.19
50	1000	162.8	108.66	146.5	97.30	167.5	106.73	146.5	97.3
100	100	133	17.22	129.8	18.12	133.7	16.69	129.2	17.42
100	250	229.2	24.22	222.6	21.92	232.7	25.34	220.4	23.85
100	500	340.8	63.64	326.7	58.57	343.2	60.47	319	49.65
100	750	437.8	104.62	414.8	96.09	438.2	98.59	411.4	98.69
100	1000	470.3	84.91	452.5	85.29	480.1	83.57	453.1	74.76
100	2000	615.4	197.06	581.8	181.55	632.4	223.03	593	210.02
150	150	198	19.06	192.5	19.68	197.9	17.65	190.1	18.35
150	250	255.4	28.7	242.3	24.69	254.9	26.1	243	24.36
150	500	376.8	39.97	360.9	37.76	378.9	35.03	358.7	35.11
150	750	513.5	97.18	481.5	94.34	502	87.82	483.1	87.65
150	1000	622.8	109.74	600.3	106.72	613.6	93.9	587.4	93.88
150	2000	833.4	233.91	790.8	206.52	804.1	253.94	770.2	231.38
150	3000	888.5	268.37	871.7	270.92	880.4	248.24	853.9	259.46
200	250	297.4	26.78	287.3	25.43	279	23.62	282.3	24.34
200	500	427	62.33	407.9	61.73	426.6	54.83	402.6	54.81
200	750	560.5	74.4	530.7	61.67	561.7	66.64	533.5	60.37
200	1000	668.1	48.15	627.5	51.92	673	66.46	626.5	60.88
200	2000	1004.7	162.63	958.7	142.13	959.4	156.86	927.2	148.86
200	3000	1140.8	176.53	1076.6	162.33	1164.2	166.26	1114.9	156.55
250	250	327.2	23	319.7	22.76	331.6	22.24	318.2	21.03
250	500	485.7	44.09	462.7	37.79	485.2	39.6	456.5	37.58
250	750	635.4	50.61	610.2	49.75	632.9	48.34	603.9	38.06
250	1000	749.7	73.98	717.7	72.13	753	61.65	702.5	59.64
250	2000	1154.3	185.42	1094.4	154.87	1154.8	173.51	1067.9	155.88
250	3000	1438.8	225.95	1341.4	216.58	1433.9	295.33	1359.8	258.38

250	5000	1741.1	448.61	1586.9	410.99	1628.7	366.79	1561	341.9
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Table 4.2 – comparison result on SM T2 instance

Table 3

MWDS heuristic comparison for Large type 1 instance

N	Edges(M)	$\frac{W(u)}{w(u)}$		$\frac{W(u)+w(u)}{w(u)}$ Prime		$\frac{d(u)}{w(u)}$		$\frac{d(u)}{w(u)} + 1$ Prime	
		AVG	SD	AVG	SD	AVG	SD	AVG	SD
300	300	3481.5	118.14	3368.6	91.83	3504.9	83.26	3364.3	78.75
300	500	2697.9	92.03	2653.5	93.65	2709.7	109.48	2663	107.62
300	750	2104.3	88.5	2061.6	92.79	2106.3	98.63	2068.1	69.59
300	1000	1688	60.42	1657.2	69.41	1674.4	55.68	1657.4	45.24
300	2000	965.6	51.4	959.3	52.97	949.5	27.81	949.8	40.47
300	3000	701	30.61	694.4	30.65	693.7	31.01	697.2	30.51
300	5000	459.8	21.74	459.8	21.74	457.2	17.25	458.6	20.39
500	500	5820.5	133.1	5657.4	139.32	5840.4	124.91	5682.4	98.82
500	1000	4039.8	121.86	3948.9	112.97	4038.9	123	3937.8	105.54
500	2000	2484.9	79.59	2458.1	80.08	2478.7	92.24	2418.6	80.15
500	5000	1177.1	32.25	1168.8	38.5	1171.3	33.45	1169.6	44.63
500	10,000	670.5	10.65	670.5	10.64	656.1	25.68	646.2	24.09
800	1000	8472.1	157.12	8250.3	120.23	8512.6	151.07	8274	173.06
800	2000	5641.4	165.59	5546.5	115.65	5625.7	85.19	5489.7	94.74
800	5000	2739.9	71.15	2709.1	64.15	2735.5	61.18	2703	57.57
800	10,000	1590.6	36.76	1582.7	23.36	1553	40.35	1551.5	27.49
1000	1000	11,666.3	162.07	11364.3	156.40	11701.4	185.26	11351.6	139.78
1000	5000	4168.5	98.69	4111.7	92.88	4114.4	68.47	4073.4	56.59
1000	10,000	2379.8	68.02	2367.6	62.77	2368.1	63.41	2339.5	45.56
100	15,000	1704	27.07	1693	31.27	1407.3	39.21	1700.1	39.89
1000	20,000	1351.3	26.86	1346	27.95	1322.9	22.94	1319.5	33.93

Table 4.3– comparison result on Large T1 instance

Table 4

MWDS heuristic comparison for Large type 2 instance

N	Edges(M)	$\frac{W(u)}{w(u)}$		$\frac{W(u)+w(u)}{w(u)}$ Prime		$\frac{d(u)}{w(u)}$		$\frac{d(u)}{w(u)} + 1$ Prime	
		AVG	SD	AVG	SD	AVG	SD	AVG	SD
300	300	397.9	27.98	384.8	27.1	401.4	25.61	383.7	21.65
300	500	516	40.73	500.4	40.13	512.9	42.04	492	41.57
300	750	680.7	57.89	648.0	49.62	675.4	65.26	639.2	52.96
300	1000	828.7	90.36	794.6	77.53	817.8	92.48	776.2	86.24
300	2000	1240.6	128.54	1181.2	131.31	1207.6	127.13	1157.2	109.54
300	3000	1555.3	163.37	1493.9	164.69	1510.1	141.32	1444.2	150.53
300	5000	1941.1	361.41	1813.7	351.16	1862.5	302.84	1813.5	333.93
500	500	668.6	31.39	647.1	33.43	678.5	26.83	648	29.46
500	1000	987.5	45.8	949.6	45.13	985.2	50.42	935.9	46.15
500	2000	1508.1	132.91	1441	123.24	1526.7	122.58	1442.5	130.86
500	5000	2668.1	283.36	2510.6	271.96	2652.5	258.04	2511.4	255.6
500	10,000	3723.3	452.27	3473.6	472.94	3630.6	439.89	3390	446.49
800	1000	1193.1	52.12	1154.4	50.80	1197	54.93	1146.9	52.01
800	2000	1813	97.39	1719	82.70	1804.5	108.64	1705.7	85.06
800	5000	3321.5	231.13	3127.5	210.26	3225.9	212.11	3051.2	180.35
800	10,000	4725.3	431.67	4447.4	338.06	4657	396.56	4409.8	364.99
1000	1000	1338.5	39.15	1296.2	36.92	1346.7	38.76	1284.8	34.58
1000	5000	3596.4	230.69	3396.6	210.53	3553.2	273.27	3364.1	239.96
1000	10,000	5432.6	286.66	5078	289.86	5368	363.5	5071.1	300.65
100	15,000	6857	461.14	6442.3	477.38	6734.3	497.71	6377.9	474.06
1000	20,000	7785.6	697.26	7313.6	672.27	7602	576.8	7241.4	515.9

Table 4.4 – comparison result on Large T2 instance

Discussion of results

From the four tables above and according to the obtaining results, we can see that the both improved heuristics gave better results on the both types T1 and T2 In comparison with Results obtained in [22].

The result of the MWDS heuristic comparison for small and medium type 1 instance are shown in table one, the numerical results of the first heuristic, we obtained 29 out of 32 case better results, however, with the second heuristic we obtained 27 out of 32 better results

The result of the MWDS heuristic comparison for small and medium type 1 instance are shown in table two, the results were as follow: in the first heuristic we obtained 32 out of 32 case better result so 100% of better result in this case, and the second 31 out of 32 case better results

The result of the MWDS heuristic comparison for Large type 1 instance are represented in the third table, the first heuristic we obtained 30 out of 32 case better results, and 30 out of 32 case better results with the second heuristic

The fourth table shows the result of the MWDS heuristic comparison for large type 2 instance, the first heuristic we obtained 32 out of 32 case improved results, as well, 32 out of 32 case better results were obtained by the second heuristic