

Table 1 shows **all** results obtain by our the MIP approach for MLHRND. Column *Instance* refers to the underlying graphs, either the names from the TSPLIB or *rand* for the random instances. The numbers followed describe the numbers of nodes, in layers 2, and layers 3, while *d* indicates a dense and *s* a sparse graph. Column *b* lists the upper bound path lengths for layers 2 and 3. Columns *lp* and *t_lp* list the LP relaxations together with its corresponding run times in seconds. Columns *lb* and *ub* list the lower bounds and upper bounds obtained by CPLEX, a dash indicates that no integral solution was found. If optimality could be proven *lb* and *ub* are printed bold. Moreover, the total run times (*t_all*) in seconds and the numbers of branch-and-bound nodes (*#BnB*) are provided.

Table 1: All experimental results.

Instance	b	lp	t_lp[s]	lb	ub	t_all[s]	#BnB
ulysses22-3-10-d	4-4	111.30	0.10	123.10	123.10	111.26	9256
	4-6	111.30	0.10	123.10	123.10	135.70	10942
ulysses22-3-10-s	4-4	111.30	0.03	125.02	125.02	2.41	714
	4-6	111.30	0.02	124.94	124.94	2.08	696
rand25-3-10-d	4-4	68311.15	0.26	71474.96	71474.96	139.21	4494
	4-6	68311.15	0.13	71035.99	71035.99	50.10	1146
rand25-3-10-s	4-4	68311.15	0.04	71474.96	71474.96	5.73	631
	4-6	68311.15	0.05	71035.99	71035.99	6.35	1010
rand30-3-10-d	4-4	78659.25	0.37	85257.11	85257.11	1004.19	11498
	4-6	78659.25	0.39	84801.63	84801.63	565.10	11311
rand30-3-10-s	4-4	78659.25	0.08	85257.11	85257.11	83.30	4210
	4-6	78659.25	0.06	85152.13	85152.13	55.02	2955
rand30-4-12-d	4-4	86371.04	0.42	91683.21	91683.21	669.00	15803
	4-6	86371.04	0.58	90709.94	90709.94	1172.91	14624
rand30-4-12-s	4-4	86371.04	0.09	93303.11	93303.11	261.06	13626
	4-6	86371.04	0.11	92329.84	92329.84	78.49	5143
rand35-3-10-d	4-4	81641.30	0.44	86242.90	87978.11	20000.02	163073
	4-6	81641.30	0.30	85056.55	85056.55	823.51	7214
rand35-3-10-s	4-4	81647.88	0.10	87942.81	87942.81	829.66	25883
	4-6	81647.88	0.07	85056.55	85056.55	68.20	1726
rand35-4-12-d	4-4	87858.01	1.60	91760.82	91760.82	2264.37	16388
	4-6	87858.01	1.55	91429.39	91429.39	1698.50	14337
rand35-4-12-s	4-4	87858.01	0.13	91772.90	91772.90	48.89	2211
	4-6	87858.01	0.24	91772.90	91772.90	72.96	2748
rand45-4-10-d	4-4	88104.76	17.27	90278.48	118680.35	20000.04	18919
	4-6	88104.76	24.92	90331.53	108467.91	20000.08	18744
rand45-4-10-s	4-4	88104.76	0.33	95073.04	110309.17	20000.01	386126
	4-6	88104.76	0.36	94549.66	100075.96	20000.01	222593
rand45-4-15-d	4-4	91655.12	3.07	95154.00	98145.55	20000.04	41051

	4-6	91655.12	4.73	94477.87	96835.30	20000.02	47186
rand45-4-15-s	4-4	91655.12	0.18	97520.05	97520.05	2879.48	52709
	4-6	91655.12	0.20	96835.30	96835.30	1854.89	33294
att48-4-10-d	4-4	54840.60	41.49	56889.57	65523.49	20000.05	6990
	4-6	54840.60	33.23	57072.71	60954.48	20000.08	13004
att48-4-10-s	4-4	54842.42	0.41	59306.56	59558.17	20000.01	147295
	4-6	54842.42	0.46	58591.88	58591.88	8660.96	70817
att48-4-15-d	4-4	57051.70	4.05	58774.12	60326.60	20000.06	43424
	4-6	57051.70	3.48	58339.09	64072.36	20000.06	55552
att48-4-15-s	4-4	57051.70	0.17	60593.11	60593.11	728.19	14261
	4-6	57051.70	0.12	60063.45	60063.45	3096.60	48173
eil51-4-10-d	4-4	665.92	57.91	683.89	–	20000.07	1690
	4-6	665.92	32.09	684.05	834.44	20000.10	2962
eil51-4-10-s	4-4	668.32	0.44	700.09	736.01	20000.01	192260
	4-6	668.32	0.34	703.46	717.83	20000.02	199000
eil51-5-15-d	4-4	714.87	13.34	723.51	986.33	20000.06	12718
	4-6	714.87	13.27	723.25	810.09	20000.03	8405
eil51-5-15-s	4-4	715.49	0.29	752.92	752.92	13260.04	126228
	4-6	715.49	0.34	742.85	742.85	4326.78	37066
berlin52-4-10-d	4-4	12215.52	26.28	12439.20	–	20000.07	2410
	4-6	12215.52	31.67	12455.12	–	20000.07	1961
berlin52-4-10-s	4-4	12417.30	0.33	12908.70	13700.51	20000.02	152552
	4-6	12417.30	0.36	12883.42	13067.24	20000.03	159927
berlin52-5-15-d	4-4	12628.36	4.74	12752.80	14187.82	20000.06	18901
	4-6	12628.36	7.06	12727.43	14665.47	20000.04	14021
berlin52-5-15-s	4-4	12628.36	0.42	13289.96	13562.28	20000.01	126714
	4-6	12628.36	0.22	13294.29	13294.29	6480.00	52401
rand55-4-10-d	4-4	101083.95	77.49	103404.02	–	20000.15	1458
	4-6	101083.95	64.69	103670.42	126000.10	20000.13	8629
rand55-4-10-s	4-4	101540.60	0.43	105037.61	120668.48	20000.02	148821
	4-6	101540.60	0.42	104394.30	107857.57	20000.02	172164
rand55-4-15-d	4-4	104566.61	50.90	107032.23	121112.43	20000.09	15256
	4-6	104566.61	43.29	106703.71	112275.51	20000.09	14502
rand55-4-15-s	4-4	104568.88	0.54	109442.82	118030.59	20000.01	259298
	4-6	104568.88	0.47	111575.10	113646.00	20000.01	198682
rand70-5-20-d	4-11	118006.73	793.46	119196.09	150184.10	20000.19	2008
	4-4	118006.73	320.39	119413.38	–	20000.18	3030
	4-7	118006.73	316.47	119096.43	–	20000.17	1191
	7-11	118006.73	517.41	119067.37	–	20000.20	1131
	7-4	118006.73	350.11	118997.68	–	20000.26	1298
	7-7	118006.73	428.23	119013.81	–	20000.18	1055
rand70-5-20-s	4-11	118629.49	2.16	121465.12	128877.80	20000.03	64480
	4-4	118629.49	1.36	120859.26	141905.15	20000.01	60440
	4-7	118629.49	1.93	120641.50	134313.20	20000.02	68883
	7-11	118629.49	1.92	121240.40	123864.74	20000.03	62988

	7-4	118629.49	1.11	120427.63	126604.26	20000.04	60110
	7-7	118629.49	1.17	120778.51	125263.11	20000.04	88090
rand70-7-25-d	4-11	118997.30	276.98	120032.28	–	20000.11	1357
	4-4	118997.30	176.50	119914.90	–	20000.06	1002
	4-7	118997.30	362.53	120561.12	–	20000.11	1222
	7-11	118997.30	460.46	119766.07	–	20000.05	1165
	7-4	118997.30	249.55	119774.48	–	20000.16	2112
	7-7	118997.30	103.49	119880.98	–	20000.09	1460
rand70-7-25-s	4-11	119254.77	0.95	123102.71	125378.93	20000.02	59622
	4-4	119254.77	1.72	122612.03	130842.75	20000.02	55591
	4-7	119254.77	1.88	122760.13	125505.95	20000.02	57865
	7-11	119254.77	2.06	121628.27	123769.10	20000.04	41836
	7-4	119254.77	2.23	121642.43	123935.43	20000.02	72537
	7-7	119254.77	2.80	121156.64	122977.98	20000.02	51723
eil76-5-20-d	4-11	834.03	66.60	842.11	–	20000.22	564
	4-4	834.03	482.04	842.76	–	20000.18	788
	4-7	834.03	76.50	840.93	–	20000.24	858
	7-11	834.03	86.79	842.30	–	20000.21	1017
	7-4	834.03	75.87	842.39	–	20000.20	896
	7-7	834.03	57.80	840.66	–	20000.19	912
eil76-5-20-s	4-11	839.34	0.62	859.63	888.33	20000.02	34644
	4-4	839.34	1.03	851.28	966.62	20000.05	59988
	4-7	839.34	0.78	852.63	916.38	20000.03	78669
	7-11	839.34	0.62	856.15	856.15	12540.38	21734
	7-4	839.34	0.53	849.20	943.33	20000.06	51504
	7-7	839.34	0.53	852.66	871.23	20000.03	55725
eil76-7-25-d	4-11	867.53	542.79	872.43	–	20000.08	683
	4-4	867.53	177.49	871.24	–	20000.17	1280
	4-7	867.53	303.73	873.56	–	20000.08	699
	7-11	867.53	159.59	872.79	–	20000.07	1105
	7-4	867.53	290.34	873.86	–	20000.02	740
	7-7	867.53	646.20	872.94	1244.13	20000.06	1181
eil76-7-25-s	4-11	869.97	0.81	884.91	906.78	20000.02	34897
	4-4	869.97	0.66	883.60	968.37	20000.04	47146
	4-7	869.97	1.00	881.28	925.16	20000.01	57392
	7-11	869.97	0.69	884.82	887.20	20000.02	47383
	7-4	869.97	0.82	883.03	931.71	20000.02	45586
	7-7	869.97	0.68	879.19	917.19	20000.02	52771