

# The Steiner Tree Challenge: An updated Study

Tobias Polzin<sup>1</sup> and Siavash Vahdati Daneshmand<sup>2</sup>

<sup>1</sup> HaCon Ingenieurgesellschaft mbH, Hannover, Germany

<sup>2</sup> Theoretische Informatik, Universität Mannheim, Germany  
`vahdati@informatik.uni-mannheim.de`

**Abstract.** We report some results of our code for the classical Steiner problem in graphs.

## 1 Description

For a description of the used algorithms and the program, see [1]. For the results in this report we have used the same code (re-compiled).

All results presented here were produced single-threaded on a PC with an Intel Core i7 920 (2.66 GHz) CPU<sup>3</sup>, using Linux 3.4.2-1.fc16.x86\_64 operating system, gcc 4.6.3 compiler and CPLEX 12.6 LP-solver.

## 2 Results for the SteinLib Instances

Here we reproduce the (exact solution) results in [1] for the SteinLib instances using the same code in a new computing environment (as described in Section 1).

All results were produced by a single run of the same program with the same parameter values (in fact, the same as in [1]), with the following exception: For the instance groups I and PUC (Tables 9 to 12) we switched off the more time-consuming routines in the branch-and-bound algorithm, allowing more branching (and spending less time in each branch-and-bound tree node). It should be noted that for many groups of instances, a specific choice of the used routines and/or parameter settings could improve the running times significantly (compare for example the results for the LIN-instances (Table 5) with or without a group of strong, but time-consuming reductions).

If an instance is solved exactly within the time limit (24 hours in this section), we give the value of the optimal solution and the total time (in seconds) for the exact solution; otherwise we give an interval [*lower* – *upper*] showing the best lower and upper bounds reached before the time limit and also the used time limit.

---

<sup>3</sup> This machine produced a score of 306.508988 using the 11th DIMACS Challenge benchmark code.

instance	size			optimum time		instance	size			optimum time	
	V	E	R				V	E	R		
d01	1000	1250	5	106	0.02	e01	2500	3125	5	111	0.08
d02	1000	1250	10	220	0.02	e02	2500	3125	10	214	0.06
d03	1000	1250	167	1565	0.00	e03	2500	3125	417	4013	0.01
d04	1000	1250	250	1935	0.00	e04	2500	3125	625	5101	0.01
d05	1000	1250	500	3250	0.00	e05	2500	3125	1250	8128	0.01
d06	1000	2000	5	67	0.05	e06	2500	5000	5	73	0.20
d07	1000	2000	10	103	0.05	e07	2500	5000	10	145	0.20
d08	1000	2000	167	1072	0.01	e08	2500	5000	417	2640	0.03
d09	1000	2000	250	1448	0.01	e09	2500	5000	625	3604	0.03
d10	1000	2000	500	2110	0.01	e10	2500	5000	1250	5600	0.02
d11	1000	5000	5	29	0.04	e11	2500	12500	5	34	0.16
d12	1000	5000	10	42	0.02	e12	2500	12500	10	67	0.12
d13	1000	5000	167	500	0.01	e13	2500	12500	417	1280	0.23
d14	1000	5000	250	667	0.02	e14	2500	12500	625	1732	0.04
d15	1000	5000	500	1116	0.01	e15	2500	12500	1250	2784	0.03
d16	1000	25000	5	13	0.04	e16	2500	62500	5	15	0.18
d17	1000	25000	10	23	0.04	e17	2500	62500	10	25	0.12
d18	1000	25000	167	223	0.12	e18	2500	62500	417	564	3.42
d19	1000	25000	250	310	0.09	e19	2500	62500	625	758	0.66
d20	1000	25000	500	537	0.02	e20	2500	62500	1250	1342	0.06

**Table 1.** Results on the D and E-instances. Type: Sparse with random weights and varying  $|E|$  and  $|R|$ , from OR-Library.

instance	size			optimum time		instance	size			optimum time	
	V	E	R				V	E	R		
1r111	625	2352	6	28000	0.03	2r111	1000	5800	9	28000	0.17
1r112	625	2352	6	28000	0.01	2r112	1000	5800	9	32000	0.18
1r113	625	2352	6	26000	0.01	2r113	1000	5800	9	28000	0.08
1r121	625	2340	6	36000	0.02	2r121	1000	5766	9	28000	0.03
1r122	625	2342	6	45000	0.12	2r122	1000	5772	9	29000	0.09
1r123	625	2343	6	40000	0.05	2r123	1000	5754	9	25000	0.12
1r131	625	2336	6	43000	0.08	2r131	1000	5726	9	27000	0.08
1r132	625	2340	6	37000	0.02	2r132	1000	5725	9	33000	1.08
1r133	625	2326	6	36000	0.02	2r133	1000	5729	9	29000	0.11
1r211	625	2352	31	77000	0.07	2r211	1000	5800	50	89000	43.88
1r212	625	2352	30	81000	0.08	2r212	1000	5800	49	80000	0.61
1r213	625	2352	29	70000	0.03	2r213	1000	5800	48	76000	8.95
1r221	625	2341	31	79000	0.05	2r221	1000	5764	50	83000	0.80
1r222	625	2343	31	68000	0.03	2r222	1000	5765	50	84000	6.01
1r223	625	2340	31	77000	0.03	2r223	1000	5770	49	84000	9.08
1r231	625	2331	30	80000	0.04	2r231	1000	5737	50	86000	8.89
1r232	625	2335	29	86000	0.03	2r232	1000	5733	49	87000	10.10
1r233	625	2327	31	71000	0.02	2r233	1000	5730	47	83000	3.57
1r311	625	2352	56	108000	0.04	2r311	1000	5800	95	129000	12.38
1r312	625	2352	60	113000	0.03	2r312	1000	5800	92	126000	14.46
1r313	625	2352	58	106000	0.03	2r313	1000	5800	97	128000	2.31
1r321	625	2338	59	118000	0.04	2r321	1000	5771	92	125000	0.34
1r322	625	2336	60	113000	0.03	2r322	1000	5753	92	130000	5.71
1r323	625	2341	60	117000	0.05	2r323	1000	5764	96	142000	13.51
1r331	625	2319	58	103000	0.02	2r331	1000	5736	93	134000	3.68
1r332	625	2333	58	109000	0.01	2r332	1000	5745	95	136000	17.46
1r333	625	2331	58	113000	0.03	2r333	1000	5741	98	143000	14.04

**Table 2.** Results on the 1R and 2R-instances. Type: 2D (respectively 3D) cross grid graph.

instance	size			optimum	time	instance	size			optimum	time
	V	E	R				V	E	R		
wrp3-11	128	227	11	1100361	0.01	wrp4-11	123	233	11	1100179	0.01
wrp3-12	84	149	12	1200237	0.00	wrp4-13	110	188	13	1300798	0.01
wrp3-13	311	613	13	1300497	0.09	wrp4-14	145	283	14	1400290	0.02
wrp3-14	128	247	14	1400250	0.01	wrp4-15	193	369	15	1500405	0.03
wrp3-15	138	257	15	1500422	0.01	wrp4-16	311	579	16	1601190	0.04
wrp3-16	204	374	16	1600208	0.03	wrp4-17	223	404	17	1700525	0.07
wrp3-17	177	354	17	1700442	0.02	wrp4-18	211	380	18	1801464	0.04
wrp3-19	189	353	19	1900439	0.03	wrp4-19	119	206	19	1901446	0.01
wrp3-20	245	454	20	2000271	0.06	wrp4-21	529	1032	21	2103283	0.29
wrp3-21	237	444	21	2100522	0.04	wrp4-22	294	568	22	2200394	0.46
wrp3-22	233	431	22	2200557	0.08	wrp4-23	257	515	23	2300376	0.14
wrp3-23	132	230	23	2300245	0.01	wrp4-24	493	963	24	2403332	0.33
wrp3-24	262	487	24	2400623	0.12	wrp4-25	422	808	25	2500828	0.13
wrp3-25	246	468	25	2500540	0.04	wrp4-26	396	781	26	2600443	2.62
wrp3-26	402	780	26	2600484	0.09	wrp4-27	243	497	27	2700441	0.22
wrp3-27	370	721	27	2700502	0.22	wrp4-28	272	545	28	2800466	0.77
wrp3-28	307	559	28	2800379	0.06	wrp4-29	247	505	29	2900484	2.67
wrp3-29	245	436	29	2900479	0.03	wrp4-30	361	724	30	3000526	3.05
wrp3-30	467	896	30	3000569	0.49	wrp4-31	390	786	31	3100526	4.25
wrp3-31	323	592	31	3100635	0.14	wrp4-32	311	632	32	3200554	2.31
wrp3-33	437	838	33	3300513	0.11	wrp4-33	304	571	33	3300655	0.11
wrp3-34	1244	2474	34	3400646	55.26	wrp4-34	314	650	34	3400525	0.15
wrp3-36	435	818	36	3600610	0.70	wrp4-35	471	954	35	3500601	3.18
wrp3-37	1011	2010	37	3700485	23.21	wrp4-36	363	750	36	3600596	2.18
wrp3-38	603	1207	38	3800656	2.73	wrp4-37	522	1054	37	3700647	6.43
wrp3-39	703	1616	39	3900450	30.38	wrp4-38	294	618	38	3800606	0.37
wrp3-41	178	307	41	4100466	0.16	wrp4-39	802	1553	39	3903734	0.56
wrp3-42	705	1373	42	4200598	6.49	wrp4-40	538	1088	40	4000758	15.24
wrp3-43	173	298	43	4300457	0.15	wrp4-41	465	955	41	4100695	5.92
wrp3-45	1414	2813	45	4500860	75.23	wrp4-42	552	1131	42	4200701	14.54
wrp3-48	925	1738	48	4800552	4.38	wrp4-43	596	1148	43	4301508	0.60
wrp3-49	886	1800	49	4900882	19.41	wrp4-44	398	788	44	4401504	12.07
wrp3-50	1119	2251	50	5000673	168.22	wrp4-45	388	815	45	4500728	0.57
wrp3-52	701	1352	52	5200825	10.30	wrp4-46	632	1287	46	4600756	6.84
wrp3-53	775	1471	53	5300847	1.36	wrp4-47	555	1098	47	4701318	1.54
wrp3-55	1645	3186	55	5500888	896.58	wrp4-48	451	825	48	4802220	0.56
wrp3-56	853	1590	56	5600872	7.60	wrp4-49	557	1080	49	4901968	1.50
wrp3-60	838	1763	60	6001164	38.41	wrp4-50	564	1112	50	5001625	1.84
wrp3-62	670	1316	62	6201016	8.63	wrp4-51	668	1306	51	5101616	1.49
wrp3-64	1822	3610	64	6400931	151.48	wrp4-52	547	1115	52	5201081	0.74
wrp3-66	2521	4858	66	6600922	496.24	wrp4-53	615	1232	53	5301351	3.39
wrp3-67	987	1923	67	6700776	8.19	wrp4-54	688	1388	54	5401534	2.36
wrp3-69	856	1621	69	6900841	2.97	wrp4-55	610	1201	55	5501952	2.52
wrp3-70	1468	2931	70	7000890	24.76	wrp4-56	839	1617	56	5602299	3.20
wrp3-71	1221	2414	71	7101028	34.97	wrp4-58	757	1493	58	5801466	3.60
wrp3-73	1890	3613	73	7301207	656.49	wrp4-59	904	1806	59	5901592	1.25
wrp3-74	1019	1941	74	7400759	28.92	wrp4-60	693	1370	60	6001782	1.53
wrp3-75	729	1395	75	7501020	2.58	wrp4-61	775	1538	61	6102210	0.50
wrp3-76	1761	3370	76	7601028	105.16	wrp4-62	1283	2493	62	6202100	6.97
wrp3-78	2346	4656	78	7801094	388.68	wrp4-63	1121	2227	63	6301479	106.13
wrp3-79	833	1595	79	7900444	4.63	wrp4-64	632	1281	64	6401996	1.34
wrp3-80	1491	2831	80	8000849	31.74	wrp4-66	844	1691	66	6602931	3.05
wrp3-83	3168	6220	83	8300906	6073.19	wrp4-67	1518	3060	67	6702800	12.00
wrp3-84	2356	4547	84	8401094	149.51	wrp4-68	917	1850	68	6801753	6.06
wrp3-85	528	1017	85	8500739	54.00	wrp4-69	574	1165	69	6902328	1.33
wrp3-86	1360	2607	86	86000746	70.87	wrp4-70	637	1269	70	7003022	0.39
wrp3-88	743	1409	88	88001175	4.26	wrp4-71	802	1609	71	7102320	0.79
wrp3-91	1343	2594	91	91000866	38.44	wrp4-72	1151	2274	72	7202807	18.81
wrp3-92	1765	3613	92	92000764	60.73	wrp4-73	1898	3616	73	7302643	39.54
wrp3-94	1976	3836	94	94001181	183.30	wrp4-74	802	1620	74	7402046	6.92
wrp3-96	2518	4985	96	96001172	532.56	wrp4-75	938	1869	75	7501712	4.57
wrp3-98	2265	4545	98	98001224	407.20	wrp4-76	766	1535	76	7602040	3.38
wrp3-99	2076	4072	99	99001097	181.37						

**Table 3.** Results on the WRP-instances. Type: Wire routing problems from industry.

instance	size			optimum	time
	V	E	R		
alve2087	1244	1971	34	1049	0.02
alve2105	1220	1858	34	1032	0.01
alve3146	3626	5869	64	2240	0.06
alve5067	3524	5560	68	2586	0.15
alve5345	5179	8165	68	3507	0.65
alve5623	4472	6938	68	3413	0.33
alve5901	11543	18429	68	3912	0.53
alve6179	3372	5213	67	2452	0.13
alve6457	3932	6137	68	3057	0.18
alve6735	4119	6696	68	2696	0.14
alve6951	2818	4419	67	2386	0.12
alve7065	34046	54841	544	23881	14.75
alve7066	6405	10454	16	2256	1.24
alve7086	34479	55494	2344	62449	10.03
alve7229	940	1474	34	824	0.00
alut0787	1160	2089	34	982	0.01
alut0805	966	1666	34	958	0.02
alut1181	3041	5693	64	2353	0.08
alut2010	6104	11011	68	3307	0.22
alut2288	9070	16595	68	3843	0.52
alut2566	5021	9055	68	3073	0.42
alut2610	33901	62816	204	12239	14.65
alut2625	36711	68117	879	35459	53.90
alut2764	387	626	34	640	0.00
diw0234	5349	10086	25	1996	0.24
diw0250	353	608	11	350	0.00
diw0260	539	985	12	468	0.00
diw0313	468	822	14	397	0.00
diw0393	212	381	11	302	0.00
diw0445	1804	3311	33	1363	0.02
diw0459	3636	6789	25	1362	0.03
diw0460	339	579	13	345	0.00
diw0473	2213	4135	25	1098	0.02
diw0487	2414	4386	25	1424	0.03
diw0495	938	1655	10	616	0.01
diw0513	918	1684	10	604	0.01
diw0523	1080	2015	10	561	0.01
diw0540	286	465	10	374	0.00
diw0559	3738	7013	18	1570	0.08
diw0778	7231	13727	24	2173	0.18
diw0779	11821	22516	50	4440	1.26
diw0795	3221	5938	10	1550	0.17
diw0801	3023	5575	10	1587	0.15
diw0819	10553	20066	32	3399	0.52
diw0820	11749	22384	37	4167	1.06
dmxa0296	233	386	12	344	0.00
dmxa0368	2050	3676	18	1017	0.03
dmxa0454	1848	3286	16	914	0.03
dmxa0628	169	280	10	275	0.00
dmxa0734	663	1154	11	506	0.01
dmxa0848	499	861	16	594	0.01
dmxa0903	632	1087	10	580	0.02
dmxa1010	3983	7108	23	1488	0.03
dmxa1109	343	559	17	454	0.00
dmxa1200	770	1383	21	750	0.01
dmxa1304	298	503	10	311	0.00
dmxa1516	720	1269	11	508	0.01
dmxa1721	1005	1731	18	780	0.01
dmxa1801	2333	4137	17	1365	0.07

instance	size			optimum	time
	V	E	R		
gap1307	342	552	17	549	0.00
gap1413	541	906	10	457	0.00
gap1500	220	374	17	254	0.00
gap1810	429	702	17	482	0.00
gap1904	735	1256	21	763	0.02
gap2007	2039	3548	17	1104	0.03
gap2119	1724	2975	29	1244	0.03
gap2740	1196	2084	14	745	0.02
gap2800	386	653	12	386	0.00
gap2975	179	293	10	245	0.00
gap3036	346	583	13	457	0.01
gap3100	921	1558	11	640	0.02
gap3128	10393	18043	104	4292	0.68
msm0580	338	541	11	467	0.00
msm0654	1290	2270	10	823	0.01
msm0709	1442	2403	16	884	0.02
msm0920	752	1264	26	806	0.01
msm1008	402	695	11	494	0.01
msm1234	933	1632	13	550	0.01
msm1477	1199	2078	31	1068	0.02
msm1707	278	478	11	564	0.00
msm1844	90	135	10	188	0.00
msm1931	875	1522	10	604	0.01
msm2000	898	1562	10	594	0.01
msm2152	2132	3702	37	1590	0.05
msm2326	418	723	14	399	0.00
msm2492	4045	7094	12	1459	0.07
msm2525	3031	5239	12	1290	0.05
msm2601	2961	5100	16	1440	0.08
msm2705	1359	2458	13	714	0.01
msm2802	1709	2963	18	926	0.02
msm2846	3263	5783	89	3135	0.13
msm3277	1704	2991	12	869	0.01
msm3676	957	1554	10	607	0.00
msm3727	4640	8255	21	1376	0.10
msm3829	4221	7255	12	1571	0.29
msm4038	237	390	11	353	0.00
msm4114	402	690	16	393	0.00
msm4190	391	666	16	381	0.00
msm4224	191	302	11	311	0.00
msm4312	5181	8893	10	2016	0.59
msm4414	317	476	11	408	0.00
msm4515	777	1358	13	630	0.01
taq0014	6466	11046	128	5326	0.48
taq0023	572	963	11	621	0.01
taq0365	4186	7074	22	1914	0.15
taq0377	6836	11715	136	6393	1.04
taq0431	1128	1905	13	897	0.03
taq0631	609	932	10	581	0.00
taq0739	837	1438	16	848	0.03
taq0741	712	1217	16	847	0.02
taq0751	1051	1791	16	939	0.03
taq0891	331	560	10	319	0.00
taq0903	6163	10490	130	5099	0.94
taq0910	310	514	17	370	0.00
taq0920	122	194	17	210	0.00
taq0978	777	1239	10	566	0.01

**Table 4.** Results on the VLSI instances. Type: Grid graph with holes (not geometric) from VLSI design.

instance	size			optimum	time	instance	size			optimum	time
	V	E	R				V	E	R		
lin01	53	80	4	503	0.00	lin01	53	80	4	503	0.00
lin02	55	82	6	557	0.00	lin02	55	82	6	557	0.00
lin03	57	84	8	926	0.00	lin03	57	84	8	926	0.00
lin04	157	266	6	1259	0.00	lin04	157	266	6	1259	0.00
lin05	160	269	9	1703	0.00	lin05	160	269	9	1703	0.00
lin06	165	274	14	1348	0.00	lin06	165	274	14	1348	0.00
lin07	307	526	6	1885	0.01	lin07	307	526	6	1885	0.00
lin08	311	530	10	2248	0.01	lin08	311	530	10	2248	0.00
lin09	313	532	12	2752	0.01	lin09	313	532	12	2752	0.01
lin10	321	540	20	4132	0.01	lin10	321	540	20	4132	0.00
lin11	816	1460	10	4280	0.04	lin11	816	1460	10	4280	0.03
lin12	818	1462	12	5250	0.06	lin12	818	1462	12	5250	0.05
lin13	822	1466	16	4609	0.03	lin13	822	1466	16	4609	0.03
lin14	828	1472	22	5824	0.05	lin14	828	1472	22	5824	0.04
lin15	840	1484	34	7145	0.04	lin15	840	1484	34	7145	0.03
lin16	1981	3633	12	6618	0.11	lin16	1981	3633	12	6618	0.10
lin17	1989	3641	20	8405	0.13	lin17	1989	3641	20	8405	0.12
lin18	1994	3646	25	9714	0.24	lin18	1994	3646	25	9714	0.24
lin19	2010	3662	41	13268	0.25	lin19	2010	3662	41	13268	0.24
lin20	3675	6709	11	6673	0.29	lin20	3675	6709	11	6673	0.29
lin21	3683	6717	20	9143	0.22	lin21	3683	6717	20	9143	0.20
lin22	3692	6726	28	10519	0.38	lin22	3692	6726	28	10519	0.38
lin23	3716	6750	52	17560	0.54	lin23	3716	6750	52	17560	0.54
lin24	7998	14734	16	15076	1.68	lin24	7998	14734	16	15076	1.73
lin25	8007	14743	24	17803	2.23	lin25	8007	14743	24	17803	2.33
lin26	8013	14749	30	21757	2.78	lin26	8013	14749	30	21757	2.98
lin27	8017	14753	36	20678	2.54	lin27	8017	14753	36	20678	2.52
lin28	8062	14798	81	32584	18.41	lin28	8062	14798	81	32584	14.59
lin29	19083	35636	24	23765	5.38	lin29	19083	35636	24	23765	5.85
lin30	19091	35644	31	27684	16.69	lin30	19091	35644	31	27684	14.74
lin31	19100	35653	40	31696	1272.35	lin31	19100	35653	40	31696	206.90
lin32	19112	35665	53	39832	3031.86	lin32	19112	35665	53	39832	816.51
lin33	19177	35730	117	56061	1017.26	lin33	19177	35730	117	56061	319.17
lin34	38282	71521	34	45018	17592.43	lin34	38282	71521	34	45018	1848.24
lin35	38294	71533	45	50559	33913.55	lin35	38294	71533	45	50559	1911.09
lin36	38307	71546	58	[55216 – 55670]	86400.00	lin36	38307	71546	58	55608	39931.77
lin37	38418	71657	172	[99098 – 99585]	86521.00	lin37	38418	71657	172	99560	19409.67

**Table 5.** Results on the LIN-instances. Type: Grid graph with holes (not geometric) from VLSI design. The table on the right shows the results using stronger reductions.

instance	size			optimum	time
	V	E	R		
es10000fst01	27019	39407	10000	716174280	138.00

instance	size			optimum	time
	V	E	R		
es1000fst01	2865	4267	1000	230535806	3.14
es1000fst02	2629	3793	1000	227886471	2.25
es1000fst03	2762	4047	1000	227807756	1.61
es1000fst04	2778	4083	1000	230200846	2.29
es1000fst05	2676	3894	1000	228330602	1.88
es1000fst06	2815	4162	1000	231028456	3.71
es1000fst07	2604	3756	1000	230945623	0.94
es1000fst08	2834	4207	1000	230639115	2.99
es1000fst09	2846	4187	1000	227745838	2.48
es1000fst10	2546	3620	1000	229267101	0.91
es1000fst11	2763	4038	1000	231605619	2.72
es1000fst12	2984	4484	1000	230904712	3.07
es1000fst13	2532	3615	1000	228031092	0.98
es1000fst14	2840	4200	1000	234318491	3.09
es1000fst15	2733	3997	1000	229965775	2.15

instance	size			optimum	time
	V	E	R		
a280fst	313	328	279	2502	0.00
att48fst	139	202	48	30236	0.05
att532fst	1468	2152	532	84009	0.80
berlin52fst	89	104	52	6760	0.00
bier127fst	258	357	127	104284	0.01
d1291fst	1365	1456	1291	481421	0.00
d1655fst	1906	2083	1655	584948	0.01
d198fst	232	256	198	129175	0.00
d2103fst	2206	2272	2103	769797	0.00
d493fst	1055	1473	493	320137	0.10
d657fst	1416	1978	657	471589	0.44
djsj1000fst	2562	3655	1000	17564659	0.31
eil101fst	330	538	101	605	0.21
eil51fst	181	289	51	409	0.38
eil76fst	237	378	76	513	1.40
fl1400fst	2694	4546	1400	17980523	26.34
fl1577fst	2413	3412	1577	19825626	0.20
fl3795fst	4859	6539	3795	25529856	31.04
fl417fst	732	1084	417	10883190	0.18
fln14461fst	17127	27352	4461	182361	1161.44
gil262fst	537	723	262	2306	0.02
kroA100fst	197	250	100	20401	0.00
kroA150fst	389	562	150	25700	0.13
kroA200fst	500	714	200	28652	0.06
kroB100fst	230	313	100	21211	0.01
kroB150fst	420	619	150	25217	0.09
kroB200fst	480	670	200	28803	0.11
kroC100fst	244	337	100	20492	0.02
kroD100fst	216	288	100	20437	0.00
kroE100fst	226	306	100	21245	0.02

**Table 6.** Results on the ES10000, ES1000 and TSP-instances. Type: Originally rectilinear instances, derived with GeoSteiner from 1000 (respectively 10000) random points in the plane or from TSPLIB.

instance	size			optimum	time
	V	E	R		
berlin52	52	1326	16	1044	0.00
brasil58	58	1653	25	13655	0.01
world666	666	221445	174	122467	0.23

**Table 7.** Results on the X-instances. Type: Complete with Euclidean weights.

instance	size			optimum	time
	V	E	R		
mc11	400	760	213	11689	0.00
mc13	150	11175	80	92	0.47
mc2	120	7140	60	71	0.25
mc3	97	4656	45	47	1.12
mc7	400	760	170	3417	0.00
mc8	400	760	188	1566	0.00

**Table 8.** Results on the MC-instances. Type: Constructed difficult instances.

instance	size			optimum	time
	V	E	R		
lin105fst	216	323	105	13429	0.02
lin318fst	678	1030	318	39335	0.09
linhp318fst	678	1030	318	39335	0.09
nrrw1379fst	5096	8105	1379	56207	35.99
p654fst	777	867	654	314925	0.00
pcb1173fst	1912	2223	1173	53301	0.03
pcb3038fst	5829	7552	3038	131895	0.63
pcb442fst	503	531	442	47675	0.00
pla7397fst	8790	9815	7397	22481625	0.04
pr1002fst	1473	1715	1002	243176	0.01
pr107fst	111	110	107	34850	0.00
pr124fst	154	165	124	52759	0.00
pr136fst	196	250	136	86811	0.00
pr144fst	221	285	144	52925	0.00
pr152fst	308	431	152	64323	0.01
pr226fst	255	269	226	70700	0.00
pr2392fst	3398	3966	2392	358989	0.03
pr264fst	280	287	264	41400	0.00
pr299fst	420	500	299	44671	0.00
pr439fst	572	662	439	97400	0.00
pr76fst	168	247	76	95908	0.01
rat195fst	560	870	195	2386	0.30
rat575fst	1986	3176	575	6808	4.23
rat783fst	2397	3715	783	8883	4.55
rat99fst	269	399	99	1225	0.03
rd100fst	201	253	100	764269099	0.00
rd400fst	1001	1419	400	1490972006	0.30
r111849fst	13963	15315	11849	8779590	0.13
r11304fst	1562	1694	1304	236649	0.01
r11323fst	1598	1750	1323	253620	0.00
r11889fst	2382	2674	1889	295208	0.04
r15915fst	6569	6980	5915	533226	0.02
r15934fst	6827	7365	5934	529890	0.03
st70fst	133	169	70	626	0.00
ts225fst	225	224	225	1120	0.00
tsp225fst	242	252	225	356850	0.00
u1060fst	1835	2429	1060	21265372	0.23
u1432fst	1432	1431	1432	1465	0.00
u159fst	184	186	159	390	0.00
u1817fst	1831	1846	1817	5513053	0.00
u2152fst	2167	2184	2152	6253305	0.00
u2319fst	2319	2318	2319	2322	0.00
u574fst	990	1258	574	3509275	0.04
u724fst	1180	1537	724	4069628	0.05
vm1084fst	1679	2058	1084	2248390	0.09
vm1748fst	2856	3641	1748	3194670	1.17

instance	size			optimum time		instance	size			optimum time	
	V	E	R				V	E	R		
i160-001	160	240	7	2490	0.00	i160-201	160	240	24	6923	0.00
i160-002	160	240	7	2158	0.00	i160-202	160	240	24	6930	0.00
i160-003	160	240	7	2297	0.00	i160-203	160	240	24	7243	0.00
i160-004	160	240	7	2370	0.00	i160-204	160	240	24	7068	0.00
i160-005	160	240	7	2495	0.00	i160-205	160	240	24	7122	0.00
i160-011	160	812	7	1677	0.00	i160-211	160	812	24	5583	0.07
i160-012	160	812	7	1750	0.00	i160-212	160	812	24	5643	0.19
i160-013	160	812	7	1661	0.00	i160-213	160	812	24	5647	0.17
i160-014	160	812	7	1778	0.00	i160-214	160	812	24	5720	0.28
i160-015	160	812	7	1768	0.00	i160-215	160	812	24	5518	0.10
i160-021	160	12720	7	1352	0.02	i160-221	160	12720	24	4729	0.03
i160-022	160	12720	7	1365	0.02	i160-222	160	12720	24	4697	0.03
i160-023	160	12720	7	1351	0.02	i160-223	160	12720	24	4730	0.03
i160-024	160	12720	7	1371	0.02	i160-224	160	12720	24	4721	0.03
i160-025	160	12720	7	1366	0.02	i160-225	160	12720	24	4728	0.03
i160-031	160	320	7	2170	0.00	i160-231	160	320	24	6662	0.00
i160-032	160	320	7	2330	0.00	i160-232	160	320	24	6558	0.01
i160-033	160	320	7	2101	0.00	i160-233	160	320	24	6339	0.00
i160-034	160	320	7	2083	0.00	i160-234	160	320	24	6594	0.00
i160-035	160	320	7	2103	0.00	i160-235	160	320	24	6764	0.01
i160-041	160	2544	7	1494	0.00	i160-241	160	2544	24	5086	0.13
i160-042	160	2544	7	1486	0.00	i160-242	160	2544	24	5106	0.34
i160-043	160	2544	7	1549	0.01	i160-243	160	2544	24	5050	0.09
i160-044	160	2544	7	1478	0.00	i160-244	160	2544	24	5076	0.36
i160-045	160	2544	7	1554	0.01	i160-245	160	2544	24	5084	0.09
i160-101	160	240	12	3859	0.00	i160-301	160	240	40	11816	0.00
i160-102	160	240	12	3747	0.00	i160-302	160	240	40	11497	0.00
i160-103	160	240	12	3837	0.00	i160-303	160	240	40	11445	0.00
i160-104	160	240	12	4063	0.00	i160-304	160	240	40	11448	0.00
i160-105	160	240	12	3563	0.00	i160-305	160	240	40	11423	0.00
i160-111	160	812	12	2869	0.00	i160-311	160	812	40	9135	0.84
i160-112	160	812	12	2924	0.01	i160-312	160	812	40	9052	0.73
i160-113	160	812	12	2866	0.01	i160-313	160	812	40	9159	1.37
i160-114	160	812	12	2989	0.01	i160-314	160	812	40	8941	0.17
i160-115	160	812	12	2937	0.02	i160-315	160	812	40	9086	0.74
i160-121	160	12720	12	2363	0.03	i160-321	160	12720	40	7876	0.03
i160-122	160	12720	12	2348	0.03	i160-322	160	12720	40	7859	0.02
i160-123	160	12720	12	2355	0.03	i160-323	160	12720	40	7876	0.03
i160-124	160	12720	12	2352	0.03	i160-324	160	12720	40	7884	0.03
i160-125	160	12720	12	2351	0.03	i160-325	160	12720	40	7862	0.04
i160-131	160	320	12	3356	0.00	i160-331	160	320	40	10414	0.00
i160-132	160	320	12	3450	0.00	i160-332	160	320	40	10806	0.03
i160-133	160	320	12	3585	0.00	i160-333	160	320	40	10561	0.00
i160-134	160	320	12	3470	0.00	i160-334	160	320	40	10327	0.00
i160-135	160	320	12	3716	0.00	i160-335	160	320	40	10589	0.00
i160-141	160	2544	12	2549	0.01	i160-341	160	2544	40	8331	0.24
i160-142	160	2544	12	2562	0.03	i160-342	160	2544	40	8348	1.52
i160-143	160	2544	12	2557	0.04	i160-343	160	2544	40	8275	0.19
i160-144	160	2544	12	2607	0.02	i160-344	160	2544	40	8307	0.21
i160-145	160	2544	12	2578	0.03	i160-345	160	2544	40	8327	0.84

**Table 9.** Results on the I160-instances. Type: Incidence networks, constructed with the aim of being difficult for known reduction techniques.

instance	size			optimum time		instance	size			optimum time	
	V	E	R				V	E	R		
i320-001	320	480	8	2672	0.00	i320-201	320	480	34	10044	0.00
i320-002	320	480	8	2847	0.00	i320-202	320	480	34	11223	0.00
i320-003	320	480	8	2972	0.00	i320-203	320	480	34	10148	0.01
i320-004	320	480	8	2905	0.00	i320-204	320	480	34	10275	0.01
i320-005	320	480	8	2991	0.00	i320-205	320	480	34	10573	0.00
i320-011	320	1845	8	2053	0.02	i320-211	320	1845	34	8039	0.95
i320-012	320	1845	8	1997	0.00	i320-212	320	1845	34	8044	1.20
i320-013	320	1845	8	2072	0.01	i320-213	320	1845	34	7984	4.16
i320-014	320	1845	8	2061	0.00	i320-214	320	1845	34	8046	1.63
i320-015	320	1845	8	2059	0.01	i320-215	320	1845	34	8015	11.53
i320-021	320	51040	8	1553	0.10	i320-221	320	51040	34	6679	0.14
i320-022	320	51040	8	1565	0.10	i320-222	320	51040	34	6686	0.15
i320-023	320	51040	8	1549	0.11	i320-223	320	51040	34	6695	0.14
i320-024	320	51040	8	1553	0.10	i320-224	320	51040	34	6694	0.15
i320-025	320	51040	8	1550	0.10	i320-225	320	51040	34	6691	0.14
i320-031	320	640	8	2673	0.00	i320-231	320	640	34	9862	0.07
i320-032	320	640	8	2770	0.00	i320-232	320	640	34	9933	0.06
i320-033	320	640	8	2769	0.00	i320-233	320	640	34	9787	0.00
i320-034	320	640	8	2521	0.00	i320-234	320	640	34	9517	0.01
i320-035	320	640	8	2385	0.00	i320-235	320	640	34	9945	0.01
i320-041	320	10208	8	1707	0.04	i320-241	320	10208	34	7027	0.32
i320-042	320	10208	8	1682	0.02	i320-242	320	10208	34	7072	2.07
i320-043	320	10208	8	1723	0.03	i320-243	320	10208	34	7044	0.80
i320-044	320	10208	8	1681	0.02	i320-244	320	10208	34	7078	0.91
i320-045	320	10208	8	1686	0.02	i320-245	320	10208	34	7046	0.32
i320-101	320	480	17	5548	0.00	i320-301	320	480	80	23279	0.01
i320-102	320	480	17	5556	0.00	i320-302	320	480	80	23387	0.01
i320-103	320	480	17	6239	0.00	i320-303	320	480	80	22693	0.01
i320-104	320	480	17	5703	0.00	i320-304	320	480	80	23451	0.03
i320-105	320	480	17	5928	0.00	i320-305	320	480	80	22547	0.01
i320-111	320	1845	17	4273	0.03	i320-311	320	1845	80	17945	356.65
i320-112	320	1845	17	4213	0.18	i320-312	320	1845	80	18122	2067.50
i320-113	320	1845	17	4205	0.15	i320-313	320	1845	80	17991	1105.61
i320-114	320	1845	17	4104	0.04	i320-314	320	1845	80	18088	2915.12
i320-115	320	1845	17	4238	0.07	i320-315	320	1845	80	17987	1535.65
i320-121	320	51040	17	3321	0.14	i320-321	320	51040	80	15648	0.43
i320-122	320	51040	17	3314	0.13	i320-322	320	51040	80	15646	0.47
i320-123	320	51040	17	3332	0.14	i320-323	320	51040	80	15654	0.37
i320-124	320	51040	17	3323	0.14	i320-324	320	51040	80	15667	0.89
i320-125	320	51040	17	3340	0.14	i320-325	320	51040	80	15649	0.30
i320-131	320	640	17	5255	0.00	i320-331	320	640	80	21517	0.46
i320-132	320	640	17	5052	0.00	i320-332	320	640	80	21674	0.06
i320-133	320	640	17	5125	0.00	i320-333	320	640	80	21339	0.70
i320-134	320	640	17	5272	0.00	i320-334	320	640	80	21415	0.13
i320-135	320	640	17	5342	0.00	i320-335	320	640	80	21378	0.48
i320-141	320	10208	17	3606	0.18	i320-341	320	10208	80	16296	102.77
i320-142	320	10208	17	3567	0.17	i320-342	320	10208	80	16228	2.65
i320-143	320	10208	17	3561	0.06	i320-343	320	10208	80	16281	58.78
i320-144	320	10208	17	3512	0.02	i320-344	320	10208	80	16295	34.82
i320-145	320	10208	17	3601	0.09	i320-345	320	10208	80	16289	59.38

**Table 10.** Results on the I320-instances. Type: Incidence networks, constructed with the aim of being difficult for known reduction techniques.

instance	size			optimum time		instance	size			optimum	time
	V	E	R				V	E	R		
i640-001	640	960	9	4033	0.00	i640-201	640	960	50	16079	0.01
i640-002	640	960	9	3588	0.00	i640-202	640	960	50	16324	0.01
i640-003	640	960	9	3438	0.00	i640-203	640	960	50	16124	0.03
i640-004	640	960	9	4000	0.00	i640-204	640	960	50	16239	0.02
i640-005	640	960	9	4006	0.00	i640-205	640	960	50	16616	0.01
i640-011	640	4135	9	2392	0.01	i640-211	640	4135	50	11984	3182.47
i640-012	640	4135	9	2465	0.03	i640-212	640	4135	50	11795	70.18
i640-013	640	4135	9	2399	0.02	i640-213	640	4135	50	11879	112.42
i640-014	640	4135	9	2171	0.01	i640-214	640	4135	50	11898	506.31
i640-015	640	4135	9	2347	0.01	i640-215	640	4135	50	12081	363.48
i640-021	640	204480	9	1749	0.52	i640-221	640	204480	50	9821	1.31
i640-022	640	204480	9	1756	0.52	i640-222	640	204480	50	9798	1.11
i640-023	640	204480	9	1754	0.51	i640-223	640	204480	50	9811	1.14
i640-024	640	204480	9	1751	0.51	i640-224	640	204480	50	9805	0.65
i640-025	640	204480	9	1745	0.52	i640-225	640	204480	50	9807	0.69
i640-031	640	1280	9	3278	0.00	i640-231	640	1280	50	15014	0.36
i640-032	640	1280	9	3187	0.00	i640-232	640	1280	50	14630	0.12
i640-033	640	1280	9	3260	0.00	i640-233	640	1280	50	14797	0.13
i640-034	640	1280	9	2953	0.00	i640-234	640	1280	50	15203	0.06
i640-035	640	1280	9	3292	0.00	i640-235	640	1280	50	14803	2.26
i640-041	640	40896	9	1897	0.25	i640-241	640	40896	50	10230	8.63
i640-042	640	40896	9	1934	0.16	i640-242	640	40896	50	10195	1.76
i640-043	640	40896	9	1931	0.13	i640-243	640	40896	50	10215	2.74
i640-044	640	40896	9	1938	0.14	i640-244	640	40896	50	10246	18.71
i640-045	640	40896	9	1866	0.10	i640-245	640	40896	50	10223	5.29
i640-101	640	960	25	8764	0.00	i640-301	640	960	160	45005	0.18
i640-102	640	960	25	9109	0.00	i640-302	640	960	160	45736	0.18
i640-103	640	960	25	8819	0.00	i640-303	640	960	160	44922	0.06
i640-104	640	960	25	9040	0.00	i640-304	640	960	160	46233	0.06
i640-105	640	960	25	9623	0.03	i640-305	640	960	160	45902	0.19
i640-111	640	4135	25	6167	1.29	i640-311	640	4135	160	[34617, 36120]	86400.00
i640-112	640	4135	25	6304	0.88	i640-312	640	4135	160	[34691, 35834]	86400.00
i640-113	640	4135	25	6249	7.84	i640-313	640	4135	160	[34572, 35591]	86400.00
i640-114	640	4135	25	6308	3.09	i640-314	640	4135	160	[34518, 35704]	86400.00
i640-115	640	4135	25	6217	2.69	i640-315	640	4135	160	[34673, 35943]	86400.00
i640-121	640	204480	25	4906	0.68	i640-321	640	204480	160	31094	55.04
i640-122	640	204480	25	4911	0.70	i640-322	640	204480	160	31068	13.28
i640-123	640	204480	25	4913	0.68	i640-323	640	204480	160	31080	17.16
i640-124	640	204480	25	4906	0.67	i640-324	640	204480	160	31092	24.93
i640-125	640	204480	25	4920	0.70	i640-325	640	204480	160	31081	25.06
i640-131	640	1280	25	8097	0.04	i640-331	640	1280	160	42796	8.66
i640-132	640	1280	25	8154	0.02	i640-332	640	1280	160	42548	354.21
i640-133	640	1280	25	8021	0.01	i640-333	640	1280	160	42345	77.78
i640-134	640	1280	25	7754	0.00	i640-334	640	1280	160	42768	1272.27
i640-135	640	1280	25	7696	0.02	i640-335	640	1280	160	43035	232.49
i640-141	640	40896	25	5199	0.96	i640-341	640	40896	160	32042	5972.89
i640-142	640	40896	25	5193	0.65	i640-342	640	40896	160	31978	423.54
i640-143	640	40896	25	5194	0.53	i640-343	640	40896	160	32015	3331.39
i640-144	640	40896	25	5205	0.59	i640-344	640	40896	160	31991	2535.53
i640-145	640	40896	25	5218	1.68	i640-345	640	40896	160	31994	1759.78

**Table 11.** Results on the I640-instances. Type: Incidence networks, constructed with the aim of being difficult for known reduction techniques.

instance	size			optimum <sup>4</sup>	time	instance	size			optimum	time
	V	E	R				V	E	R		
cc10-2p	1024	5120	135	[34133, 35680]	86400.02	bip42p	1200	3982	200	24657	43511.43
cc10-2u	1024	5120	135	[331, 343]	86400.08	bip42u	1200	3982	200	236	57600.07
cc11-2p	2048	11263	244	[61773, 64366]	86400.22	bip52p	2200	7997	200	[24180, 24742]	86400.02
cc11-2u	2048	11263	244	[600, 620]	86400.01	bip52u	2200	7997	200	[230, 234]	86400.01
cc12-2p	4096	24574	473	[117941, 122925]	86400.51	bip62p	1200	10002	200	[22436, 22886]	86400.02
cc12-2u	4096	24574	473	[1144, 1197]	86400.60	bip62u	1200	10002	200	[214, 221]	86400.05
cc3-10p	1000	13500	50	[12173, 12881]	86400.09	bipa2p	3300	18073	300	[34671, 35548]	86400.24
cc3-10u	1000	13500	50	[115, 127]	86400.00	bipa2u	3300	18073	300	[330, 341]	86400.08
cc3-11p	1331	19965	61	[14883, 15797]	86400.03	bipe2p	550	5013	50	5616	503.81
cc3-11u	1331	19965	61	[140, 154]	86400.06	bipe2u	550	5013	50	54	484.49
cc3-12p	1728	28512	74	[17947, 19010]	86400.05	hc10p	1024	5120	512	[59202, 60416]	86400.01
cc3-12u	1728	28512	74	[171, 186]	86400.12	hc10u	1024	5120	512	[568, 575]	86400.12
cc3-4p	64	288	8	2338	1.99	hc11p	2048	11264	1024	[117360, 120854]	86400.34
cc3-4u	64	288	8	23	1.37	hc11u	2048	11264	1024	[1126, 1159]	86400.22
cc3-5p	125	750	13	3661	87.98	hc12p	4096	24576	2048	[232849, 239741]	86400.02
cc3-5u	125	750	13	36	115.83	hc12u	4096	24576	2048	[2233, 2303]	86400.20
cc5-3p	243	1215	27	7299	8254.25	hc6p	64	192	32	4003	5.65
cc5-3u	243	1215	27	71	41176.78	hc6u	64	192	32	39	2.62
cc6-2p	64	192	12	3271	0.40	hc7p	128	448	64	7905	3140.66
cc6-2u	64	192	12	32	0.90	hc7u	128	448	64	77	3440.11
cc6-3p	729	4368	76	[19847, 20406]	86400.01	hc8p	256	1024	128	15322	81963.74
cc6-3u	729	4368	76	[194, 198]	86400.01	hc8u	256	1024	128	[146, 148]	86400.00
cc7-3p	2187	15308	222	[54694, 57413]	86400.16	hc9p	512	2304	256	[29866, 30271]	86400.00
cc7-3u	2187	15308	222	[531, 554]	86400.17	hc9u	512	2304	256	[287, 292]	86400.02
cc9-2p	512	2304	64	[16520, 17346]	86400.06						
cc9-2u	512	2304	64	[161, 170]	86400.13						

**Table 12.** Results on the PUC-instances. Type: Constructed difficult instances: hypercubes, from code covering, and bipartite graphs.

instance	size			optimum	time
	V	E	R		
antiwheel5	10	15	5	7	0.00
design432	8	20	4	9	0.00
oddcycle3	6	9	3	4	0.00
oddwheel3	7	9	4	5	0.00
se03	13	21	4	12	0.00
w13c29	783	2262	406	[500 - 507]	86400.12
w23c23	1081	3174	552	[684 - 690]	86400.48
w3c571	3997	10278	2284	2854	897.11

**Table 13.** Results on the SP-instances. Type: Constructed difficult instances, combination of odd wheels and odd circles, difficult for linear programming approaches.

<sup>4</sup> Note that the branch-and-bound algorithm called for these instances (I and PUC) performs only fast calculations of bounds. Better bounds could be achieved by using specific methods.

### 3 Results for the New Instances

Here we report the results for some instances not present in SteinLib at the time [1] was written.

All results were produced by a single run of the same program with the same parameter values. In fact, the calls were quite similar to those in Section 2, with some minor changes. For example, as some of the new instances have edges of cost zero, we added a preprocessing step eliminating such edges (by non-cyclic contraction). Also, as some of the new instances are quite large, some more time-consuming reduction routines were omitted or restricted to the advanced stages of the reduction process.

If an instance is solved exactly within the time limit (usually 24 hours in this section), we give the value of the optimal solution and the total time (in seconds) for the exact solution; otherwise we give an interval [*lower* – *upper*] showing the best lower and upper bounds reached before the time limit and also the used time limit.

instance	size			optimum	time <sup>5</sup>
	V	E	R		
ind1	18	31	10	604	0.00
ind2	31	57	10	9500	0.00
ind3	16	23	10	600	0.00
ind4	74	146	25	1086	0.00
ind5	114	228	33	1341	0.01
rc01	21	35	10	25980	0.00
rc02	87	176	30	41350	0.00
rc03	109	202	50	54160	0.00
rc04	121	197	70	59070	0.00
rc05	247	486	100	74070	0.04
rc06	2502	6244	100	79714	22.43
rc07	2740	6578	200	108740	56.37
rc08	7527	18170	200	112564	617.99
rc09	6128	15264	200	111005	299.16
rc10	1572	3245	500	164150	1.89
rc11	2858	5819	1000	230837	6.48
rt01	262	740	10	2146	0.08
rt02	788	1938	50	45852	1.99
rt03	1725	4092	100	7964	14.05
rt04	9469	22743	100	9693	5603.23
rt05	15473	38928	200	51313	95314.98

**Table 14.** Results on the Copenhagen(14)-instances. Type: Originally obstacle-avoiding rectilinear Steiner tree instances, transformed to instances of the Steiner problem in networks via FST-generation by the software package ObSteiner.

---

<sup>5</sup> Using other parameters, the same code solved the instance rt05 in 18778 seconds.

instance	size			optimum	time <sup>6</sup>	instance	size			optimum	time
	V	E	R				V	E	R		
G101	67966	82485	100	3492405	14.10	G101a	10734	16345	96	2528993	9.99
G102	111707	160504	2052	15187538	296.12	G102a	27896	43925	2003	12707118	281.56
G103	135543	201803	3033	19938744	523.33	G103a	36270	57370	2930	16686894	513.66
G104	158212	240022	3914	26165528	864.96	G104a	44251	70029	3776	21794694	1133.44
G105	79244	101189	550	12507877	85.87	G105a	14586	22450	525	9690792	80.80
G106	204621	318136	5556	44547208	3588.28	G106a	62618	100067	5373	36879201	6476.49
G107	85568	114113	938	7325530	32.48	G107a	15536	23858	893	6143970	41.64
G201	44624	56205	190	3484028	10.13	G201a	8286	12617	188	2978695	9.68
G202	62174	87562	1015	6849423	38.17	G202a	14028	21610	985	5926154	35.20
G203	88728	133625	2041	13155210	175.71	G203a	25651	40610	1999	11754775	187.56
G204	50002	65203	386	5313548	13.18	G204a	9939	15249	376	4513194	19.35
G205	120866	187312	3224	24819583	595.61	G205a	37398	59323	3146	21276170	1814.62
G206	60446	82940	803	9175622	59.38	G206a	13688	21197	789	7843219	46.03
G207	42481	52552	97	2265834	5.45	G207a	7565	11521	98	1967178	4.90
G301	80736	98750	191	4797441	20.39	G301a	13291	20261	181	3891983	23.30
G302	117756	165153	1879	13300990	96.18	G302a	24951	38647	1797	10834825	104.80
G303	147718	214176	2992	27941456	548.35	G303a	37085	57711	2915	23210268	687.58
G304	86413	108872	419	6721180	29.54	G304a	15213	23329	403	5466965	33.23
G305	172687	255825	3902	40632152	1009.73	G305a	47016	73861	3809	34364413	1268.35
G306	196404	300036	4937	33949874	2813.22	G306a	55423	87779	4766	28198617	1066.92
G307	235686	366093	6313	51219090	4384.97	G307a	71184	113616	6107	42269121	4468.17
G308	78834	95732	88	4699474	20.79	G308a	13298	20351	86	3756628	26.07
G309	97928	128632	902	11256303	58.25	G309a	18704	28851	868	9218709	67.73

**Table 15.** Results on the (Vienna-)Geo-instances. Type: Real-world fiber-optic network design problems. The table on the right contains the same instances after some "advanced" preprocessing by the creators.

<sup>6</sup> For the instance G306 we switched off the CPXbaropt routine of CPLEX as a makeshift remediation concerning a (memory allocation) bug (but this does not necessarily mean that the bug is in CPLEX).

instance	size			optimum	time	instance	size			optimum	time
	V	E	R				V	E	R		
1001	30190	47748	1184	253921201	5.37	1001a	14675	22055	941	55295019	4.81
1002	49920	77871	1665	399809303	17.87	1002a	23800	35758	1282	58566202	16.15
1003	44482	73419	3222	788774494	31.20	1003a	16270	23919	2336	96567800	35.54
1004	5556	8552	570	279512692	0.19	1004a	867	1238	263	42990860	0.09
1005	10284	15980	1017	390876350	0.39	1005a	1677	2430	491	53974585	0.11
1006	31754	52875	2202	504526035	37.38	1006a	13339	19532	1842	136193630	28.92
1007	15122	24371	737	177909660	2.33	1007a	6873	10299	599	37370196	1.71
1008	15714	25567	871	201788202	2.68	1008a	6522	9629	708	33153078	1.58
1009	33188	52007	1262	275558727	5.56	1009a	14977	22435	1053	48394720	4.75
1010	29905	47457	943	207889674	2.72	1010a	13041	19545	782	47321625	2.04
1011	25195	41298	1428	317589880	5.62	1011a	9298	13685	1202	63848241	5.00
1012	12355	19962	503	118893243	0.49	1012a	3500	5214	387	20593258	0.22
1013	18242	28976	891	193190339	2.16	1013a	7147	10608	670	37689678	1.66
1014	12715	20632	475	105173465	0.54	1014a	3577	5311	364	19455897	0.21
1015	48833	79987	2493	592240832	23.71	1015a	20573	30541	2119	146197744	24.19
1016	72038	115055	4391	1110914623	48.37	1016a	27214	39824	3434	165077665	114.02
1017	15095	24091	478	109739695	1.17	1017a	7571	11571	386	19021186	1.13
1018	31121	51113	1898	463887832	9.90	1018a	12258	18014	1549	67324183	9.36
1019	25946	41645	866	217647693	3.06	1019a	11693	17624	732	49575126	2.51
1020	21808	34921	594	146515460	1.33	1020a	6405	9564	508	24770758	0.79
1021	16013	25269	392	106470644	0.90	1021a	5195	7861	295	17025666	0.45
1022	16224	25691	437	106799980	2.95	1022a	8869	13551	356	24538643	2.77
1023	22805	35307	582	131044872	4.58	1023a	13724	20863	403	17381764	4.16
1024	68464	108732	3001	758483415	23.54	1024a	32357	48250	2511	170437219	22.13
1025	23412	37952	945	232790758	4.48	1025a	10055	14961	833	57209916	4.77
1026	47429	79307	3334	928032223	44.74	1026a	18155	26568	2661	137747708	42.02
1027	85085	138888	3954	976812226	36.28	1027a	40772	60555	3490	257384375	35.62
1028	72701	115430	1790	384053191	18.72	1028a	43690	66461	1597	102890845	19.98
1029	69988	111804	2162	492193565	15.11	1029a	32979	49627	1946	129941358	17.81
1030	33188	53680	1263	321646787	3.56	1030a	12941	19279	1093	79824759	2.87
1031	54351	88211	2182	578284709	5.59	1031a	21054	31410	1832	124055874	4.41
1032	56023	91399	3017	773096651	13.65	1032a	21345	31353	2454	144185378	11.94
1033	18555	29730	636	134461857	2.59	1033a	8500	12700	548	31604828	2.20
1034	22311	35516	735	165115148	2.59	1034a	9128	13668	606	28842122	2.22
1035	30585	50454	1704	414440370	6.20	1035a	13129	19420	1428	102037560	6.42
1036	37208	60356	1411	375260864	9.98	1036a	17036	25482	1258	104902070	8.75
1037	13694	22126	427	105720727	1.47	1037a	5886	8869	392	29768713	1.27
1038	18747	30639	967	255767543	12.27	1038a	7733	11478	798	48470499	11.52
1039	8755	14449	347	85566290	0.74	1039a	3719	5533	306	22582804	0.45
1040	40389	65820	1762	431498867	9.07	1040a	18837	28156	1501	88121321	8.02
1041	47197	75307	1193	301914840	6.45	1041a	22466	33868	1014	61286700	6.01
1042	51896	85550	2171	532131412	7.58	1042a	23925	35806	1923	144759521	7.24
1043	10398	16787	367	95722094	0.92	1043a	4511	6740	335	24407752	0.69
1044	68905	113889	3358	804532332	29.74	1044a	31500	46757	2954	232129301	30.77
1045	14685	23466	421	105944062	1.30	1045a	6775	10227	378	23565890	1.07
1046	70843	117209	3598	925470052	23.65	1046a	32376	48054	3154	233783282	24.16
1047	28524	46251	2354	695163406	20.46	1047a	10622	15440	1791	121092256	19.74
1048	13189	21219	358	91509264	0.97	1048a	4920	7356	320	15853402	0.59
1049	30857	49591	990	294811505	4.41	1049a	15045	22713	821	35284597	4.06
1050	43073	71276	2868	792599114	581.28	1050a	17787	26176	2232	172893060	224.37
1051	27028	45406	1524	357230839	10.71	1051a	12130	17892	1337	86017056	11.39
1052	2363	3761	40	13309487	0.04	1052a	160	237	23	2091965	0.00
1053	3224	5285	126	30854904	0.10	1053a	693	1023	102	7323696	0.05
1054	3803	6213	38	15841596	0.11	1054a	540	817	25	3980445	0.03
1055	13332	21580	570	144164924	0.86	1055a	4701	6979	483	12836314	0.64
1056	1991	3176	51	14171206	0.05	1056a	290	439	34	3862936	0.00
1057	33231	55149	1569	412746415	5.76	1057a	13078	19368	1346	74679827	4.87
1058	23527	39628	1256	305024188	1.88	1058a	7877	11657	997	57811949	1.41
1059	9287	14975	363	107617854	0.46	1059a	2800	4157	286	13114616	0.24
1060	42008	67572	1242	337290460	10.03	1060a	18991	28536	1158	120144739	9.90
1061	39160	63659	1458	363042722	10.44	1061a	20958	31465	1337	64707445	10.19
1062	66048	110491	3343	792941137	10.46	1062a	23714	35305	2812	188764371	8.86
1063	26840	43661	1645	459801704	10.98	1063a	9600	14042	1291	79669224	7.67
1064	63158	107345	3458	863103567	623.54	1064a	31712	46711	3182	186838948	441.26
1065	3898	6356	144	32965718	0.21	1065a	1185	1756	119	5371105	0.12
1066	15038	24596	551	174219813	0.79	1066a	4551	6821	417	29106036	0.52
1067	20547	33230	627	175540750	3.72	1067a	10318	15588	579	40604110	3.23
1068	33118	55127	1553	420730046	4.44	1068a	12191	18023	1302	81648214	3.99
1069	9574	16208	543	135161583	1.16	1069a	3508	5156	452	17391265	1.07
1070	15079	24608	550	136700139	1.69	1070a	6739	10064	511	27055351	1.41
1071	33203	54427	1494	382539099	4.24	1071a	12772	18886	1281	54833821	3.51
1072	26948	44194	993	289019226	2.30	1072a	11628	17411	851	60112400	1.79
1073	21653	35171	1847	663004987	9.67	1073a	7510	10873	1337	126342447	9.11
1074	13316	22033	653	165573383	0.91	1074a	4441	6562	548	40966401	0.58
1075	57551	95381	2973	815404026	11.52	1075a	23195	34362	2498	179352127	9.54
1076	14023	22895	598	166249692	0.79	1076a	4909	7268	498	31927556	0.53
1077	20856	34237	1787	472503150	46.03	1077a	9153	13363	1490	191673586	45.86
1078	13294	21948	835	185525490	1.67	1078a	5864	8662	692	56348302	1.29
1079	19867	31271	565	150506933	4.25	1079a	7933	11807	497	30571900	4.44
1080	18695	29708	548	164299652	1.76	1080a	7589	11256	499	26039027	1.70
1081	25081	40739	888	247527679	2.43	1081a	10747	16029	751	48911750	2.09
1082	15592	24788	515	147407632	1.07	1082a	5850	8693	435	32637881	0.60
1083	89596	148583	4991	1405593856	20.53	1083a	34221	50301	4138	323126608	16.77
1084	44934	73727	2319	627187559	13.79	1084a	17050	25201	1918	130135969	14.20
1085	9113	14491	301	80628079	0.51	1085a	2780	4123	243	14397376	0.24

**Table 16.** Results on the (Vienna-)I-instances. Type: Real-world fiber-optic network design problems. The tables on the left and right contain the instances after some "simple" and "advanced" preprocessing by the creators.

## References

1. S. Vahdati Daneshmand. *Algorithmic Approaches to the Steiner Problem in Networks*. PhD thesis, University of Mannheim, 2004. <http://bibserv7.bib.uni-mannheim.de/madoc/volltexte/2004/176>.