

# Appendix for New Large-Scale Data Instances for CARP and New Variations of CARP

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## Data instances for the CARP

This appendix provides details about the new CARP graphs and instances. Tables 1 and 2 give characteristics about the graphs: Column 1 contains the name of the graph. Columns 2 to 5 hold information on the number of nodes, number of edges, and number of required edges as well as on the percentage of required edges. Column 6 states the average node degree, i.e. the average number of edges incident to each node. Columns 7 and 8 give the number of connected components  $\Theta$  when only considering required edges, and the average number of required edges in each of these components, respectively. Finally, column 9 gives the total cost of the required edges,  $\bar{C} = \sum_{(i,j) \in \mathcal{E}_R} c_{ij}$ , and column 10 states the household types (HT) that are used to provide demand information in each graph.

Tables 3 and 4 provide the following information related to each of the three vehicle files assigned to each graph: The id of the vehicle file (VF), the minimum number of routes needed ( $\hat{K}$ ) calculated as  $\left\lceil \frac{\sum_{(i,j) \in \mathcal{E}_R} q_{ij}}{\gamma W} \right\rceil$ , and the average number of required edges per route if  $\hat{K}$  vehicles are used.

	$ \mathcal{N} $	$ \mathcal{E} $	$ \mathcal{E}_R $	$\frac{100 \mathcal{E}_R }{ \mathcal{E} }$	$\frac{2 \mathcal{E} }{ \mathcal{N} }$	$\Theta$	$\frac{ \mathcal{E}_R }{\Theta}$	$\mathcal{C}$	HT
CARP_F1_g	812	1124	780	69.4	2.8	74	10.5	92982	AR
CARP_F1_p	795	1106	728	65.8	2.8	89	8.2	88765	AR
CARP_F6_g	531	780	299	38.3	2.9	68	4.4	39561	R
CARP_F6_p	502	741	280	37.8	3.0	61	4.6	37085	R
CARP_F9_g	788	1096	686	62.6	2.8	94	7.3	84701	A
CARP_F9_p	770	1077	636	59.1	2.8	112	5.7	80802	A
CARP_F10_g	415	565	376	66.5	2.7	49	7.7	44656	AR
CARP_F11_g	191	267	173	64.8	2.8	21	8.2	17907	AR
CARP_F12_g	80	110	72	65.5	2.8	10	7.2	7688	AR
CARP_F13_g	26	33	19	57.6	2.5	5	3.8	1859	AR
CARP_F14_g	399	549	397	72.3	2.8	31	12.8	46882	AR
CARP_F15_g	198	265	197	74.3	2.7	13	15.2	21798	AR
CARP_F16_g	82	106	76	71.7	2.6	8	9.5	7561	AR
CARP_F17_g	28	35	26	74.3	2.5	4	6.5	2519	AR
CARP_K1_g	11640	12675	8566	67.6	2.2	2579	3.3	1267557	ARS
CARP_K1_p	8382	9295	5383	57.9	2.2	2180	2.5	765404	ARS
CARP_K2_g	11636	12671	8563	67.6	2.2	2578	3.3	1266775	ARs
CARP_K3_g	11072	12081	8101	67.1	2.2	2452	3.3	1211571	RS
CARP_K4_g	11068	12077	8098	67.1	2.2	2451	3.3	1210789	RS
CARP_K5_g	11405	12435	8267	66.5	2.2	2591	3.2	1236307	AR
CARP_K6_g	10832	11835	7799	65.9	2.2	2461	3.2	1180108	R
CARP_K6_p	7983	8882	5073	57.1	2.2	2071	2.4	730168	R
CARP_K7_g	1193	1499	546	36.4	2.5	186	2.9	76365	S
CARP_K8_g	1140	1421	541	38.1	2.5	183	3.0	75144	s
CARP_K9_g	2773	3472	950	27.4	2.5	726	1.3	137482	A
CARP_K9_p	1735	2226	509	22.9	2.6	392	1.3	63916	A
CARP_K10_g	5095	5511	3735	67.8	2.2	1109	3.4	446624	ARS
CARP_K11_g	3111	3358	2276	67.8	2.2	705	3.2	306868	ARS
CARP_K12_g	1131	1220	802	65.7	2.2	283	2.8	153086	ARS
CARP_K13_g	393	421	282	67.0	2.1	95	3.0	53121	ARS
CARP_K14_g	3462	3809	2630	69.0	2.2	733	3.6	422837	ARS
CARP_K15_g	3176	3505	2420	69.0	2.2	670	3.6	387645	ARS
CARP_K16_g	1323	1470	1014	69.0	2.2	269	3.8	175821	ARS
CARP_K17_g	375	412	286	69.4	2.2	77	3.7	60211	ARS

Table 1: CARP graph information for sets F and K.

	$ \mathcal{N} $	$ \mathcal{E} $	$ \mathcal{E}_R $	$\frac{100 \mathcal{E}_R }{ \mathcal{E} }$	$\frac{2 \mathcal{E} }{ \mathcal{N} }$	$\Theta$	$\frac{ \mathcal{E}_R }{\Theta}$	$\mathcal{C}$	HT
CARP_N1_g	8537	9725	6339	65.2	2.3	1748	3.6	982882	ARS
CARP_N1_p	6980	8041	4838	60.2	2.3	1583	3.1	805339	ARS
CARP_N2_g	8537	9725	6339	65.2	2.3	1748	3.6	982882	ARs
CARP_N3_g	8257	9429	6076	64.4	2.3	1699	3.6	951447	RS
CARP_N4_g	8257	9429	6076	64.4	2.3	1699	3.6	951447	Rs
CARP_N5_g	8444	9631	6165	64.0	2.3	1804	3.4	969574	AR
CARP_N6_g	8164	9335	5901	63.2	2.3	1753	3.4	938054	R
CARP_N6_p	6648	7683	4577	59.6	2.3	1506	3.0	777062	R
CARP_N7_g	1587	1950	784	40.2	2.5	324	2.4	87957	S
CARP_N8_g	1587	1950	784	40.2	2.5	324	2.4	87957	s
CARP_N9_g	2018	2655	589	22.2	2.6	449	1.3	78587	A
CARP_N9_p	1743	2296	498	21.7	2.6	381	1.3	64150	A
CARP_N10_g	3686	4175	2790	66.8	2.3	743	3.8	441412	ARS
CARP_N11_g	2134	2411	1599	66.3	2.3	447	3.6	256125	ARS
CARP_N12_g	925	1035	698	67.4	2.2	192	3.6	95286	ARS
CARP_N13_g	451	499	364	72.9	2.2	78	4.7	38788	ARS
CARP_N14_g	4091	4656	2989	64.2	2.3	857	3.5	446385	ARS
CARP_N15_g	2171	2459	1627	66.2	2.3	419	3.9	174921	ARS
CARP_N16_g	915	1030	739	71.7	2.3	149	5.0	51325	ARS
CARP_N17_g	268	305	219	71.8	2.3	44	5.0	12493	ARS
CARP_O1_g	10283	11863	8581	72.3	2.3	1436	6.0	1091626	AR
CARP_O1_p	9957	11492	8220	71.5	2.3	1395	5.9	1040388	R
CARP_O6_g	9563	11073	7831	70.7	2.3	1311	6.0	1003823	R
CARP_O6_p	9247	10719	7515	70.1	2.3	1265	5.9	962851	R
CARP_O9_g	4362	5628	2057	36.5	2.6	1055	1.9	291686	A
CARP_O9_p	4018	5238	1781	34.0	2.6	928	1.9	239933	A
CARP_O10_g	5847	6941	4791	69.0	2.4	825	5.8	553481	AR
CARP_O11_g	2805	3263	2107	64.6	2.3	455	4.6	255330	AR
CARP_O12_g	761	852	535	62.8	2.2	149	3.6	60672	AR
CARP_O13_g	228	247	170	68.8	2.2	48	3.5	15298	AR
CARP_O14_g	5149	6159	4450	72.3	2.4	668	6.7	475395	AR
CARP_O15_g	2031	2650	1911	72.1	2.6	192	10.0	216303	AR
CARP_O16_g	942	1263	968	76.6	2.7	67	14.4	109483	AR
CARP_O17_g	351	451	320	71.0	2.6	40	8	29165	AR
CARP_S1_g	6149	7110	3797	53.4	2.3	1543	2.5	463079	ARS
CARP_S1_p	3879	4607	1893	41.1	2.4	1086	1.7	219924	ARS
CARP_S2_g	6149	7110	3797	53.4	2.3	1543	2.5	463079	ARs
CARP_S3_g	5957	6896	3687	53.5	2.3	1481	2.5	454981	RS
CARP_S4_g	5957	6896	3687	53.5	2.3	1481	2.5	454981	Rs
CARP_S5_g	6104	7063	3732	52.8	2.3	1553	2.4	455415	AR
CARP_S6_g	5909	6846	3620	52.9	2.3	1490	2.4	447219	R
CARP_S6_p	3667	4366	1787	40.9	2.4	1018	1.8	211721	R
CARP_S7_g	2099	2591	864	33.3	2.5	541	1.6	131127	S
CARP_S8_g	2099	2591	864	33.3	2.5	541	1.6	131127	s
CARP_S9_g	1094	1447	229	15.8	2.6	203	1.1	22689	A
CARP_S9_p	782	1030	166	16.1	2.6	144	1.2	15353	A
CARP_S10_g	3404	3921	2221	56.6	2.3	814	2.7	284463	ARS
CARP_S11_g	1564	1805	961	53.2	2.3	398	2.4	126463	ARS
CARP_S12_g	755	866	407	47.0	2.3	207	2.0	51374	ARS
CARP_S13_g	322	374	176	47.1	2.3	81	2.2	20169	ARS
CARP_S14_g	3072	3557	1942	54.6	2.3	747	2.6	211885	ARS
CARP_S15_g	1605	1853	1046	56.4	2.3	384	2.7	113395	ARS
CARP_S16_g	542	616	381	61.9	2.3	129	3.0	45168	ARS
CARP_S17_g	342	388	247	63.7	2.3	81	3.0	29082	ARS

Table 2: CARP graph information for sets N, O, and S.

	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$
CARP_F1_g	6	60	13	5	76	11	4	104	8
CARP_F1_p	6	8	91	4	13	56	2	25	30
CARP_F6_g	6	5	60	4	8	38	2	16	19
CARP_F6_p	3	2	140	2	2	140	1	4	70
CARP_F9_g	6	55	13	5	70	10	4	96	8
CARP_F9_p	5	9	71	4	12	53	1	47	14
CARP_F10_g	6	25	16	5	31	13	4	43	9
CARP_F11_g	6	11	16	4	19	10	2	37	5
CARP_F12_g	6	5	15	4	8	9	2	15	5
CARP_F13_g	4	2	10	3	3	7	2	4	5
CARP_F14_g	6	35	12	5	44	10	4	61	7
CARP_F15_g	6	18	11	5	23	9	4	31	7
CARP_F16_g	6	7	11	5	9	9	4	12	7
CARP_F17_g	5	3	9	3	6	5	2	9	3
CARP_K1_g	6	41	209	5	52	165	2	141	61
CARP_K1_p	3	15	359	2	22	245	1	44	123
CARP_K2_g	3	92	94	4	69	125	2	137	63
CARP_K3_g	3	65	125	4	49	166	2	97	84
CARP_K4_g	6	27	300	4	47	173	3	62	131
CARP_K5_g	6	39	212	4	67	124	2	134	62
CARP_K6_g	5	33	237	3	60	130	1	178	44
CARP_K6_p	3	12	423	2	18	282	1	35	145
CARP_K7_g	5	3	182	2	8	69	1	15	37
CARP_K8_g	3	3	181	2	4	136	1	7	78
CARP_K9_g	5	17	56	4	23	42	2	45	22
CARP_K9_p	3	3	170	2	5	102	1	9	57
CARP_K10_g	6	21	178	4	36	104	2	71	53
CARP_K11_g	6	12	190	4	21	109	3	28	82
CARP_K12_g	4	5	161	2	9	90	1	17	48
CARP_K13_g	3	3	94	2	4	71	1	7	41
CARP_K14_g	5	16	165	3	29	91	2	43	62
CARP_K15_g	5	15	162	3	27	90	1	81	30
CARP_K16_g	6	6	169	4	11	93	1	41	25
CARP_K17_g	3	3	96	2	4	72	1	7	41

Table 3: CARP vehicle information for sets F and K.

	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$	VF	$\hat{K}$	$\lceil \frac{ \mathcal{E}_R }{K} \rceil$
CARP_N1_g	6	25	254	3	58	110	2	87	73
CARP_N1_p	5	11	440	3	20	242	1	58	84
CARP_N2_g	5	30	212	4	42	151	3	55	116
CARP_N3_g	3	45	136	2	67	91	1	134	46
CARP_N4_g	6	18	338	4	32	190	1	126	49
CARP_N5_g	5	29	213	4	40	155	2	79	79
CARP_N6_g	5	22	269	4	30	197	3	40	148
CARP_N6_p	4	13	353	3	17	270	1	49	94
CARP_N7_g	3	6	131	2	9	88	1	17	47
CARP_N8_g	3	3	262	2	5	157	1	9	88
CARP_N9_g	6	6	99	3	13	46	2	20	30
CARP_N9_p	5	2	249	2	5	100	1	10	50
CARP_N10_g	5	12	233	2	33	85	1	66	43
CARP_N11_g	4	10	160	2	20	80	1	39	41
CARP_N12_g	6	3	233	2	10	70	1	20	35
CARP_N13_g	6	2	182	3	4	91	1	11	34
CARP_N14_g	6	14	214	4	24	125	2	47	64
CARP_N15_g	5	12	136	3	22	74	1	66	25
CARP_N16_g	6	6	124	4	10	74	1	38	20
CARP_N17_g	5	3	73	3	5	44	1	15	15
CARP_O1_g	6	73	118	5	93	93	4	128	68
CARP_O1_p	4	32	257	3	43	192	2	64	129
CARP_O6_g	6	43	183	4	75	105	2	149	53
CARP_O6_p	3	25	301	2	38	198	1	75	101
CARP_O9_g	6	31	67	5	39	53	2	107	20
CARP_O9_p	6	8	223	3	18	99	1	53	34
CARP_O10_g	6	50	96	5	63	77	3	115	42
CARP_O11_g	6	18	118	4	31	68	3	41	52
CARP_O12_g	6	4	134	2	12	45	1	23	24
CARP_O13_g	5	2	85	2	5	34	1	9	19
CARP_O14_g	6	49	91	4	86	52	2	172	26
CARP_O15_g	6	28	69	5	36	54	2	98	20
CARP_O16_g	6	18	54	4	31	32	2	62	16
CARP_O17_g	5	9	36	3	16	20	2	24	14
CARP_S1_g	6	19	200	5	24	159	1	128	30
CARP_S1_p	4	6	316	2	11	173	1	21	91
CARP_S2_g	6	18	211	2	60	64	1	120	32
CARP_S3_g	5	20	185	3	36	103	1	108	35
CARP_S4_g	6	15	246	2	50	74	1	100	37
CARP_S5_g	6	17	220	3	38	99	2	57	66
CARP_S6_g	6	14	259	4	23	158	2	46	79
CARP_S6_p	3	6	298	2	9	199	1	17	106
CARP_S7_g	4	4	216	2	8	108	1	16	54
CARP_S8_g	3	3	288	2	4	216	1	8	108
CARP_S9_g	4	6	39	2	11	21	1	21	11
CARP_S9_p	3	2	83	2	2	83	1	4	42
CARP_S10_g	6	11	202	4	19	117	1	76	30
CARP_S11_g	5	5	193	3	9	107	2	13	74
CARP_S12_g	5	2	204	3	4	102	1	11	37
CARP_S13_g	3	2	88	2	3	59	1	5	36
CARP_S14_g	5	14	139	3	25	78	1	75	26
CARP_S15_g	6	7	150	3	15	70	2	23	46
CARP_S16_g	5	3	127	2	6	64	1	12	32
CARP_S17_g	3	3	83	2	4	62	1	8	31

Table 4: CARP vehicle information for sets N, O, and S.