On the exact solution of the multi-depot open vehicle routing problem

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1. Introduction

This text contains supplementary materials for the paper "On the exact solution of the multi-depot open vehicle routing problem". In specific, we present detailed computational results for each OVRP instance from the classes A, B, E, F, M and P and we present the parameterization of the proposed VRPSolver model.

2. Detailed Computational Results

All experiments here presented are performed on a computer with an Intel Core i7-4790 processor with 3.6 GHz and 16 GB of RAM on Ubuntu 18.04.2 LTS operating system. All experiments were performed on a computer with an Intel Core i7-3770 processor with 3.40 GHz and 16 GB of RAM on Ubuntu 18.04.2 LTS operating system. We used the VRPSolver v0.4.1 that can be downloaded at `https://vrpsolver.math.u-bordeaux.fr/`. Each instance is solved using a single thread. CPLEX v12.9 is used as linear programming and MILP solvers. All instances tested in this paper can be found at `https://github.com/mcroboredo/MDOVRP_OVRP`.

Tables 1, 2, 3 and 4 present detailed results for instances respectively from classes A, B, E-F-M and P. For each instance, we present the instance name (Column *Instance*), the number of customers (Column $|V^+|$), the best cost found by the proposed approach (Column *Best ub*), the percentage relative difference between the best upper bound and the bound at the root node (Column *Root Gap(#)*), the total number of branch-and-bound nodes (Column *#Nodes*) and the total CPU time in seconds consumed by the proposed approach (Column *Total time(s)*). For the reasons explained in the paper, we stopped any experiment whose the total time reached 540s.

Instance	$\|V^+\|$	Best ub	Root Gap(%)	#Nodes	Total Time(s)
A-n32-k5	31	487.31	0.00	1	1.14
A-n33-k5	32	424.54	0.00	1	3.61
A-n33-k6	32	462.43	0.00	1	5.53
A-n34-k5	33	508.17	0.00	1	2.28
A-n36-k5	35	519.46	0.00	1	1.93
A-n37-k5	36	486.24	0.00	1	2.01
A-n37-k6	36	581.07	0.00	1	10.5
A-n38-k5	37	498.00	0.00	1	2.4
A-n39-k5	38	549.68	0.00	1	2.17
A-n39-k6	38	533.07	0.00	1	1.6
A-n44-k6	43	617.39	0.00	1	2.51
A-n45-k6	44	488.39	0.00	1	2.46
A-n45-k7	44	685.16	0.23	3	6.96
A-n46-k7	45	583.54	0.00	1	2.05
A-n48-k7	47	669.83	0.00	1	2.24
A-n53-k7	52	655.18	0.00	1	3.37
A-n54-k7	53	709.27	0.00	1	3.93
A-n55-k9	54	669.06	0.59	5	18.97
A-n60-k9	59	798.01	0.35	5	49.47
A-n61-k9	60	678.30	0.62	3	22.93
A-n62-k8	61	783.18	0.00	1	5.1
A-n63-k10	62	778.46	0.00	1	9.45
A-n63-k9	62	941.53	0.00	1	7.73
A-n64-k9	63	848.16	0.41	13	288.66
A-n65-k9	64	728.59	0.00	1	3.12
A-n69-k9	68	757.76	0.08	3	14.46
A-n80-k10	79	1067.09	0.06	3	47.37
Avg.	48.44	648.48	0.09	2.04	19.41

Table 1: Detailed results of our approach for OVRP instances from class A.

3. Parameterization of the VRPSolver

The parameterization of the proposed VRPSolver model for the MDOVRP is presented in Table 5.

Instance	$\|V^+\|$	Best ub	Root Gap(%)	#Nodes	Total Time(s)
B-n31-k5	31	362.73	0.00	1	6.39
B-n34-k5	33	458.76	0.00	1	2.74
B-n35-k5	34	557.33	0.00	1	1.8
B-n38-k6	37	445.63	0.00	1	1.6
B-n39-k5	38	322.54	0.00	1	2.59
B-n41-k6	40	483.07	0.00	1	2.1
B-n43-k6	42	428.17	0.00	1	1.95
B-n44-k7	43	501.31	0.00	1	1.96
B-n45-k5	44	488.07	0.00	1	2.88
B-n45-k6	44	403.81	0.00	1	5.66
B-n50-k7	49	437.15	0.00	1	2.47
B-n50-k8	49	720.79	0.38	3	22.96
B-n51-k7	50	625.14	0.00	1	3.64
B-n52-k7	51	441.19	0.00	1	2.11
B-n56-k7	55	420.48	0.09	3	8.55
B-n57-k7	56	646.36	0.00	1	5.03
B-n57-k9	56	869.32	0.00	1	6.49
B-n63-k10	62	837.07	0.00	1	4.06
B-n64-k9	63	520.47	0.00	1	19.57
B-n66-k9	65	755.27	0.00	1	5.28
B-n67-k10	66	616.54	0.65	11	154.59
B-n68-k9	67	701.72	0.00	1	7.19
B-n78-k10	77	722.71	0.20	3	55.76
Avg.	50.09	555.03	0.06	1.70	14.23

Table 2: Detailed results of our approach for OVRP instances from class B.

Instance	$\lvert V^+ \rvert$	Best ub	Root Gap(%)	#Nodes	Total Time(s)
E-n22-k4	21	252.61	0.00	1	0.97
E-n23-k3	22	442.98	0.00	1	1.14
E-n30-k3	29	393.51	3.81	3	161.25
E-n33-k4	32	511.26	0.00	1	1.98
E-n51-k5	50	416.06	0.00	1	4.39
E-n76-k10	75	567.14	0.06	3	32.91
E-n76-k14	75	623.55	0.00	1	6.19
E-n76-k7	75	530.02	0.05	3	73.91
E-n76-k8	75	537.24	0.00	1	4.88
E-n101-k14	100	711.58	0.28	11	286.41
E-n101-k8	100	639.74	0.08	3	124.02
F-n45-k4	44	463.90	0.00	1	2.82
F-n72-k4	71	177.00	0.00	1	310.03
F-n135-k7	134	-	-	1	540
M-n101-k10	100	534.24	0.00	1	9.8
M-n121-k7	120	-	-	1	540
M-n151-k12	150	733.13	0.00	1	94.83
Avg.	74.88	502.26	0.29	2.06	129.15

Table 3: Detailed results of our approach for OVRP instances from classes E, F and M.

Instance	$\lvert V^+ \rvert$	Best ub	Root Gap(%)	#Nodes	Total Time(s)
P-n16-k8	31	235.06	0.00	1	1.14
P-n19-k2	32	168.57	0.00	1	3.61
P-n20-k2	32	170.28	0.00	1	5.53
P-n21-k2	33	163.88	0.00	1	2.28
P-n22-k2	35	167.19	0.00	1	1.93
P-n22-k8	36	345.87	0.00	1	2.01
P-n23-k8	36	302.87	0.00	1	10.5
P-n40-k5	37	349.55	0.00	1	2.4
P-n45-k5	38	391.81	0.00	1	2.17
P-n50-k7	38	397.38	0.00	1	1.6
P-n50-k8	43	436.51	1.10	11	2.51
P-n50-k10	44	440.44	0.00	1	2.46
P-n51-k10	44	480.78	0.21	3	6.96
P-n55-k7	45	411.58	0.00	1	2.05
P-n55-k8	47	414.47	0.00	1	2.24
P-n55-k10	52	444.31	0.14	3	3.37
P-n55-k15	53	587.60	0.27	3	3.93
P-n60-k10	54	482.09	0.00	1	18.97
P-n60-k15	59	569.43	0.00	1	49.47
P-n65-k10	60	522.50	0.00	1	22.93
P-n70-k10	61	552.65	0.00	1	5.1
P-n76-k4	62	522.94	0.22	3	9.45
P-n76-k5	62	525.64	0.34	5	7.73
P-n101-k4	63	621.75	0.03	3	288.66
Avg.	45.71	404.38	0.10	2.00	19.13

Table 4: Detailed results of our approach for OVRP instances from class P.

Parameter	value
RCSPhardTimeThresholdInPricing	25
RCSPmaxNumOfLabelsInEnumeration	500000
RCSPmaxNumOfEnumeratedSolutions	5000000
RCSPrankOneCutsMemoryType	0
CutTailingOffThreshold	0.015
StrongBranchingPhaseOneCandidatesNumber	100
StrongBranchingPhaseOneTreeSizeEstimRatio	0.2
StrongBranchingPhaseTwoCandidatesNumber	3
StrongBranchingPhaseTwoTreeSizeEstimRatio	0.02
GlobalTimeLimit	540

Table 5: Parameterization of the proposed VRPSolver model for the MDOVRP