

ABSTRACT

Title of dissertation: VEHICLE ROUTING PROBLEMS
THAT MINIMIZE THE COMPLETION TIME:
HEURISTICS, WORST-CASE ANALYSES,
AND COMPUTATIONAL RESULTS

Xingyin Wang
Doctor of Philosophy, 2016

Dissertation directed by: Professor Bruce Golden
Applied Mathematics & Statistics,
and Scientific Computation
Robert H. Smith School of Business

In the standard Vehicle Routing Problem (VRP), we route a fleet of vehicles to deliver the demands of all customers such that the total distance traveled by the fleet is minimized. In this dissertation, we study variants of the VRP that minimize the completion time, i.e., we minimize the distance of the longest route. We call it the min-max objective function. In applications such as disaster relief efforts and military operations, the objective is often to finish the delivery or the task as soon as possible, not to plan routes with the minimum total distance. Even in commercial package delivery nowadays, companies are investing in new technologies to speed up delivery instead of focusing merely on the min-sum objective.

In this dissertation, we compare the min-max and the standard (min-sum) objective functions in a worst-case analysis to show that the optimal solution with respect to one objective function can be very poor with respect to the other. The

results motivate the design of algorithms specifically for the min-max objective. We study variants of min-max VRPs including one problem from the literature (the min-max Multi-Depot VRP) and two new problems (the min-max Split Delivery Multi-Depot VRP with Minimum Service Requirement and the min-max Close-Enough VRP). We develop heuristics to solve these three problems. We compare the results produced by our heuristics to the best-known solutions in the literature and find that our algorithms are effective. In the case where benchmark instances are not available, we generate instances whose near optimal solutions can be estimated based on geometry.

We formulate the Vehicle Routing Problem with Drones and carry out a theoretical analysis to show the maximum benefit from using drones in addition to trucks to reduce delivery time. The speed-up ratio depends on the number of drones loaded onto one truck and the speed of the drone relative to the speed of the truck.

VEHICLE ROUTING PROBLEMS THAT MINIMIZE THE
COMPLETION TIME : HEURISTICS, WORST-CASE
ANALYSES, AND COMPUTATIONAL RESULTS

by

Xingyin Wang

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2016

Advisory Committee:
Professor Bruce Golden, Chair/Advisor
Professor Edward Wasil
Professor Radu Balan
Professor Ilya Ryzhov
Professor Paul Schonfeld

© Copyright by
Xingyin Wang
2016

Dedication

This dissertation is dedicated to my wife, Yuejia, and my first born son, Jonah.

Acknowledgments

I am indebted to so many people who have helped me with the dissertation. I do not think these two pages are enough to thank them.

I thank my adviser, Dr. Bruce Golden. He puts the right amount of pressure on me, not too much so that I will not feel discouraged, and not little so that I will not waste my time. He has taught me an important principle from the beginning: Make progress every week. I still remember he told me that even small progress every week will make a huge difference in two years. He is also a caring adviser. I remember the first time I received a rejection from a journal. He comforted me, assuring me that the paper was well-written. He encouraged me to improve the paper by addressing the reviewers' comments. We had the paper published in another journal later.

I thank Dr. Edward Wasil, especially for the infinite number of hours he spent to edit my writings. I am not a native speaker, so he has to improve almost every sentence I write. I was shocked the first time I saw the paper full of red comments returned to me. But I really appreciate his help. I learned from him how to write with clarity and with style.

I want to thank Dr. Radu Balan, Dr. Ilya Ryzhov, and Dr. Paul Schonfeld who served on my committee with Dr. Golden and Dr. Wasil. Thanks for the questions and comments on my dissertation and presentation.

I want to thank my coauthors. Chapter 2 is joint work with Dr. Luca Bertazzi. He initiated this collaboration and proved the worst-case results for the versions of infinite vehicle capacity and the multiple TSP. Even though we were communicating

via email, the work was completed in less than three months. I want to thank Rui Zhang. In Chapter 4, he used his expertise in Integer Linear Programming to prove that our estimated solutions to a set of tested instances are optimal or near-optimal. I thank Stefan Poikonen. We have been working together on the drone project. Part of the project is now in Chapter 5 and we will continue to publish more results. I want to thank Dr. Carmine Cerrone and Oliver Lum. They are my coauthors for work not included in the dissertation. I want to thank them here because I learned lots of coding techniques from these two expert programmers.

I want to thank the senior Ph.D. students in our group Dr. David Anderson and Dr. Stuart Price. Thanks for giving me a ride to the group meeting when I did not know how to drive. Thanks for all the advice on the way. I thank the program coordinators Alverda McCoy and Janet Cavanagh for being so helpful with the administrative work whenever I needed help.

I do not think I have included all the people who have helped me along the way. I thank God for his amazing grace to give me the opportunity to study at the University of Maryland and to meet so many great people.

Table of Contents

List of Tables	viii
List of Figures	xiii
List of Abbreviations	xv
1 Introduction	1
2 Min-Max vs. Min-Sum Vehicle Routing: A Worst-Case Analysis	7
2.1 Introduction	7
2.2 Description of problems	10
2.3 Capacitated VRP with an infinite number of vehicles	12
2.4 Capacitated VRP with a finite number of vehicles	16
2.4.1 Worst-case ratios of the min-max and min-sum solutions	17
2.4.2 Relation between min-max, min-sum, and route-optimal routing plans	22
2.5 Multiple TSP	25
2.6 Service time VRP with a finite number of vehicles	30
2.6.1 Impact of service time on min-max and min-sum solutions	31
2.6.1.1 Invariant min-sum solution	31
2.6.1.2 Impact on min-max solution	31
2.6.2 Worst-case ratios with service times	35
2.7 Conclusion	40
3 The Min-Max Multi-Depot Vehicle Routing without service time	41
3.1 Introduction	41
3.2 LP-based load balancing	44
3.3 MD algorithm	47
3.3.1 Initialization	47
3.3.1.1 Step 1: Assignment	47
3.3.1.2 Step 2: Solving the TSP	48
3.3.2 Local search	49
3.3.3 Perturbation	50

3.4	Alternative methods	51
3.4.1	VNS	52
3.4.1.1	Local Search	52
3.4.1.2	Neighborhood structure	53
3.4.1.3	VNS algorithm	55
3.4.2	VRPH	55
3.5	Computational results	56
3.5.1	Comparing LB, MD, VNS, and VRPH	57
3.5.2	Detailed comparison of MD and VNS	62
3.5.2.1	New data sets	62
3.5.2.2	Practical data	65
3.6	Conclusions	66
4	The Min-Max Multi-Depot Vehicle Routing with service	68
4.1	Introduction	68
4.2	Problem description	71
4.3	Structural properties of optimal solutions	72
4.4	Algorithm	77
4.4.1	Improving MD	78
4.4.2	Cluster balance subroutine	88
4.4.2.1	Alternative objective functions in the cluster balance subroutine	93
4.4.3	Local search	98
4.4.4	Perturbation	101
4.4.5	Satisfying the minimum delivery requirement	101
4.5	Computational results	103
4.5.1	Test Set 1	104
4.5.2	Test Set 2	106
4.5.2.1	Data generation	106
4.5.2.2	Estimated solution	107
4.5.2.3	Mathematical model and exact solutions for Test Set 2	109
4.5.2.4	MDS solution	120
4.5.3	Test Set 3	122
4.6	Conclusions	126
5	The Vehicle Routing Problem with Drones	128
5.1	Introduction and motivation	128
5.2	Problem description	130
5.3	Main results	131
5.4	Extending our model	158
5.5	Conclusions and future work	166

6	The Min-Max Close-Enough Vehicle Routing Problem	168
6.1	Introduction	168
6.2	MMCEVRP	171
6.2.1	Problem description	171
6.2.2	Steiner zone	171
6.3	Algorithm	175
6.3.1	Construction procedures	175
6.3.1.1	Customer pruning	175
6.3.1.2	Steiner zone construction	178
6.3.1.3	Set covering	181
6.3.1.4	MMVRP solver	183
6.3.2	Improvement procedures	183
6.3.2.1	Intra-route improvement	184
6.3.2.2	Inter-route improvement	185
6.4	Computational results	188
6.4.1	CETSP	188
6.4.2	MMCEVRP	189
6.5	Conclusions and future work	191
7	Conclusions and future work	193
A	The MD algorithm illustration	196
A.1	Initialization	196
A.2	Local search	197
A.2.1	Improvement by perturbation	201
B	Min-Max Multi-Depot Vehicle Routing Problem test instances	209
C	Min-Max Single-Depot Vehicle Routing Problem test instances	544
D	Close-Enough Traveling Salesman Problem test instances	599
	Bibliography	759

List of Tables

1.1	Recent Survey Articles in Vehicle Routing	3
2.1	Distance matrix for Example 5	25
2.2	Travel time matrix for Example 8	32
2.3	Travel time matrix for Example 9	33
2.4	Travel time matrix for Example 10	34
3.1	VNS algorithm	56
3.2	Computational results for LB, MD, VNS, and VRPH	58
3.3	Contributions of local search and perturbation in MD	61
3.4	MD vs VNS on uniform customer locations and small customer-to-vehicle ratios	64
3.5	MD vs VNS on uniform customer locations and large customer-to-vehicle ratios	64
3.6	MD vs VNS on non-uniform customer locations and small customer-to-vehicle ratios	65
3.7	MD vs VNS on non-uniform customer locations and large customer-to-vehicle ratios	66
4.1	Estimated arc cost of the auxiliary graph for cyclic transfer [87]	82
4.2	Algorithm to generate the auxiliary graph for cyclic transfer in the min-max problem	84
4.3	One-point move	85
4.4	Two-point move	86
4.5	Route destruction and reconstruction	87
4.6	Modified MD	88
4.7	Results of MD and MMD on Test Set 1	105
4.8	Average improvement of MMD over MD	106
4.9	Algorithm to estimate the optimal solution	108
4.10	Estimated solutions	110
4.11	Two Symmetric Solutions	113
4.12	Results for Test Set 2	116
4.13	MDS solutions vs the estimated solutions	121

4.14	Savings (in %) from the non-split solutions	123
4.15	Average savings (in %) from splitting with four minimum delivery fractions and three service times	124
4.16	Average savings (%) from splitting with four minimum delivery fractions and three r_{ctv} values	124
4.17	Split distribution (in %) by the number of times a customer receives service	126
4.18	Split distribution (in %) by the smallest portion a customer receives	126
5.1	Positions of the depot and the customers in Figure 5.11(a)	162
6.1	Status of the sweep line	180
6.2	Overview of MMSZ	187
6.3	Results produced by MMSZ and seven heuristics on 14 CETSP instances	190
6.4	Results produced by MMSZ on 14 MMCEVRP instances	192
A.1	Savings if a customer is removed from route 3	198
A.2	Cost of inserting customer 10 onto routes 1 and 2	199
A.3	Savings if a customer is removed from route 2	200
A.4	Cost of inserting customer 10 onto route 3	200
A.5	Cost of inserting customer 7 onto routes 1 and 3	204
A.6	Depot perturbation	208
A.7	Angles of each perturbation	208
B.1	Depot locations and number of vehicles for MS1	210
B.2	Customer locations and service time for MS1	210
B.3	Depot locations and number of vehicles for MS2	211
B.4	Customer locations and service time for MS2	211
B.5	Depot locations and number of vehicles for MS3	217
B.6	Customer locations and service time for MS3	217
B.7	Depot locations and number of vehicles for MS4	223
B.8	Customer locations and service time for MS4	223
B.9	Depot locations and number of vehicles for MS5	233
B.10	Customer locations and service time for MS5	233
B.11	Depot locations and number of vehicles for MS6	243
B.12	Customer locations and service time for MS6	243
B.13	Depot locations and number of vehicles for MS7	253
B.14	Customer locations and service time for MS7	253
B.15	Depot locations and number of vehicles for MS8	254
B.16	Customer locations and service time for MS8	254
B.17	Depot locations and number of vehicles for MS9	260
B.18	Customer locations and service time for MS9	260
B.19	Depot locations and number of vehicles for MS10	270
B.20	Customer locations and service time for MS10	270
B.21	Depot locations and number of vehicles for MS11	272

B.22 Customer locations and service time for MS11	272
B.23 Depot locations and number of vehicles for MS12	275
B.24 Customer locations and service time for MS12	275
B.25 Depot locations and number of vehicles for MS13	278
B.26 Customer locations and service time for MS13	278
B.27 Depot locations and number of vehicles for MS14	283
B.28 Customer locations and service time for MS14	283
B.29 Depot locations and number of vehicles for MS15	289
B.30 Customer locations and service time for MS15	289
B.31 Depot locations and number of vehicles for MS16	295
B.32 Customer locations and service time for MS16	295
B.33 Depot locations and number of vehicles for MS17	308
B.34 Customer locations and service time for MS17	308
B.35 Depot locations and number of vehicles for MS18	317
B.36 Customer locations and service time for MS18	317
B.37 Depot locations and number of vehicles for MS19	327
B.38 Customer locations and service time for MS19	327
B.39 Depot locations and number of vehicles for MS20	337
B.40 Customer locations and service time for MS20	337
B.41 Depot locations and number of vehicles for MS21	350
B.42 Customer locations and service time for MS21	350
B.43 Depot locations and number of vehicles for MS22	357
B.44 Customer locations and service time for MS22	357
B.45 Depot locations and number of vehicles for MS23	364
B.46 Customer locations and service time for MS23	364
B.47 Depot locations and number of vehicles for MS24	370
B.48 Customer locations and service time for MS24	370
B.49 Depot locations and number of vehicles for MS25	381
B.50 Customer locations and service time for MS25	381
B.51 Depot locations and number of vehicles for MS26	392
B.52 Customer locations and service time for MS26	392
B.53 Depot locations and number of vehicles for MS27	400
B.54 Customer locations and service time for MS27	400
B.55 Depot locations and number of vehicles for MS28	407
B.56 Customer locations and service time for MS28	407
B.57 Depot locations and number of vehicles for MS29	420
B.58 Customer locations and service time for MS29	420
B.59 Depot locations and number of vehicles for MS30	429
B.60 Customer locations and service time for MS30	429
B.61 Depot locations and number of vehicles for MS31	440
B.62 Customer locations and service time for MS31	440
B.63 Depot locations and number of vehicles for MS32	446
B.64 Customer locations and service time for MS32	446
B.65 Depot locations and number of vehicles for MS33	448
B.66 Customer locations and service time for MS33	448

B.67	Depot locations and number of vehicles for MS34	454
B.68	Customer locations and service time for MS34	454
B.69	Depot locations and number of vehicles for MS35	467
B.70	Customer locations and service time for MS35	467
B.71	Depot locations and number of vehicles for MS36	471
B.72	Customer locations and service time for MS36	471
B.73	Depot locations and number of vehicles for MS37	482
B.74	Customer locations and service time for MS37	482
B.75	Depot locations and number of vehicles for MS38	491
B.76	Customer locations and service time for MS38	491
B.77	Depot locations and number of vehicles for MS39	497
B.78	Customer locations and service time for MS39	497
B.79	Depot locations and number of vehicles for MS40	504
B.80	Customer locations and service time for MS40	504
B.81	Depot locations and number of vehicles for MS41	510
B.82	Customer locations and service time for MS41	510
B.83	Depot locations and number of vehicles for MS42	523
B.84	Customer locations and service time for MS42	523
B.85	Depot locations and number of vehicles for MS43	535
B.86	Customer locations and service time for MS43	535
C.2	Min-Max Single-Depot Split-Delivery VRP instance SD1	544
C.1	SD instance specifications	545
C.3	Min-Max Single-Depot Split-Delivery VRP instance SD2	545
C.4	Min-Max Single-Depot Split-Delivery VRP instance SD3	545
C.5	Min-Max Single-Depot Split-Delivery VRP instance SD4	546
C.6	Min-Max Single-Depot Split-Delivery VRP instance SD5	547
C.7	Min-Max Single-Depot Split-Delivery VRP instance SD6	548
C.8	Min-Max Single-Depot Split-Delivery VRP instance SD7	549
C.9	Min-Max Single-Depot Split-Delivery VRP instance SD8	550
C.10	Min-Max Single-Depot Split-Delivery VRP instance SD9	551
C.11	Min-Max Single-Depot Split-Delivery VRP instance SD10	553
C.12	Min-Max Single-Depot Split-Delivery VRP instance SD11	554
C.13	Min-Max Single-Depot Split-Delivery VRP instance SD12	556
C.14	Min-Max Single-Depot Split-Delivery VRP instance SD13	559
C.15	Min-Max Single-Depot Split-Delivery VRP instance SD14	561
C.16	Min-Max Single-Depot Split-Delivery VRP instance SD15	564
C.17	Min-Max Single-Depot Split-Delivery VRP instance SD16	568
C.18	Min-Max Single-Depot Split-Delivery VRP instance SD17	572
C.19	Min-Max Single-Depot Split-Delivery VRP instance SD18	576
C.20	Min-Max Single-Depot Split-Delivery VRP instance SD19	580
C.21	Min-Max Single-Depot Split-Delivery VRP instance SD20	584
C.22	Min-Max Single-Depot Split-Delivery VRP instance SD21	591
D.1	CETSP instance kroD100rdmRad	600

D.2	CETSP instance rat195rdmRad	603
D.3	CETSP instance lin318rdmRad	608
D.4	CETSP instance rd400rdmRad	616
D.5	CETSP instance pcb442rdmRad	626
D.6	CETSP instance d493rdmRad	637
D.7	CETSP instance dsj1000rdmRad	650
D.8	CETSP instance team1_100rdmRad	675
D.9	CETSP instance team_200rdmRad	678
D.10	CETSP instance team3_300rdmRad	683
D.11	CETSP instance team4_400rdmRad	691
D.12	CETSP instance team5_499rdmRad	701
D.13	CETSP instance team6_500rdmRad	714
D.14	CETSP instance bonus1000rdmRad	727

List of Figures

1.1	Number of articles published in JORS, Networks, C&OR, and EJOR from 1970 to 2013 [93]	2
2.1	Min-sum vs. min-max optimal solutions in Example 1	13
2.2	Min-max vs. min-sum optimal solutions in Example 2	15
2.3	Min-sum vs. min-max optimal solutions in Example 3	20
2.4	Min-max vs. min-sum optimal solutions in Example 4	22
2.5	Illustrating the sequence of travel	24
2.6	Solutions to Example 5	25
2.7	Min-sum vs. min-max optimal solutions in Example 6	27
2.8	Min-max vs. min-sum optimal solutions in Example 7	29
2.9	The impact of service times (Example 8)	33
2.10	The impact of service times (Example 9)	34
2.11	The impact of service times (Example 10)	34
2.12	Min-sum vs. min-max optimal solutions in Example 11	36
2.13	Min-max vs. min-sum optimal solutions in Example 12	39
3.1	Comparison of MD, VNS, and VRPH to LB	59
3.2	MD running time against average number of customers per route	62
4.1	Illustrating Property 1	73
4.2	Examples of clusters of routes	76
4.3	Cyclic transfer	83
4.4	Auxiliary graphs of the customers in Figure 4.2	91
4.5	Example 13	95
4.6	Example 14	96
4.7	Intersections of contours of objective functions (4.17), (4.18), and (4.19) with Π	98
4.8	Illustration of cluster merge	100
4.9	Large minimum delivery fraction causing infeasibility	102
4.10	Example of instances	107
4.11	Sub-problem of SD10 and its estimated solution	107

5.1	A VRPD _{1,1} solution with $k = 2$	134
5.2	Decomposition of a VRPD _{1,1} solution	134
5.3	A feasible TSP solution from the optimal VRPD solution	135
5.4	A worst-case VRPD _{1,1} example with $k = 2$	136
5.5	A worst-case VRPD _{1,α} example with $k = 2$	139
5.6	A worst-case VRP* example with $m = 3$	142
5.7	Adding drone customers to truck route	146
5.8	Comparison of the intermidate routes in TSP route construction	147
5.9	Comparison of the TSP solutions constructed in the proofs	148
5.10	A worst-case VRPD _{m,α} example with $k = 2$	151
5.11	Truck and drone follow different distance metrics	162
6.1	An MMCEVRP example with 11 customers and routes for two vehicles	172
6.2	Steiner zones of various degrees	174
6.3	Customer pruning	176
6.4	Sweep line algorithm	179
6.5	One pass of the selection process	185
A.1	Locations of customers and depots	198
A.2	Initial solution	199
A.3	Iteration 1	200
A.4	A feasible solution to the perturbed problem	202
A.5	Solution to the perturbed problem after local search	205
A.6	A feasible solution to the original problem	206
A.7	The feasible solution generated after one perturbation	207
D.1	Solution to kroD100rdmRad produced by MMSZ	752
D.2	Solution to rat195rdmRad produced by MMSZ	752
D.3	Solution to lin318rdmRad produced by MMSZ	753
D.4	Solution to rd400rdmRad produced by MMSZ	753
D.5	Solution to pcb442rdmRad produced by MMSZ	754
D.6	Solution to d493rdmRad produced by MMSZ	754
D.7	Solution to dsj1000rdmRad produced by MMSZ	755
D.8	Solution to team1_100rdmRad produced by MMSZ	755
D.9	Solution to team2_200rdmRad produced by MMSZ	756
D.10	Solution to team3_300rdmRad produced by MMSZ	756
D.11	Solution to team4_400rdmRad produced by MMSZ	757
D.12	Solution to team5_499rdmRad produced by MMSZ	757
D.13	Solution to team6_500rdmRad produced by MMSZ	758
D.14	Solution to bonus1000rdmRad produced by MMSZ	758

List of Abbreviations

BIP	Binary Integer Program
BPP	Bin Packing Problem
CEVRP	Close-Enough Vehicle Routing Problem
CETSP	Close-Enough Traveling Salesman Problem
LKH	Lin Kernighan Helsgaun
LP	Linear Program
MMCEVRP	min-max Close-Enough Vehicle Routing Problem
MMMDVRP	min-max Multi-Depot Vehicle Routing Problem
MMSDMDVRP-MSR	min-max Split-Delivery Multi-Depot Vehicle Routing Problem with Minimum Service Requirement
RFID	Radio Frequency Identification
VRP	Vehicle Routing Problem
VRPD	Vehicle Routing Problem with Drones
TSP	Traveling Salesman Problem

Chapter 1: Introduction

In the standard version of the Vehicle Routing Problem (VRP), a homogeneous fleet of vehicles makes deliveries to customers. All routes start and end at the depot. The total demands delivered on one route cannot exceed a vehicle's capacity. Each customer must have its demand delivered by one vehicle in one visit. The objective is to minimize the total distance traveled by the fleet. The VRP is related to two well-known combinatorial optimization problems: the Traveling Salesman Problem (TSP) and the Bin Packing Problem (BPP). In the TSP, a salesman is required to visit a set of cities and return to the starting city, such that each city is visited exactly once (except the starting city). The total distance traveled is minimized. In the BPP, we want to pack a set of items of known weights into identical bins, such that the total weight of items packed into one bin cannot exceed the bin capacity. The number of bins used is minimized. In the VRP, if the vehicle capacity is at least the total demand of all customers, the problem reduces to the TSP. If all customers are at the same location, the VRP reduces to the BPP. Therefore, the VRP has both a TSP dimension and a BPP dimension.

The VRP was introduced by Dantzig and Ramser [34] as the truck dispatching problem. The authors modeled the distribution of gasoline from a central depot.

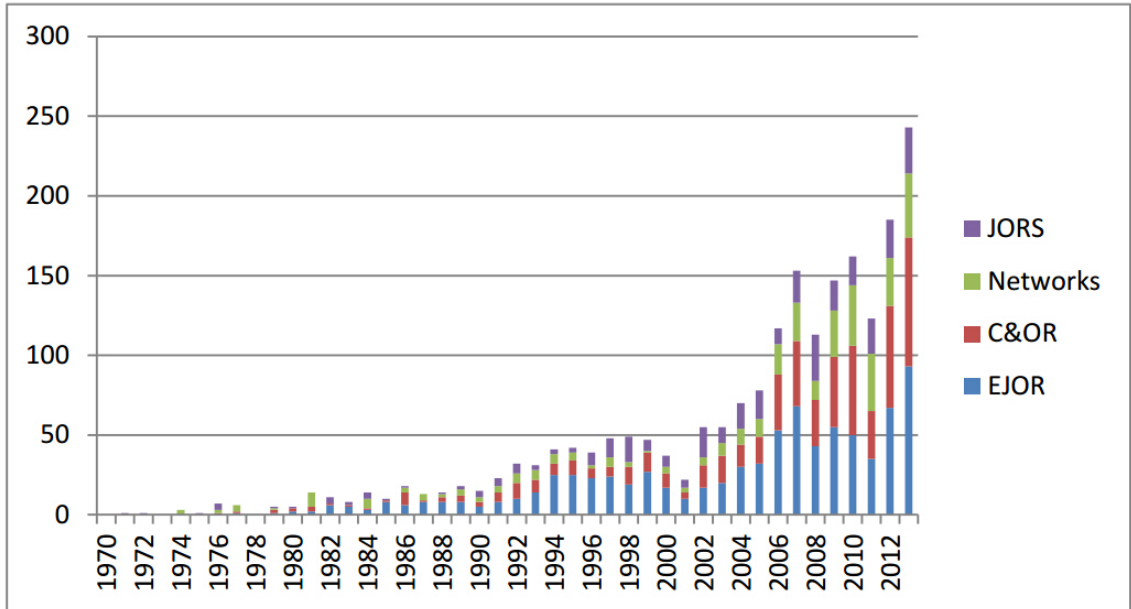


Figure 1.1: Number of articles published in JORS, Networks, C&OR, and EJOR from 1970 to 2013 [93]

Since the publication of the Dantzig and Ramser paper in 1959, many papers have been published on the VRP and its variants. In Figure 1.1, we show the number of articles published on the VRP in four journals: Journal of the Operational Research Society (JORS), Networks, Computers & Operations Research (C&OR), and European Journal of Operational Research (EJOR) from 1970 to 2013 (Figure 1.1 is taken from [93]). These four journals are the primary outlets for publishing work on the VRP. For recent books on the VRP and its variants, we refer the reader to Golden et al. [46] and Toth and Vigo [89]. In Table 1.1, we present a list of references of recent survey articles on VRP. Table 1.1 is taken from [93] with a few recent articles added.

In this dissertation, we focus on variants of the VRP with the min-max objective. Instead of minimizing the total distance traveled by all vehicles, we minimize

Table 1.1: Recent Survey Articles in Vehicle Routing

Topic	Authors	Published in	Year	Reference
Vehicle routing in general	Marinakis, Migdalas	Operational Research	2007	[69]
	Laporte	Naval Res. Log.	2007	[64]
Adaptive search	Laporte	Trans. Science	2009	[65]
	Ekşioglu et al.	Computers & IE	2009	[39]
	Kritzinger et al.	Yugoslav J. of OR	2015 (1 & 2)	[62, 63]
	Hertz	book chapter	2005	[57]
Arc routing	Wøhlk	Networks	2008	[97]
	Corberan, Prins	book chapter	2010	[31]
Dynamic vehicle routing	Ritzinger et al.	Int. J. Prod. Res	2015	[81]
	Pillac et al.	EJOR	2013	[75]
Evolutionary algorithms	Potvin	INFORMS JOC	2009	[78]
	Baldacci et al.	4 OR	2007	[11]
Exact algorithms	Lin et al.	Expert Systems with Applications	2014	[68]
	Andersson et al.	Computers & OR	2010	[2]
Green vehicle routing	Bertazzi, Speranza	EURO J. Transport & Logistics	2012	[16]
	Bertazzi, Speranza	EURO J. Transport & Logistics	2013	[17]
Inventory routing	Funke et al.	J. of Heuristics	2005	[42]
	Nagy, Salhi	EJOR	2007	[72]
Local search	Prodhom, Prins	EJOR	2014	[79]
	Jozefowicz et al.	EJOR	2008	[60]
Location-routing	Cambell, Wilson	Networks	2014	[22]
	Laprote, Martin	Networks	2007	[66]
Multi-objective vehicle routing	Vansteenkoven et al.	EJOR	2011	[91]
	Drexler	Logistics Research	2012	[36]
Periodic vehicle routing	Caceres-Cruz et al.	ACM Computing Review	2014	[20]
	Iori, Martello	Yugoslav J. of OR	2013	[59]
Prize/profit collecting VRPs	Park, Kim	EJOR	2010	[74]
	Archetti, Speranza	ITOR	2012	[6]
Rich vehicle routing	Berbeglia et al.	TOP	2007	[13]
	Drexler	Trans. Science	2012	[37]
Routing & loading	Gendreau et al.	C & OR	2015	[44]
	Braysy, Gendreau	Trans. Science	2005 (1 & 2)	[18, 19]
School bus routing	Cuda et al.	Computers & OR	2015	[33]
Split deliveries				
Static pickup & delivery problems				
Synchronization in vehicle routing				
Time-dependent routing				
Time windows				
Two-echelon routing				

the duration (distance plus service time, if there is any) of the longest route. The min-max objective function is more applicable than the classic (min-sum) objective function when we want to finish delivering all demands as soon as possible or when the timing of the last delivery is crucial. For example, in disaster relief efforts, it is vital that all victims receive supplies as soon as possible. In military operations, it is crucial that we finish surveying targets as soon as we can. In newspaper delivery, it is important that we deliver papers to all the subscribers early in the morning. Some problems that do not appear to have a routing component can also be modeled by the min-max VRP. For example, in computer networks, a server and its clients can be modeled by the depot and customers. When the connection cost between a server and a client is high while the connection cost between clients is low, it is important to minimize the maximum latency between a server and a client [23]. It can be achieved using the min-max objective function. Furthermore, the min-max solution tends to have balanced routes. If the longest route is minimized, the variability in route lengths tends to be small. Therefore, the min-max objective can also be used to balance the workload among drivers.

Each of the five chapters in this dissertation describes work on variants of the min-max VRP. We use both theoretical and computational approaches. Computational approaches use local-search-based heuristics organized in multi-phase algorithms. Every algorithm constructs an initial feasible solution and iteratively improves on it. Sometimes an exact solver is employed to solve a small subproblem. Theoretical approaches focus on worst-case analyses. We compare new variants to standard problems to show how their solutions differ in the worst (or best) cases.

In Chapter 2, we compare the optimal solutions of several variants of the min-sum and min-max VRP from a worst-case point of view. The aim is two-fold. First, we motivate the design of algorithms for the min-max VRP, because the optimal solution to the min-sum VRP can be very poor when used to solve the min-max VRP. Second, we show that the min-max approach should be adopted only when it is well justified, because the corresponding total distance can be very large with respect to the one obtained by optimally solving the classical min-sum VRP.

In Chapter 3, we study the min-max VRP with multiple depots proposed by Carlsson [23]. This problem is called the min-max Multi-Depot Vehicle Routing Problem (MMMDVRP) and does not have customer service times. We develop a heuristic (denoted by MD) that has three stages: (1) assign customers to routes and optimize the routes; (2) improve the solution using local search strategies; (3) improve the solution by perturbation and local search strategies.

In Chapter 4, we extend the MMMDVRP by incorporating customer service times. We also consider the possibility of service splits and minimum service requirement. We call this problem the min-max Split-Delivery Multi-Depot Vehicle Routing Problem with Minimum Service Requirement (MMSDMDVRP-MSTR). We develop a heuristic (denoted by MDS) that solves the MMSDMDVRP-MSTR in three stages: (1) initialize a feasible solution without splits; (2) improve the longest routes by splitting service times; (3) ensure all minimum service time requirements are satisfied.

In Chapter 5, we introduce the Vehicle Routing Problem with Drones (VRPD). A fleet of trucks loaded with drones delivers packages to customers. The objective

minimizes the maximum duration of the routes (i.e., the completion time). The VRPD is motivated by package delivery companies including Amazon, DHL, and Federal Express actively exploring the use of commercial drones. After stating our simplifying assumptions, we pose several questions in order to study the maximum savings that can be obtained from using drones. Then we derive some worst-case results. The worst-case results depend on the number of drones per truck and the speed of the drone relative to the speed of the truck. We consider several extensions to the basic model.

In Chapter 6, we introduce the min-max Close-Enough Vehicle Routing Problem (MMCEVRP), where a vehicle only needs to get close enough to service a customer. The objective minimizes the distance of the longest route. The problem is motivated by the development of radio frequency identification (RFID) technology. A utility company employee does not have to visit a house to read its meter. Instead, the employee uses a wireless receiver and drives close to a house to read its meter. The MMCEVRP has other applications such as surveying ground targets with a drone. We develop a heuristic that has a four-step construction phase, an intra-route improvement phase, and an inter-route improvement phase.

In Chapter 7, we provide our concluding remarks and mention directions for future research.

Chapter 2: Min-Max vs. Min-Sum Vehicle Routing: A Worst-Case Analysis

2.1 Introduction

The Vehicle Routing Problem (VRP) is the problem of determining a set of routes that visit a set of customers at minimum distance, where each route satisfies a capacity constraint. This problem is interesting both from the theoretical and the practical points of view. In fact, finding an optimal solution is really challenging and this problem is solved daily by companies worldwide. In the last 50 years, numerous variants have been studied, including the case with one vehicle (Traveling Salesman Problem - TSP), the case with multiple uncapacitated vehicles (Multiple TSP - MTSP), and the more traditional case with several capacitated vehicles (Capacitated VRP - CVRP). The latter case, which was introduced in Dantzig and Ramser in 1959 [34], plays a central role in distribution management. The first exact algorithms for the CVRP were proposed by Christofides et al. ([26, 27]). The best known exact algorithms are the ones proposed by Fukasawa et al. ([41]) and Baldacci et al. ([8, 9]). For a recent survey on exact algorithms for the CVRP, we refer the reader to Baldacci et al. ([10]). Although it is possible to optimally solve instances of

the TSP with several thousands of customers, the CVRP remains very difficult to solve optimally, even if a few hundred customers are considered. Therefore, both heuristic and metaheuristic algorithms have been proposed for its solution. The most famous heuristic is the Saving algorithm by Clarke and Wright [28]. The best known metaheuristics are the Adaptive large neighborhood search by Pisinger and Ropke [76] and the Hybrid genetic algorithm recently proposed by Vidal et al. [92]. We refer to Toth and Vigo [88, 89] and Golden et al. [46] for two comprehensive books on the VRP and to Laporte et al. [67] for a recent overview of exact, heuristic, and metaheuristic approaches.

The classical objective function of the VRP is the minimization of the total distance traveled by all vehicles (min-sum). In this paper, we also focus on the case in which the aim is to minimize the longest route (min-max). This new objective function is important in several situations. For example, in disaster relief efforts the aim is to serve all victims as soon as possible, in computer networks the aim is to minimize the maximum latency between a server and a client, in workload balance the aim is to balance the amount of work among drivers on a given day or across a time horizon. A limited number of papers is devoted to the min-max VRP. A tabu search algorithm is proposed in França et al. [40] for the Multiple TSP. Averbakh and Berman [7] study the problem in which two salesmen must visit nodes on a tree. Applegate et al. [3] develop specialized cutting planes and a distributed search algorithm to solve the so-called *Newspaper routing problem*. Carlsson et al. [23] study the multi-depot case and propose an LP-based balancing approach and a region partition heuristic. Wang et al. [94, 96] develop two heuristics that

are able to significantly improve upon the LP-based balancing approach. Ren [80] proposes a hybrid genetic algorithm. Campbell et al. [21] propose for the first time a comparison of the solutions obtained with alternative objective functions. They define min-max and min-sum in a different way: Min-max aims at minimizing the arrival time to the latest customer and min-avg (or min-sum) aims at minimizing the average arrival time or, equivalently, the sum of the arrival times to the customers. The paper by Huang et al. [58] extends this work by studying how alternative objectives, based on equity, efficiency, and efficacy metrics, influence the structure of the routes. The solutions obtained on the basis of the definitions of min-max and min-sum used in Campbell et al. [21] can be very different from the ones obtained on the basis of our definition of min-max and min-sum. Consider for example the simpler TSP case. Our min-sum and min-max objectives are equivalent, while if the aim is to minimize the latest arrival, the routing can significantly differ. In fact, Campbell et al. [21] show that the worst-case ratio between the total length of the route obtained by minimizing the latest arrival and the total length of the route obtained by minimizing the total length is $3/2$.

The length of the longest route in the min-sum VRP is not lower than the length of the longest route in the min-max VRP, while the total distance in the min-max VRP is not lower than the total distance in the min-sum VRP. Our aim is to consider several variants of the VRP. For each of these variants, we aim to answer the following questions:

1. What is the ratio of the length of the longest route in the min-sum VRP to

the length of the longest route in the min-max VRP, in the worst case?

2. What is the ratio of the total distance of the min-max VRP to the total distance of the min-sum VRP, in the worst case?

The answer to the first question tells us if minimizing the total distance can imply a significant increase in the length of the longest route. In that case, the design of heuristic, metaheuristic, and matheuristic algorithms for the min-max VRP is well-motivated. The answer to the second question tells us if minimizing the longest route can imply a significant increase in the total distance. In that case, this objective should be really well-justified to be adopted.

The remainder of the chapter is organized as follows. In Section 2.2, the variants of the VRP studied in the paper are formally described. In Section 2.3, the worst-case analysis concerning the Capacitated VRP with an infinite number of vehicles is shown. Section 2.4 focuses on the Capacitated VRP with a finite number of vehicles. Section 2.5 concerns the Multiple TSP. Section 2.6 focuses on the Service time VRP with a finite number of vehicles. Some conclusions are presented in Section 2.7.

2.2 Description of problems

Let $G(V, E)$ be a complete graph, where $V = \{0, 1, \dots, n\}$ is the set of vertices and E is the corresponding set of edges. Vertex 0 corresponds to the depot, while vertices $1, 2, \dots, n$ correspond to the customers. Each customer has to be served in full by one route (i.e., splitting of the demand is not allowed). Let c_{ij} be the distance

corresponding to the edge $(i, j) \in E$. We consider the following four variants of the VRP:

1. *Capacitated VRP with an infinite number of vehicles*: Each customer $i = 1, 2, \dots, n$ has a demand $d_i > 0$ not greater than the vehicle capacity C . An infinite fleet of vehicles is available.
2. *Capacitated VRP with a finite number of vehicles*: Each customer $i = 1, 2, \dots, n$ has a demand $d_i > 0$ not greater than the vehicle capacity C . At most k vehicles are available.
3. *Multiple TSP*: The customers just have to be visited (i.e., no demand has to be satisfied). Each vehicle has infinite capacity. Exactly k routes have to be determined.
4. *Service time VRP with a finite number of vehicles*: Distances are replaced by travel times. Customer demands are given in terms of service times. The duration of any route is the sum of travel time and service times of the customers visited by the route. At most k vehicles are available and there is no limit on the total load or duration of a route.

In the min-sum VRP, the problem is to determine a set of routes that minimizes the total distance (or total time). Instead, in the min-max VRP, the problem is to determine a set of routes that minimizes the length (or duration) of the longest route.

2.3 Capacitated VRP with an infinite number of vehicles

In the Capacitated VRP with an infinite number of vehicles, each customer $i = 1, 2, \dots, n$ has a demand $d_i > 0$ not greater than the vehicle capacity C . An infinite fleet of vehicles is available.

Let us denote by r_{MM}^∞ the length of the longest route in the optimal solution of the min-max Capacitated VRP with an infinite number of vehicles and by r_{MS}^∞ the length of the longest route in the optimal solution of the min-sum Capacitated VRP with an infinite number of vehicles.

Theorem 1. *There exists an instance class with parameter ϵ such that $\frac{r_{MS}^\infty}{r_{MM}^\infty} \rightarrow \infty$ for $\epsilon \rightarrow 0$.*

Proof. Let $0 \leq \epsilon < 1$ be a real number such that $\frac{1}{\epsilon}$ is an integer. Consider the following instance class with parameter ϵ :

Example 1.

- *Single depot called node 0.*
- *Number of customers: $n = 1 + \frac{1}{\epsilon}$ (nodes $1, 2, \dots, 1 + \frac{1}{\epsilon}$).*
- *Vehicle capacity: $C = \frac{1}{\epsilon}$.*
- *Demand of customer 1: $d_1 = \frac{1}{\epsilon}$.*
- *Demand of customers $i = 2, 3, \dots, n$: $d_i = \epsilon$.*
- *Depot to customer distances: $c_{0i} = 1$, for $i = 1, 2, \dots, n$.*

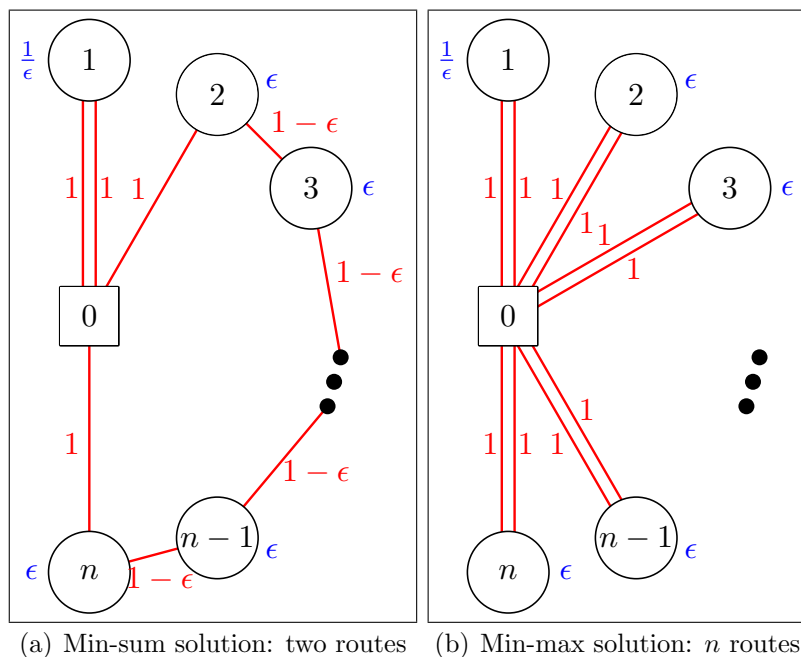


Figure 2.1: Min-sum vs. min-max optimal solutions in Example 1

- Customer to customer distances: $c_{ij} = 1 - \epsilon$ for $i, j = 1, 2, \dots, n, i \neq j$.

The corresponding optimal solutions are shown in Figures 2.1(a) and 2.1(b).

An optimal solution of the min-sum Capacitated VRP with an infinite number of vehicles is the following: Serve customer 1 directly and all the remaining customers $2, 3, \dots, n$ in the same route. In fact, since $d_1 = C$ and splitting of the demand is not allowed, customer 1 has to be served directly. Moreover, the length of the route serving customers $2, 3, \dots, n$ is $1 + (1 - \epsilon)(\frac{1}{\epsilon} - 1) + 1 = \frac{1}{\epsilon} + \epsilon$. This length cannot be reduced by using more routes to serve these customers. In fact, let $2 \leq R \leq \frac{1}{\epsilon}$ (R integer) be the number of routes to serve these customers. The corresponding length is $2R + (1 - \epsilon)(\frac{1}{\epsilon} - R)$, which is greater than $\frac{1}{\epsilon} + \epsilon$ for $R \geq 2$. Therefore, the length of the longest route is $r_{MS}^\infty = \frac{1}{\epsilon} + \epsilon$.

An optimal solution of the min-max Capacitated VRP with an infinite number

of vehicles is the following: Serve each customer $1, 2, \dots, n$ directly. In fact, since customer 1 has to be served directly, a lower bound on the optimal length of the min-max VRP is given by the length of the route serving customer 1, that is 2. Since the solution in which each customer $1, 2, \dots, n$ is served directly has length equal to 2, this solution is optimal for the min-max Capacitated VRP with an infinite number of vehicles. Therefore, the length of the longest route is $r_{MM}^\infty = 2$.

Hence, in this instance class

$$\frac{r_{MS}^\infty}{r_{MM}^\infty} = \frac{\frac{1}{\epsilon} + \epsilon}{2} \rightarrow \infty \quad \text{for } \epsilon \rightarrow 0.$$

□

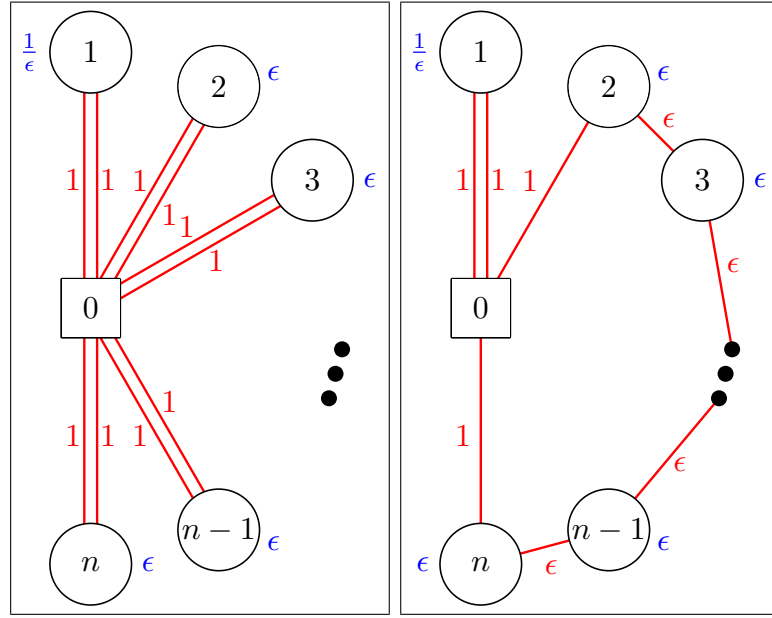
Let us now denote by z_{MS}^∞ the total distance in an optimal solution of the min-sum Capacitated VRP with an infinite number of vehicles and by z_{MM}^∞ the total distance in an optimal solution of the min-max Capacitated VRP with an infinite number of vehicles.

Theorem 2. *There exists an instance class with parameter ϵ such that $\frac{z_{MM}^\infty}{z_{MS}^\infty} \rightarrow \infty$ for $\epsilon \rightarrow 0$.*

Proof. Let $0 \leq \epsilon < 1$ be a real number such that $\frac{1}{\epsilon}$ is an integer. Consider the following instance class with parameter ϵ :

Example 2.

- Single depot called node 0.
- Number of customers: $n = 1 + \frac{1}{\epsilon}$ (nodes $1, 2, \dots, 1 + \frac{1}{\epsilon}$).



(a) Min-max solution: n routes (b) min-sum solution: two routes

Figure 2.2: Min-max vs. min-sum optimal solutions in Example 2

- Vehicle capacity: $C = \frac{1}{\epsilon}$.
- Demand of customer 1: $d_1 = \frac{1}{\epsilon}$.
- Demand of customers $i = 2, 3, \dots, n$: $d_i = \epsilon$.
- Depot to customer distances: $c_{0i} = 1$, for $i = 1, 2, \dots, n$.
- Customer to customer distances: $c_{ij} = \epsilon$, for $i, j = 1, 2, \dots, n$, $i \neq j$.

The corresponding optimal solutions are shown in Figures 2.2(a) and 2.2(b).

An optimal solution of the min-max Capacitated VRP with an infinite number of vehicles is the following: Serve each customer $1, 2, \dots, n$ directly. In fact, since $d_1 = C$ and splitting of the demand is not allowed, customer 1 has to be served directly. Therefore, a lower bound on the optimal length of the min-max Capacitated VRP with an infinite number of vehicles is given by the length of the route serving

customer 1, that is 2. Since the solution in which each customer $1, 2, \dots, n$ is served directly has length equal to 2, this solution is optimal for the min-max Capacitated VRP with an infinite number of vehicles. Therefore, the optimal total distance is $z_{MM}^\infty = 2n = 2(1 + \frac{1}{\epsilon})$.

An optimal solution of the min-sum Capacitated VRP with an infinite number of vehicles is the following: Serve customer 1 directly and all the remaining customers $2, 3, \dots, n$ in the same route. In fact, customer 1 has to be served directly. Moreover, the length of the route serving customers $2, 3, \dots, n$ is $1 + \epsilon(\frac{1}{\epsilon} - 1) + 1 = 3 - \epsilon$. This length cannot be reduced by using more routes to serve these customers. In fact, even the length of any solution having just two routes to serve these customers is at least 4. Therefore, the optimal total distance is $z_{MS}^\infty = 5 - \epsilon$.

Hence, in this instance class

$$\frac{z_{MM}^\infty}{z_{MS}^\infty} = \frac{2(1 + \frac{1}{\epsilon})}{5 - \epsilon} \rightarrow \infty \quad \text{for } \epsilon \rightarrow 0.$$

□

2.4 Capacitated VRP with a finite number of vehicles

In subsection 2.4.1, we develop Theorems 3 and 4 relating to the worst-case ratios of the min-sum and min-max solutions. In subsection 2.4.2, we define route-optimal routing plans and extend Theorems 3 and 4. (We point out that route-optimal routing plans are used in proving Theorem 11.) We discover that the bounds apply not only to the ratios between the min-max and the min-sum solutions, but

also to ratios between any route-optimal solution and the min-max or the min-sum solutions.

2.4.1 Worst-case ratios of the min-max and min-sum solutions

In the Capacitated VRP with a finite number of vehicles, each customer $i = 1, 2, \dots, n$ has a demand $d_i > 0$ not greater than the vehicle capacity C . At most k vehicles are available.

Let us denote by r_{MM}^k the length of the longest route in the min-max VRP solution, r_{MS}^k the length of the longest route in the min-sum VRP solution, z_{MM}^k the total distance of the min-max VRP solution, and z_{MS}^k the total distance of the min-sum VRP solution.

In this section, we want to extend what we know about r_{MM}^∞ vs. r_{MS}^∞ and z_{MM}^∞ vs. z_{MS}^∞ beyond Theorems 1 and 2, when we add the constraint that there are at most k vehicles available.

Theorem 3. $\frac{r_{MS}^k}{r_{MM}^k} \leq k$ and the bound is tight.

Proof. $r_{MS}^k \leq z_{MS}^k \leq z_{MM}^k \leq kr_{MM}^k$. A worst-case example is displayed in Example 3. Note that Theorem 3 reduces to Theorem 1 as $k \rightarrow \infty$. Consider the following instance class with parameter ϵ :

Example 3.

- Single depot called node 0.
- $2k$ customers:

- k inner loop customers (nodes 1 to k)
- k outer loop customers (nodes $k + 1$ to $2k$).
- Vehicle capacity: C .
- Customer demand: $d_i = \frac{C}{2k}$ ($i = 1, \dots, 2k$).
- Depot to customer distances:
 - inner loop: $c_{0i} = \epsilon \ll 1$ ($i = 1, \dots, k$)
 - outer loop: $c_{0,k+i} = 1 + \epsilon$ ($i = 1, \dots, k$).
- Customer to customer distances:
 - between inner customers: $c_{ij} = \epsilon$ ($i, j = 1, \dots, k, i \neq j$)
 - between outer customers: $c_{k+i,k+j} = 2 + \epsilon$ ($i, j = 1, \dots, k, i \neq j$)
 - between inner and outer customers:

$$c_{i,k+j} = \begin{cases} 1 & \text{if } i = j \\ 1 + \epsilon & \text{if } i \neq j. \end{cases}$$

The optimal solutions of the min-sum and the min-max VRP are shown in Figures 2.3(a) and 2.3(b). The min-sum solution has a single route, serving the inner and outer customers alternately in a sequence $\{1, k + 1, 2, k + 2, \dots, k, 2k\}$. The min-sum solution has objective $r_{MS}^k = 2k + (k + 1)\epsilon$. The solution cannot be improved by using more routes. In fact, all the outer customers must be served on the same route. Suppose the customers are served on R routes with $2 \leq R \leq k$

(R integer). The length of these R routes is at least $2R(1 + \epsilon) + (2 + \epsilon)(k - R) = 2k + (k + R)\epsilon > 2k + (k + 1)\epsilon$. If all the outer customers are served on a single route, this route has length at least $2k + (k + 1)\epsilon$. Hence, a lower bound on the min-sum solution is $2k + (k + 1)\epsilon$ and the solution in Figure 2.3(a) is optimal with respect to the min-sum objective.

The min-max solution has k routes. The i^{th} route ($i \in \{1, 2, \dots, k\}$) serves the inner customer i and the outer customer $i + k$. The min-max solution has objective $r_{MM}^k = 2 + 2\epsilon$. In fact, in any feasible solution, the route serving at least one outer customer has length no less than $2 + 2\epsilon$. Therefore, a lower bound on the optimal length of the min-max solution is $2 + 2\epsilon$. Hence, the solution in Figure 2.3(b) is optimal with respect to the min-max objective. Since $r_{MS}^k = 2k + (k + 1)\epsilon$ and $r_{MM}^k = 2 + 2\epsilon$, we have the relationship $r_{MS}^k = kr_{MM}^k - (k - 1)\epsilon$. Hence, in this instance class

$$\frac{r_{MS}^k}{r_{MM}^k} = \frac{kr_{MM}^k - (k - 1)\epsilon}{r_{MM}^k} \rightarrow k \quad \text{for } \epsilon \rightarrow 0.$$

□

Theorem 4. $\frac{z_{MM}^k}{z_{MS}^k} \leq k$ and the bound is tight.

Proof. $z_{MM}^k \leq kr_{MM}^k \leq kr_{MS}^k \leq kz_{MS}^k$. A worst-case example is displayed in Example 4. Note that Theorem 4 reduces to Theorem 2 as $k \rightarrow \infty$. Consider the following instance class with parameter ϵ :

Example 4.

- Single depot called node 0.

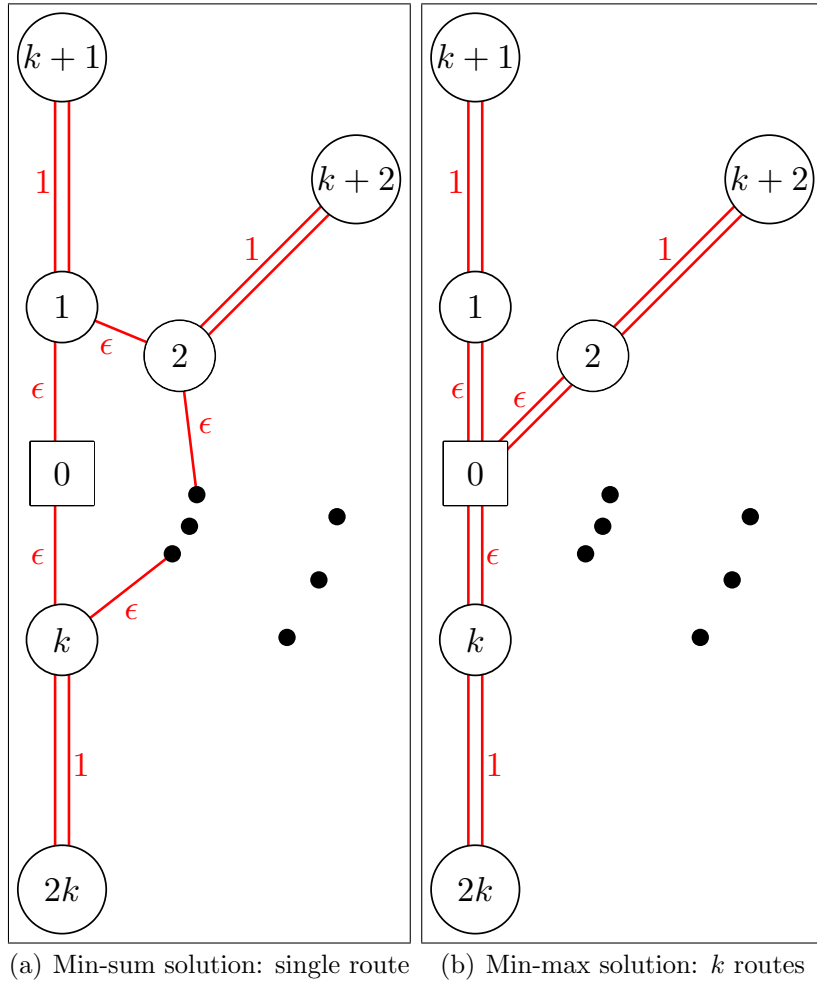


Figure 2.3: Min-sum vs. min-max optimal solutions in Example 3

- k customers (nodes 1 to k).
- Vehicle capacity: C .
- Customer demand: $d_i = \frac{C}{k}$ ($i = 1, \dots, k$).
- Depot to customer distances: $c_{0i} = 1$ ($i = 1, \dots, k$).
- Customer to customer distances $c_{ij} = \epsilon \ll 1$ ($i, j = 1, \dots, k, i \neq j$).

The optimal solutions of the min-max and the min-sum VRPs are shown in Figures 2.4(a) and 2.4(b). The min-max solution has objective $z_{MM}^k = 2k$ and the min-sum solution has objective $z_{MS}^k = 2 + \epsilon(k - 1)$. The solution in Figure 2.4(a) is optimal with respect to the min-max objective because any route serving at least one customer will have length at least 2. The solution in Figure 2.4(b) is optimal with respect to the min-sum objective because a solution with R routes, where $2 \leq R \leq k$ (R integer), has length not less than $2R + \epsilon(k - R)$. For sufficiently small ϵ , this value is greater than $2 + \epsilon(k - 1)$. Therefore, we have the relationship $z_{MM}^k = kz_{MS}^k - \epsilon k(k - 1)$. Hence, in this instance class

$$\frac{z_{MM}^k}{z_{MS}^k} = \frac{kz_{MS}^k - \epsilon k(k - 1)}{z_{MS}^k} \rightarrow k \quad \text{for } \epsilon \rightarrow 0.$$

□

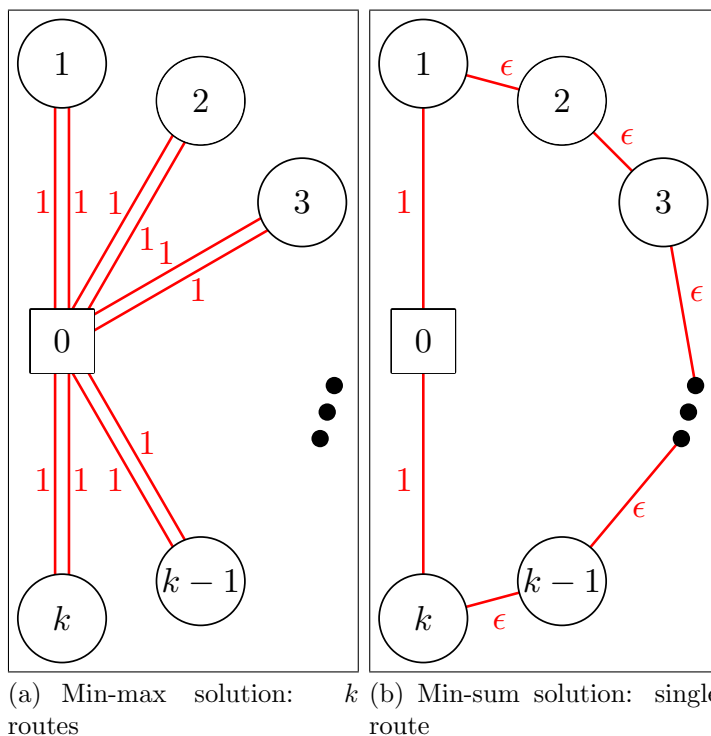


Figure 2.4: Min-max vs. min-sum optimal solutions in Example 4

2.4.2 Relation between min-max, min-sum, and route-optimal routing plans

A *route-optimal routing plan* is one in which every individual route in the plan is optimized in terms of total distance. Therefore, what differentiates two route-optimal routing plans is only the assignment of customers to the routes. The min-sum solution is obviously route-optimal. A min-max solution may not be route-optimal because, if we focus on only the maximal route, the other routes do not need to be optimal. However, among these min-max solutions, there is at least one route-optimal solution. We consider route-optimal min-max solutions in this paper.

Let us denote with r_{MM}^k the length of the longest route in the min-max so-

lution, r_{MS}^k the length of the longest route in the min-sum solution, r_R^k the length of the longest route in any route-optimal solution, z_{MM}^k the total distance of the min-max solution, z_{MS}^k the total distance of the min-sum solution, and z_R^k the total distance of any route-optimal solution.

Theorem 5. *Assume the triangle inequality is valid, then $\frac{r_R^k}{r_{MM}^k} \leq k$ and the bound is tight.*

Proof. Given a min-max solution with at most k routes, we traverse every route in a sequence. For example, as illustrated in Figure 2.5, the min-max solution has two routes. Suppose route one is $0 - 1 - 2 - 0$ and route two is $0 - 3 - 4 - 0$. The sequence is therefore $0 - 1 - 2 - 0 - 3 - 4 - 0$. The length of travel is $L = z_{MM}^k$. Then $r_R^k \leq L = z_{MM}^k \leq k r_{MM}^k$. The first inequality is valid because the maximal route of a route-optimal solution serves only a subset of the customers served by the giant route. By route-optimality and the triangle inequality, $r_R^k \leq L$. The bound is tight (see Example 3), since a min-sum solution is a route-optimal solution. \square

Remark 1. *If r_R^k is replaced by r_{MS}^k , Theorem 5 reduces to Theorem 3.*

Theorem 6. *Assume the triangle inequality is valid, then $\frac{z_R^k}{z_{MS}^k} \leq k$ and the bound is tight.*

Proof. Given a min-sum solution with at most k routes, we traverse every route in a sequence in the same manner as in the proof of Theorem 5. The length of travel is $L = z_{MS}^k$. The length of each route ρ in a route-optimal solution $r_R^{(k,\rho)} \leq L = z_{MS}^k$ because every route serves only a subset of the customers served by the

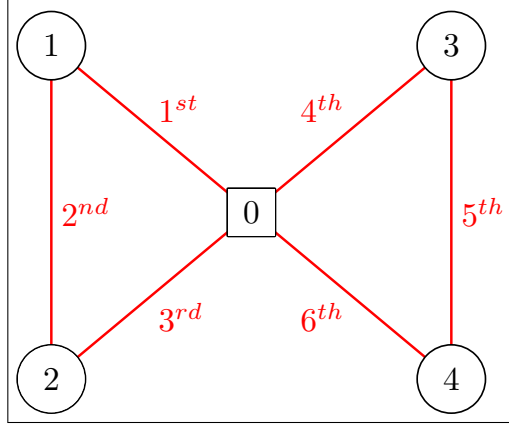


Figure 2.5: Illustrating the sequence of travel

giant route. By route-optimality and the triangle inequality, the above inequality holds. Therefore, $z_R^k = \sum_{\rho=1}^{k'} r_R^{(k,\rho)} \leq kL = kz_{MS}^k$, where $k' \leq k$ indicates the actual number of routes in a solution. The bound is tight because the min-max solution in Example 4 is a route-optimal solution. So, we can use Example 4 as our worst-case example. \square

Remark 2. If z_R^k is replaced by z_{MM}^k , Theorem 6 reduces to Theorem 4.

Remark 3. The distances must satisfy the triangle inequality, otherwise the bounds in Theorems 5 and 6 may not hold. In fact, these ratios can be arbitrarily large, as shown in Example 5.

Example 5. There are four customers and at most two vehicles. We assume that the capacity of each vehicle is greater than the sum of demands of all the customers. The distance matrix is presented in Table 2.1. Observe that the triangle inequality is violated if $M > 2$. The solution displayed in Figure 2.6(a) is optimal with respect to both the min-max and the min-sum objectives. Therefore, $r_{MM}^2 = 3$ and $z_{MS}^2 = 6$. The solution shown in Figure 2.6(b) is route-optimal and $r_R^2 = 2 + M$ and $z_R^2 =$

Nodes	0	1	2	3	4
0	-	1	1	1	1
1	1	-	M	2	1
2	1	M	-	1	2
3	1	2	1	-	M
4	1	1	2	M	-

Table 2.1: Distance matrix for Example 5

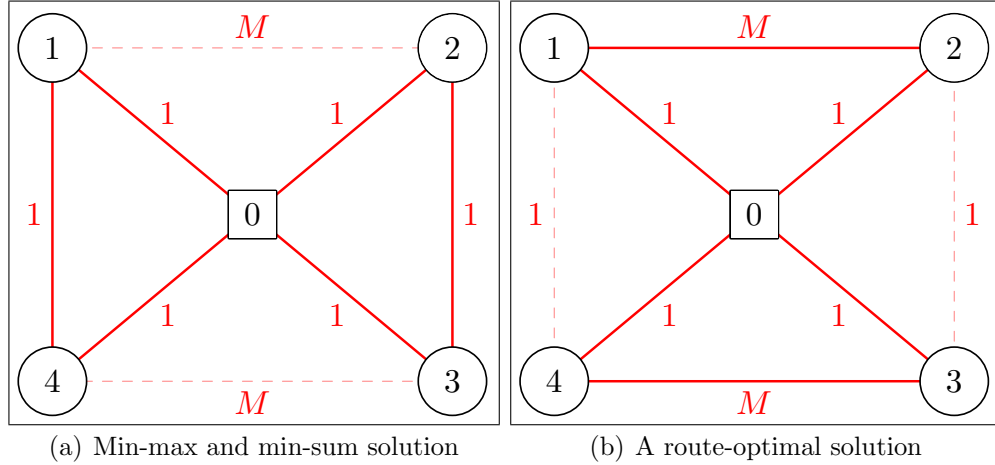


Figure 2.6: Solutions to Example 5

$4 + 2M$. The ratio $\frac{r_R^2}{r_{MM}^2} = \frac{z_R^2}{z_{MS}^2} = \frac{2+M}{3}$ can be made arbitrarily large for sufficiently big M .

2.5 Multiple TSP

In the Multiple TSP, the customers just have to be visited (i.e., no demand has to be satisfied), the capacity of each vehicle is infinite, and exactly $k \geq 2$ routes have to be determined.

Let us denote by r_{MM}^M the length of the longest route in the optimal solution of the min-max Multiple TSP, r_{MS}^M the length of the longest route in the min-sum Multiple TSP, z_{MM}^M the total distance in the optimal solution of the min-max

Multiple TSP, and z_{MS}^M the total distance in the optimal solution of the min-sum Multiple TSP.

Theorem 7. $\frac{r_{MS}^M}{r_{MM}^M} \leq k$ and the bound is tight.

Proof. $r_{MS}^M \leq z_{MS}^M \leq z_{MM}^M \leq kr_{MM}^M$. From Example 6, we see that the bound is tight. Consider the following instance class with parameter ϵ :

Example 6.

- Number of routes: $k \geq 2$.
- Single depot called node 0.
- Number of customers: $2k - 1$ (nodes $1, 2, \dots, 2k - 1$).
- Depot to customer distances: $c_{0i} = 1$ for customers $i = 1, 2, \dots, k$, while $c_{0i} = \epsilon^2$ for customers $i = k + 1, k + 2, \dots, 2k - 1$, where $\epsilon < \frac{1}{2(k-1)}$.
- Customer to customer distances: $c_{ij} = 2 - \epsilon$ for $i, j = 1, 2, \dots, k, i \neq j$, while $c_{i,k+i} = 1 - \epsilon^2$ for $i = 1, 2, \dots, k - 1$. The remaining distances satisfy the triangle inequality.

The corresponding optimal solutions are displayed in Figures 2.7(a) and 2.7(b).

An optimal solution of the min-sum Multiple TSP is as follows: Serve customers $i = 1, 2, \dots, k$ in the same route and serve customers $i = k+1, k+2, \dots, 2k-1$ directly. The total distance of this solution is $2 + (2 - \epsilon)(k - 1) + 2\epsilon^2(k - 1)$. This solution is optimal. In fact, since the triangle inequality holds, any solution in which the customers $i = 1, 2, \dots, k$ are not served in the same route has a length

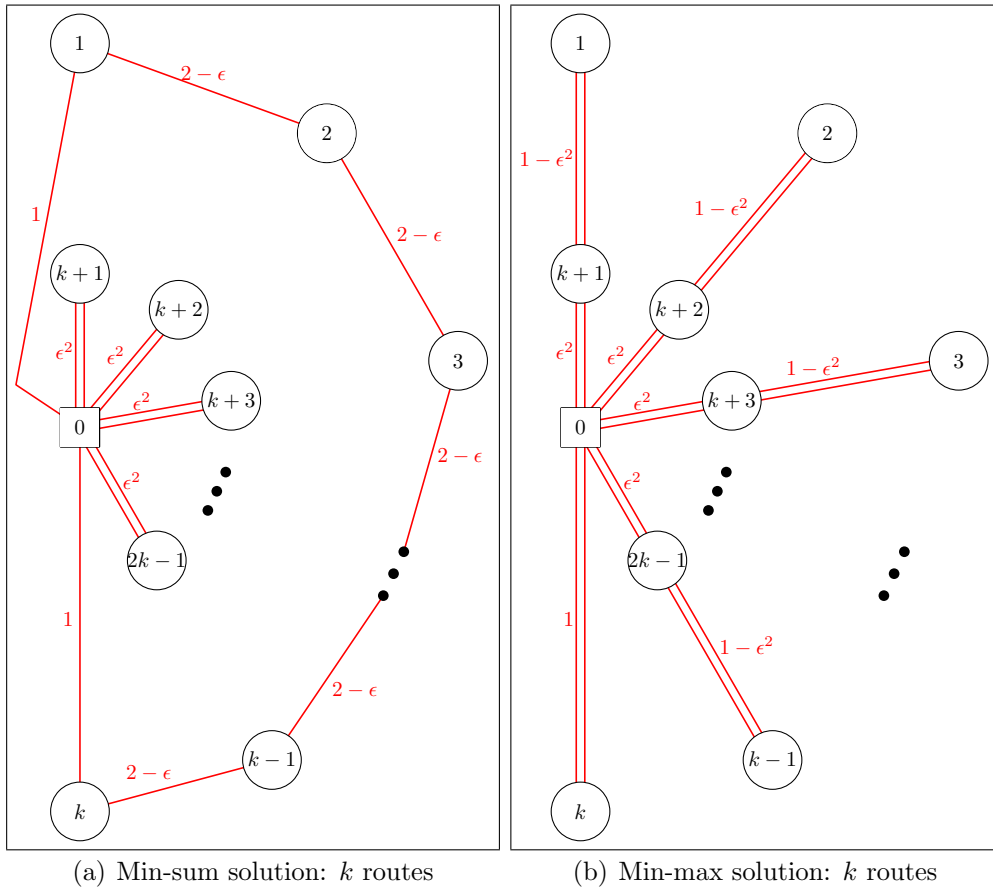


Figure 2.7: Min-sum vs. min-max optimal solutions in Example 6

at least equal to $2R + (2 - \epsilon)(k - R)$, where $2 \leq R \leq k$ (R integer) is the number of routes built to serve these customers. Since $\epsilon < \frac{1}{2(k-1)}$, $2R + (2 - \epsilon)(k - R) > 2 + (2 - \epsilon)(k - 1) + 2\epsilon^2(k - 1)$. Therefore, in any optimal solution, customers $i = 1, 2, \dots, k$ are served in the same route. Moreover, since k routes have to be built, customers $i = k + 1, k + 2, \dots, 2k - 1$ have to be served directly. Therefore, the length of the longest route is $r_{MS}^M = 2 + (2 - \epsilon)(k - 1) = 2k - \epsilon(k - 1)$.

An optimal solution of the min-max Multiple TSP is as follows: Serve customers i and $k + i$ in the same route, for $i = 1, 2, \dots, k - 1$, and serve customer k directly. The length of the corresponding longest route r_{MM}^M is 2. This solution is optimal because any route serving one of the customers $i = 1, 2, \dots, k$ has a length at least equal to 2.

Hence, in this instance class

$$\frac{r_{MS}^M}{r_{MM}^M} = \frac{2k - \epsilon(k - 1)}{2} \rightarrow k \quad \text{for } \epsilon \rightarrow 0.$$

□

Theorem 8. $\frac{z_{MM}^M}{z_{MS}^M} \leq k$ and the bound is tight.

Proof. $z_{MM}^M \leq kr_{MM}^M \leq kr_{MS}^M \leq kz_{MS}^M$. From Example 7, we see that the bound is tight. Consider the following instance class with parameter ϵ :

Example 7.

- Number of routes: $k \geq 2$.
- Single depot called node 0.

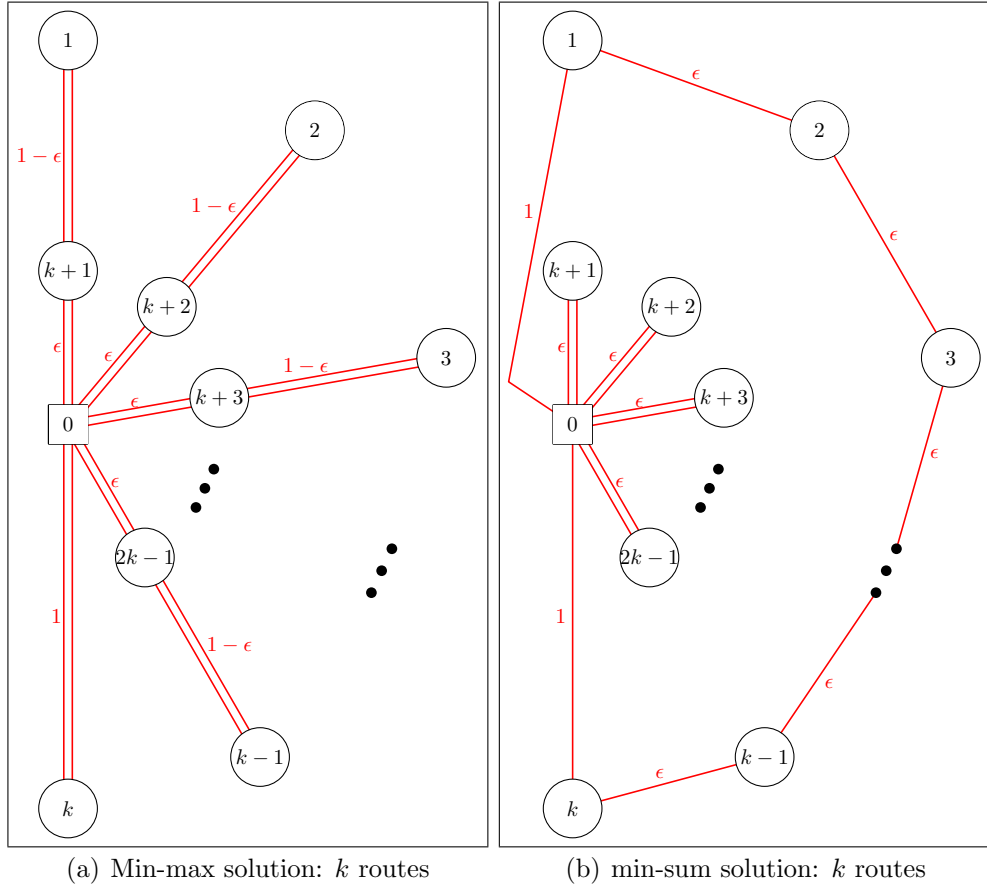


Figure 2.8: Min-max vs. min-sum optimal solutions in Example 7

- Number of customers: $2k - 1$ (nodes $1, 2, \dots, 2k - 1$).
- Depot to customer distances: $c_{0i} = 1$ for customers $i = 1, 2, \dots, k$, while $c_{0i} = \epsilon$ for customers $i = k + 1, k + 2, \dots, 2k - 1$, where $\epsilon < \frac{2}{3(k-1)}$.
- Customer to customer distances: $c_{ij} = \epsilon$ for $i, j = 1, 2, \dots, k$, $i \neq j$, while $c_{i,k+i} = 1 - \epsilon$ for $i = 1, 2, \dots, k - 1$. The remaining distances satisfy the triangle inequality.

The corresponding optimal solutions are shown in Figures 2.8(a) and 2.8(b).

An optimal solution of the min-max Multiple TSP is as follows: Serve customers i and $k + i$ in the same route, for $i = 1, 2, \dots, k - 1$, and serve customer k

directly. The length of the corresponding longest route is 2. This solution is optimal because any route serving one of the customers $i = 1, 2, \dots, k$ has a length at least equal to 2. Therefore, $z_{MM}^M = 2k$.

An optimal solution of the min-sum Multiple TSP is as follows: Serve customers $i = 1, 2, \dots, k$ in the same route and serve customers $i = k+1, k+2, \dots, 2k-1$ directly. The total distance of this solution is $2 + 3\epsilon(k-1) < 4$, as $\epsilon < \frac{2}{3(k-1)}$. This solution is optimal. In fact, any solution in which the customers $i = 1, 2, \dots, k$ are not served in the same route has a total distance at least equal to 4, as at least two routes are needed to serve these customers and the length of each of these routes is at least equal to 2. Therefore, in any optimal solution, these customers are served in the same route. Moreover, since k routes are needed to have a feasible solution, customers $i = k+1, k+2, \dots, 2k-1$ have to be served directly.

Hence, in this instance class

$$\frac{z_{MM}^M}{z_{MS}^M} = \frac{2k}{2 + 3\epsilon(k-1)} \rightarrow k \quad \text{for } \epsilon \rightarrow 0.$$

□

2.6 Service time VRP with a finite number of vehicles

In this section, we introduce a variant of the VRP in which the customer demands are given in terms of service times. Therefore, the demands contribute directly to route duration. We replace distances with travel times, so the total duration of a route is the sum of travel time and service times of the customers

visited by the route. We assume there are at most k routes and no limit on the duration of a route. Additional notation is introduced in Section 2.6.1. The goal is to compare the quality of the min-max and the min-sum solutions.

This section is organized as follows. In subsection 2.6.1, we discuss how and to what extent the routing of the Min-sum and min-max solutions will change with the addition of customer service times. In subsection 2.6.2, we explore whether the bounds for the ratios in Theorems 3 and 4 are still valid or tight when we include service times.

2.6.1 Impact of service time on min-max and min-sum solutions

Here, we provide some additional notation. Let T be the total service time of all the customers, z_{MM}^S be the total duration of the min-max solution including travel and service times, and z_{MS}^S be the total duration of the min-sum solution including travel and service times.

2.6.1.1 Invariant min-sum solution

Theorem 9. *Since no maximum route-duration constraint is assumed, the routing of the min-sum solution is unaffected by service times. Therefore, $z_{MS}^S = z_{MS}^k + T$.*

2.6.1.2 Impact on min-max solution

The routing of the min-max solution may, however, be affected by customer service times. We present three examples next. In Figure 2.9, we see that the

Nodes	0	1	2	3	4
0	-	1	1	1	1
1	1	-	2	2	1
2	1	2	-	1	2
3	1	2	1	-	2
4	1	1	2	2	-

Table 2.2: Travel time matrix for Example 8

min-max routing plan may change by adding different service times for customers. In Figure 2.10, we see that even with uniform service times, the min-max solution can change. In Figure 2.11, we see that even when the original solution is perfectly balanced (same number of customers and same travel time on every route), the solution may still change with the addition of uniform service times. Therefore we have $z_{MM}^S \neq z_{MM}^k + T$ in general.

Example 8. *There are four customers and two routes. The travel time matrix is presented in Table 2.2. Assume a service time of 1 unit for customers 1 and 4 and service time of 3 units for customers 2 and 3. The min-max solutions without and with service times are displayed in Figures 2.9(a) and 2.9(b). The travel times are labeled next to edges and the service times are labeled next to nodes. If the routing plan in Figure 2.9(a) were used in the problem with service times, the min-max value would be 9. The min-max value of the routing plan in Figure 2.9(b) is 8.*

Example 9. *There are four customers and two routes. The travel time matrix is presented in Table 2.3. Assume a uniform service time of 10 units. The min-max solutions without and with service times are displayed in Figures 2.10(a) and 2.10(b). If the routing plan in Figure 2.10(a) were used in the problem with service*

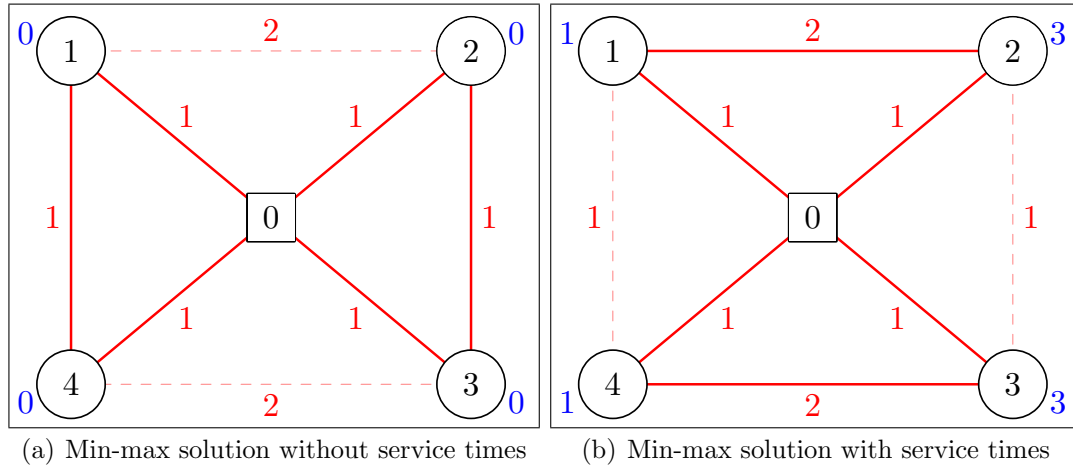


Figure 2.9: The impact of service times (Example 8)

Nodes	0	1	2	3	4
0	-	2	1	1	1
1	2	-	3	3	3
2	1	3	-	1	2
3	1	3	1	-	1
4	1	3	2	1	-

Table 2.3: Travel time matrix for Example 9

times, the min-max value would be 34. The min-max value of the routing plan in Figure 2.10(b) is 26.

Example 10. There are six customers and two routes. The travel time matrix is presented in Table 2.4. Assume a uniform service time of 10 units. The min-max solutions without and with service times are displayed in Figures 2.11(a) and 2.11(b). If the routing plan in Figure 2.11(a) were used in the problem with service times, the min-max value would be 53. The min-max value of the routing plan in Figure 2.11(b) is 45.

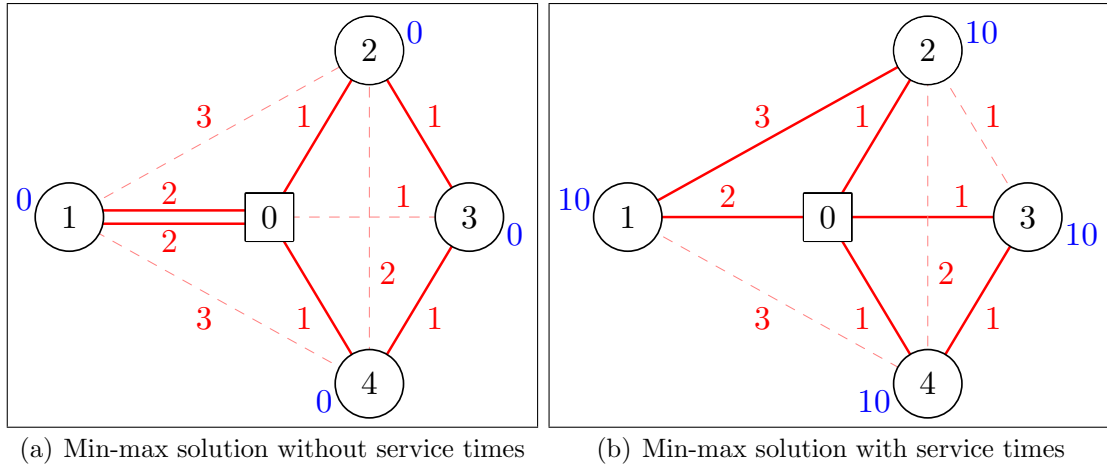


Figure 2.10: The impact of service times (Example 9)

Nodes	0	1	2	3	4	5	6
0	-	10	10	1	1	1	1
1	10	-	5	11	11	11	11
2	10	5	-	11	11	11	11
3	1	11	11	-	1	2	2
4	1	11	11	1	-	1	2
5	1	11	11	2	1	-	1
6	1	11	11	2	2	1	-

Table 2.4: Travel time matrix for Example 10

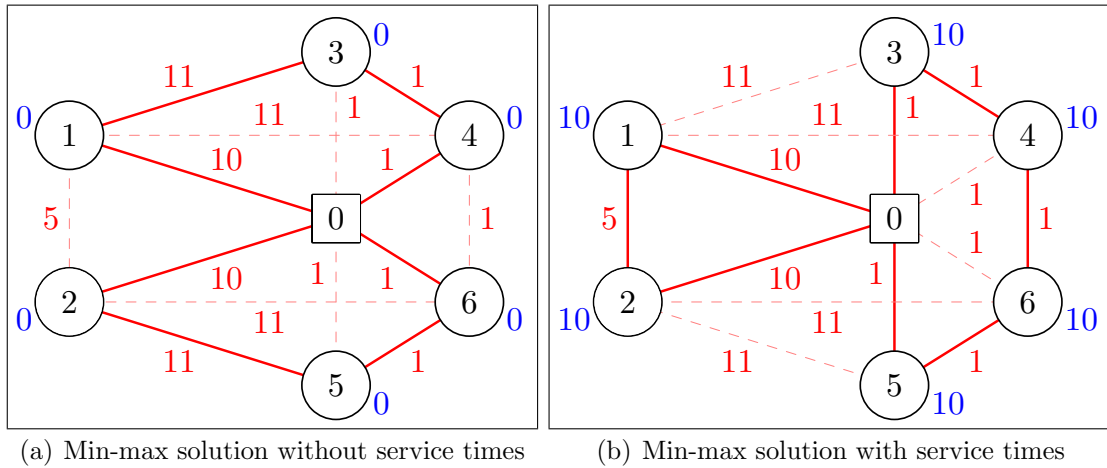


Figure 2.11: The impact of service times (Example 10)

2.6.2 Worst-case ratios with service times

In this subsection, we extend Theorems 3 and 4 to include nontrivial service times. Let r_{MS}^S be the duration of the longest route in the min-sum solution, r_{MM}^S be the duration of the longest route in the min-max solution, including travel and service times.

Theorem 10. *When we consider service times, $\frac{r_{MS}^S}{r_{MM}^S} \leq k$ and the bound is tight.*

Proof. The inequality can be proved in the same way as with Theorem 3. To show that the bound is tight, we modify Example 3, which was used to prove Theorem 3, by considering a uniform service time of t units for each customer (see Example 11).

Example 11. *The solution in Figure 2.12(a) is optimal with respect to the min-sum objective by Theorem 6, so $r_{MS}^S = 2k + 2kt + (k+1)\epsilon$. We now show that the solution in Figure 2.12(b) is optimal with respect to the min-max objective. The duration of the maximal route is the sum of three parts, the travel time and the service times of inner and outer customers.*

- *Service of the outer customers:*

The solution in Figure 2.12(b) is feasible which gives the objective function value an upper bound of $2 + 2t + 2\epsilon$. Therefore, every route in the optimal solution could serve at most one outer customer. If a route serves two or more outer customers, the duration of that route is at least $4 + 2t + 3\epsilon$. Since there are k routes and k outer customers, each route serves exactly one outer

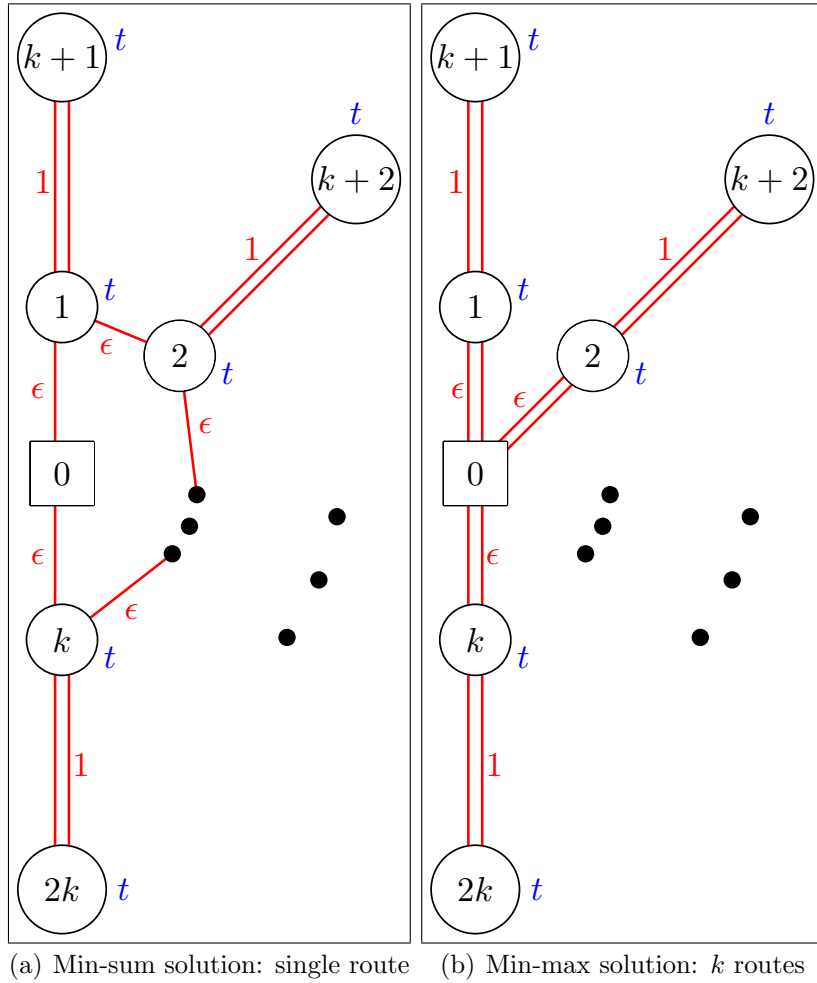


Figure 2.12: Min-sum vs. min-max optimal solutions in Example 11

customer. The service time contribution is exactly t for this one customer.

- *Travel time:*

Given that a route serves one outer customer, its travel time is at least $2 + 2\epsilon$.

- *If any route serves two or more inner customers, its duration is at least $2 + 3t + 3\epsilon$ and the solution is worse than the one in Figure 2.12(b), so all routes serve exactly one inner customer in the optimal solution. The service time contribution from each inner customer is t .*

Summing the three parts, a lower bound on the min-max objective function value is $2 + 2t + 2\epsilon$ and it is achieved by the solution in Figure 2.12(b). Hence, $r_{MM}^S = 2 + 2t + 2\epsilon$ and $r_{MS}^S = kr_{MM}^S - (k - 1)\epsilon$.

Therefore, in this instance class

$$\frac{r_{MS}^S}{r_{MM}^S} = \frac{kr_{MM}^S - (k - 1)\epsilon}{r_{MM}^S} \rightarrow k \quad \text{for } \epsilon \rightarrow 0.$$

□

Theorem 11. *Assume the triangle inequality is valid, then $z_{MM}^S \leq kz_{MS}^S - (k - 1)T$, and the bound is tight.*

Proof.

$$z_{MM}^S = z_R^k + T \quad (2.1)$$

$$\leq kz_{MS}^k + T \quad (2.2)$$

$$= k(z_{MS}^S - T) + T \quad (2.3)$$

$$= kz_{MS}^S - (k - 1)T. \quad (2.4)$$

In equation (2.1), the total duration of the min-max solution is the sum of service times and travel time. We assume that the min-max solution is route-optimal (if not, we can apply to each individual route an exact algorithm to optimally solve the corresponding TSP), which allows us to apply Theorem 6, which states that $z_R^k \leq kz_{MS}^k$, to obtain equation (2.2). From Theorem 9, we have $z_{MS}^S = z_{MS}^k + T$, which yields equation (2.3).

To show that the bound is tight, we modify Example 4, which was used to prove Theorem 4, by considering a uniform service time of $t = \frac{T}{k}$ units for each customer (see Example 12).

Example 12. *The optimal solutions of the min-max and the min-sum VRPs are shown in Figures 2.13(a) and 2.13(b). The min-max solution has objective $z_{MM}^S = 2k + T$ and the min-sum solution has objective $z_{MS}^S = 2 + \epsilon(k - 1) + T$. The solution in Figure 2.13(a) is optimal with respect to the min-max objective because any route serving at least one customer will have duration at least $2 + t$. The min-sum solution in Figure 2.13(b) has the same configuration as that in Figure 2.4(b)*

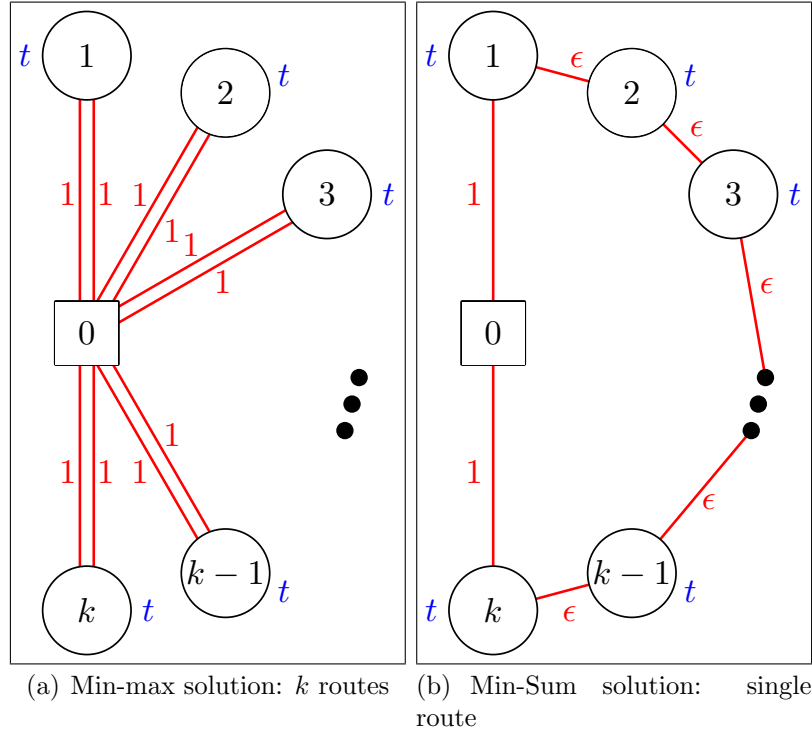


Figure 2.13: Min-max vs. min-sum optimal solutions in Example 12

because the min-sum solution is independent of service time (Theorem 9). Therefore,

$$z_{MM}^S = 2k + T = k(2 + \epsilon(k-1) + T) - k\epsilon(k-1) - (k-1)T = kz_{MS}^S - k\epsilon(k-1) - (k-1)T.$$

Hence, in this instance class

$$z_{MM}^S \rightarrow kz_{MS}^S - (k-1)T \quad \text{for } \epsilon \rightarrow 0.$$

□

Remark 4. Although the RHS of the inequality in Theorem 11 is written as a difference, it is never negative because $z_{MS}^S \geq T$. In fact the RHS is at least equal to T .

Remark 5. When $T = 0$ or $k = 1$ and the triangle inequality is valid, Theorem 11

reduces to Theorem 4.

2.7 Conclusion

In this paper, the optimal solutions of several variants of min-max and min-sum VRPs are compared from the worst-case point of view. The carried out theoretical analysis allows us to draw the following two key conclusions. The first is that the length of the longest route in the min-sum VRP problems is at most k times, where k is the number of available vehicles, the length of the longest route in the min-max VRP. Therefore, when k tends to infinity, the ratio of these two lengths tends to infinity. This motivates the need to design heuristic, metaheuristic, and matheuristic algorithms for the min-max VRP. The second conclusion concerns the comparison of the total distance of the min-max VRP with the total distance of the min-sum VRP. The worst-case analysis shows that the former total distance is at most k times, where k is the number of available vehicles, the latter total distance. Therefore, when k tends to infinity, the ratio of these two total distances tends to infinity. This implies that the aim of minimizing the longest route should be really well-justified before deciding to adopt a min-max approach. Future research can be devoted to study variants of the problems analyzed in this paper, e.g., the case with asymmetric distances, the case with a limit on the total length of a route, and the case with split delivery. Moreover, the exploration of the efficient frontier of the multi-objective VRP, with both min-sum and min-max objectives, is a promising research avenue.

Chapter 3: The Min-Max Multi-Depot Vehicle Routing without service time

3.1 Introduction

In the classic vehicle routing problem (VRP) proposed by Dantzig and Ramser [34], a fleet of vehicles needs to be routed to meet the demands of customers. Each vehicle starts and ends at the same depot. Each tour must not exceed a maximum length. The total demand of customers on a route must not exceed a vehicle's capacity. Each customer is visited exactly once, so that all demand is satisfied at one time by one vehicle. The objective is to minimize the total distance traveled by the fleet.

In the multi-depot vehicle routing problem (MDVRP), there are several depots. A vehicle must start and end at the same depot. The objective is to minimize the total distance traveled by all vehicles across the depots. The MDVRP has been studied in the literature with a variety of assumptions. For example, Chen, Golden, and Wasil [25] solved the VRP with split deliveries by applying an integer programming-based heuristic to iteratively improve the solutions. Gulczynski, Golden, and Wasil [50] solved the MDVRP with a similar integer programming-based

method but improved the solution by relocating strings of consecutive customers on the routes.

The min-max multi-depot vehicle routing problem (Min-max MDVRP) is a new variant that was recently proposed by Carlsson et al. [23]. Their objective was to minimize the distance of the longest tour. According to the authors, there are a variety of applications for the min-max MDVRP. For example, in computer networks, the depots and customers represent servers and clients, respectively. The objective is to minimize the maximum latency between a server and a client. This formulation is useful when the connection cost between a server and a client is high while the cost between clients is low. Other relevant applications include newspaper distribution and humanitarian logistics. In both cases, it is desirable that all customers be served as soon as possible. Furthermore, a solution to the min-max problem tends to be balanced, which means the route lengths are similar. From this observation, the formulation can also be applied to balance the amount of work among drivers. If each route represents trips on different working days, the min-max approach balances the workload on each working day.

There are two papers that develop procedures for the min-max MDVRP. Carlsson et al. [23] proposed four procedures and found that an LP-based heuristic with load balancing and a region partition heuristic with local improvement performed the best. In the LP-based heuristic, customers are assigned to vehicles by solving a linear program. A solver for the traveling salesman problem (TSP) is applied to generate a route from the depot where a vehicle is stationed over the customers assigned to the vehicle. In the region partition heuristic, the entire region is di-

vided into equal convex polygons with exactly one vehicle in each polygon. A TSP solver is applied to the customers in the same region. On 13 test instances with uniform customer locations, both heuristics produced nearly the same number of best solutions. Narasimha et al. [73] developed an ant colony optimization technique and, in limited computational experiments, tested it on three instances with uniform customer locations. The results were better than the LP-based heuristic with load balancing. They also demonstrated the consistency of the performance in two simulation studies on a 5-depot, 16-vehicle, 140-customer scenario with uniform customer locations.

We point out that two papers consider the min-max routing problem with a single depot. Ren [80] suggested a hybrid genetic algorithm with mountain climbing and simulated annealing in addition to crossover and mutation operators. The algorithm was applied to an instance with 20 customers. Yakici and Karasakal [99] studied a variant in which vehicles did not have to return to the depot. The fleet was heterogeneous and split deliveries were allowed.

In this chapter, we develop a heuristic (denoted by MD) that has three stages: (1) simplify the multi-depot problem into a single depot problem and solve the simplified problem; (2) improve the maximal route; (3) improve all routes by exchanging customers between routes. MD adapts the load balancing idea of Carlsson et al. [23] to generate an initial solution and continues with local search and a scheme that perturbs the current solution to break away from a local optimum. The local search and improvement procedures of MD are much different from the LP-based heuristic which concentrates on load balancing at the global level and the ant colony method

which uses parameters (heuristic desirability, pheromone updating rule, and probabilistic transition rule) to mimic real ants searching for food.

The remainder of the chapter is organized as follows. In Section 3.2, we present the LP-based, load balancing algorithm from Carlsson et al. [23]. In Section 3.3, we develop our first algorithm, denoted by MD, which incorporates the load balancing idea to initialize a solution followed by local improvements and perturbation procedures. In Section 3.4, we discuss two alternative heuristic approaches. In Section 3.5, we compare the results from the four methods on a set of test problems. Finally, we give brief concluding remarks in Section 3.6.

3.2 LP-based load balancing

Carlsson et al. [23] are the first to discuss the min-max MDVRP. The authors implemented several heuristic methods to solve this problem. Their linear programming-based load balancing method (LB) is among the best performers. LB is based on the idea that, in an optimal plan, the loads of all vehicles must be nearly balanced, that is, all vehicles travel about the same distance. Therefore, in a model with uniformly distributed customer locations, the number of customers visited by each vehicle is nearly equal. A MATLAB implementation of LB is available online ([100]).

Next, an overview of the solution procedure developed by Carlsson et al. [23] is presented. The assumptions used by the authors are then relaxed and the new implementation details are described. Given a set of m depots, indexed by j , each

with one vehicle of unlimited capacity, and a set of n customers (n divisible by m), indexed by i , uniformly distributed on a square region, the LB-based method solves the relaxation of the following binary integer program to produce a customer-vehicle assignment.

$$(IP) \quad \min \quad \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij} \quad (3.1)$$

$$\text{s.t.} \quad \sum_{j=1}^m x_{ij} = 1 \quad \forall i = 1, 2, \dots, n \quad (3.2)$$

$$\sum_{i=1}^n x_{ij} = \frac{n}{m} \quad \forall j = 1, 2, \dots, m \quad (3.3)$$

$$x_{ij} \in \{0, 1\} \quad \forall i = 1, 2, \dots, n, j = 1, 2, \dots, m \quad (3.4)$$

Constraint (2) assigns each customer i to one and only one vehicle. Constraint (3) specifies the number of customers that each vehicle can serve. The Euclidean distance between customer i and depot j is denoted by c_{ij} . The binary variable x_{ij} is equal to 1 if customer i is assigned to depot j .

After the assignment of customers to depots, an optimal TSP route is generated for each vehicle by the Concorde solver [30]. The length of route j (denoted by L_j) is stored in descending order L_1, L_2, \dots, L_m . If the lengths are nearly balanced, i.e., $\frac{L_1 - L_m}{L_m} < r$ for some predetermined r , the procedure terminates. Otherwise, IP is solved with a decreased number of customers assigned to the vehicles with longer routes and an increased number of customers assigned to the vehicles with shorter routes. This procedure is repeated until the lengths are nearly balanced or a maximum number of iterations is reached. The best solution is returned.

We now give the details of the implementation.

1. If there are multiple vehicles per depot, the locations of the vehicles are perturbed before solving IP.
2. For m and n , there exist integers p and q , such that $n = pm + q$ with $0 \leq q \leq m - 1$. The first q vehicles are assigned with $p + 1$ customers and the remaining vehicles are assigned with p customers.
3. If $\frac{L_1 - L_m}{L_m} \geq r$, denote \bar{L} as the average length of all routes, $U = \{k | L_k \geq \bar{L}\}$ as the set of long routes, and $D = \{k | L_k < \bar{L}\}$ as the set of short routes. If $|U| \leq |D|$, compute $d_j = \frac{L_j - \bar{L}}{\bar{L}}$ which is the relative drift defined by Carlsson et al. [23]. For each $j \in U$, decrease the number of customers assigned to vehicle j by $\lfloor \frac{\alpha d_j}{r} \rfloor$, where α is set to 2 by the authors. For each $j \in D$, increase the number of customers assigned to vehicle j by $\lfloor \frac{\alpha d_j}{r} \rfloor$. If the number of customers removed from U is more than those added to D , add one customer to each element in D sequentially from the vehicle with the fewest nodes. A similar procedure is used when $|U| > |D|$.

We have two observations about LB.

1. LB starts with an initial solution based on the load balancing idea and performs refinement by global adjustment. It is faster than methods that include local improvement. The running time seems to be independent of the size of the problem.
2. Empirically, LB performs relatively well for uniformly distributed customer

locations, but does not do well if the customer locations are not generated uniformly. It also does not perform well if there are multiple vehicles at a depot.

3.3 MD algorithm

Our algorithm (MD) for the min-max MDVRP uses three stages to produce solutions: initialization, local search, and improvement by perturbation. The first stage produces a feasible solution. The second stage uses a procedure repeatedly to improve an existing solution and generate a local optimum. The third stage perturbs the solution to search for better solutions. Next, we describe the three stages in detail. We illustrate MD by applying it to an example in [Appendix A](#).

3.3.1 Initialization

MD applies the load balancing idea from [\[23\]](#) to construct an initial solution in two steps.

3.3.1.1 Step 1: Assignment

Given a set of m depots, indexed by j , each with one vehicle of unlimited capacity, and a set of n customers (n divisible by m), indexed by i , distributed over a square region, we solve IP using Gurobi [\[52\]](#) to produce an initial assignment of customers to vehicles.

If there is only one depot and there is more than one vehicle at the depot,

all possible assignments of customers to the vehicles produce the same objective function value for IP. A similar problem exists if there are multiple depots and some of them have more than one vehicle. To avoid this, we perturb the location of any depot having multiple vehicles. We call this the specification of the vehicle locations. Vehicles are placed symmetrically on a circle centered at the depot with a small radius (0.1 is used in our implementation). The vehicles are rotated counter-clockwise around the depot using a randomly specified angle.

3.3.1.2 Step 2: Solving the TSP

A vehicle and the customers assigned to it form a group of nodes. The Lin-Kernighan-Helsgaun (LKH) solver [55] is used to obtain a near-optimal TSP tour on the group of nodes. Each tour is called a route. The tour with the longest length is called the maximal route. The objective is to minimize the length of the maximal route. We modified an initialization procedure described by Golden, Magnanti, and Nguyen. [47] that was used by Gulczynski, Golden, and Wasil [50]. This method assigns customers to depots in two rounds. In the first round, if the distance from a customer to its nearest depot is much shorter than the distance to its second nearest depot, this customer is assigned to its nearest depot. In the second round, those customers that are unassigned are allocated to one of their two nearest depots (the depot with the shorter route). This method did not perform as well as the load balancing procedure.

3.3.2 Local search

We perform a local search on the maximal route. The idea is to remove a customer from the maximal route and insert it onto another route. This approach has three steps.

First, we need to determine the customer to remove from the maximal route. For each customer on the maximal route, the reduction of route length, or savings, is estimated if that customer is removed. Suppose the customer located at (x_i, y_i) is preceded by customer (x_{i-1}, y_{i-1}) and followed by customer (x_{i+1}, y_{i+1}) . Either the preceding customer or the succeeding customer may be a depot in the analysis. The savings is estimated to be

$$\text{dist}((x_i, y_i), (x_{i-1}, y_{i-1})) + \text{dist}((x_i, y_i), (x_{i+1}, y_{i+1})) - \text{dist}((x_{i+1}, y_{i+1}), (x_{i-1}, y_{i-1})), \quad (3.5)$$

where $\text{dist}((P_1, P_2))$ is the Euclidean distance between points P_1 and P_2 . The estimated savings is conservative and the actual savings can be greater. We generate a sequence of customers arranged in descending order of their savings. The customer with the largest estimated savings on the maximal route is removed first.

Second, we identify the route on which to insert the customer. The insertion cost is the increase in the length of the route due to the insertion of the customer. The insertion cost is estimated in the following way. Assume customers located at (x_{i-1}, y_{i-1}) and (x_{i+1}, y_{i+1}) are adjacent nodes on the same route. If the customer located at (x_i, y_i) is inserted between them, the insertion cost is also given by (3.5).

The cost of inserting the customer onto a route is estimated to be the least cost considering all adjacent pairs of nodes on the route. This is a conservative estimate and the actual cost may be smaller. The customer is inserted onto the route with the least insertion cost.

Third, the LKH solver is used to solve the TSP on the old maximal route with the customer removed and on the new route with the customer inserted. If the length of the new maximal route is less than the length of the previous maximal route, the solution is updated. We continue to compute the savings of each customer on the maximal route. If the objective function is not improved, we try to remove the customer on the maximal route with the second largest savings. The local improvement procedure ends when all the customers on the maximal route have been considered and no improvement is found.

3.3.3 Perturbation

The solution generated so far is a local minimum. It cannot be improved any further by assigning a customer on the maximal route to other routes. To move away from the local minimum, we apply the idea described by Codenotti et al. [29] to generate a new solution by perturbing the locations of the depots. For each depot, we compute the average of its distances from the preceding customer (last customer on the route) and the succeeding customer (first customer on the route). The depot is then relocated to a location at this average distance away from its original position. The angle of the first perturbation or the direction in which we move the depot is

random. We keep the same sequence of customer visits in the feasible solution to the original problem to obtain a feasible solution to the perturbed problem. The solution may not be optimal or even locally optimal, so we apply the local search procedure to get a locally optimal solution. The depots are then set to their original positions to recover the original problem. Our local search procedure is applied to generate a different solution from the solution before perturbation. If it improves, the solution is updated. This completes one perturbation. In our implementation, the perturbation procedure is carried out until there is no improvement for five consecutive iterations. The angle of each subsequent perturbation depends on the previous one. The second is at an angle of 144° from the first one, the third is at an angle of 144° to the second, and so on. The sixth direction is the same as the first direction. When perturbation stops, we have good coverage of the perturbation directions and consecutive directions are almost opposite each other.

3.4 Alternative methods

In this section, we present two alternative methods for generating solutions. In Section 3.4.1, the improvement stages of MD are replaced by variable neighborhood search (VNS). In Section 3.4.2, the initialization stage of MD is replaced by one which makes use of a library for solving the standard VRP (minimize the total distance traveled by the fleet).

3.4.1 VNS

3.4.1.1 Local Search

The local search procedure for VNS (LSVNS) is similar to the local search procedure for MD (LSMD). Both procedures improve a solution by removing a customer on the maximal route and inserting it onto another route. First, we estimate the savings generated by the removal of each customer on the maximal route. The three customers with the greatest potential savings are candidates for removal. A random number is drawn from a uniform distribution so that each of the three candidates is selected with equal probability.

We try to insert the removed customer onto other routes with the smallest estimated cost. We apply the LKH solver to the newly constructed route (old route plus the inserted customer). If the total cost of the new route is less than the old route, an improved solution is found. We apply the LKH solver to the old maximal route. Across all routes, we try to find the new maximal route and we repeat removing one of the three most costly customers on that route. If the total cost of the route after accepting the customer is greater than the old objective function value, the move is rejected and no improved solution is found. We return to the maximal route and try to remove another candidate customer. (The same customer may be chosen with a probability of 0.33). If no improvement is found in five consecutive trials, LSVNS terminates.

LSVNS differs from LSMD in three ways.

1. LSMD always tries to remove a customer with the greatest potential savings among all unexplored customers on the maximal route. LSVNS randomly tries to remove one of the three customers with the greatest potential savings.
2. LSMD explores the customers on the maximal route in a defined sequence (decreasing estimated savings). LSVNS randomly picks one of the three customers with the greatest potential savings.
3. LSMD terminates after exploring all the customers on the maximal route without improving the solution. LSVNS terminates after five consecutive iterations without an improvement.

3.4.1.2 Neighborhood structure

Solution B is in the first neighborhood (Nbr1) of solution A if it can be obtained from solution A by swapping a customer on the maximal route with a customer not on the maximal route. In the basic VNS [54], a random solution from a neighborhood is generated and local search is then applied. In our implementation of VNS, three promising solutions from Nbr1 are identified deterministically, and we randomly select one of the three solutions with equal probability. For each customer on the maximal route, we find the nearest neighbor not on the maximal route. We compute the distance from this nearest customer and select the three customers with the shortest distances. Each of the three candidate solutions is obtained by swapping one of these three customers with a neighbor. We apply the LKH solver to the affected routes immediately after the swap.

Solution C is in the second neighborhood (Nbr2) of solution A if it can be obtained by moving a fragment of two or three consecutive customers from the maximal route to some other route. Two random numbers are generated. One number determines the length of the fragment to remove (two or three customers), and the other number determines the position of the fragment on the maximal route. We now need to determine where to insert the fragment. For all customers on the fragment, we find their nearest customers not on the maximal route. If there is any common neighbor (there can be at most one), we insert the entire fragment before this common neighbor. If the two or three neighbors are distinct, we insert the entire fragment before one of the neighboring customers according to a probability distribution. If the distance between the fragment and a neighboring customer is given by the distance from the neighbor to its nearest customer on the fragment, then the probability of inserting the fragment in front of a neighboring customer is proportional to the sum of the other neighbors' distances from the fragment. For example, suppose customers 1, 2, and 3 are the three neighbors which are at a distance of 10, 10, and 30 away from the fragment, respectively. Then the probabilities of inserting the fragment before customers 1, 2, and 3 have the ratio 40 : 40 : 20, which corresponds to a probability distribution of 0.4, 0.4, and 0.2. In our implementation, we apply the LKH solver to the affected routes immediately after the insertion.

3.4.1.3 VNS algorithm

In the basic VNS algorithm, neighborhoods are ordered 1 through n . If the local search procedure does not improve a random solution from the k^{th} neighborhood, another random solution is generated from the $(k + 1)^{\text{st}}$ neighborhood. When a solution from the n^{th} neighborhood does not lead to an improvement, the algorithm terminates. In our implementation of VNS, there are only two neighborhoods. We do not move to the next neighborhood or terminate the algorithm immediately when a solution does not lead to an improvement. If the first solution from the first neighborhood does not improve the current solution, we generate a second solution from the same neighborhood. If the second solution does not improve the current solution, we generate a third one and so on until we have produced five solutions from the first neighborhood. We then move to the second neighborhood. We do not terminate the algorithm until we have generated 20 solutions from the second neighborhood and none of them leads to an improvement. Our VNS algorithm is shown in Table 3.1.

3.4.2 VRPH

This approach uses the local search heuristic library for the standard VRP developed by Chris Groër (see [48]) and denoted by VRPH. First, customers are assigned to depots (not vehicles) by a procedure described in Golden, Magnanti, and Nguyen [47]. A customer is assigned to the nearest depot unless the customer is about the same distance from its nearest and second nearest depots. Subsequently,

Table 3.1: VNS algorithm

Given an initial feasible solution x .	
1. $x \leftarrow \text{LSVNS}(x)$	4. Set $k = 0$
2. Set $k = 0$	5. While $k < 20$
3. While $k < 5$	(a) $x_2 \leftarrow \text{Nbr2}(x)$
(a) $x_1 \leftarrow \text{Nbr1}(x)$	(b) $x_2 \leftarrow \text{LSVNS}(x_2)$
(b) $x_1 \leftarrow \text{LSVNS}(x_1)$	(c) If x_2 is better than x
(c) If x_1 is better than x	i $x \leftarrow x_2$
i. $x \leftarrow x_1$	ii Go to step 2
ii. Go to step 2	else
else	i $k++$
i $k++$	end if
end if	end while
end while	

those customers are assigned to one of the two nearest depots depending which depot has a shorter route.

Second, the depot with its assigned customers is a single depot VRP. We use VRPH to solve this problem. The customer demands are set to 1. The capacity of the vehicle is set so that the number of routes in the VRPH solution matches the number of vehicles in that depot in the min-max problem. We then generate an initial feasible solution and we carry out the second and third stages of MD.

3.5 Computational results

In this section, we apply four heuristics (LB, MD, VNS, and VRPH) to a set of test instances and compare their results. The code for LB is given in [100]. We point out that neither the code nor the test instances for the ant colony optimization technique are available.

3.5.1 Comparing LB, MD, VNS, and VRPH

Twenty sets of data were generated with varying numbers of depots, customers, and vehicles per depot (five were supplied by Carlsson in a personal communication). The locations of customers and depots for each data set are given in the online appendix. The detailed computational results are given in Table 3.2. MD, VNS, and VRPH used an Intel Pentium CPU with a 2.20GHz processor, while LB used an Intel Core i3 CPU with a 2.40GHz processor (the MATLAB code from [100] for LB could only be implemented on a 32-bit machine).

In Table 3.2, the first column shows the problem identifier. The second and the third columns give the number of depots and the number of customers. The fourth column gives the number of vehicles per depot: 1 means a single vehicle per depot, 2 means there are two vehicles per depot, and 3, 2, 2, 1 means there are three vehicles at the first depot, two vehicles at the second and third depots, and a single vehicle at the fourth depot. The fifth to the twelfth columns give computational results for the four algorithms (LB, MD, VNS, VRPH). All algorithms produce the same solution to MM6 which appears to be optimal, based on geometric considerations. However, the resulting objective function values are not identical. This could be due to the accumulation of rounding error from the TSP solver. Specifically, the LKH solver produces only integer lengths.

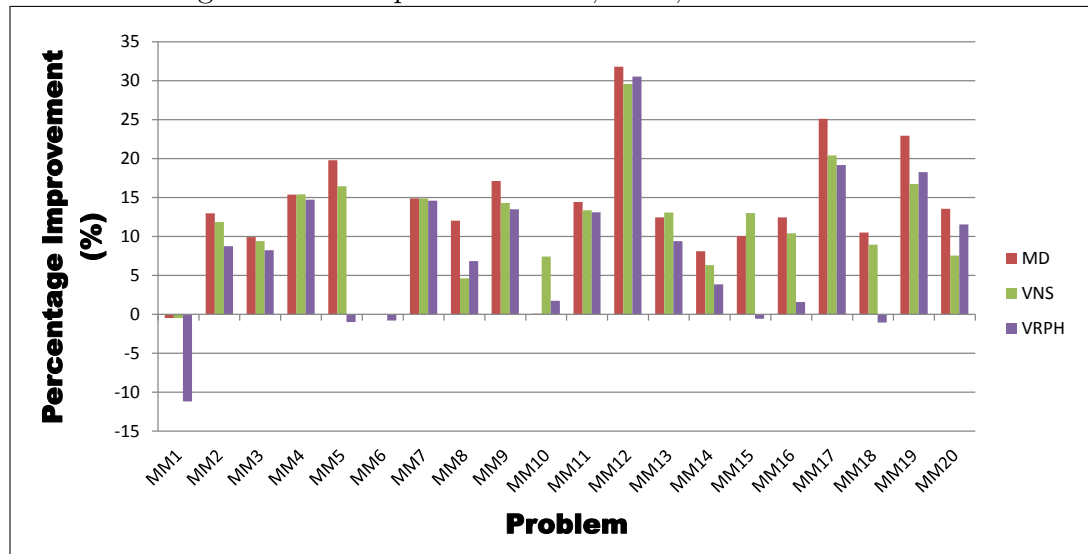
In Figure 3.1, we show the percentage improvement of the objective function values of MD, VNS, and VRPH compared to LB. For each test instance, the three

Table 3.2: Computational results for LB, MD, VNS, and VRPH

Problem identifier	Size of data		LB		MD		VNS		VRPH		
	Number of depots	Number of customers	Number of vehicles per depot	Objective function values	Running time (s)	Objective function values	Running time (s)	Objective function values	Running time (s)	function values	Running time (s)
MM1	3	10	1	<i>170.109</i>	21.750	170.909	1	170.909	1	189.1	2.4
MM2	10	200	1	149.225	38.188	<i>130.800</i>	11	131.497	6	136.1	26.6
MM3	5	200	1	265.349	61.359	<i>238.973</i>	18	240.397	13	243.5	44.7
MM4	5	395	1	569.453	43.859	<i>479.676</i>	18	481.595	340	485.6	308.4
MM5	10	390	1	398.970	40.219	<i>315.889</i>	33	333.376	18	402.9	68.7
MM6	4	400	1	<i>82.187</i>	6.0470	82.226	44	82.226	16	82.8	104.1
MM7	1	25	3	222.071	14.469	<i>189.016</i>	2	<i>189.016</i>	5	189.6	2.5
MM8	3	200	2	242.730	73.187	<i>217.383</i>	30	231.493	27	226.1	38.6
MM9	4	400	3, 2, 2, 1	183.157	36.797	<i>152.504</i>	112	156.972	57	158.4	150.7
MM10	5	50	1	197.594	32.859	197.390	4	<i>182.926</i>	9	194.2	8.9
MM11	10	100	1	119.658	78.516	<i>102.346</i>	3	103.663	8	104.0	10.0
MM12	15	100	1	114.826	37.859	<i>78.903</i>	3	80.828	5	79.7	11.5
MM13	10	150	1	138.823	35.782	121.872	5	<i>120.688</i>	11	125.8	14.6
MM14	10	200	1	146.492	35.531	<i>134.613</i>	8	137.219	11	140.8	23.0
MM15	15	200	1	110.963	41.031	99.805	5	<i>96.524</i>	7	111.6	14.6
MM16	20	500	1	115.744	60.171	<i>101.680</i>	23	103.696	28	113.9	52.8
MM17	2	350	2	325.708	56.793	<i>248.588</i>	235	259.255	28	263.2	340.3
MM18	2	400	1, 3	439.606	68.371	<i>390.160</i>	619	400.269	58	444.2	323.0
MM19	3	400	1, 1, 2	474.935	68.379	<i>365.657</i>	616	395.371	159	388.1	404.5
MM20	3	500	1, 2, 2	385.297	92.140	<i>339.920</i>	360	356.176	152	340.8	472.5
Number of best solutions				2		15		4			0

Italics indicates best solution.

Figure 3.1: Comparison of MD, VNS, and VRPH to LB



bars show results, from left to right, of MD, VNS, and VRPH. For example, for MM5, the objective function value of the solution produced by MD is 20% less than the objective function value produced by LB. In most of the instances, MD, VNS, and VRPH outperform LB, and MD is the most effective in terms of objective function value. On average, over the 20 instances, MD outperforms LB by 12.89%, VNS outperforms LB by 11.67%, and VRPH outperforms LB by 8.1%. It is surprising that VNS is not as effective as MD which relies on simple local search and a perturbation technique. If we apply the second and the third stages to solutions produced by VNS, the final result will outperform MD by only 0.7%. Over the 20 instances, MD produces 15 best solutions, followed by VNS, which produces four best solutions. LB produces two best solutions and VRPH produces none.

Data sets MM2, MM3, MM7, MM8, MM10 to MM16, and MM18 are generated by a uniform distribution of customer locations. On these 12 data sets, the average improvement by MD over LB is 12.27%. Data sets MM4, MM5, MM9, MM17,

MM19, and MM20 are generated by non-uniform distributions of customer locations. The average improvement by MD over LB is 18.51%. MD outperforms LB to a greater extent when the distribution of customers is not uniform.

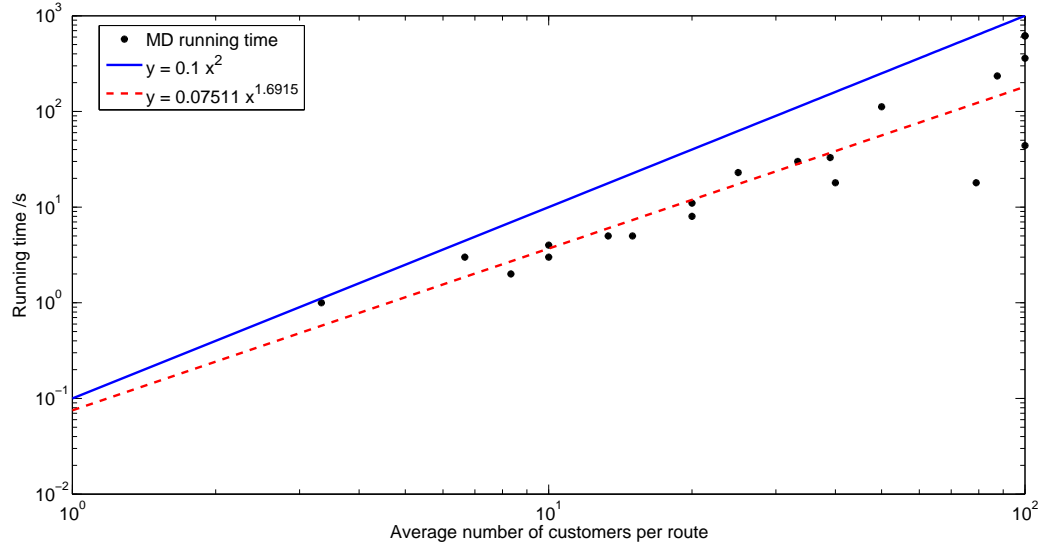
In Table 3.3, we give a detailed account of the improvements contributed by three steps in MD. Columns two, three, and four show the objective function value of the feasible solution at the end of initialization, local search, and perturbation. Columns five and six give the amount of improvement and the percentage of total improvement of the final solution with respect to the initial solution. Columns seven and eight give the improvement due to local search (Step 2). Columns nine and ten give the improvement due to perturbation (Step 3). To illustrate, for problem MM20, MD produces an initial solution value of 391.043. After local search, the value is 346.700 which is a decrease of 11.34%. After perturbation, the value is 339.920 which is a decrease of 1.73%. On average, over all 20 problems, the improvement procedures of MD decrease the value of the initial solution by 19.23% (16.12% is from local search and 3.11% is from perturbation).

The running time for MD increases as the average number of customers per route increases. In Figure 3.2, we plot the running time for MD against the average number of customers per route together with $y = 0.1x^2$ and the best fit $y = 0.07511x^{1.6915}$ on a logarithmic scale. On these 20 instances, the worst-case growth in running time is bounded quadratically. The average growth in running time is of the order 1.7 with $R^2 = 0.8377$. It is not straightforward to compare the running times for LB and MD. LB is implemented in MATLAB, while MD is imple-

Table 3.3: Contributions of local search and perturbation in MD

Problem identifier	Objective function values after				Improvement					
	Local search		Perturbation		Total		Local search		Perturbation	
	Initialization	Local search	Local search	Perturbation	Value	Percent (%)	Value	Percent (%)	Value	Percent (%)
MM1	219.445	170.909	170.909	170.909	48.536	22.12	48.536	22.12	0.000	0.00
MM2	158.173	135.431	130.800	130.800	27.373	17.31	22.742	14.38	4.631	2.93
MM3	278.069	241.356	238.937	238.937	39.132	14.07	36.713	13.20	2.419	0.87
MM4	646.377	499.517	479.676	479.676	171.737	26.57	146.860	22.72	24.877	3.85
MM5	429.563	338.428	315.889	315.889	113.674	26.46	91.135	21.22	22.539	5.25
MM6	82.226	82.226	82.226	82.226	0.000	0.00	0.000	0.00	0.000	0.00
MM7	198.411	192.798	189.016	189.016	9.395	4.74	5.613	2.83	3.782	1.91
MM8	257.131	242.365	217.383	217.383	44.413	16.71	31.077	11.69	13.336	5.02
MM9	194.311	153.739	153.739	153.739	40.572	20.88	40.572	20.88	0.000	0.00
MM10	236.766	197.894	197.390	197.390	39.376	16.63	38.872	16.42	0.504	0.21
MM11	161.146	116.939	102.346	102.346	58.800	36.49	44.207	27.43	14.593	9.06
MM12	109.011	88.814	78.903	78.903	30.108	27.62	20.197	18.53	9.9112	9.09
MM13	216.704	139.423	121.872	121.872	94.832	43.76	77.281	35.66	17.551	8.10
MM14	161.166	137.986	134.613	134.613	26.737	16.59	23.180	14.38	3.557	2.21
MM15	117.301	100.258	99.805	99.805	17.496	14.92	17.043	14.53	0.453	0.39
MM16	125.900	105.775	101.680	101.680	24.220	19.24	20.125	15.98	4.095	3.25
MM17	281.897	260.477	248.588	248.588	39.668	13.57	30.926	10.58	8.742	2.99
MM18	421.670	392.673	390.160	390.160	30.158	7.05	20.829	4.87	9.329	2.18
MM19	522.391	399.656	365.657	365.657	139.903	26.78	123.125	23.57	16.778	3.21
MM20	391.043	346.700	339.920	339.920	51.123	13.07	44.343	11.34	6.780	1.73
Average						19.23		16.12		3.11

Figure 3.2: MD running time against average number of customers per route



mented in C++. The 32-bit requirement of MATLAB forced us to solve problems with LB and MD on different machines (they are very close in processor speed). However, we observe that MD runs faster when the average number of customers per route is small (less than 40).

3.5.2 Detailed comparison of MD and VNS

3.5.2.1 New data sets

We now focus our attention on the two best-performing methods (MD, VNS) and examine their performance on instances with specific distributions of customer locations and customer-to-vehicle ratios (number of customers divided by the number of vehicles).

We generated an additional 23 test instances and combined them with 17 instances from MM1 to MM20 (we did not use the two smallest problems, MM1

and MM7, and a highly symmetric problem, MM6). The 40 test instances are grouped into four categories with 10 instances each based on the distribution of customer locations and size of the customer-to-vehicle ratios. We applied MD and VNS to these 40 instances and report the results in Tables 3.4 to 3.7. We retain the problem identifier for instances 1 to 20 and denote the additional test instances by 21 to 43. The locations of customers and depots for the additional test instances are given in appendix B.

In Table 3.4, customers are uniformly located and the customer-to-vehicle ratio is less than 40. A small ratio implies that the average number of customers per route is small. The first column gives the problem identifier. The second column gives the customer-to-vehicle ratio. All ratios are less than or equal to 40. The third and fourth columns give the objective function values of the MD and VNS solutions, respectively. The fifth column compares the result of MD to VNS. A negative percentage indicates that MD underperforms VNS. Overall, the two methods perform about the same. MD is slightly better than VNS by 0.22%, on average. On the instances where VNS outperforms MD (MM10, MM13, and MM15), the customer-to-vehicle ratios tend to be small, 10, 15, and 13.3, respectively.

In Table 3.5, customers are uniformly distributed and the customer-to-vehicle ratio is high (greater than or equal to 50). MD outperforms VNS on all 10 instances. On average, MD is better than VNS by 2.47%.

In Table 3.6, the customer-to-vehicle ratios are less than or equal to 40. On average, MD is slightly better than VNS by 0.05%. In Table 3.7, when the average number of customers per route is large, MD produces solutions which are better

Table 3.4: MD vs VNS on uniform customer locations and small customer-to-vehicle ratios

Uniform small	Customer-to-vehicle ratio	MD	VNS	% MD outperforms VNS
MM2	20.0	<i>130.80</i>	131.50	0.53
MM3	40.0	<i>238.94</i>	240.40	0.61
MM8	33.3	<i>217.38</i>	231.49	6.10
MM10	10.0	197.89	<i>182.93</i>	-8.18
MM11	10.0	<i>102.35</i>	103.66	1.27
MM12	6.7	<i>78.90</i>	80.83	2.38
MM13	15.0	121.87	<i>120.69</i>	-0.98
MM14	20.0	<i>134.61</i>	137.22	1.90
MM15	13.3	99.81	<i>96.52</i>	-3.40
MM16	25.0	<i>101.68</i>	103.70	1.94
# best solutions		7	3	
Average	19.3			0.22

Note: Italics indicate better solutions.

Table 3.5: MD vs VNS on uniform customer locations and large customer-to-vehicle ratios

Uniform small	Customer-to-vehicle ratio	MD	VNS	% MD outperforms VNS
MM5	100.0	<i>390.16</i>	400.27	2.53
MM21	50.0	<i>259.14</i>	274.10	5.46
MM22	83.3	<i>400.60</i>	413.27	3.07
MM23	66.7	<i>374.97</i>	378.71	0.99
MM24	50.0	<i>204.00</i>	206.22	1.08
MM25	66.7	<i>272.61</i>	274.84	0.81
MM26	75.0	<i>364.56</i>	369.10	1.23
MM27	50.0	<i>290.37</i>	298.46	2.71
MM28	100.0	<i>354.31</i>	367.72	3.65
MM29	87.5	<i>364.01</i>	376.18	3.24
# best solutions		10	0	
Average	72.9			2.47

Note: Italics indicate better solutions.

Table 3.6: MD vs VNS on non-uniform customer locations and small customer-to-vehicle ratios

Uniform small	Customer-to -vehicle ratio	MD	VNS	% MD outperforms VNS
MM18	39.0	<i>315.89</i>	333.38	5.25
MM30	40.0	<i>140.34</i>	149.54	6.16
MM31	20.0	124.32	<i>112.52</i>	-10.49
MM32	10.0	103.15	<i>98.45</i>	-4.78
MM33	13.3	<i>97.56</i>	100.93	3.34
MM34	25.0	<i>84.64</i>	85.58	1.09
MM35	15.0	109.30	<i>107.86</i>	-1.34
MM36	33.3	155.99	<i>153.27</i>	-1.77
MM37	23.3	156.41	<i>151.19</i>	-3.46
MM38	33.3	<i>155.46</i>	166.30	6.52
# best solutions		5	5	
Average	25.22			0.05

Note: Italics indicate better solutions.

than VNS by 2.42%, on average.

Based on our computational experiments, MD outperforms VNS by about 2.4%, on average, when the customer-to-vehicle ratios are large for both uniform and non-uniform distributions of customers. For small ratios, MD and VNS perform nearly the same, on average, for both types of customer distributions.

3.5.2.2 Practical data

We apply MD and VNS to a real-world instance (problem real01 given in [98]). The original problem has a single depot and 914 customers. We modify this problem and treat the first nine customer locations as depots. We now have a multi-depot problem with 10 depots and 905 customers. The coordinates are scaled by a factor of 10^{-4} . MD generates a solution with an objective function value of 9893.52 in

Table 3.7: MD vs VNS on non-uniform customer locations and large customer-to-vehicle ratios

Uniform small	Customer-to -vehicle ratio	MD	VNS	% MD outperforms VNS
MM4	79.0	<i>479.68</i>	481.60	0.40
MM9	50.0	<i>153.74</i>	156.97	2.06
MM17	87.5	<i>248.59</i>	259.26	4.11
MM19	100.0	<i>365.66</i>	395.37	7.52
MM20	100.0	<i>339.92</i>	356.18	4.56
MM39	50.0	<i>209.85</i>	223.67	6.18
MM40	66.7	<i>243.47</i>	250.68	2.88
MM41	83.3	257.16	<i>255.27</i>	-0.74
MM42	90.0	367.44	<i>357.17</i>	-2.88
MM43	87.5	<i>375.16</i>	375.55	0.10
# best solutions		8	2	
Average	79.4			2.42

Note: Italics indicate better solutions.

2005 seconds and VNS generates a solution with objective function value 10907.6 in 1892 seconds. MD outperforms VNS by 9.3% on this instance.

3.6 Conclusions

We developed three heuristic procedures (MD, VNS, VRPH) for the min-max MDVRP. We applied these three procedures and an existing heuristic based on load balancing (LB) to 20 test instances with 10 to 500 customers and 1 to 20 depots. Among the four procedures, MD produced 15 best solutions. Furthermore, computational experiments on instances with various distributions of customers and different ratios of customers to vehicles showed that MD was very effective in producing high-quality results.

In future work, we would like to extend the min-max MDVRP to handle

the service time at each customer and apply our heuristic to additional real-world problems.

Chapter 4: The Min-Max Multi-Depot Vehicle Routing with service

4.1 Introduction

The classical Vehicle Routing Problem (VRP) models the distribution of goods from a single depot to the customers. A customer has a demand that must be satisfied in full by one visit of a vehicle. The sum of the demands delivered by a vehicle cannot exceed its capacity. A vehicle must start and end its route at the depot. There is usually no constraint on the number of vehicles used. The objective is to minimize the total distance traveled by all vehicles. The VRP was introduced by Dantzig and Ramser [34] in 1959 to model gasoline delivery. Many variants of the VRP have been developed to model real-world problems. We refer interested readers to Golden et al. [46] and Toth and Vigo [88, 89] for comprehensive surveys of the VRP and its variants.

While most of the published research focuses on minimizing the sum of the route costs, minimizing the maximum route cost is applicable in situations where the last delivery is crucial or the balance of the route lengths is desired. Last delivery applications include military operations, disaster relief routing, newspaper delivery, and computer networks. Balancing route length applications include school bus routing and workload balance among drivers. Campbell et al. [21] and Bertazzi

et al. [15] showed that, from the worst-case perspective, a solution to the min-max objective can be very different from the solution to the traditional min-sum objective. This finding motivates the development of exact and heuristic algorithms specifically designed for the min-max objective. Carlsson et al. [23] first proposed the min-max Multi-Depot VRP and solved it using a linear program-based, load balancing approach [100] and a region partitioning approach. Wang et al. [94] developed a three-stage heuristic (denoted by MD) that combined local search and perturbation strategies and improved the results of Carlsson et al. [23] significantly. Narasimha et al. [73] constructed an ant colony procedure to solve both the multi-depot and single-depot versions of the min-max problem. Ren [80] proposed a hybrid genetic algorithm for the single-depot min-max VRP.

Recently, Yakici and Karasakal [99] studied a min-max service VRP with split delivery and heterogeneous demands. Customer demands are described by the service times and the service types that are required. Customer service can be split among vehicles if it improves the min-max objective. If there is no route duration constraint, service times do not alter the routing plan of the classic VRP solution, but can change the routing plan of the min-max solution [15]. Split delivery often reduces the total cost to the carrier ([4], [5],[38]), but can inconvenience the customers because of work disruptions and paper work. Gulczynski et al. [49] introduced a split delivery VRP with minimum delivery amounts. A customer's demand can be satisfied by multiple visits, provided each delivery is not less than a specified fraction of total demand.

In this chapter, we study the min-max Split Delivery Multi-Depot Vehicle

Routing Problem with Minimum Service Time Requirement (min-max SDMDVRP-MSTR). The objective function value has two components: (1) the travel times of the vehicles and (2) the service times of the customers on the route. They contribute differently to the objective. When the minimum delivery fraction is greater than one half, i.e., no split deliveries allowed, the service time contribution is determined entirely by individual customers. However, the travel time contribution is determined by all customers. In particular, if a new customer is added to the route, the increase in service time can be readily obtained, but the exact increase in travel time cannot be computed easily. When travel times dominate, the problem is closer to the min-max MDVRP studied by Carlsson et al. [23]. When service times dominate, the problem is closer to the Multi-Way Number Partitioning Problem [61]. Both problems are difficult to solve. When the travel times and service times are comparable, the problem represents a trade-off between the two equally weighted objectives.

We develop a heuristic algorithm (denoted by MDS) to solve the min-max SDMDVRP-MSTR. The MD solver developed by Wang et al. [94] is modified to generate a good initial solution without splits. Next, a network flow model is used to improve the solution by splitting service, assuming no minimum service time requirement. Finally, a linear program is solved to ensure that each visit by a vehicle has at least the minimum service time.

There are numerous potential applications of the SDMDVRP-MSTR including military operations, disaster relief, and the distribution of industrial gases and other products where the delivery service time is relatively large.

The remainder of the chapter is organized as follows. In Section 4.2, the min-max SDMDVRP-MSTR is described formally. In Section 4.3, structural properties of the optimal solution when the minimum service time fraction is zero are provided. In Section 4.4, a heuristic algorithm (MDS) for the general problem is developed. In Section 4.5, the computational results are presented and discussed. Finally, Section 4.6 gives our concluding remarks.

4.2 Problem description

Let $\mathcal{G}(W \cup V, E)$ be a complete graph, where $W = \{w_1, w_2, \dots, w_{m-1}, w_m\}$ and $V = \{v_1, v_2, \dots, v_{n-1}, v_n\}$ are two sets of vertices, and E is the corresponding set of edges. A vertex, $w_j \in W$, where $j = 1, 2, \dots, m$, corresponds to a depot where a fixed number, l_j , of vehicles are stationed. A vehicle that starts from w_j must return to w_j at the end of its route. Unlike the classic min-sum VRP, which seldom specifies a finite number of vehicles, the min-max problem requires the number of vehicles in advance; otherwise the optimal solution will consist entirely of routes serving only one customer. A vertex, $v_i \in V$, where $i = 1, 2, \dots, n$, corresponds to a customer who requires a service time of s_i . A customer can be visited multiple times by different vehicles as long as the service requirement is met in full at the end of the last visit and each visit delivers the minimum required service time. An edge $e \in E$ is associated with a cost, t_e , representing the travel time between the two vertices that define the edge. We assume that the travel times satisfy the triangle inequality. The total cost of a route, or its duration T , is the sum of the travel times

spent on the road and the service times spent at the customers. Unlike the classic min-sum VRP, which often poses a constraint on the maximum length of a route, the min-max problem does not require a maximum duration constraint, because the objective is to minimize the duration of the longest route.

4.3 Structural properties of optimal solutions

Dror and Trudeau [38] provided a set of properties for the optimal solution to the (min-sum) Split Delivery Capacitated Vehicle Routing Problem (SDCVRP). In this section, we develop a similar set of properties that provide insights on the structure of an optimal solution to the min-max SDMDVRP with no minimum service time fraction.

Property 1. Any min-max SDMDVRP has an optimal solution in which no two routes share more than one customer.

Proof. Suppose that, in an optimal solution, routes R_1 and R_2 both service customers C_1 and C_2 , as illustrated in Figure 4.1(a). Let $s_i^{(j)}$ be the service time delivered by route R_j at customer C_i , where $i, j = 1$ or 2 . Without loss of generality, assume further that $s_2^{(1)} \geq s_1^{(2)}$. We can construct a new solution by transferring the service time spent at C_1 by route R_2 ($s_1^{(2)}$) to route R_1 and, at the same time, transferring the same amount of service time spent at C_2 by route R_1 to route R_2 . The new solution is shown in Figure 4.1(b). Route R_1 serves C_1 in full and spends $s_2^{(1)} - s_1^{(2)}$ at C_2 . Route R_2 spends the remaining service time required by C_2 . The duration of R_1 remains unchanged and the duration of R_2 may be reduced because

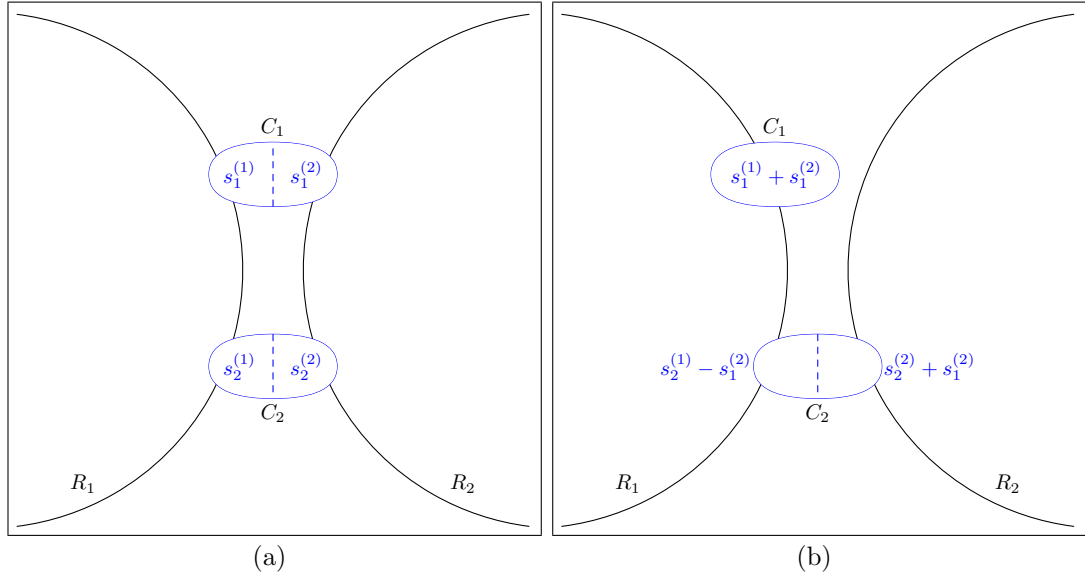


Figure 4.1: Illustrating Property 1

it does not have to visit C_1 . Therefore, the objective function value of this solution is no more than the objective function value of the previous solution, and routes R_1 and R_2 share only one customer. \square

Corollary 1. Let v_i and v_j be two customers. Any min-max SDMDVRP has an optimal solution in which the edge (v_i, v_j) is traversed at most once (in either direction). If the edge is traversed by one route, it will never be traversed by another route.

Proof. Assume this is not true. Then, we can have at least two routes which share customers v_i and v_j at the same time which is contrary to the Property 1. \square

We can generalize Property 1 to Property 2 by using the definition of the k -split cycle given by Dror and Trudeau [38].

Definition 1. A set of k customers C_1, C_2, \dots, C_{k-1} , and C_k form a k -split cycle, if there exists a set of k routes, R_1, R_2, \dots, R_{k-1} , and R_k such that R_1 visits customers

C_1 and C_2 , R_2 visits customers C_2 and C_3 , \dots , R_{k-1} visits customers C_{k-1} and C_k , and R_k visits customers C_k and C_1 .

Property 2. Any min-max SDMDVRP has an optimal solution in which there is no k -split cycle.

Proof. Assume that there exists a k -split cycle. Let $s_i^{(j)}$ be the service time spent at customer C_i by route R_j . Let

$$l_{min} = \arg \min_{l \in \{1, 2, \dots, k\}} \{s_l^{(l)}\}$$

and

$$s_{min} = s_{l_{min}}^{(l_{min})}.$$

We construct a new solution by transferring s_{min} amount of service time of customer C_i from route R_i to R_{i-1} for $i = 2, 3, \dots, k$ and transferring s_{min} amount of service time of customer C_1 from route R_1 to R_k . The sum of service times on each route remains unchanged, but the travel time of route $R_{l_{min}}$ may be reduced because it does not have to visit customer $C_{l_{min}}$. Therefore, the objective function value of the new solution is no more than the objective function value of the previous solution and the k -split cycle is broken. □

Property 3. Any min-max SDMDVRP has an optimal solution in which any two routes that split a customer have the same duration.

Proof. Suppose that two routes, R and R' , in the optimal solution split a customer C , but the duration of R , denoted by T_R , is strictly greater than the duration of

R' , denoted by $T_{R'}$. Let $s_C^{(R)}$ be the service time spent at customer C by route R . If $s_C^{(R)} \leq T_R - T_{R'}$, we construct a new solution by transferring the entire service time $s_C^{(R)}$ from route R to route R' , so that customer C is serviced in full by R' . The resulting solution is no worse than the previous solution, and the two routes R and R' no longer both serve customer C . On the other hand, if $s_C^{(R)} > T_R - T_{R'}$, we construct a new solution by transferring $\frac{1}{2}(T_R - T_{R'})$ of customer C 's service time from route R to route R' . In the new solution, both routes have duration $\frac{1}{2}(T_R + T_{R'}) < T_R$, and they still split customer C . \square

Definition 2. Consider an auxiliary graph whose vertices represent the routes in a solution. Two vertices are connected by an edge if and only if the corresponding two routes have a customer in common. Then a cluster of routes is a set of routes with the corresponding vertices in a connected component.

Possible structures of clusters are shown in Figure 4.2. The larger unfilled circles represent routes and the smaller filled circles represent split customers. Figure 4.2(a) shows a single route that serves all of its customers in full. Figure 4.2(b) shows a cluster with two routes splitting one customer. Figure 4.2(c) has three routes splitting two customers. Figure 4.2(d) has three routes splitting only one customer. Figure 4.2(e) has a cluster with four routes in which two routes split one customer and three routes split a different customer.

Using the definition of clusters of routes, we extend Property 3 to Property 4.

Property 4. Any min-max SDMDVRP has an optimal solution with all routes in the same cluster having the same duration.

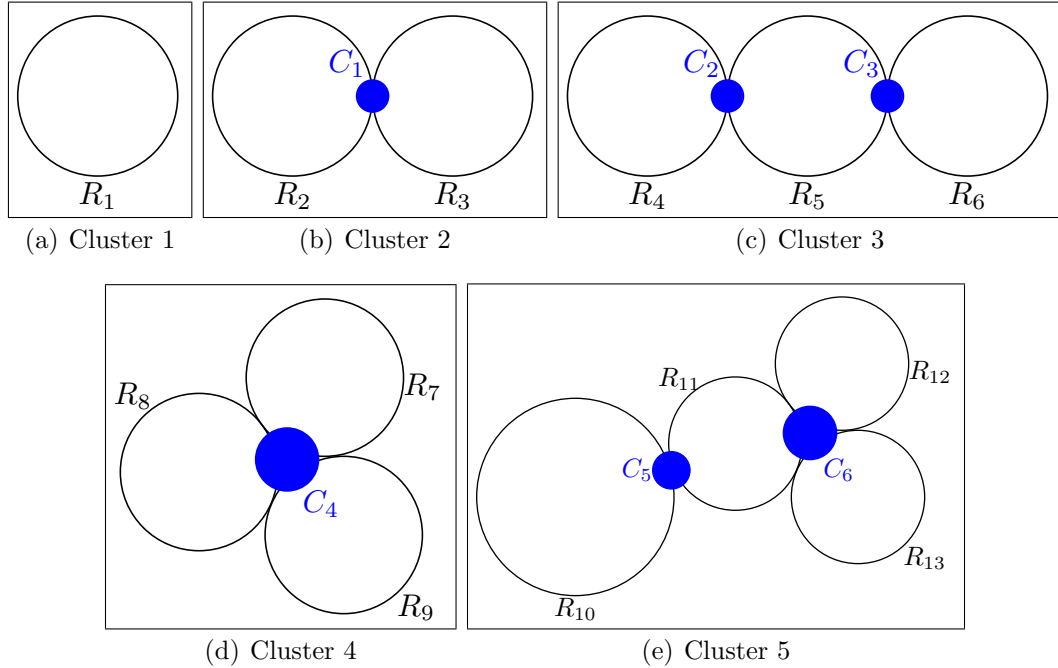


Figure 4.2: Examples of clusters of routes

Proof. We start with an optimal solution with no k -split cycle. Each cluster is optimized with respect to the min-max objective function. In general, if a cluster does not contain the longest route of the solution, it need not be min-max optimal. However, an optimal solution with all clusters min-max optimal always exists because we can think of the customers, vehicles, and depots in this cluster as a smaller min-max problem and solve it optimally. (Although solving the sub-problem may lead to a solution with more clusters, we can apply the same procedure and solve the smaller problems.)

Suppose that, in this solution, a cluster has routes of different duration, and there are n longest routes in the cluster. In this cluster, we can always identify a longest route that splits a customer with another shorter route, because not all routes have the same duration and the vertices representing the routes are connected.

We apply the same procedure in the proof of Property 3 to transfer some or all of the service time of the shared customer from the longer route to the shorter route. There are two possibilities. Both routes have the same duration (the number of longest routes drops by one) or the cluster breaks up into two smaller clusters. The cluster breaks when all of the shared customer's service time is shifted to the shorter route (and there is no k -split cycle within the cluster). In either case, the min-max objective function value is no worse than the previous value. We apply this procedure to any cluster that contains routes with unequal duration until either all the n longest routes are shortened, which implies that the original cluster is not optimized with respect to the min-max objective, or the cluster breaks into a set of clusters with single routes and clusters with routes of equal duration. \square

4.4 Algorithm

We develop a three-stage algorithm for the min-max SDMDVRP-MSTR. First, we modify a procedure developed by Wang et al. [94] in order to generate a good solution with no split service and no minimum service time requirement. Second, clusters are formed, merged, and broken through local search in order to improve solutions through split service while ignoring the minimum service time requirement. When our local search procedure cannot improve solutions anymore, a perturbation procedure is applied to improve the solution from the local minimum. Finally, a clean-up process ensures that the minimum service time requirement is satisfied.

4.4.1 Improving MD

Wang et al. [94] developed an effective heuristic (denoted by MD) to solve the min-max MDVRP. MD has three operators: initialization by solving a linear program, local search by relocating customers from the longest route to other routes, and perturbation by repositioning the depots. The three operators are summarized below with an emphasis on how we modify each one to solve a problem with service time. In addition, we develop four operators that improve MD.

To initialize a feasible solution, MD solved a generalized assignment problem using the Gurobi solver [52] to allocate an approximately equal number of customers to each vehicle. The generalized assignment problem (AP) formulation was introduced by Carlsson et al. [23] in their LP-based load balancing heuristic. The cost of assigning a customer to a vehicle was the Euclidean distance from the customer location to the depot where the vehicle was stationed. In the min-max SDMDVRP, the assignment cost is the travel time from the customer to the depot. The objective was to minimize the total assignment cost. The Lin-Kernighan-Helsgaun (LKH) [55]

solver was used to route the customers that were assigned to the same vehicle.

$$(AP) \quad \min \quad \sum_{i=1}^n \sum_{j=1}^m t_{ij} x_{ij} \quad (4.1)$$

$$\text{s.t.} \quad \sum_{j=1}^m x_{ij} = 1 \quad \forall i = 1, 2, \dots, n \quad (4.2)$$

$$\sum_{i=1}^n x_{ij} = \left\lfloor \frac{n}{m} \right\rfloor \text{ or } \left\lfloor \frac{n}{m} \right\rfloor + 1 \quad \forall j = 1, 2, \dots, m \quad (4.3)$$

$$x_{ij} \in \{0, 1\} \quad \forall i = 1, 2, \dots, n, j = 1, 2, \dots, m \quad (4.4)$$

The decision variable x_{ij} takes the value 1 if and only if customer i is assigned to route j . In the objective function (4.1), n and m are the number of customers and the number of routes, respectively. t_{ij} is the distance between customer i and the depot of route j . Constraints (4.2) imply that every customer is served on exactly one route. Constraints (4.3) imply that every route serves either $\lfloor \frac{n}{m} \rfloor$ or $\lfloor \frac{n}{m} \rfloor + 1$ customers. Constraints (4.4) define a binary decision variable.

To improve a solution, a local search procedure (denoted by LS_NoSplit) was applied. MD tried to remove a customer with the greatest potential savings from the longest route and insert it onto other routes in the least-cost way. The sequence for which a customer was considered depended on the estimate of the savings. For example, if a vehicle served customers at locations A , B , and C in that sequence, and the customer at B was considered for removal, then the savings was estimated to be $(AB + BC - AC)$. To adapt the procedure to the service problem, we include the service time of the customer at B , denoted by s_B , in the estimation of the savings. Furthermore, the savings estimation is modified to $(s_B + AB + BC - \lambda AC)$, where

λ is a parameter whose value is determined based on computational experiments (more about λ in Section 4.5.2.4). The local search procedure is repeated until no improvements are found.

A series of perturbations (denoted by Ptb_NoSplit) was carried out to improve the solution and move it from the local minimum. In each perturbation, depots were shifted to slightly different positions determined by perturbation angles and radii to form a perturbed problem. The customers were still visited in the same sequence to form a feasible solution to the perturbed problem. LS_NoSplit was applied to the feasible solution to get a local minimum solution to the perturbed problem. The depots were then set back to their original positions. MD continued with LS_NoSplit to get a different and, hopefully better, local minimum to the original problem.

Ptb_NoSplit was repeated until there was no improvement for five consecutive perturbations. The perturbation radius was the average distance from the depot to the first and the last customers on the route. The first perturbation angle was random, but subsequent perturbation angles were set to 144 degrees counter-clockwise to the previous one. This scheme made consecutive perturbations of a depot in almost opposite directions. It had full coverage of the directions when it stopped after five iterations with no improvement.

We now develop and add four operators to MD: cyclic transfer, one-point move, two-point move, route destruction and reconstruction.

Cyclic transfer is not new to the VRP literature. Thompson and Psaraftis [87] applied this operator to solve the min-sum VRP. The idea is to simultaneously relocate k customers. Suppose we have routes R_1, R_2, \dots , and R_k serving customers

$C_1, C_2, \dots,$ and C_k , respectively. After cyclic transfer, we may have C_1 ejected on R_1 and C_2 served, C_2 ejected on R_2 and C_3 served, etc, and C_k ejected on R_k and C_1 served. To identify cyclic transfers that reduce the value of the objective function, Thompson and Psaraftis first generated an auxiliary graph with each node representing a customer. Denote by R_j the route serving customer C_j and by $R_j \setminus j$ the route if C_j is removed. The cost of the arc from node i to node j was the estimated least-cost increase of R_j if customer C_i was inserted while customer C_j was removed. Thompson and Psaraftis proved that if the three least-cost insertion positions of customer C_i onto R_j are $r, s,$ and t with costs $c_r, c_s,$ and c_t , respectively, and $c_r \leq c_s \leq c_t$, the least-cost insertion position of C_i onto $R_j \setminus j$ is one of the four positions, $r, s, t,$ and $j - 1$. The authors developed an algorithm (see Table 4.1) to compute all arc costs in $O(N^2)$ time, where N is the total number of customers. Looking for cyclic transfers that reduce the objective function value amounted to identifying negative cost cycles from the auxiliary graph. Thompson and Psaraftis applied different modules to identify negative cost cycles. The modules may require searching in a restricted neighborhood, e.g., cycles involving only two nodes, or generating only part of the auxiliary graph, to reduce the computational burden. A negative cost cycle signaled a likely decrease in the min-sum objective function value. The magnitude of the negative cost indicated the extent to which the objective function value was expected to decrease.

The cyclic transfer neighborhood may be useful in the min-max problem. If the longest route is surrounded by other long routes, it is unlikely that LS_NoSplit can improve the solution any further, but the larger cyclic transfer neighborhood

Table 4.1: Estimated arc cost of the auxiliary graph for cyclic transfer [87]

Algorithm 1

For all customers i

For routes R that does not serve i

 Calculate c_r , c_s , and c_t

For all customers j on R

 Calculate the increase in cost of $R \setminus j$, $c_i(j)$, if i is inserted between $j - 1$ and $j + 1$

 Denote the estimated cost of adding i onto $R \setminus j$ by c_{ij}

If $j \in \{r, r + 1\}$

If $j = s + 1$

$c_{ij} = \min\{c_i(j), c_t\}$

Else

$c_{ij} = \min\{c_i(j), c_s\}$

Endif

Else

$c_{ij} = \min\{c_i(j), c_r\}$

Endif

Endfor

Endfor

Endfor

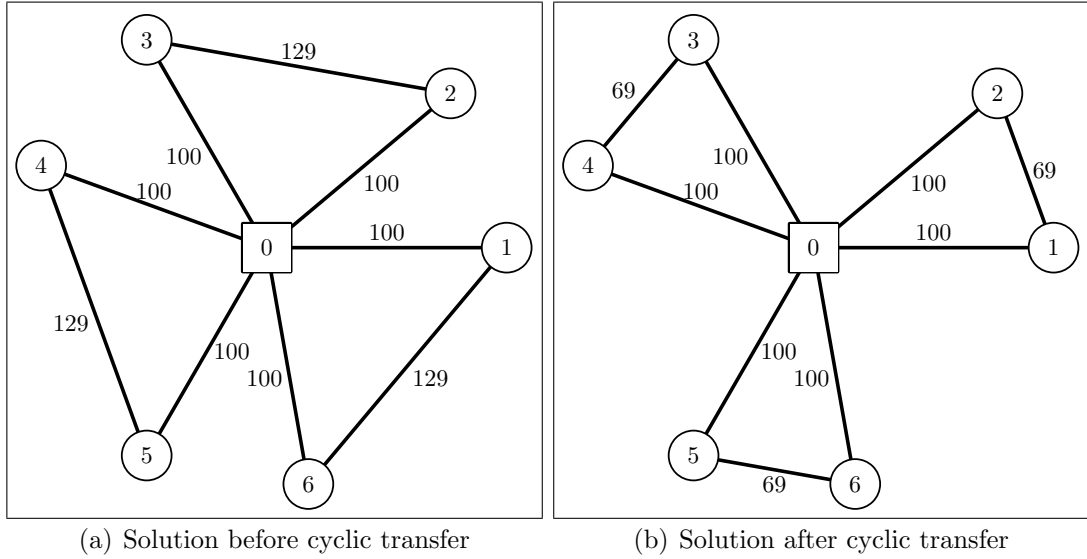


Figure 4.3: Cyclic transfer

may help break away from the local minimum. An example is shown in Figure 4.3. Six customers served by three vehicles are located at a distance of 100 from the depot. The distances are given next to the edges. The solution in Figure 4.3(a) has three routes of equal duration 329 that cannot be improved by LS_NoSplit. But if we invoke a cyclic transfer with customers 1, 3, and 5, the solution can be improved to have three routes of duration 269, which is shown in Figure 4.3(b).

To adapt Thompson and Psaraftis’s cyclic transfer to handle our problem, we construct an auxiliary graph with the number of nodes equal to the number of customers. For every pair of customers C_i and C_j not on the same route, denote the route that serves C_j to be route R_j . We estimate the duration of $R_j \setminus j + i$, i.e., if customer C_i is added to the route and customer C_j is removed. If the duration is expected to be greater than the maximum duration, arc (i, j) is not included in the auxiliary graph. Otherwise, if R_j is among the longest routes, arc (i, j) is added to the auxiliary graph and assigned cost -1 . If R_j is not among the longest routes, arc

Table 4.2: Algorithm to generate the auxiliary graph for cyclic transfer in the min-max problem

Algorithm 2

Initialize the auxiliary graph, \mathcal{G}_{aux} , to have n nodes but no arcs

For all ordered pairs of customers C_i and C_j that are on different routes R_i and R_j

 Estimate the duration of $R_j \setminus j$, denoted by $T_{R_j \setminus j}$

 Estimate the cost increase, Δ_{ij} , if C_i is inserted onto $R_j \setminus j$,

 using the algorithm in Table 4.1 and add the service time of C_i

If $T_{R_j \setminus j} + \Delta_{ij} < T_{\text{max}}$

If R_j is not a longest route

 Add arc (i, j) with cost 0 to \mathcal{G}_{aux}

Else

 Add arc (i, j) with cost -1 to \mathcal{G}_{aux}

Endif

Endif

Endfor

(i, j) is added to the auxiliary graph and assigned cost 0. Therefore, a negative cost cycle signals a likely decrease in the min-max objective function value. In Table 4.2, we present the algorithm to generate the auxiliary graph. Since the resulting auxiliary graph is usually sparse, we apply Tarjan’s algorithm [86] to decompose it into strongly connected components. For each component, we find at most 10 negative cost cycles by a depth-first search. Not all of the cyclic transfers suggested by these negative cycles will actually improve the min-max objective, because the duration of $R_j \setminus j$ and the increase in duration when customer i is inserted onto $R_j \setminus j$ are only estimates. We apply the cyclic transfers suggested by the negative cost cycles one by one until we find an improved solution.

We also apply one-point and two-point moves to reduce the total duration of the fleet provided they do not worsen the min-max objective function value. Even if these two operators do not reduce the maximum duration directly, they may open up opportunities for LS_NoSplit later in our algorithm. In the one-point move, we

Table 4.3: One-point move

Algorithm 3

For every route R_A in the solution (Loop A1)**For** every customer C_A on route R_A (Loop A2)Estimate the change in duration if C_A is removed

$$\Delta T_{R_A} = p(C_A)s(C_A) - p(C_A)C_A - C_A s(C_A) - s_A,$$

where $p(C_A)$ and $s(C_A)$ are nodes before and after C_A **For** every route R_B that is different from R_A in the solution (Loop B1)Compute the allowed duration increase $\Delta T_{\text{allowed}} = T_{\text{max}} - T_{R_B}$ **For** every edge (C_{B1}, C_{B2}) on route R_B (Loop B2)Estimate the increase in R_B 's duration $\Delta T_{R_B} = C_A C_{B1} + C_A C_{B2} - C_{B1} C_{B2} + s_A$ **If** $\Delta T_{R_B} \leq \Delta T_{\text{allowed}}$ and $\Delta T_{R_A} + \Delta T_{R_B} < 0$ Relocate C_A between C_{B1} and C_{B2}

Continue with Loop A2

Endif**Endfor****Endfor****Endfor****Endfor****For** every route R in the solution

Apply the LKH solver to optimize the route

Endfor

consider relocating a customer between two other customers (or the depot) that are on a different route. In the two-point move, we consider exchanging the positions of two customers not on the same route. The two operators are presented in Tables 4.3 and 4.4. The LKH solver [55] is used in both operators.

Route destruction and reconstruction applies the ruin-and-recreation principle of Schrimpf et al. [84]. If a long route serves only a few customers, it may be an inefficient route. We destroy the route and insert its customers onto other routes in a least-cost way. Meanwhile, a route that adds a customer from the inefficient

Table 4.4: Two-point move

Algorithm 4

For every route R_A in the solution (Loop A1)

For every customer C_A on route R_A (Loop A2)

For every route R_B with an index larger than that of R_A in the solution ((Loop B1))

For every customer C_B on route R_B (Loop B2)

 Estimate R_A 's duration, $T_{R_A,\text{aft}}$, after the swap

 Estimate R_B 's duration, $T_{R_B,\text{aft}}$, after the swap

If $\max\{T_{R_A,\text{aft}}, T_{R_B,\text{aft}}\} \leq T_{\max}$ and $T_{R_A,\text{aft}} + T_{R_B,\text{aft}} < T_{R_A,\text{bfr}} + T_{R_B,\text{bfr}}$,
 where $T_{R_A,\text{bfr}}$ is the duration of R_A before the swap

 Swap C_A and C_B

 Continue with Loop A2

Endif

Endfor

Endfor

Endfor

Endfor

For every route R in the solution

 Apply the LKH solver to optimize the route

Endfor

Table 4.5: Route destruction and reconstruction

Algorithm 5

Set threshold $\delta = 20\%$, and the set of inefficient routes $S = \emptyset$

Number of empty routes is $N_{\text{empty}} = 0$

For every route R in the solution

 Compute and store the average travel time per customer for route R , $T_{\text{avg},R}$

If R is empty

 Increment N_{empty}

Endif

Endfor

Compute the average of $T_{\text{avg},R}$, not including the empty routes and denote the average by T_{avg}

For every route R in the solution

If $T_{\text{avg},R} > (1 + \delta)T_{\text{avg}}$

 Add R to S

Endif

Endfor

For every route $R \in S$

For every customer C on R

 Insert C onto some route $\tilde{R} \notin S$ in a least-cost way

 Eject the nearest customer to R 's depot from route \tilde{R}

Endfor

 Form a new route with all the ejected customers

Endfor

route must eject a customer that is nearest to the depot of the inefficient route. A new route is constructed from these ejected customers. At the end of the process, we have the same number of routes in the solution, and each route has the same number of customers as it previously had. The route destruction and reconstruction algorithm is presented in Table 4.5 and the complete modified MD is presented in Table 4.6.

Table 4.6: Modified MD

Algorithm 6

Initialize a solution, S_0 , using AP and LKH [55]

Local search LS_NoSplit

Perturbation Ptb_NoSplit

Cyclic transfer

Local search LS_NoSplit

Perturbation Ptb_NoSplit

Two-point move

One-point move

Local search LS_NoSplit

Perturbation Ptb_NoSplit

Record the solution S_1

Route destruction and reconstruction

Local search LS_NoSplit

Perturbation Ptb_NoSplit

Record the solution S_2

Report the better solution of S_1 and S_2

4.4.2 Cluster balance subroutine

Before we present the local search and perturbation used in the second stage of MDS, we describe a cluster balance subroutine that is used repeatedly in the second stage. We want to keep the cluster with the longest route balanced, i.e., all routes in the cluster have the same duration. Otherwise, we can apply the service transfer process in the proof of Property 1 to reduce the duration of the longest route. In addition, we keep the other clusters in the intermediate solutions balanced as well. Although we would like to have all clusters balanced, a balanced structure is disrupted whenever we remove a customer or add a customer during the local search procedure. Sometimes balance can be restored by transferring the service

time of the split customer from one route to another. For example, suppose that in cluster 2 in Figure 4.2(b), the service requirement of customer C_1 is 20, which is split evenly between routes R_2 and R_3 . The duration of each route is 100. Suppose the duration of R_3 falls to 90 after some customer other than C_1 is removed. To restore balance, we can transfer five time units of customer C_1 's service from route R_2 to route R_3 so that the duration of each route is 95 with R_2 taking 25% of C_1 's service requirement. When balance cannot be restored, we break the cluster into smaller ones. For example, suppose a customer, other than C_1 , from R_3 is removed and the duration drops from 95 to 80. The balance cannot be restored, because it requires 7.5 time units of service to be transferred from R_2 to R_3 , but R_2 's share on C_1 is only five units. Therefore, we break cluster 2 into two clusters, each with a single route, by transferring the remaining five units on R_2 to R_3 . C_1 is now served in full by R_3 with duration 85 and R_2 has duration at most 90.

In the solution process, clusters are often much more complex and unbalanced clusters arise very often. We need a subroutine to restore balance or break up a cluster in a specific way if balance is not possible.

Our cluster balance subroutine is based on a network flow model. Each cluster is represented by an auxiliary directed graph $\mathcal{H}(N, A)$, where N is a set of nodes that correspond to the routes. Two nodes are connected by two arcs in opposite directions if and only if the corresponding routes serve a customer in common. The auxiliary graphs of the five clusters in Figure 4.2 are given in Figure 4.4. In Figure 4.2(a), cluster 1 has a single route, so that its auxiliary graph in Figure 4.4(a) has a single node without any arcs. In Figure 4.2(b), cluster 2 has routes R_2 and R_3

splitting customer C_1 , so that the auxiliary graph in Figure 4.4(b) has two nodes connected by two arcs. The two non-negative numbers, $U_{2,3}$ and $U_{3,2}$, on each arc are the maximum flows in the arcs. In this cluster, the service time required by customer C_1 is $U_{2,3} + U_{3,2}$. $U_{2,3}$ is delivered by R_2 and $U_{3,2}$ is delivered by R_3 . In Figure 4.2(c), cluster 3 has two split customers, C_2 and C_3 . In Figure 4.4(c), the arcs with maximum flow $U_{4,5}$ and $U_{5,4}$ are induced by customer C_2 , whereas the arcs with maximum flow $U_{5,6}$ and $U_{6,5}$ are induced by customer C_3 . Cluster 4 in Figure 4.2(d) has three routes, all splitting the same customer C_4 , so that its auxiliary graph in Figure 4.4(d) has three nodes. Every pair of nodes is connected by two arcs in opposite directions. The labels on each arc give the maximum flows through the arcs. In this example, $U_{8,7} + U_{8,9}$ is the service time at C_4 by R_8 . $U_{7,8} + U_{7,9}$ is the service time at C_4 by R_7 . $U_{9,7} + U_{9,8}$ is the service time at C_4 by R_9 .

Whenever a cluster is modified, we carry out a cluster balance subroutine by

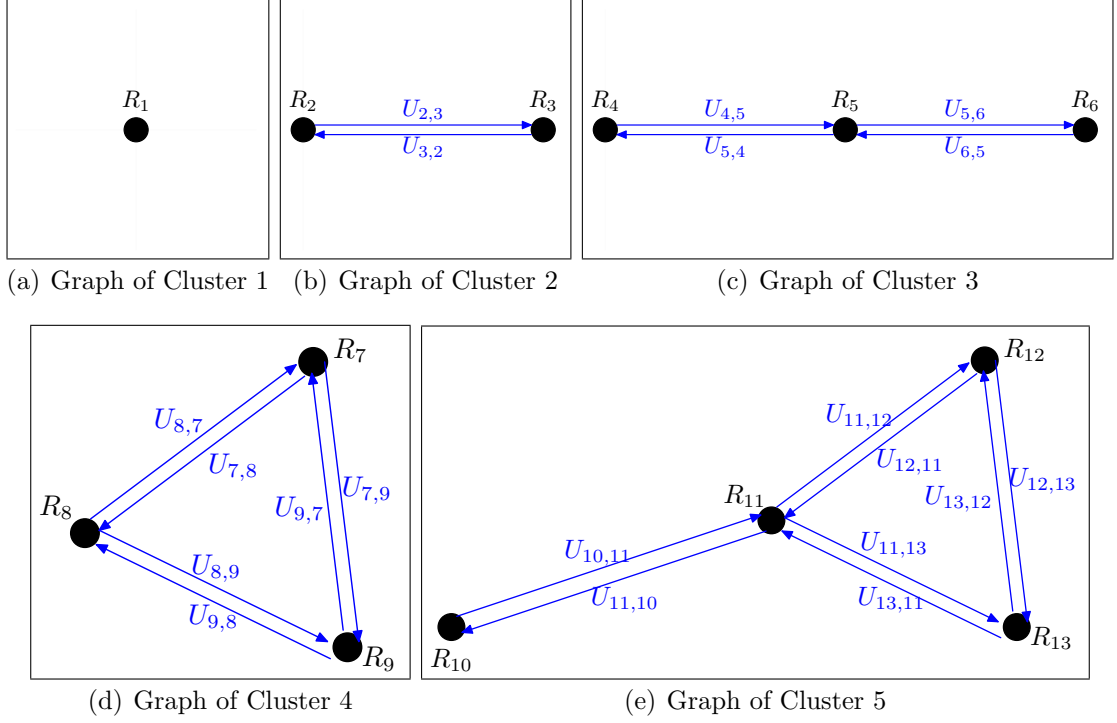


Figure 4.4: Auxiliary graphs of the customers in Figure 4.2

solving the following LP repeatedly.

$$(LP) \quad \min \quad z \quad (4.5)$$

$$\text{s.t.} \quad T_i = \tilde{T}_i - \sum_{j:(i,j) \in A} x_{ij} + \sum_{j:(j,i) \in A} x_{ji} \quad \forall i \quad (4.6)$$

$$z \geq T_i - T^* \quad \forall i \quad (4.7)$$

$$z \geq T^* - T_i \quad \forall i \quad (4.8)$$

$$s_i^{(l)} \geq \sum_{j:(i,j) \in A(l)} x_{ij} - \sum_{j:(j,i) \in A(l)} x_{ji} \quad \forall l, i \exists j(i,j) \in A(l) \quad (4.9)$$

$$x_{ij} \geq 0 \quad \forall (i,j) \in A \quad (4.10)$$

$$T_i \geq 0 \quad \forall i \quad (4.11)$$

$$z \geq 0 \quad (4.12)$$

The nodes are indexed by i or j . In constraint (4.6), the parameter \tilde{T}_i is the duration of the route represented by node i before balancing. The decision variable x_{ij} gives the amount of flow in the arc $(i, j) \in A$. Therefore, constraint (4.6) indicates that the variable T_i is the duration of the corresponding route after balancing. In constraints (4.7) and (4.8), the parameter T^* is the targeted route duration. Since the total duration within a cluster is preserved unless the cluster breaks after balancing, we can compute the target by dividing the total duration by the number of routes in the cluster. Therefore, constraints (4.7) and (4.8), together with the minimization objective, force z to be the maximum absolute deviation of the duration of the routes from the target after balancing. In constraint (4.9), $s_l^{(i)} = \sum_{j:(i,j) \in A(l)} U_{i,j}$ is the service time spent by route i at customer l , and $A(l) \subset A$ is a subset of arcs induced by l . This constraint implies that the maximum net outflows from node i through arcs induced by customer l cannot exceed the service delivered by route i at customer l . Constraints (4.10) to (4.12) define the variable types. In fact, x_{ij} is the only decision variable. When the values of x_{ij} are fixed, the values of T_i and z_i are fixed as well. T_i and z_i are introduced to make the presentation of constraints clearer. The objective function (4.5) minimizes the maximum absolute deviation from the target duration after balancing. A zero value of the objective function indicates that the cluster can be balanced; otherwise the cluster cannot be balanced without breaking it up. Other objective functions are possible (see Section 4.4.2.1).

Even if balance cannot be achieved, we still apply the flows from the solution to LP, and then determine how to break up the cluster. Initially, we attach a different label to each route. If two routes share a customer, we take the union of all routes

with those two labels and attach the same label to them. All routes with the same label form a new cluster.

If a cluster is broken up, the smaller clusters that are formed may not be balanced. We solve LP again to balance the smaller clusters until all clusters are balanced. It seems that restoring balance may take a lot of effort, but the size of LP is usually very small. The number of nodes in the auxiliary graphs is equal to the number of routes in the cluster. The number of edges is related to the number of split customers. Although we may have a customer serviced by several routes, the number of split customers is less than the number of routes as a result of Property 2.

4.4.2.1 Alternative objective functions in the cluster balance subroutine

We discuss three objective functions (4.13), (4.14), and (4.15) that balance the cluster if possible, and break up the cluster if balancing is not possible. We explain why we have chosen (4.14).

$$\min \sum_{i=1}^n |T_i - T^*| \tag{4.13}$$

$$\min \max_i |T_i - T^*| \tag{4.14}$$

$$\min \sum_{i=1}^n |T_i - T^*|^2 \tag{4.15}$$

Objective function (4.13) minimizes the sum of absolute deviations from the target duration. Objective function (4.14) minimizes the maximum absolute deviation and is the same as (4.5). Objective function (4.15) minimizes the sum of absolute deviations squared. Each function gives an optimal value of zero if the cluster is balanced. However, each performs differently if balance cannot be achieved as illustrated by the following two examples.

Example 13.

In the unbalanced cluster shown in Figure 4.5(a), there are four routes, R_1 , R_2 , R_3 , and R_4 , with durations 70, 70, 10, and 10, respectively. Routes R_1 and R_2 split customer C_1 . Routes R_2 and R_3 split customer C_2 . Routes R_3 and R_4 split customer C_3 . The number next to an arc indicates the maximum flow in that arc. The target duration of a route is $[70(2) + 10(2)]/4 = 40$, so there has to be a net outflow of $2(70 - 40) = 60$ from nodes R_1 and R_2 , and a net inflow of the same amount into nodes R_3 and R_4 in order to balance the cluster. However, the maximum flow in arc (R_2, R_3) is 10, so the cluster breaks with R_3 serving C_2 in full. By inspection, the desired balanced two smaller clusters are shown in Figure 4.5(b), with R_1 and R_2 having the same duration 65, and R_3 and R_4 having the same duration 15, assuming the savings from travel time is negligible.

Both objective functions (4.14) and (4.15) produce the desired clusters in Figure 4.5(b) in one call of the cluster balance subroutine. However, objective function (4.13) requires three calls in the worst case. As long as R_3 takes the entire C_2 , objective function (4.13) is indifferent as to how to split C_1 between R_1 and R_2 ,

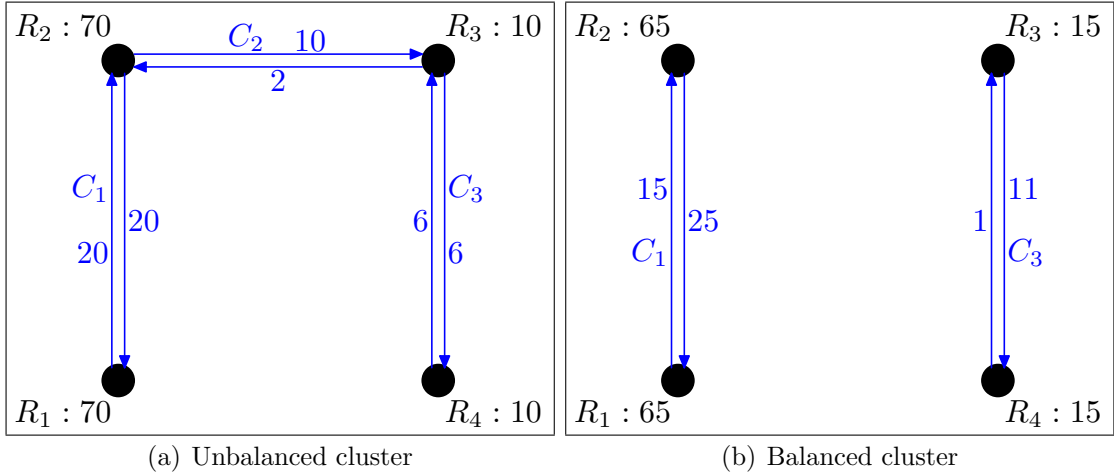


Figure 4.5: Example 13

or how to split C_3 between R_3 and R_4 , because the function value is constant at 100. We have to call the subroutine again to balance the smaller clusters. However, functions (4.14) and (4.15) break the cluster and balance the smaller clusters at the same time in this example.

Example 14.

As shown in Figure 4.6(a), the unbalanced cluster has three routes, R_5 , R_6 , and R_7 . R_5 and R_6 have duration 50 and R_7 has duration 20. The target duration is 40. Therefore, there has to be a net outflow of 20 from nodes R_5 and R_6 and net inflow of 20 into R_7 to balance the cluster. However, because the maximum flow in arc (R_6, R_7) is 10, the cluster has to break with R_7 , thereby servicing customer C_5 in full. Figure 4.6(b) shows the desired balanced clusters, assuming that the savings in travel time is negligible.

Only objective function (4.15) produces the desired clusters in one call to the subroutine. Both functions (4.13) and (4.14) take two calls in the worst case. After

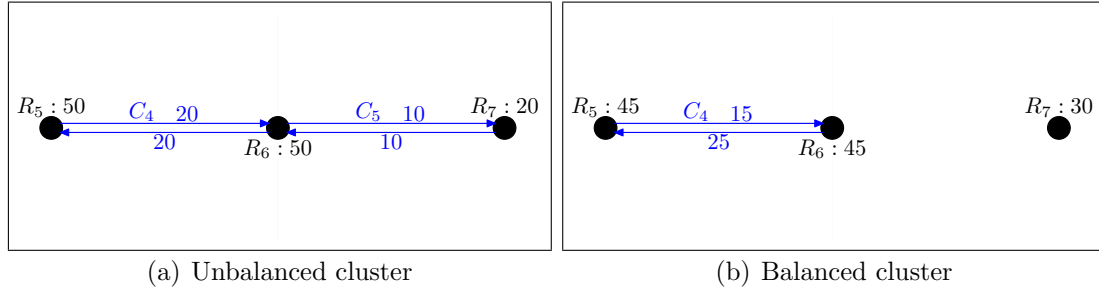


Figure 4.6: Example 14

R_7 takes C_5 , the value of function (4.13) remains constant at 20, and the value of function (4.14) remains constant at 10, as long as neither R_1 nor R_2 has duration less than 40.

It is not a coincidence that objective function (4.15) requires the fewest function calls to achieve balance, while objective function (4.13) has the most in these examples. To explain this, we consider the change of variables

$$y_i = T_i - T^* \quad i = 1, 2, \dots, n. \quad (4.16)$$

The objective functions then become

$$\min \sum_{i=1}^n |y_i| \quad (4.17)$$

$$\min \max_i |y_i| \quad (4.18)$$

$$\min \sum_{i=1}^n |y_i|^2 \quad (4.19)$$

subject to an additional constraint that

$$\sum_{i=0}^n y_i = 0. \tag{4.20}$$

Geometrically, the contours of objective function (4.19) are concentric spheres centered at the origin in \mathbb{R}^n . The contours of (4.18) are cubes with edges parallel to the axes. The contours of (4.17) are octahedrons with vertices on the axes. The optimal solution occurs where the boundary of the feasible region is tangent to a contour. Since constraint (4.20) specifies a hyperplane passing through the origin that is normal to the vector $(1, 1, \dots, 1)^T$ in \mathbb{R}^n , we need only consider points on this plane, denoted by Π . The intersections of the octahedrons, the cubes, or the spheres with the hyperplane Π are regular hexagons, equilateral triangles, or circles, all centered at the origin, shown in Figures 4.7(a), 4.7(b), and 4.7(c). The feasible region is a convex polygon on the same plane. If this region contains the origin, the optimal solution is unique for all three formulations. If this region does not contain the origin, the optimal solution to objective function (4.19) is still unique because the feasible region is a convex polygon, which is enclosed by (straight) line segments. The optimal solutions to functions (4.17) and (4.18) may not be unique when the boundary of the feasible region has a line segment parallel to part of the level curves. In addition, as shown in Figures 4.7(a) and 4.7(b), each of the three sides of a equilateral triangle is parallel to one of the six sides of a regular hexagon, but not vice verse. This implies that if (4.18) has infinitely many optimal solutions, (4.17) is likely to have infinitely many optimal solutions as well.

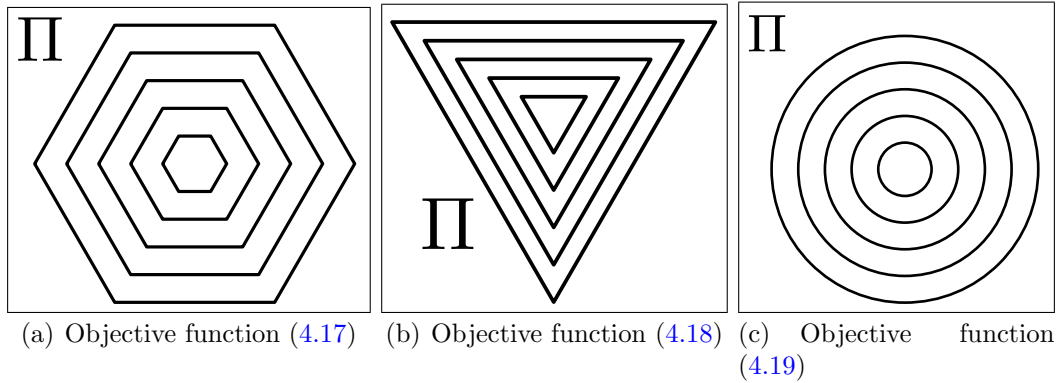


Figure 4.7: Intersections of contours of objective functions (4.17), (4.18), and (4.19) with Π

A thorough discussion of the three formulations is not within the scope of this paper, but we use objective function (4.14) in our implementation because it usually requires fewer function calls than (4.13) and can be easily linearized. It also conforms with the overall min-max style objective.

4.4.3 Local search

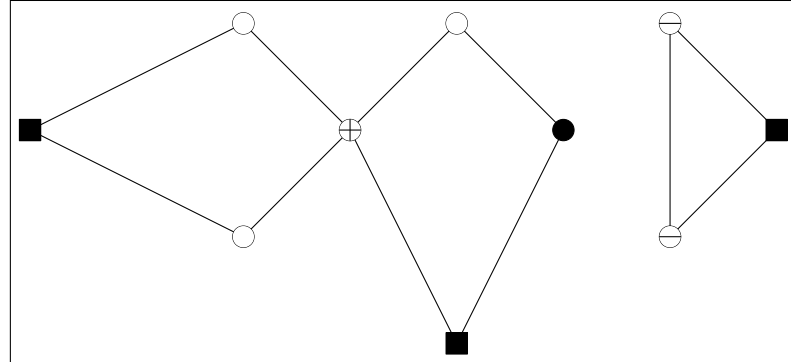
The solution that has been generated so far does not involve any split service. Using the local search procedure LS_Split, we explore the possibility of splitting some customers from the cluster containing the longest routes to further reduce the min-max objective function value. A series of merge and balance restoration operations are used.

The sequence in which the customers are considered for splits can affect the local minimum that results. In LS_Split, we consider an alternating sequence, i.e., the customers near the beginning or the end of the routes are explored first. The motivation is that routes through the same depot are allowed to merge before routes

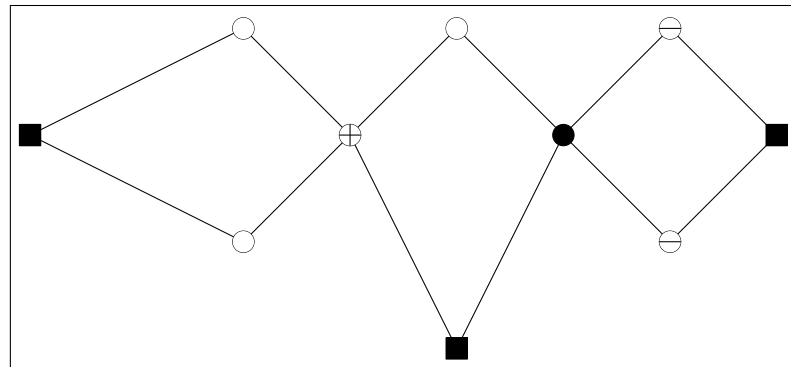
with different depots. We illustrate the alternating sequence with a cluster containing two routes that serve three and four customers respectively. Denote by (p, q) the q^{th} customer on the p^{th} route. The alternating sequence explores the customers in the order $(1, 1) \rightarrow (2, 1) \rightarrow (1, 3) \rightarrow (2, 4) \rightarrow (1, 2) \rightarrow (2, 2) \rightarrow (2, 3)$. We have tried two other sequences: (1) the order in which the customers are stored in a solution, i.e., $(1, 1) \rightarrow (1, 2) \rightarrow (1, 3) \rightarrow (2, 1) \rightarrow (2, 2) \rightarrow (2, 3) \rightarrow (2, 4)$ in the illustration, and (2) the order of decreasing service times. We found that the alternating sequence performed best among the three.

Starting with the first customer in the sequence, we identify a position on a route in a different cluster in which the customer can be inserted in the cheapest way. Instead of removing this customer completely from the longest route and inserting it onto a shorter route in a different cluster, we merge the two clusters into one with that customer as a connection. Then we apply the cluster balance subroutine to the newly formed cluster. As shown in Figure 4.8, the filled squares represent three depots and circles represent customers. In Figure 4.8(a), suppose the cluster on the left with two routes contains the longest routes. If the customer represented by the filled circle is to be inserted onto routes in the other cluster in the least cost way, it will be inserted between the two customers represented by circles with a dash. Instead of removing the filled customer, we merge the three routes to form a larger cluster shown in Figure 4.8(b). This cluster may not be balanced, so we apply the cluster balance subroutine, which may result in breaking up this cluster, as shown in Figure 4.8(c).

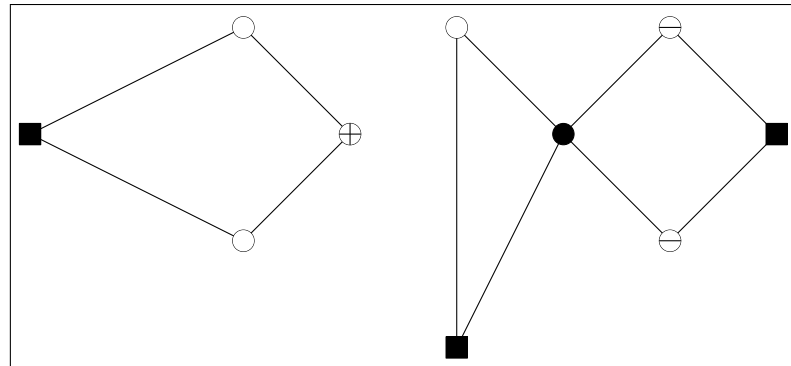
If the objective function value decreases after balance is restored, the merge is



(a) Before merge



(b) Merged cluster



(c) Balance restored

Figure 4.8: Illustration of cluster merge

accepted and we continue with the local search on the new cluster with the longest route; otherwise the move is rejected and we explore the possibility of splitting the next customer in the sequence.

4.4.4 Perturbation

The perturbation technique, `Ptb.Split`, used in this stage is the same as `Ptb.NoSplit`, except we use `LS.Split` instead of `LS.NoSplit` as the local search operator.

4.4.5 Satisfying the minimum delivery requirement

The solution produced at the end of the perturbation step may not satisfy the minimum delivery requirements. In the final clean-up stage, we satisfy the minimum requirement of all split customers by solving LP with the added constraints (4.21) and (4.22) shown below.

Suppose route i serves a fraction p of customer l 's demand, and $p \in (0, \frac{1}{2}f]$, i.e., p is less than or equal to half the minimum delivery fraction (denoted by f). We add constraint (4.21) to LP, so that customer l is completely removed from route i .

$$s_l^{(i)} = \sum_{j:(i,j) \in A(l)} x_{ij} - \sum_{j:(j,i) \in A(l)} x_{ji} \quad (4.21)$$

If $p \in (\frac{1}{2}f, f)$, we add constraint (4.22) to LP, so that route i serves at least fraction

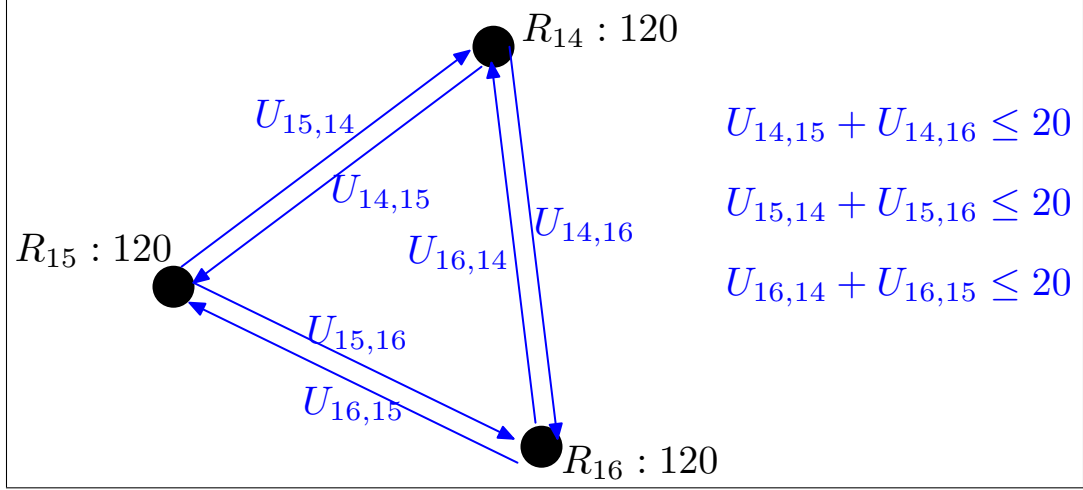


Figure 4.9: Large minimum delivery fraction causing infeasibility

f of customer l .

$$\sum_{j:(j,i) \in A(l)} x_{ji} - \sum_{j:(i,j) \in A(l)} x_{ij} \geq f * t_l - s_l^{(i)} \quad (4.22)$$

Occasionally, these two constraints may render LP infeasible because f is large and the split customer is serviced by three or more routes. We illustrate this in Figure 4.9. In this situation, we revert to the non-split feasible solution at the end of Stage 1 as the final solution.

Suppose we have a cluster before the final clean-up stage shown in Figure 4.9. There are three routes of duration 120, each serving one-third of a customer whose total demand is 60. The minimum delivery fraction $f = 0.35$. Since R_{14} delivers only one-third of the customer demand which is greater than $\frac{1}{2}f = 0.175$, we add constraint $U_{15,14} + U_{16,14} - U_{14,15} - U_{14,16} \geq 60 \times 0.35 - 20 = 1$. Solving LP results in a cluster with durations of $R_{14} = 121$, $R_{15} = 119.5$, and $R_{16} = 119.5$, i.e., one unit of service time is transferred from R_{15} and R_{16} to R_{14} . With this arrangement, R_{15} serves 19.5 units of service time or $0.325 > 0.175$ of the customer's demand, so

we add the constraint $U_{14,15} + U_{16,15} - U_{15,14} - U_{15,16} \geq 1$ to LP. Solving LP results in a cluster with the durations of $R_{14} = 121$, $R_{15} = 121$, and $R_{16} = 118$, i.e., two units of service time is transferred from R_{16} to R_{14} and R_{15} . With this arrangement, R_{16} serves 18 units of service time or $0.3 > 0.175$ of the customer's demand, so we add the constraint $U_{14,16} + U_{15,16} - U_{16,14} - U_{16,15} \geq 1$ to LP. However, the three constraints that we have added define an infeasible region.

4.5 Computational results

In this section, we present the computational results of our algorithm on three sets of instances. The first set of 43 instances (with no service times) is from Wang et al. [94]. The data can be found in Appendix B. We want to show that modified MD produces better results on these instances than MD. The second set of 21 instances was generated by modifying the instances in Chen et al. [25]. The data can be found in Appendix C. Taking advantage of the geometric symmetry, we develop a simple greedy algorithm to obtain good min-max solutions that can be compared to the solutions produced by MDS. The third set of 258 instances was generated based on the first set. We analyze the savings from split service and the patterns of splits as we vary the average customer service time and the average number of customers served by one route. In all instances, we assume that the travel time is equal in magnitude to the Euclidean distance. All experiments were done with a CPU of 2.20 GHz and RAM of 4.0 GB. The proposed method is coded in C++.

4.5.1 Test Set 1

The results of the modified MD algorithm (denoted by MMD) on the first set of 43 instances are shown in Table 4.7. The first column gives the problem identifiers. The second to fourth columns describe the size of data. The fifth and sixth column give the results of MD. The running times of instances MM21 to MM43 are not reported in [94]. The seventh and the eighth columns give the results of MMD. The objective function value for MMD is the best of four runs with $\lambda = 0.3, 0.6, 0.8,$ and 1.2 . The running time for MMD is the sum of the running times of the four runs. The last column gives the percentage improvement of MMD over MD. The average improvement on the 43 instances is about 2%, but the magnitude varies depending on the instance. The largest improvement is on MM31 (11.41%). There are six instances with negative improvement. This may be due to the parameter λ introduced in LS_NoSplit and the initial random perturbation angles. The sum of the running times of the first 20 instances for MMD is 6.8 times that of MD, but we point out that MMD with different λ values can run in parallel if the machine has four cores, so that the running time can be reduced significantly. Wang et al. [94] divided 40 of the instances (MM1, MM6, and MM7 excluded) into four groups according to the distribution of customer locations and the customer-to-vehicle ratio. The average improvement of MMD over MD for each group is shown in Table 4.8. MMD produces the largest improvement when the customers are not uniformly distributed and the customer-to-vehicle ratio is small.

Table 4.7: Results of MD and MMD on Test Set 1

Problem identifier	Size of data			MD		MMD		Improvement of MMD over MD (%)
	Number of depots	Number of customers	Number of vehicles per depot	Objective function value	Running time (s)	Objective function value	Running time (s)	
MM1	3	10	1	170.91	1	170.91	7	0.00
MM2	10	200	1	130.80	11	128.25	97	1.95
MM3	5	200	1	238.94	18	236.14	147	1.17
MM4	5	395	1	479.68	18	468.54	2058	2.32
MM5	10	390	1	315.89	33	312.19	408	1.17
MM6	4	400	1	82.23	44.0	81.74	124	0.59
MM7	1	25	3	189.02	2	189.01	15	0.00
MM8	3	200	2	217.38	30	208.47	321	4.10
MM9	4	400	3, 2, 2, 1	153.74	112	150.14	760	2.34
MM10	5	50	1	197.39	4	194.31	37	1.56
MM11	10	100	1	102.35	3	102.35	23	0.00
MM12	15	100	1	78.90	3	73.80	28	6.47
MM13	10	150	1	121.87	5	121.07	58	0.66
MM14	10	200	1	134.61	8	133.13	87	1.10
MM15	15	200	1	99.81	5	96.23	76	3.58
MM16	20	500	1	101.68	23	99.59	201	2.06
MM17	2	350	2	248.59	235	249.68	2478	-0.44
MM18	2	400	1, 3	390.16	619	394.28	1953	-1.06
MM19	3	400	1, 1, 2	365.66	616	359.19	3200	1.77
MM20	3	500	1, 2, 2	339.92	360	333.99	2571	1.75
MM21	10	400	1	259.14	-	253.93	575	2.01
MM22	10	200	1	400.60	-	400.59	1471	0.00
MM23	5	50	1	374.97	-	376.40	463	-0.38
MM24	15	200	1	204.00	-	200.62	542	1.66
MM25	20	500	1	272.61	-	270.75	821	0.68
MM26	5	150	2	364.56	-	361.52	825	0.83
MM27	4	400	3	290.37	-	291.16	447	-0.27
MM28	5	350	3	354.31	-	354.34	2581	-0.01
MM29	3	200	2	364.01	-	368.96	670	-1.36
MM30	5	250	1	140.34	-	136.12	496	3.01
MM31	3	250	1	124.32	-	110.13	193	11.41
MM32	3	200	1	103.15	-	98.85	43	4.17
MM33	8	400	1	97.56	-	94.61	116	3.02
MM34	6	400	1	84.64	-	83.62	329	1.20
MM35	2	300	2	109.30	-	102.98	99	5.78
MM36	2	250	2, 3	155.99	-	145.07	1200	7.00
MM37	3	500	1, 2, 2	156.41	-	150.69	137	3.65
MM38	2	350	2	155.46	-	154.62	328	0.54
MM39	5	250	1	209.85	-	209.85	518	0.00
MM40	3	200	1	243.47	-	241.10	897	0.97
MM41	3	500	2	257.16	-	244.90	2174	4.77
MM42	2	450	2, 3	367.44	-	345.35	2651	6.01
MM43	2	350	2	375.16	-	365.21	1122	2.65
Average								2.06

Table 4.8: Average improvement of MMD over MD

Distribution of customer locations	Customer-to-vehicle ratio	Average improvement (%)
Uniform	Small	2.26
Uniform	Large	0.43
Non-uniform	Small	3.87
Non-uniform	Large	2.21

4.5.2 Test Set 2

4.5.2.1 Data generation

In the VRP literature, some benchmark test instances are generated with symmetric customer locations, so that estimated solutions with high quality can be visualized using geometric considerations. In particular, Chen et al. [25] provided SDVRP instances with customers located on concentric circles centered at the depot. By varying the number of customers per circle (denoted by A) and the number of circles (denoted by B), the authors generated 21 test instances. In Figures 4.10(a) and 4.10(b), we show instance SD1, with $A = 4$ and $B = 2$, and instance SD10, with $A = 16$ and $B = 4$.

We modify the 21 instances from [25] and produce min-max SDVRP instances. The parameters A and B are the same for the 21 instances generated in [25]. The difference in the radius between adjacent circles is 100, and the customer service time is 100. There are $\frac{3}{2}A$ vehicles stationed at the depot (A is even in each instance).

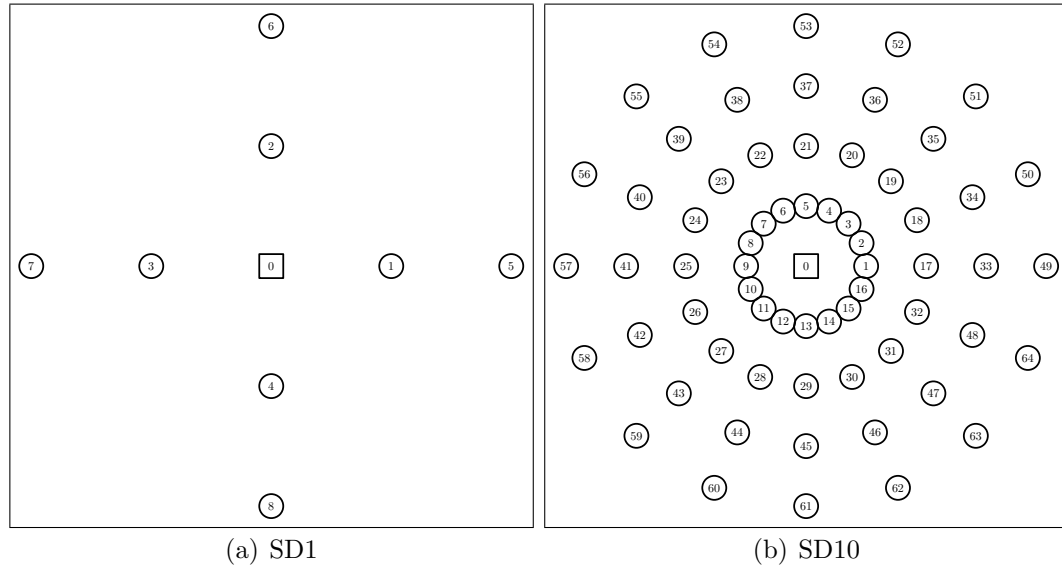


Figure 4.10: Example of instances

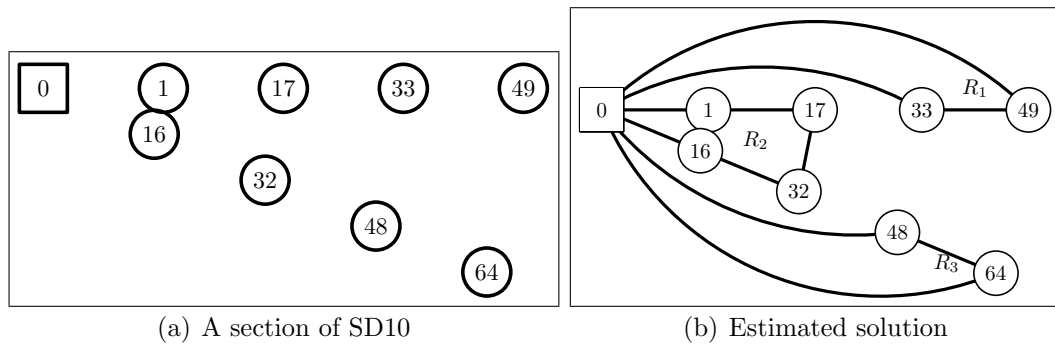


Figure 4.11: Sub-problem of SD10 and its estimated solution

4.5.2.2 Estimated solution

A simple heuristic approach is used to find solutions to the 21 problems. We partition the region into $\frac{A}{2}$ equal sectors. Each sector has $2B$ customers located on two rays at an angle of $\theta = \frac{360^\circ}{A}$ that emanate from the depot. There are three vehicles. We solve the sub-problem over the sector. Figure 4.11(a) shows one sector obtained from SD10. There are eight customers, four on each of the two rays from the depot, and three routes. The angle between the two rays is 22.5° .

Table 4.9: Algorithm to estimate the optimal solution

Algorithm 7

Denote the estimated optimal objective function value by Z_e

For $k = 1$ to B

travel time of R_1 , $TR(R_1) = 200B$

travel time of R_3 , $TR(R_3) = 200B$

travel time of R_2 , $TR(R_1) = 200k(1 + \sin(\frac{\theta}{2}))$

total service time, $S = 200B$

average duration, $D_{ave} = 200B + \frac{200k}{3}(1 + \sin(\frac{\theta}{2}))$

$D_{max} = 300B$

$D_{min} = 300B - 100k$

If $D_{avg} < D_{min}$

$Z_e^{(k)} = D_{min}$

Elseif $D_{min} \leq D_{avg} \leq D_{max}$

$Z_e^{(k)} = D_{avg}$

Else

$Z_e^{(k)} = 3D_{avg} - 2D_{max}$

Endif

Endfor

Pick the k with the smallest $Z_e^{(k)}$ which gives the best estimated solution

In the estimated solution to the sub-problem, the first (third) route travels along the first (second) ray until it reaches the farthest customer, and returns to the depot along the same path, serving some customers fully or partly along the way. The second route travels along the first ray until it reaches the k^{th} customer, then visits the k^{th} customer on the second ray, and returns to the depot along the second ray. We expect that the first and the third routes have equal duration, which is not less than the duration of the second route. The number k and the estimated solution is determined by the algorithm in Table 4.9. In Figure 4.11(b), we show the routes of the estimated solution to the sub-problem of SD10 with $k = 2$.

The estimated solutions are given in Table 4.10. The first column gives the problem identifier. The second to fifth columns describe each instance. A is the

number of customers per circle, B is the number of concentric circles, n is the total number of customers, and m is the number of routes. The sixth to ninth columns describe the the estimated solutions. The Max column gives the duration of the longest route, i.e., the objective function value in the estimated solution. The Min column gives the duration of the shortest route. The Min/Max column gives the ratio of shortest duration to the longest duration. Because of symmetry, there may be more than one longest route in the estimated solution. The number of routes with duration equal to the objective function value is given in the column with heading l .

Next, we show that the estimated solutions of the first 12 instances and the sixteenth instance are, in fact, optimal. The remaining estimated solutions (except for SD21) are all within 2% of optimality. For SD21, the estimated solution is within 6.51% of optimality.

4.5.2.3 Mathematical model and exact solutions for Test Set 2

In this section, we formulate a mixed integer program (MIP) to solve instances SD1 to SD21. We prove that the estimated solutions to 13 instances (SD1 to SD12 and SD16) are optimal. Another seven estimated solutions are within 2% of optimality.

Table 4.10: Estimated solutions

Problem	A	B	n	m	Max	Min	Min/Max	l
SD1	4	2	8	6	513.81	513.81	1.00	6
SD2	4	4	16	6	1027.61	1027.61	1.00	6
SD3	8	2	16	12	500.00	476.54	0.95	8
SD4	12	2	24	18	500.00	451.76	0.90	12
SD5	8	4	32	12	1000.00	953.07	0.95	8
SD6	16	2	32	24	500.00	439.02	0.88	16
SD7	4	10	40	6	2569.04	2569.04	1.00	6
SD8	4	12	48	6	3082.84	3082.84	1.00	6
SD9	12	4	48	18	1000.00	903.53	0.90	12
SD10	16	4	64	24	1000.00	878.04	0.88	16
SD11	4	20	80	6	5100.00	4872.79	0.96	4
SD12	8	10	80	12	2500.00	2382.68	0.95	8
SD13	8	12	96	12	3000.00	2859.22	0.95	8
SD14	12	10	120	18	2500.00	2258.82	0.90	12
SD15	12	12	144	18	2987.45	2987.45	1.00	18
SD16	72	2	144	108	500.00	408.72	0.82	72
SD17	8	20	160	12	5000.00	4765.37	0.95	8
SD18	16	10	160	24	2478.04	2478.04	1.00	24
SD19	16	12	192	24	2957.71	2957.71	1.00	24
SD20	12	20	240	18	4923.13	4923.13	1.00	18
SD21	72	4	288	108	1000.00	817.45	0.82	72

A : number of customers per circle

B : number of concentric circles

n : total number of customers

m : number of routes

l : number of longest routes

$$\text{(MIP) min } z \quad (4.23)$$

$$\text{s.t. } z \geq \sum_{i,j \in I} c_{ij} x_{ij}^{(k)} + \sum_{i \in I} c_{ki} x_{ki} + \sum_{i \in I} c_{ik} x_{ik} + \sum_{i \in I} s_i^{(k)} \quad \forall k \in K \quad (4.24)$$

$$y_i^{(k)} = \sum_{j \in I} x_{ji}^{(k)} + x_{ki} \quad \forall i \in I, \forall k \in K \quad (4.25)$$

$$1 = \sum_{i \in I} x_{ki} \quad \forall k \in K \quad (4.26)$$

$$0 = \sum_{j \in I} x_{ji}^{(k)} - \sum_{j \in I} x_{ij}^{(k)} + x_{ki} - x_{ik} \quad \forall i \in I, \forall k \in K \quad (4.27)$$

$$t_i = \sum_{k \in K} s_i^{(k)} \quad \forall i \in I \quad (4.28)$$

$$s_i^{(k)} \leq t_i y_i^{(k)} \quad \forall i \in I, \forall k \in K \quad (4.29)$$

$$0 = x_{ii}^{(k)} \quad \forall i \in I, \forall k \in K \quad (4.30)$$

$$\sum_{i \in I} \sum_{j \in I} x_{ij}^{(k)} \leq |S| - 1 \quad \forall S \subseteq I, S \neq \emptyset, \forall k \in K \quad (4.31)$$

$$x_{ki} \in \{0, 1\}, \quad x_{ik} \in \{0, 1\}, y_i^{(k)} \in \{0, 1\}, \forall i \in I, \forall k \in K \quad (4.32)$$

$$x_{ij}^{(k)} \in \{0, 1\} \quad \forall i \in I, \forall j \in I, \forall k \in K \quad (4.33)$$

$$s_i^{(k)} \geq 0 \quad \forall i \in I, \forall k \in K \quad (4.34)$$

$$z \geq 0 \quad (4.35)$$

Let I denote the set of customers and K denote the set of routes. The decision variables are x_{ki} , x_{ik} , $y_i^{(k)}$, $x_{ij}^{(k)}$, $s_i^{(k)}$, and z . x_{ki} (or x_{ik}) is binary and equals 1 if and only if customer i is the first (or last) customer on route k . $y_i^{(k)}$ is binary and equals 1 if and only if customer i is served on route k . $x_{ij}^{(k)}$ is binary and equals 1 if and

only if customer i proceeds customer j on route k . $s_i^{(k)}$ is continuous and determines the amount of service time delivered to customer i by route k . z is continuous and is the duration of the longest route.

The objective function (4.23) minimizes the maximum duration. In constraints (4.24), the parameters c_{ij} , c_{ki} , and c_{ik} denote the travel times from customer i to j , from the depot to customer i , and from customer i to the depot. The first three terms on the right-hand side of the inequality sum to the travel time of route k , and the last term is the service time on route k . Constraints (4.24) together with the minimization objective ensure that z is the duration of the longest route. Constraints (4.25) imply that customer i is served (partly or fully) by route k if and only if there is an incoming arc to i traveled by route k . Constraints (4.26) imply that on every route, there is exactly one customer that is visited immediately after the vehicle leaves the depot. In constraints (4.27), for every customer, the number of incoming arcs of route k is equal to the number of outgoing arcs of route k . Constraints (4.28) ensure that every customer is fully served. In constraints (4.29), customer i receives some service from route k only if the customer is on the route. Constraints (4.30) eliminate self loops. Constraints (4.31) are the sub-tour elimination constraints. Constraints (4.32) to (4.35) define the variable types and bounds. Note that (MIP) applies to the multi-depot problem as well.

We add valid inequalities to strengthen the formulation. Some of the inequalities apply to general instances, and the other inequalities apply to only specific instances.

First, from Corollary 1, every edge linking two customers is traversed at most

Solution 1		Solution 2	
Vehicles	Order of Customers	Vehicles	Order of Customers
1	5, 6, 7, 8	1	1, 2, 3, 4
2	1, 2, 3, 4	2	5, 6, 7, 8

Table 4.11: Two Symmetric Solutions

once, in either direction. We add

$$\sum_{k \in K} x_{ij}^{(k)} + x_{ji}^{(k)} \leq 1 \quad \forall i \in I, \forall j \in I \quad (4.36)$$

Second, we exploit the symmetry of the model. We realized that exchanging the assignment of customers between any two vehicles produces an alternative solution. This increases the running time because the search tree spends time identifying these solutions. To remove this type of symmetry, we introduce the following valid inequalities:

$$\sum_{i \in I} ix_{ki} \leq \sum_{i \in I} ix_{k+1,i} \quad \forall k \in \{1, 2, \dots, K-1\} \quad (4.37)$$

Essentially, this set of valid inequalities enforces a lexicographic order on the vehicles. The index of the first customer on route $k+1$ is at least as big as that of the first customer on route k where k takes on values from 1 to $K-1$. Consider the example in Table 4.11 where both solutions are feasible without constraints (4.37). After enforcing this set of inequalities, only Solution 2 is feasible.

The second type of symmetry for a given route comes from switching the order in which customers are visited. This is an alternative solution because the travel

cost is symmetric. We introduce the following valid inequalities:

$$\sum_{i \in I} ix_{ki} \leq \sum_{i \in I} ix_{ik} \quad \forall k \in K \quad (4.38)$$

Here, we enforce a lexicographic order on each route such that the index of the last customer is at least as large as that of the first customer. For example, Solution 2 in Table 4.11 could also have route 2 with the following order of customers: 8, 7, 6, 5. With the set of inequalities (4.38), 5, 6, 7, 8 is the only feasible order. However, we cannot have this set of inequalities (4.38) if the travel costs are asymmetric.

Next, we present the third set of valid inequalities. Let S be a subset of I and $\delta(S) = \{(i, j) : i \in S, j \notin S\}$ denote the set of arcs leaving S . The sub-tour elimination constraints are enough to prevent sub-tours in the solution. To strengthen the formulation, we add the following set of inequalities:

$$\sum_{k \in K} \sum_{(i, j) \in \delta(S)} x_{ij}^{(k)} \geq 1 \quad \forall S \subset I, |S| \geq 2, \quad (4.39)$$

where $|S|$ is the cardinality of the set S . We refer to this set of inequalities as the connectivity cuts. In order to ensure the connectivity of the solution, we need to separate the sub-tour elimination constraints and the connectivity cuts. For the separation of the sub-tour elimination constraints, we find connected components in the supported graph and add violated constraints if there is more than one component. For the connectivity cuts, we solve a maximum flow problem from each vertex to the depot. We note that the sub-tour elimination constraints are separated for

integer solutions. The connectivity cuts are only separated in the root node for fractional solutions.

For the fourth set of valid inequalities, we use the estimated solutions to construct additional valid inequalities. For example, if the objective value of the estimated solution is 500, we know that some pair of customers cannot be served on the same route if the optimal objective function value of the traveling salesman problem including three nodes, two customers and the depot is greater than 500. Similarly, we prevent some groups of three customers from being served on the same route. Therefore, we have constraints (4.40) and (4.41), where F_1 (or F_2) is the set of customer pairs (or groups of three customers) that are not served on the same route in the optimal solution.

$$y_i^{(k)} + y_j^{(k)} \leq 1 \quad \forall (i, j) \in F_1 \quad (4.40)$$

$$y_i^{(k)} + y_j^{(k)} + y_l^{(k)} \leq 2 \quad \forall k \in K, \forall (i, j, l) \in F_2 \quad (4.41)$$

Furthermore, if we regard F_1 as the edge set of an auxiliary graph whose vertices are I , and identify a clique in the graph, additional equality constraints on $y_i^{(k)}$ can be constructed. For example, as long as $F_1 \neq \emptyset$, we have a clique of two vertices. For example, if $(i, j) \in F_1$, we can add four equality constraints, $y_i^{(k_1)} = 1, y_i^{(k_2)} = 0, y_j^{(k_1)} = 0, y_j^{(k_2)} = 1$, fixing some $k_1, k_2 \in K$ and $k_1 \neq k_2$. For these 21 instances, we find the maximum cardinality clique in the graph. If a clique (denoted by CLQ) of customers, $i_1, i_2, \dots, i_{|CLQ|}$, is found, we add $|CLQ|^2$ equality

Table 4.12: Results for Test Set 2

Problem	Estimate	Shortest Two Outermost Customers	Slack Two Outermost Customers	Possible Service	Gap (%)
SD1	513.81	682.84	0.00	113.81	0.00
SD2	1027.61	1365.69	0.00	227.61	0.00
SD3	500.00	553.07	0.00	100.00	0.00
SD4	500.00	503.53	0.00	100.00	0.00
SD5	1000.00	1106.15	0.00	200.00	0.00
SD6	500.00	478.04	21.96	100.00	0.00
SD7	2569.04	3414.21	0.00	569.04	0.00
SD8	3082.84	4097.06	0.00	682.84	0.00
SD9	1000.00	1007.06	0.00	200.00	0.00
SD10	1000.00	956.07	43.93	200.00	0.00
SD11	5100.00	6828.43	0.00	1100.00	0.00
SD12	2500.00	2765.37	0.00	500.00	0.00
SD13	3000.00	3318.44	0.00	600.00	0.95
SD14	2500.00	2517.64	0.00	500.00	1.87
SD15	2987.45	3021.17	0.00	587.45	1.56
SD16	500.00	417.45	82.55	100.00	0.00
SD17	5000.00	5530.73	0.00	1000.00	1.16
SD18	2478.04	2390.18	87.86	478.04	1.99
SD19	2957.71	2868.22	89.49	557.71	1.40
SD20	4923.13	5035.28	0.00	923.13	0.62
SD21	1000.00	834.90	165.10	200.00	6.51

constraints. We fix $|CLQ|$ distinct routes, $k_1, k_2, \dots, k_{|CLQ|}$ and include:

$$y_{i_p}^{(k_q)} = \begin{cases} 1 & \text{if } p = q \\ 0 & \text{otherwise} \end{cases} \quad \forall p, q \in \{1, 2, \dots, |CLQ|\} \quad (4.42)$$

in our model.

Finally, we make the following observations that allow us to add valid cuts to instances in Test Set 2. We refer to the route that serves at least one of the outermost customers as an outermost route.

Observation 1. From SD1 to SD20, there exists an optimal solution which has A outermost routes (A is the number of customers per circle as shown in Table 4.10).

Proof. To serve the outermost customers, we can send out one vehicle for each outermost customer. We have A outermost routes.

First, we will show that we need at least A outermost routes. For each instance, we calculate the shortest possible distance for an outermost route. This can be found in the column Shortest Two Outermost Customers in Table 4.12. For most instances, this distance is longer than the estimated solution which is indicated as 0 in the column Slack Two Outermost Customers. There are six instances that have positive slack. Except for SD21, the slack amount is small so that we have to use at least three vehicles to serve two outermost customers if each vehicle serves at least two outermost customers. So, there are at least A outermost routes.

Then, we have at most $\frac{1}{2}A$ vehicles remaining. All outermost customers should be satisfied already, so, we would no longer visit any outermost customers. Thus, we do not need to assign any outermost routes. \square

Observation 2. From SD1 to SD20, there exists an optimal solution where the travel time of each outermost route is $200 \times B$ (B is the number of concentric circles as shown in Table 4.10).

Proof. In order to make the best use of these outermost routes, we can have all outermost routes with a travel time of $200 \times B$ because the travel time between two adjacent customers is 100. The travel time from the depot to the nearest customer is also 100. In this way, the outermost route has the smallest possible travel time.

This allows us to assign each outermost route the largest possible amount of service time before an outermost route exceeds the pre-specified bound. The total service time is $A \times B \times 100$ because there are $A \times B$ customers and each has a service time of 100. Then, the total service time of the remaining $\frac{1}{2}A$ vehicles is the minimum possible. Thus, the resulting solution is optimal. \square

Let O denote the set of outermost customers. Observation 2 tells us that the vehicle on the outermost route travels along the ray. So, we can visit all customers in an outermost route in the path leaving the depot because the travel costs are symmetric. This leads to the following set of inequalities for SD1 to SD20 of Test Set 2:

$$\sum_{k \in K} x_{ik} = 1 \quad \forall i \in O \quad (4.43)$$

We note that this set of inequalities (4.43) dominates constraint set (4.42).

We label a ray by the smallest index of those customers on it. Thus, in SD1, ray 1 has customers 1 and 5. In SD10, ray 1 has customers 1, 17, 33, and 49. We refer to customer rays 1 to $\frac{A}{2}$ as partition 1 and customer rays $\frac{A}{2} + 1$ to A as partition 2.

Observation 3. From SD1 to SD20, we can solve each instance by focusing on partition 1 and $\frac{3A}{4}$ vehicles.

Proof. Feasibility is satisfied by the geometric symmetry. We can mimic the routes for customer rays $\frac{A}{2} + 1$ to A .

For optimality, we have A rays which is a multiplier of four. Hence, $\frac{3A}{2}$ is an even number. The number of vehicles (denoted by v) served in partition 1 should be equal to the number in partition 2. v is an even number and the number of vehicles that serves both partitions is also an even number. Furthermore, there exists an optimal solution where no vehicles serve both partition 1 and partition 2 at the same time. We call this a non-crossing solution. Those vehicles serving both partitions need to travel across the space between ray 1 and ray A and the one between $\frac{A}{2}$ and $\frac{A}{2} + 1$ in order to serve all customers. Thus, the total travel time is not smaller than that of the non-crossing solution. Hence, the non-crossing solution is at least as good as the solution with crossing given that the total service time is fixed. \square

Observation 4. For SD21, 934.90 is a valid lower bound on the optimal value.

Proof. The objective value of the best found solution is 969.98 for SD21. If we assign each outermost route one outermost customer, then the optimal value is 1000 which can be verified by solving the IP formulation. It exceeds the incumbent value of 969.98. Thus, we cannot have an optimal solution where each outermost route serves only one outermost customer.

Therefore, we have at least one outermost route visiting two outermost customers. The smallest possible traveling time is 834.90. The service time is at least 100 because we have less than 72 outermost routes given that we have some routes visiting more than one outermost customer. Therefore, the lower bound is 934.90. \square

MIP was solved using CPLEX 12.6.0 with a time limit of two hours. The exact

solver was able to find optimal solutions to the first 12 instances and the sixteenth instance. All 13 optimal solutions are the same as the estimated solutions in Section 4.5.2.2. The exact solver shows that the estimated solution to the largest instance (SD21) is within 6.51% of optimality. In addition, for the the largest instance (SD21), the best solution found by the exact solver has an objective function value of 969.98 which is within 3.62% of optimality. The estimated solutions to the remaining seven instances are all within 2% of optimality.

4.5.2.4 MDS solution

We tested MDS with 16 different λ values from 0.0 to 1.5 and chose $\lambda = 0.3, 0.6, 0.8,$ and 1.2 based on results from the 21 instances. The solutions from MDS are presented in Table 4.13. The first column gives the problem identifiers. The second and the third columns give the number of customers and routes. The fourth column gives the known optimal solutions. The fifth column gives our estimated solutions. The sixth and seventh columns give the best solutions of four runs of MDS with $\lambda = 0.3, 0.6, 0.8,$ and 1.2 . The running time is the sum of the times of the four runs. The eighth column gives the percentage gaps of the MDS solutions with respect to the estimated solutions. The average gap is 1.5% on the 21 instances. The ninth column gives the best solution of the 16 runs of MDS with different λ values. Six solutions were not generated by the four specified λ values (0.3, 0.6, 0.8, 1.2). The tenth column shows that the average gap from the estimated solution is 1.31%.

Table 4.13: MDS solutions vs the estimated solutions

Problem identifier	Number of customers	Number of routes	Exact solution	Estimated solution	MDS solution	MDS running time (s)	Gap (%) between MDS solution and estimated solution	Best MDS solution found	Gap (%) between best MDS solution and estimated solution
SD1	8	6	513.81	513.81	513.81	2.9	0.00	513.81	0.00
SD2	16	6	1027.61	1027.61	1027.61	12.9	0.00	1027.61	0.00
SD3	16	12	500.00	500.00	500.00	4.3	0.00	500.00	0.00
SD4	24	18	500.00	500.00	500.00	2.8	0.00	500.00	0.00
SD5	32	12	1000.00	1000.00	1000.00	34.0	0.00	1000.00	0.00
SD6	32	24	500.00	500.00	500.00	4.4	0.00	500.00	0.00
SD7	40	6	2569.04	2569.04	2600.00	44.5	1.21	2569.03 ^a	0.00
SD8	48	6	3082.84	3082.84	3100.00	54.0	0.56	3100.00	0.56
SD9	48	18	1000.00	1000.00	1026.28	40.6	2.63	1026.28	2.63
SD10	64	24	1000.00	1000.00	1017.20	53.6	1.72	1014.21 ^b	1.42
SD11	80	6	5100.00	5100.00	5100.00	105.5	0.00	5100.00	0.00
SD12	80	12	2500.00	2500.00	2583.79	96.8	3.35	2583.79	3.35
SD13	96	12	-	3000.00	3012.49	106.3	0.42	3000.00 ^c	0.00
SD14	120	18	-	2500.00	2553.28	158.5	2.13	2553.28	2.13
SD15	144	18	-	2987.45	3067.69	227.2	2.69	3063.44 ^d	2.54
SD16	144	108	500.00	500.00	503.21	300.0	0.64	503.21	0.64
SD17	160	12	-	5000.00	5023.53	233.0	0.47	5000.00 ^e	0.00
SD18	160	24	-	2478.04	2600.00	248.3	4.92	2563.41 ^f	3.45
SD19	192	24	-	2957.71	3054.28	346.6	3.27	3054.28	3.27
SD20	240	18	-	4923.13	5119.63	826.1	3.99	5119.63	3.99
SD21	288	108	-	1000.00	1034.90	333.7	3.49	1034.90	3.49
Average							1.50		1.31

^a $\lambda = 1.0$ ^b $\lambda = 0.0$ ^c $\lambda = 1.0$ ^d $\lambda = 0.4$ ^e $\lambda = 0.2$ ^f $\lambda = 0.2$

4.5.3 Test Set 3

The 43 instances supplied by Wang et al. [94] have both uniform and non-uniform distributions of customer locations. The number of customers in an instance ranges from 10 to 500, and the number of depots from 3 to 20. For each instance, we generate six instances with a service time requirement according to the following procedure, while keeping the locations of customers and depots unchanged.

1. Supply every customer with a service time uniformly distributed over $(1, 10)$.

This is the short service time scenario.

2. Multiply every service time by 10 to construct the medium service time scenario; if a customer requires a service time of 1.5 in the short service scenario, the requirement is 15 in the median service scenario.

3. Multiply every service time by 100 to construct the long service time scenario; if a customer requires a service time of 1.5 in the short service scenario, the requirement is 150 in the long service scenario.

4. For each of the three instances, we double the number of vehicles at each depot. Therefore, we derived six instances from one of the 43 instances in Wang et al. [94].

There are 258 instances in total with 86 instances in each service time category.

We can categorize the instances according to the customer-to-vehicle ratio, denoted by r_{ctv} , which indicates the average number of customers per route in a solution.

Table 4.14: Savings (in %) from the non-split solutions

	Short route	Medium route	Long route	Average
Short service	1.07	0.48	0.24	0.62
Medium service	2.94	1.08	0.34	1.50
Long service	2.74	0.79	0.19	1.29
Average	2.25	0.78	0.26	1.14

The short route scenario has $r_{ctv} < 20$ and there are 90 instances in this category. The medium route scenario has $20 \leq r_{ctv} < 50$ and there are 90 instances in this category. The long route scenario has $50 \leq r_{ctv} \leq 100$ and there are 78 instances in this category. Since there are no other procedures available for comparison, we compare the solutions produced by MDS to the non-split solutions from MMD.

We show the savings from the non-split solutions in each scenario with no minimum delivery requirement in Table 4.14. From the second column to the fourth column, the customer-to-vehicle ratio increases. From the second row to the fourth row, the service time increases. The average savings is given by $(0.62 + 1.50 + 1.29)/3 = 1.14\%$, or by $[90(2.25) + 90(0.78) + 78(0.26)]/258$. We observe that the savings decreases as the average number of customers per route increases. This observation is expected. The savings from the non-split solution comes from reducing the time spent at a particular customer (the split customer). If there is a large number of customers on a route, it is unlikely that reducing the time spent at just one customer will result in a large percentage decrease in the total duration. The trend in percentage savings is less straightforward as we vary the service times. The results suggest that instances with a medium level of service time produce the largest savings.

Table 4.15: Average savings (in %) from splitting with four minimum delivery fractions and three service times

	Minimum delivery fraction				
	0.0	0.1	0.2	0.3	0.4
Short service *	0.62	0.58	0.49	0.38	0.26
Medium service	1.50	1.35	1.05	0.74	0.39
Long service	1.29	1.06	0.69	0.42	0.22
Average	1.14	1.00	0.74	0.52	0.29

* 86 instances in each service time category

Table 4.16: Average savings (%) from splitting with four minimum delivery fractions and three r_{ctv} values

	Minimum delivery fraction				
	0.0	0.1	0.2	0.3	0.4
Small r_{ctv} *	2.25	1.97	1.43	0.97	0.57
Medium r_{ctv}	0.78	0.70	0.55	0.39	0.21
Large r_{ctv}	0.26	0.22	0.18	0.11	0.07
Average	1.14	1.00	0.74	0.52	0.29

* 90, 90, 78 instances in the three r_{ctv} categories, respectively

In Tables 4.15 and 4.16, we give the average savings from splitting with minimum delivery fractions 0.0 to 0.4. The formats of the two tables are similar. The first column specifies how the 258 test instances are grouped. Table 4.15 categorizes the instances by the level of service time. Table 4.16 categorizes the instances by the magnitude of the customer-to-vehicle ratio. The second to the sixth columns give the average savings from splitting with minimum delivery fraction 0.0 to 0.4. The bottom row gives the weighted average of the savings. In both tables, the savings decreases as the minimum delivery requirement increases. We observe that medium service times and smaller customer-to-vehicle ratios result in larger savings with all minimum delivery fractions.

We also study how customers are split in the solutions. In general, customers do not prefer multiple visits, and they will favor solutions with fewer splits and splits into no more than two deliveries. In Table 4.17, we show the distribution of the splits by the number of times a customer is visited. For example, the second column shows that, with no minimum delivery amount, 84.77% of the splits results in two services, and 0.43% of the splits results in five or more splits. As the minimum delivery fraction increases, the total number of splits decreases from 1878 to 573. The percentage of splits into two parts increases to 100% when the minimum delivery fraction is 0.4.

When several vehicles visit a customer, one of them delivers the smallest amount. In general, customers do not prefer very small deliveries, and they will prefer a solution with a few large deliveries. In Table 4.18, we present the distribution of splits by the smallest amount. For example, the second column shows that, with no minimum delivery amount, 39.35% of the splits deliver less than 10% of a customer's demand. Only 10.92% of the splits have minimum delivery 40% to 50% of a customer's demand. We observe that, for fractions 0.1 to 0.4, the largest percentage occurs where the minimum delivery fraction falls. When the fraction is 0, 39.35% of the splits have the smallest delivery less than 10%. When the fraction is 0.1, about half of the splits have the smallest delivery between 10% and 20%.

The running time depends on the level of service time used to generate the instances. On average, the initialization with the modified MD, the local search, and the perturbation constitute more than 95% of the running time. For the short service time scenario, these three procedures take about 13.6 minutes on average for

Table 4.17: Split distribution (in %) by the number of times a customer receives service

	Minimum delivery fraction				
	0	0.1	0.2	0.3	0.4
Split into two	84.77	92.17	95.76	97.70	100.00
Split into three	13.37	7.42	4.24	2.30	0.00
Split into four	1.44	0.34	0.00	0.00	0.00
Split into five or more	0.43	0.07	0.00	0.00	0.00
Total number of splits	1878	1469	1155	868	573

Table 4.18: Split distribution (in %) by the smallest portion a customer receives

	Minimum delivery fraction				
	0	0.1	0.2	0.3	0.4
< 10%	39.35	0.00	0.00	0.00	0.00
10% - 20%	23.59	48.06	0.00	0.00	0.00
20% - 30%	14.54	21.03	59.65	0.00	0.00
30%- 40%	11.61	15.86	19.57	74.54	0.00
40% - 50%	10.92	15.04	20.78	25.46	100.00
Total number of splits	1878	1469	1155	868	573

the 86 test instances. For the medium service time scenario, these three procedures take about 8.3 minutes on average. For the long service time scenario, these three procedures take about 3.6 minutes on average. We run MDS with $\lambda = 0.3, 0.6, 0.8,$ and 1.2 in serial, so the total running time is the sum of the times of the four runs.

4.6 Conclusions

We developed a heuristic procedure (MDS) to solve the min-max Split Delivery Multi-Depot Vehicle Routing Problem with Minimum Service Time Requirement. MDS has three stages. In the first stage, we improved an existing procedure to initialize a good solution without any service splits. In the second stage, we explored

the opportunity to improve solutions by splitting service, but ignored the minimum service time requirement. In the third stage, we applied a post-processor to ensure the minimum service time requirement is met.

We tested MDS on three sets of instances. On the first set of 43 instances, the first stage of MDS outperformed the existing procedure by 2% on average. The second set of 21 instances have good estimated solutions. The solutions produced by the first two stages of MDS are, on average, 1.5% away from the estimated solutions. On the third set of 258 instances, we showed that the savings from splitting service is more substantial when the average number of customers per route is small with a medium level of average customer service time.

Chapter 5: The Vehicle Routing Problem with Drones

5.1 Introduction and motivation

The Vehicle Routing Problem (VRP) is a well-studied problem [45, 90]. In its simplest form, it seeks to route a fleet of homogeneous vehicles to deliver identical packages from a depot to a number of customer locations while minimizing the total travel cost. Following recent advancements in drone technology, Amazon [12, 77], DHL [35], Federal Express [14], and other large companies with an interest in package delivery, have begun investigating the viability of incorporating drone delivery into their commercial package delivery services.

Drone delivery (from trucks) would enable trucks to visit customers located centrally on the route and drones to visit farther-away customers. In other words, trucks would get "close enough" to more distant customers and then dispatch drones. Drone delivery could reduce the number of required trucks and drivers on the road. Perhaps more significantly, drones might speed up delivery.

In 2013, Jeff Bezos, CEO of Amazon, expressed his desire to use drones to offer delivery to Amazon's elite customers within 30 minutes of ordering [82]. This is a primary motivation for our work. Given Amazon's focus on speed of delivery, we think the most appropriate objective function here is to minimize the time until

the last delivery. However, since all vehicles have to return to the depot, we seek to minimize the completion time. This is a good approximation to the time until last delivery when the last customer is close to the depot.

To date, there has been very little research on drone delivery of packages from trucks. Three recent papers are Murray and Chu [71], Agatz et al. [1], and Gambella et al. [43]. All of these focus on developing computational techniques (either exact or heuristic) for solving a variant of this problem. As far as we know, our paper is the first to study the problem from a worst-case point of view. Given the emerging status of drone and truck delivery technology, we think our results are especially valuable. They indicate, in a quantitative way, that the maximal potential savings relative to a traditional truck-based model to companies like Amazon and others are very substantial. Actualizing even a fraction of the maximal potential savings would likely justify the cost of adopting this technology.

The remainder of the chapter is organized as follows. In Section 5.2, we describe our problem in detail and give the common notation we used throughout the chapter. In Section 5.3, we formulate and prove our main worst-case theorems for the simple VRPD model. Next, in Section 5.4, we extend our model and prove three additional results. Finally, in Section 5.5, we conclude the chapter and give some directions of future work.

5.2 Problem description

Suppose there are n customers to be served by a homogeneous fleet of m trucks, each carrying k drones. Every customer demands one parcel, which can be delivered by either a truck or a drone. A truck has a capacity of C parcels and a drone can carry at most one parcel while in the air. Further, we assume that the drone has a battery life of U time units, which initially is unrestrictively large. (Later, in Theorem 19, we explicitly consider a restrictive battery life U .) We assume that the driver keeps a number of fully charged batteries on board and replacing a battery is instantaneous. The speed of the drone is α times the speed of the truck, and both the drone and the truck follow the same distance metric. More specifically, we assume that the truck and drone must travel from a to b along the street network. (Later, in Theorem 20, we relax this assumption so that the drone can travel as the crow flies.) A drone launched from a truck must be picked up by the same truck. The truck can dispatch and pick up a drone only at a node, i.e., the depot or a customer location. The truck can continue serving customers after a drone is dispatched and pick up the drone at, possibly, a different node. The vehicle (truck or drone) that arrives at the pick-up node first has to wait for the other one. There is no service time for a delivery. The objective is to minimize the completion time, i.e., from the time the trucks are dispatched from the depot with the drones to the time when the last truck or the last drone returns to the depot.

We will refer to this new vehicle routing problem as the Vehicle Routing Problem with Drones, denoted by $\text{VRPD}_{m,\alpha}$, where m is the number of trucks in the

fleet and α is the ratio of the drone speed to the truck speed. Common notation used in the remainder of this paper is listed below:

- $Z(P)$: The optimal objective function value of problem P (e.g., TSP, VRPD $_{m,\alpha}$)
- $Z^f(P)$: The objective function value of a feasible solution to the problem P (the feasible solution will be specified whenever the notation is used)
- L_r : The length of route r
- T_r^{veh} : The travel time by vehicle veh ($\text{veh}=\text{trc}$ for truck, and $\text{veh}=\text{drn}$ for drone) on route r
- W_r^{veh} : The waiting time by vehicle veh on route r
- $D_r^{\text{veh}} = T_r^{\text{veh}} + W_r^{\text{veh}}$: The duration of route r by vehicle veh .

5.3 Main results

Before a company like Amazon commits to a delivery strategy predicated on the utilization of drones, it might want to know the answer to a key question: At maximum, how much time could be saved, in the best case, using trucks and drones vs. using trucks only? If we look at this question from another angle, it becomes: How much longer will deliveries take with trucks only? This is commonly referred to as worst-case analysis.

In this section, our goal is to provide theoretical bounds on the benefit from using drones. In each of the theorems presented, we compare two related problems P_t and P_{td} . The two problems have the same set of customers, but different fleets.

In P_t , the fleet consists of trucks only. In P_{td} , the fleet consists of trucks and drones. The fleet in P_{td} can serve the customers faster (due to parallelization). That is, we expect $Z(P_{td}) \leq Z(P_t)$. We want to determine the lowest upper bound on the ratio $\frac{Z(P_t)}{Z(P_{td})}$. For example, in the theorem below, we compare the TSP (traveling salesman problem) with VRPD_{1,1}.

Theorem 12. *If the triangle inequality is valid,*

$$\frac{Z(TSP)}{Z(VRPD_{1,1})} \leq k + 1,$$

and the bound is tight.

Remark 6. Theorem 12 is a special case of later theorems; nonetheless, we present a proof here because it serves as an easy-to-follow template for the other proofs. We remind the reader that k is the number of drones per truck throughout this paper.

Proof of Theorem 12. We start with the optimal VRPD_{1,1} solution, and construct a closed (not necessarily simple) walk of all the nodes. We then convert the closed walk to a feasible TSP solution with bounded duration.

A VRPD_{1,1} solution can be decomposed into $k + 1$ routes: one truck route and k drone routes. Figures 5.1 and 5.2 illustrate the decomposition of a solution with $k = 2$. The square labeled 0 represents the depot and the eight circles labeled 1 to 8 represent the customers. The black line represents the path followed by the truck and the red and blue lines are paths followed by the two drones, respectively. The dashed red (or blue) lines are paths of the drone while in the air and the solid red

(or blue) lines are paths of the drone while it is on the truck. Therefore, the red drone is launched from the truck at customer 1 to serve customer 2, and picked up at customer 5 where it is immediately launched again to serve customer 7. The red drone is finally picked up at customer 4 and returns to the depot with the truck. The blue drone is dispatched from the depot to serve customer 8 and picked up at customer 4. This VRPD solution can be decomposed into three routes as shown in Figure 5.2. The truck route is shown in Figure 5.2(a). Its duration is the sum of the travel time of cycle $0 \rightarrow 1 \rightarrow 6 \rightarrow 5 \rightarrow 3 \rightarrow 4 \rightarrow 0$ and the waiting time at customer 5. The red drone route is shown in Figure 5.2(b). Its duration is the sum of the travel time of cycle $0 \rightarrow 1 \rightarrow 2 \rightarrow 5 \rightarrow 7 \rightarrow 4 \rightarrow 0$ and the waiting time at customer 4. The blue drone route is shown in Figure 5.2(c). Its duration is the sum of the travel time of cycle $0 \rightarrow 8 \rightarrow 4 \rightarrow 0$ and the waiting time at customer 4. All three routes have the same duration, which is equal to the objective function value.

Given an optimal $\text{VRPD}_{1,1}$ solution, we decompose it into $k + 1$ routes, and construct a giant route, denoted by R , that traverses the $k + 1$ routes, one after another. In the example shown in Figure 5.1, the sequence that the nodes are traversed in R is $0 \rightarrow 1 \rightarrow 6 \rightarrow 5 \rightarrow 3 \rightarrow 4 \rightarrow 0 \rightarrow 1 \rightarrow 2 \rightarrow 5 \rightarrow 7 \rightarrow 4 \rightarrow 0 \rightarrow 8 \rightarrow 4 \rightarrow 0$. Every node is visited at least once in R and some are visited multiple times. In particular, the depot is always visited $k + 2$ times, if we include both the start and the end of the route. We have the travel time of R ,

$$T_R^{\text{trc}} \leq D_R^{\text{trc}} = (k + 1)Z(\text{VRPD}_{1,1}). \quad (5.1)$$

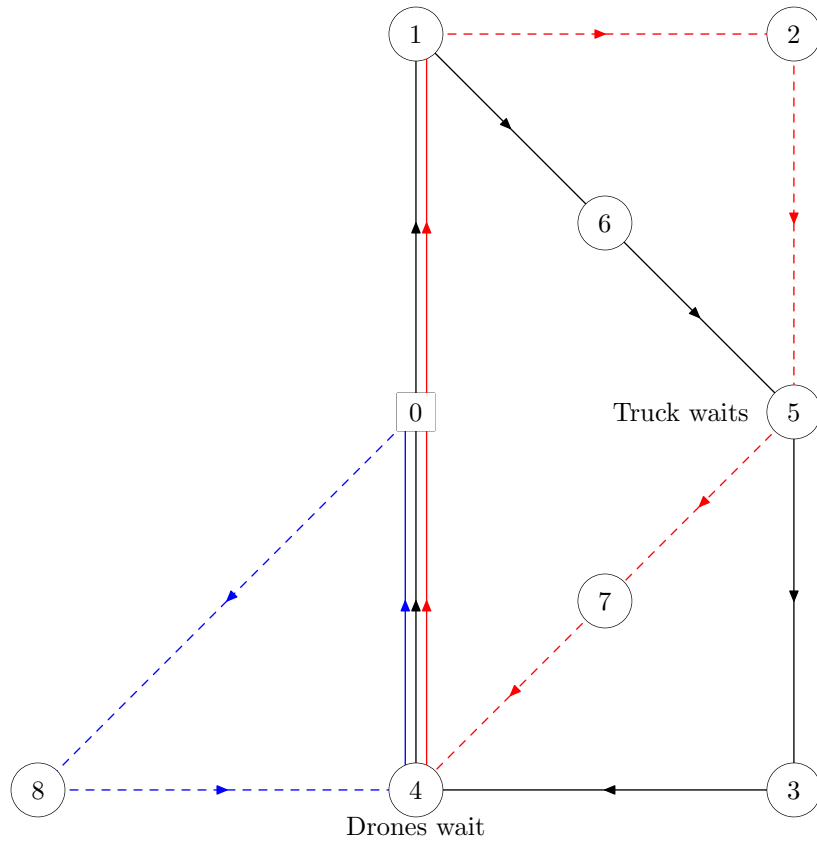


Figure 5.1: A $\text{VRPD}_{1,1}$ solution with $k = 2$

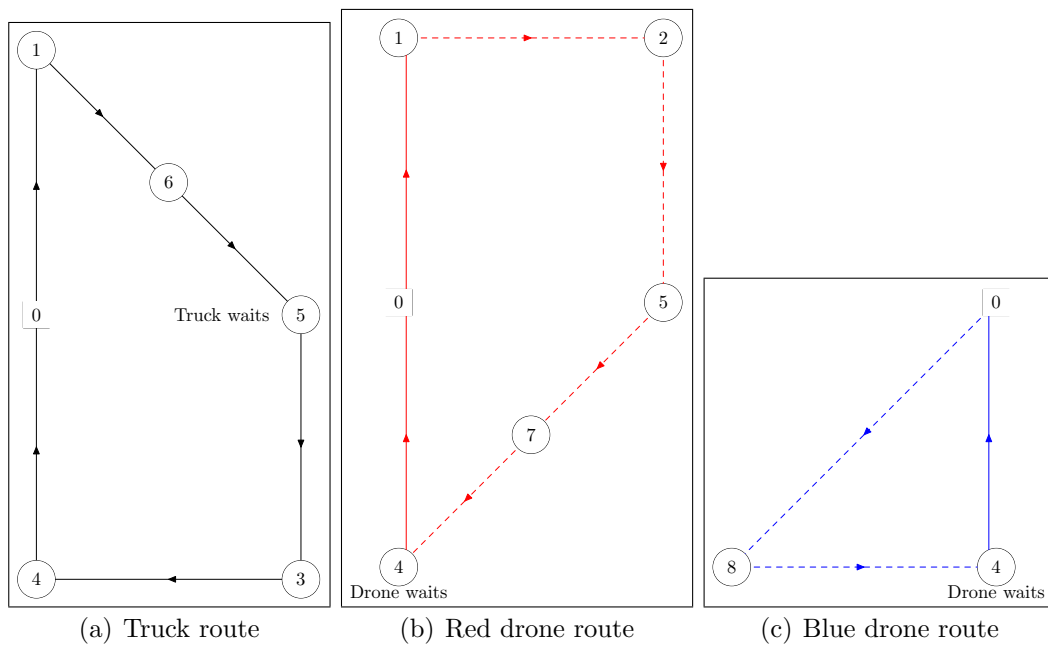


Figure 5.2: Decomposition of a $\text{VRPD}_{1,1}$ solution

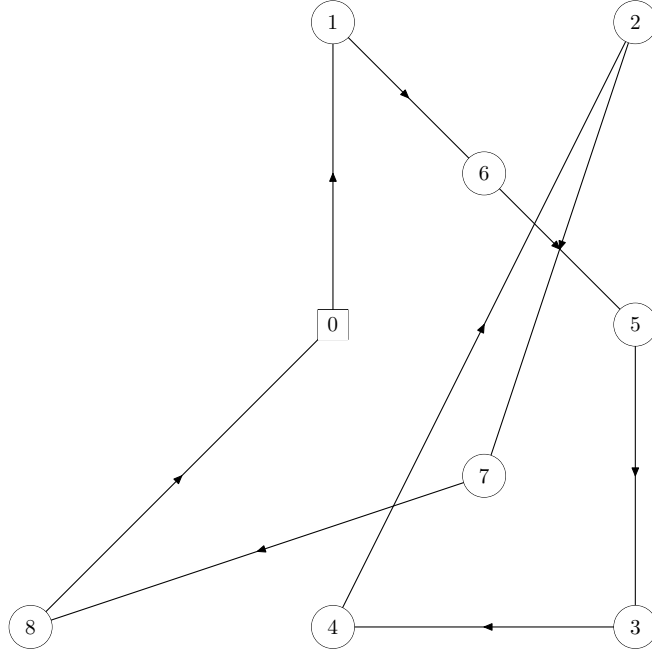


Figure 5.3: A feasible TSP solution from the optimal VRPD solution

A feasible TSP solution can be obtained from R by deleting repeated customers and keeping depots only at the beginning and the end. For the example shown in Figure 5.1, the feasible TSP solution is $0 \rightarrow 1 \rightarrow 6 \rightarrow 5 \rightarrow 3 \rightarrow 4 \rightarrow 2 \rightarrow 7 \rightarrow 8 \rightarrow 0$ as shown in Figure 5.3. Since the triangle inequality is valid, we must have $Z^f(\text{TSP}) \leq T_R^{\text{trc}}$. Therefore,

$$Z(\text{TSP}) \leq Z^f(\text{TSP}) \leq (k + 1)Z(\text{VRPD}_{1,1}) \quad (5.2)$$

or

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,1})} \leq (k + 1). \quad (5.3)$$

To show that the bound is tight, we consider an example with $k + 1$ customers,

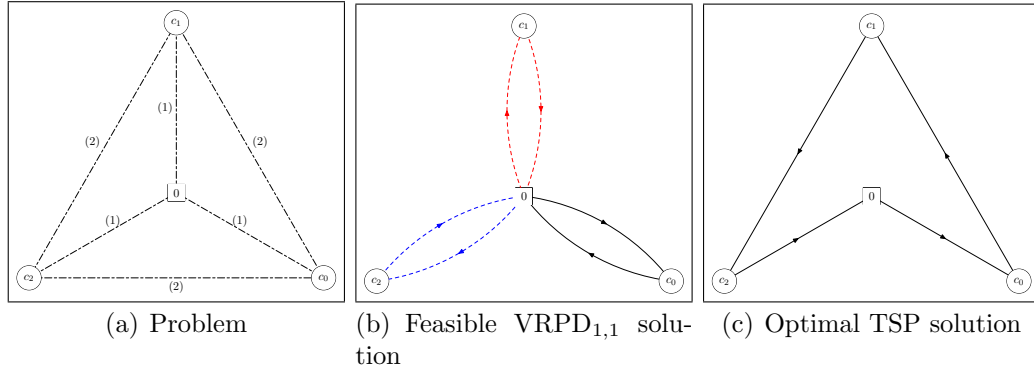


Figure 5.4: A worst-case VRPD_{1,1} example with $k = 2$

c_0, c_1, \dots, c_k . All customers are located at a distance 1 from the depot. The distance between every pair of customers is 2. (See Figure 5.4(a) for the case with $k = 2$. The distances are given in parentheses next to the edges.) Both the truck and the drones travel at a speed of 1. The capacity of the truck $C = k + 1$ and the battery life of a drone is 2 time units. An optimal TSP solution visits the customers c_0 to c_k in sequence, and $Z(\text{TSP}) = 2(k + 1)$. A feasible VRPD_{1,1} solution serves customer c_0 with the truck and serves each of the remaining customers using a drone, which is launched at the depot and picked up at the depot. All vehicles return to the depot at the same time with $Z^f(\text{VRPD}_{1,1}) = 2$. In this example,

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,1})} \geq \frac{Z(\text{TSP})}{Z^f(\text{VRPD}_{1,1})} = \frac{2(k + 1)}{2} = k + 1. \quad (5.4)$$

□

Theorem 13. *If the triangle inequality is valid and $\alpha \geq 1$,*

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha})} \leq \alpha k + 1,$$

and the bound is tight.

Remark 7. Theorem 13 uses the same construction procedure as in Theorem 12 and generalizes Theorem 12.

Proof of Theorem 13. Without loss of generality, we assume the truck speed is 1 and the drone speed is α (since we are interested in only the ratio of the objective function values). As in our proof of Theorem 12, we decompose an optimal $\text{VRPD}_{1,\alpha}$ solution into $k + 1$ routes and traverse them one after another to form a giant route R . If R is traveled by the truck, the travel time

$$T_R^{\text{trc}} = \sum_{j=0}^k T_{r_j}^{\text{trc}} = T_{r_0}^{\text{trc}} + \sum_{j=1}^k \frac{L_{r_j}}{1} \leq T_{r_0}^{\text{trc}} + \sum_{j=1}^k \alpha T_{r_j}^{\text{drn}}. \quad (5.5)$$

In equation (5.5), we have the length of a drone route $L_{r_j} \leq \alpha T_{r_j}^{\text{drn}}$, but not $L_{r_j} = \alpha T_{r_j}^{\text{drn}}$, because some part of L_{r_j} is traveled at the truck speed. But since $\alpha \geq 1$, the inequality always holds. After we remove the revisited customers and depots in the middle of R , because of the triangle inequality, we obtain $Z^f(\text{TSP})$. This yields

$$Z(\text{TSP}) \leq Z^f(\text{TSP}) \leq T_R^{\text{trc}} \leq T_{r_0}^{\text{trc}} + \sum_{j=1}^k \alpha T_{r_j}^{\text{drn}}. \quad (5.6)$$

Therefore,

$$Z(\text{VRPD}_{1,\alpha}) = \max\{D_{r_0}^{\text{trc}}, D_{r_1}^{\text{drn}}, \dots, D_{r_k}^{\text{drn}}\} \quad (5.7)$$

$$\geq \max\{T_{r_0}^{\text{trc}}, T_{r_1}^{\text{drn}}, \dots, T_{r_k}^{\text{drn}}\} \quad (5.8)$$

$$\geq \frac{1}{\alpha k + 1} (T_{r_0}^{\text{trc}} + \sum_{j=1}^k \alpha T_{r_j}^{\text{drn}}) \quad (5.9)$$

$$\geq \frac{Z(\text{TSP})}{\alpha k + 1} \quad (5.10)$$

Inequality (5.8) is valid because travel time on a route is never greater than the duration of the route. Inequality (5.9) is valid because the maximum is never less than any weighted average. Inequality (5.10) is due to inequality (5.6). Rearranging the terms, we have,

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha})} \leq \alpha k + 1. \quad (5.11)$$

To show the tightness of the bound, we consider an example with $k + 1$ customers, c_0, c_1, \dots, c_k . c_0 is at a distance of 1 from the depot and $c_j, j > 0$, is at a distance of α from the depot. The distance between c_0 and $c_j, j > 0$, is $1 + \alpha$ and the distance between c_i and $c_j, i \neq j$ and $i, j > 0$, is 2α . (An example with $k = 2$ is shown in Figure 5.5.) The truck speed is 1 and the drone speed is α . The capacity of the truck $C = k + 1$, and the battery life of a drone is 2 time units. An optimal TSP solution serves c_0 to c_k in sequence and $Z(\text{TSP}) = 2\alpha k + 2$. A feasible $\text{VRPD}_{1,\alpha}$ solution serves customer c_0 with the truck and each of the other customers using a drone, which is launched at the depot and picked up at the depot. All vehicles

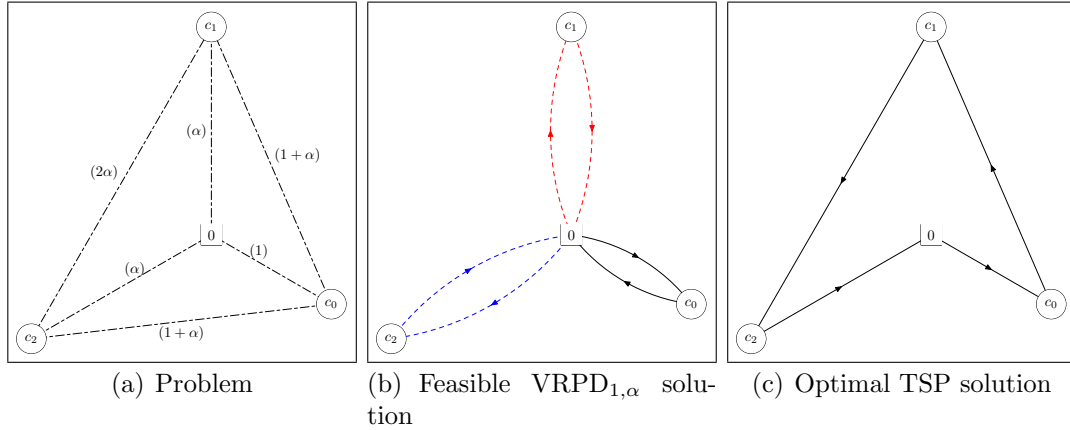


Figure 5.5: A worst-case $\text{VRPD}_{1,\alpha}$ example with $k = 2$

return to the depot at the same time with $Z^f(\text{VRPD}_{1,\alpha}) = 2$. In this example,

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha})} \geq \frac{Z(\text{TSP})}{Z^f(\text{VRPD}_{1,\alpha})} = \frac{2\alpha k + 2}{2} = \alpha k + 1. \quad (5.12)$$

□

Suppose the drone can travel 50% faster than the truck and that the truck carries $k = 2$ drones. Then, Theorem 13 tells us that completion time can be up to 4 times as long without using drones as it is with drones. Based on this, it is easy to understand the widespread interest in drones for package delivery.

The next theorem does not involve drones in particular, but its proof uses the same approach as in the proofs of Theorems 12 and 13. We decompose an optimal VRPD solution into several routes and traverse them one after another to form a giant route R , from which we construct a feasible TSP solution with bounded objective value.

Theorem 14. *Let n customers be served by a fleet of m trucks of different speeds, v_1, v_2, \dots, v_m , such that the combined speed, $V = \sum_{i=1}^m v_i$. Denote the optimal (min-max) objective function value by $Z(\text{VRP}^*)$. If these customers are served by one truck with speed v and of sufficient capacity, the optimal objective function value is denoted by $Z(\text{TSP}_v)$. If the triangle inequality is valid, we have*

$$\frac{Z(\text{TSP}_v)}{Z(\text{VRP}^*)} \leq \frac{V}{v}$$

and the bound is tight.

Proof of Theorem 14. We use the truck with speed v to traverse the giant route R formed by joining the m routes in the optimal VRP^* solution, one after another. The length of route R is denoted by L_R . There is no waiting time in a VRP^* solution. Denote the travel time of the i^{th} truck in the optimal VRP^* solution by T_i . We have

$$Z(\text{VRP}^*) = \max\{T_1, T_2, \dots, T_m\} \tag{5.13}$$

$$\geq \frac{v_1 T_1 + v_2 T_2 + \dots + v_m T_m}{v_1 + v_2 + \dots + v_m} \tag{5.14}$$

$$= \frac{L_R}{V} \tag{5.15}$$

$$= \frac{L_R}{v} \frac{v}{V}. \tag{5.16}$$

Again (5.14) is valid because a weighted average never exceeds the maximum. Since we assume that the triangle inequality is valid, after we skip the depots in the middle

of R , we have a feasible TSP solution such that $L_R \geq vZ(\text{TSP})$. Therefore,

$$Z(\text{VRP}^*) \geq Z(\text{TSP}) \frac{v}{V}, \quad (5.17)$$

i.e.,

$$\frac{Z(\text{TSP})}{Z(\text{VRP}^*)} \leq \frac{V}{v}. \quad (5.18)$$

To show the tightness of the bound, we construct an example of m customers, c_1 to c_m (an example with $m = 3$ is shown in Figure 5.6). The distance from c_i to the depot is v_i . The distance between c_i and c_j , $i \neq j$, is $v_i + v_j$. An optimal TSP solution has objective function value $Z(\text{TSP}) = 2(v_1 + v_2 + \dots + v_m)/v = 2V/v$. A feasible VRP* solution serves customer c_i on a dedicated route by the truck with speed v_i . All trucks finish their routes with the same travel time 2. The objective function value is $Z^f(\text{VRP}^*) = 2$. Therefore, in this example,

$$\frac{Z(\text{TSP})}{Z(\text{VRP}^*)} \geq \frac{Z(\text{TSP})}{Z^f(\text{VRP}^*)} = \frac{V}{v}. \quad (5.19)$$

□

In view of Theorem 14, we have an alternate proof of the inequality in Theorem 13. There are two differences between VRPD_{1,α} and VRP*. First, in VRP*, there is no waiting time, but in VRPD_{1,α}, duration is the sum of travel and waiting times. Second, in VRP*, every route i is traversed at a constant speed, v_i , but in VRPD_{1,α}, a drone route is traversed at the truck speed when the drone is on the truck and traversed at the drone speed when the drone is in the air. We introduce average

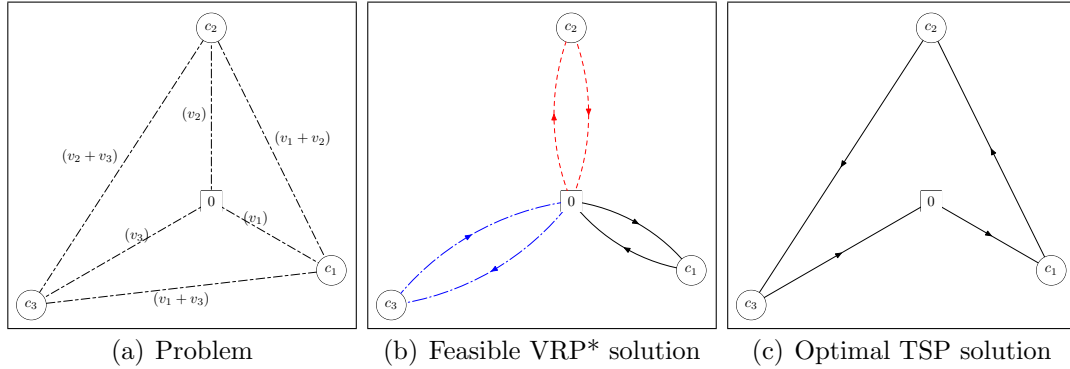


Figure 5.6: A worst-case VRP* example with $m = 3$

speeds in looking at the optimal solution to the $\text{VRPD}_{1,\alpha}$ so that it can be converted into a feasible VRP* solution. The average speed on a route is the ratio of the route length to the route duration. The average speed of the truck route r_0 is $v_0 \leq 1$ because of possible waiting time by the truck. (We normalize the vehicle speed so that the truck speed is always 1). The average speed on a drone route r_j is $v_j \leq \alpha$, $j > 0$, because of lower truck speed and possible waiting by the drone. Therefore, the optimal $\text{VRPD}_{1,\alpha}$ solution can be viewed as a feasible VRP* solution with a combined speed as defined in Theorem 14, $V \leq 1 + \alpha k$. Therefore,

$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha})} = \frac{Z(\text{TSP})}{Z^f(\text{VRP}^*)} \leq \frac{Z(\text{TSP})}{Z(\text{VRP}^*)} \leq 1 + \alpha k. \quad (5.20)$$

The worst-case example is the same as in the original proof.

Remark 8. We generally expect that the drone travels faster than the truck, i.e., $\alpha > 1$, but we also consider the case in which drones travel slower because of possible regulatory rules. Both the original and the alternate proof encounter difficulty if we relax the assumption $\alpha \geq 1$ in Theorem 13. In the original proof, the inequality in

(5.5) fails. In the alternate proof, the average speed of drone route r_j , $v_j, j > 0$, may be greater than α , and therefore, the combined speed, V , as defined in Theorem 14, may be greater than $1 + \alpha k$. Nevertheless, the worst-case bound still holds even if we drop the assumption $\alpha \geq 1$ because of the following theorem.

Theorem 15. *If the triangle inequality is valid,*

$$\frac{Z(TSP)}{Z(VRPD_{1,\alpha})} \leq \alpha k + 1,$$

and the bound is tight.

Proof of Theorem 15. We consider regular feasible solutions such that the truck and the drone never both simultaneously wait at a pick-up node. This is a reasonable assumption because any irregular solution is dominated by another regular feasible solution (i.e., dispatch the truck immediately after the drone is picked up).

We start with the truck route, denoted by r_0 , in the optimal $VRPD_{1,\alpha}$ and add customers served by the drones to form a feasible TSP solution.

We denote the duration of the truck route by $D_{r_0}^{\text{trc}}$. (Note that $D_{r_0}^{\text{trc}} = Z(VRPD_{1,\alpha})$.) We add all the customers served by the first drone to r_0 . The goal is to show the increase in duration is not greater than $\alpha D_{r_0}^{\text{trc}}$. Suppose customer k is served by the first drone that is dispatched at node i and picked up at node j . Denote, by D_{ij}^{trc} , the time taken from the drone dispatchment at i to the truck's arrival at j . Denote, by W_j^{trc} , the possible waiting time of the truck at j . Denote the lengths from i to k and from k to j by L_{ik} and L_{kj} , respectively. Let the possible waiting time of the

drone at j be W_j^{drn} . We must have

$$D_{ij}^{\text{trc}} + W_j^{\text{trc}} = \frac{L_{ik} + L_{kj}}{\alpha} + W_j^{\text{drn}}. \quad (5.21)$$

Both sides of equation (5.21) measure the time elapsed from the launch of the drone to the pick-up of the drone. The left-hand side measures it from the perspective of the truck and the right-hand side measures it from the perspective of the drone.

In a regular solution, either $W_j^{\text{trc}} = 0$ or $W_j^{\text{drn}} = 0$.

Case 1 ($W_j^{\text{drn}} = 0$): Equation (5.21) becomes $D_{ij}^{\text{trc}} + W_j^{\text{trc}} = \frac{L_{ik} + L_{kj}}{\alpha}$, or

$$L_{ik} + L_{kj} = \alpha(D_{ij}^{\text{trc}} + W_j^{\text{trc}}). \quad (5.22)$$

If $L_{ik} \leq L_{kj}$, we loop customer k at i to form part of the route $i - k - i - \dots - j$.

We have the duration of this part of the route

$$2L_{ik} + D_{ij}^{\text{trc}} + W_j^{\text{trc}} \leq (L_{ik} + L_{kj}) + D_{ij}^{\text{trc}} + W_j^{\text{trc}} \quad (5.23)$$

$$\leq \alpha(D_{ij}^{\text{trc}} + W_j^{\text{trc}}) + D_{ij}^{\text{trc}} + W_j^{\text{trc}} \quad (5.24)$$

$$\leq (1 + \alpha)(D_{ij}^{\text{trc}} + W_j^{\text{trc}}). \quad (5.25)$$

Inequality (5.23) is due to the assumption that $L_{ik} \leq L_{kj}$. Inequality (5.24) is due to equation (5.22). From (5.25), the additional duration is bounded by $\alpha(D_{ij} + W_j^{\text{trc}})$.

If $L_{ik} > L_{kj}$, we loop customer k at j to form the partial route $i - \dots - j - k - j$, and the argument is the same.

Case 2 ($W_j^{\text{trc}} = 0$): If $L_{ik} \leq L_{kj}$, we still loop customer k at i to form part of the route $i - k - i - \dots - j$. We have the duration of this part of the route

$$\begin{aligned} 2L_{ik} + D_{ij}^{\text{trc}} &\leq (L_{ik} + L_{kj}) + D_{ij}^{\text{trc}} \\ &\leq \alpha(D_{ij}^{\text{trc}} - W_j^{\text{drn}}) + D_{ij}^{\text{trc}} \\ &\leq (1 + \alpha)D_{ij}^{\text{trc}}. \end{aligned}$$

The additional duration is bounded by $\alpha D_{ij}^{\text{trc}}$. If $L_{ik} > L_{kj}$, we loop customer k at j to form the partial route $i - \dots - j - k - j$, and the argument is the same.

In Figure 5.7(a), we show a typical part of an optimal VRPD_{1,α} solution. The truck route is in black and the drone route is in red. At customer 1, the drone is launched to visit customer 8. At customer 4, the truck waits to pick up the drone, which is then launched at customer 5 to serve customer 6. The drone reaches and waits at customer 7, where it is picked up. In Figure 5.2(b), we show part of the intermediate route when customers 8 and 6, previously served by the drone, are added to the truck route. Since customer 1 is nearer than customer 4 to customer 8, we form a loop $1 \rightarrow 8 \rightarrow 1$ around customer 1. Similarly, we loop customer 6 around customer 7, instead of customer 5. (After all drone customers, including those served by other drones, are inserted, we skip the revisited customers 1 and 7 to get part of the feasible TSP solution shown in Figure 5.7(c).)

For a particular drone, there is no overlap of the truck path on which this drone is not with the truck. For example, in Figure 5.7(a), the path $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$ and $5 \rightarrow 9 \rightarrow 10 \rightarrow 7$ do not overlap. Therefore, we can add all the customers

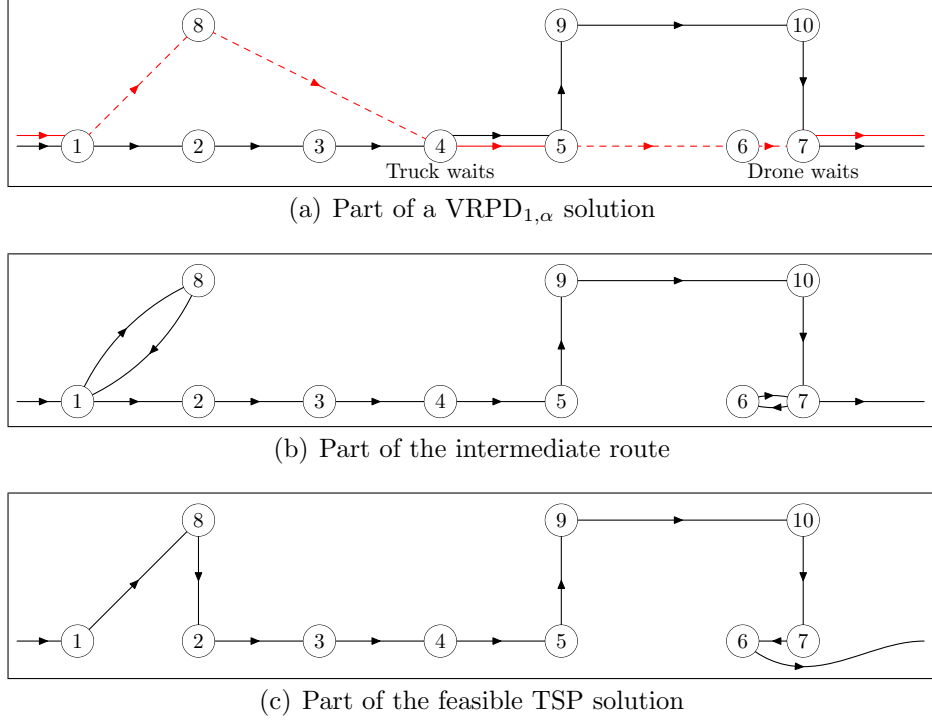


Figure 5.7: Adding drone customers to truck route

served by a drone in the same manner such that the additional duration is bounded by $\alpha D_{r_0}^{\text{trc}}$.

We then add the customers served by the second drone, and the third, and so on until the k^{th} drone. Each time the increase in duration is bounded by $\alpha D_{r_0}^{\text{trc}}$. After all customers served by the drones are added to the truck route, the duration is no greater than $(1 + \alpha k) D_{r_0}^{\text{trc}}$. A feasible TSP solution is generated by removing all the truck-related waiting time and revisits to customers. The objective function value is also bounded by $(1 + \alpha k) D_{r_0}^{\text{trc}}$ and we have shown that the inequality holds.

To show the bound is tight, consider a $\text{VRPD}_{1,\alpha}$ with $k + 1$ customers. Customer c_0 is located at a distance of 1 from the depot. Customers c_1, c_2, \dots, c_k are located at a distance of α from the depot. The distances between c_0 and $c_j, j > 0$ are $1 + \alpha$. The distances between any two customers c_i and $c_j, i > 0, j > 0$, are 2α .

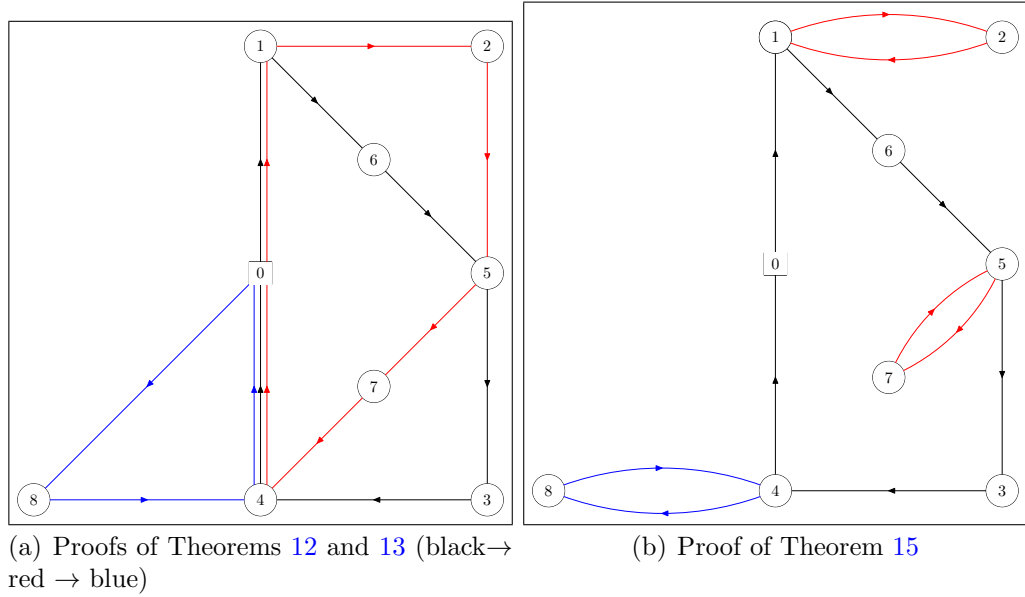


Figure 5.8: Comparison of the intermediate routes in TSP route construction

The speed of the truck is 1. An optimal TSP solution is to visit the customers in the sequence c_0, c_1, \dots, c_k , so $Z(\text{TSP}) = 2(1 + \alpha k)$. A feasible $\text{VRPD}_{1,\alpha}$ solution is to dispatch the k drones at the depot to serve customers c_1 to c_k , while the truck serves customer c_0 . All vehicles will return to the depot at the same time, after 2 time units. Therefore, $Z^f(\text{VRPD}_{1,\alpha}) = 2$. So $\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha})} \geq \frac{Z(\text{TSP})}{Z^f(\text{VRPD}_{1,\alpha})} = 1 + \alpha k$. \square

Remark 9. We constructed different TSP solutions from the same optimal $\text{VRPD}_{1,\alpha}$ solution. We compare the construction using the example shown in Figure 5.1. The giant route in the proofs of Theorems 12 and 13 and the intermediate route in the proof of Theorem 15 are shown in Figure 5.8. The feasible TSP solutions are shown in Figure 5.9.

In the next theorem, we consider $\text{VRPD}_{m,\alpha}$ with m trucks, each carrying k drones.

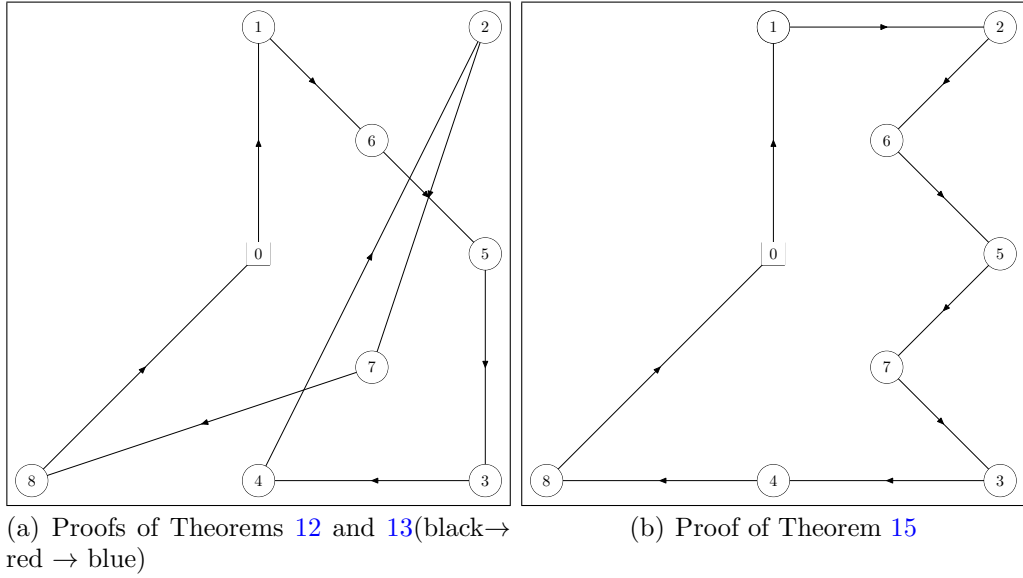


Figure 5.9: Comparison of the TSP solutions constructed in the proofs

Theorem 16. *If the triangle inequality is valid,*

$$\frac{Z(TSP)}{Z(VRPD_{m,\alpha})} \leq m(\alpha k + 1),$$

and the bound is tight.

Proof of Theorem 16. Given an optimal $VRPD_{m,\alpha}$ solution, we can decompose the problem into m subproblems. Let S_i be the set of customers served by either the i^{th} truck or a drone on the i^{th} truck. The i^{th} subproblem is a $VRPD_{1,\alpha}$ on the set of customers S_i . The optimal $VRPD_{m,\alpha}$ solution gives feasible solutions to all m subproblems. If we denote the TSP on S_i by $TSP^{(i)}$, by Theorem 15, we have

$$Z(TSP^{(i)}) \leq (\alpha k + 1)Z(VRPD_{1,\alpha}^{(i)}) \leq (\alpha k + 1)Z^f(VRPD_{1,\alpha}^{(i)}). \quad (5.26)$$

We join the TSP solutions to subproblems to form a giant route that serves all

the customers and then we skip the visits to the depots in the middle of the route.

The result is a feasible TSP solution over all the customers. Therefore,

$$Z(TSP) \leq \sum_{i=1}^m Z(TSP^{(i)}) \quad (5.27)$$

$$\leq \sum_{i=1}^m (\alpha k + 1) Z^f(\text{VRPD}_{1,\alpha}^{(i)}) \quad (5.28)$$

$$\leq (\alpha k + 1) \sum_{k=1}^m Z(\text{VRPD}_{m,\alpha}) \quad (5.29)$$

$$= m(\alpha k + 1) Z(\text{VRPD}_{m,\alpha}). \quad (5.30)$$

Inequality (5.27) holds because its right-hand side is the duration of a route that visits every customer exactly once and visits the depot $m+1$ times. Inequality (5.28) holds because of inequality (5.26). Inequality (5.29) holds because $Z(\text{VRPD}_{m,\alpha}) = \max_i \{Z^f(\text{VRPD}_{1,\alpha}^{(i)})\}$.

Rearranging the terms, we prove the inequality in Theorem 16. To prove that the bound is tight, we consider a $\text{VRPD}_{m,\alpha}$ with $m(k+1)$ customers, $c_j^{(i)}$, where $i \in I = \{1, 2, \dots, m\}$ and $j \in J = \{0, 1, \dots, k\}$. The truck capacity is $C = m(k+1)$ parcels and the battery life of a drone is 2. The speeds of the trucks and the drones are 1 and α , respectively. The distance metric is described below:

- Distance between the depot and customer $c_0^{(i)}$ is 1, $\forall i \in I$
- Distance between the depot and customer $c_j^{(i)}$ is α , $\forall i \in I, \forall j \in J \setminus \{0\}$
- Distance between customers $c_0^{(i_1)}$ and $c_0^{(i_2)}$ is 2, $\forall i_1, i_2 \in I, i_1 \neq i_2$
- Distance between customers $c_0^{(i_1)}$ and $c_j^{(i_2)}$ is $1 + \alpha$, $\forall i_1, i_2 \in I$ and $\forall j \in J \setminus \{0\}$

- Distance between customers $c_{j_1}^{(i_1)}$ and $c_{j_2}^{(i_2)}$ is 2α , $\forall i_1, i_2 \in I, \forall j_1, j_2 \in \mathcal{J} \setminus \{0\}, (i_1, j_1) \neq (i_2, j_2)$

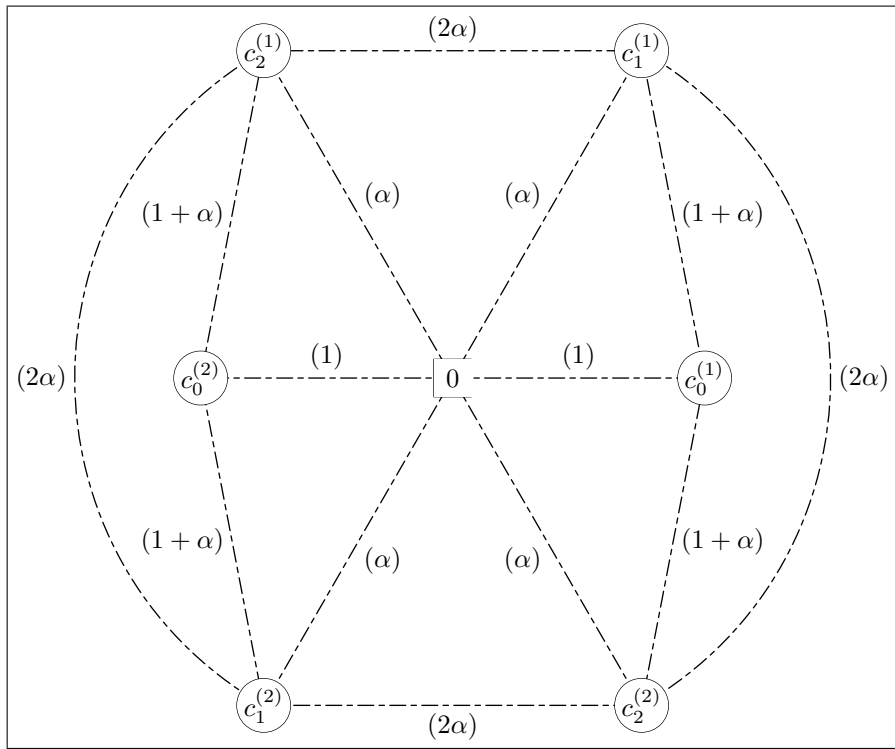
An example with $m = 2$ and $k = 2$ is illustrated in Figure 5.10. The example is intentionally constructed as a symmetric example with perfect synchronicity between trucks and drones by placing “drone nodes” at distance α and “truck nodes” at distance 1 from the depot. In addition, the triangle inequality always holds at equality. This allows for zero wait time, constant utilization of all vehicles, and knowledge that we are utilizing the most direct routes possible.

An optimal TSP solution has duration $Z(\text{TSP}) = 2m(1 + \alpha k)$. In fact, serving the customers in any sequence will result in duration of $2m(1 + \alpha k)$. A feasible $\text{VRPD}_{m,\alpha}$ solution dispatches all drones at the depot. The j^{th} drone on the i^{th} truck serves customer $c_j^{(i)}$. The i^{th} truck serves customer $c_0^{(i)}$ on a dedicated route. All vehicles return to the depot at the same time and $Z^f(\text{VRPD}_{m,\alpha}) = 2$. Therefore, in this example, we have

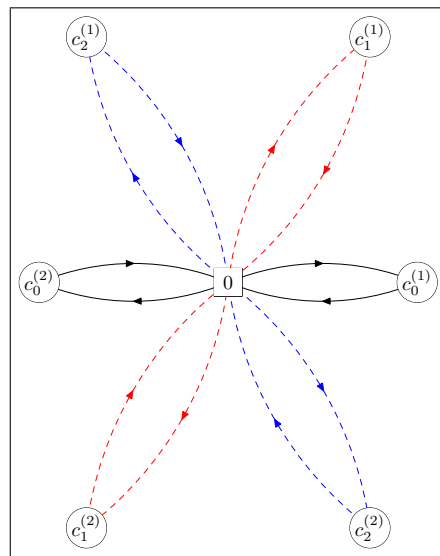
$$\frac{Z(\text{TSP})}{Z(\text{VRPD}_{m,\alpha})} \geq \frac{Z(\text{TSP})}{Z^f(\text{VRPD}_{m,\alpha})} = \frac{2m(1 + \alpha k)}{2} = m(1 + \alpha k). \quad (5.31)$$

□

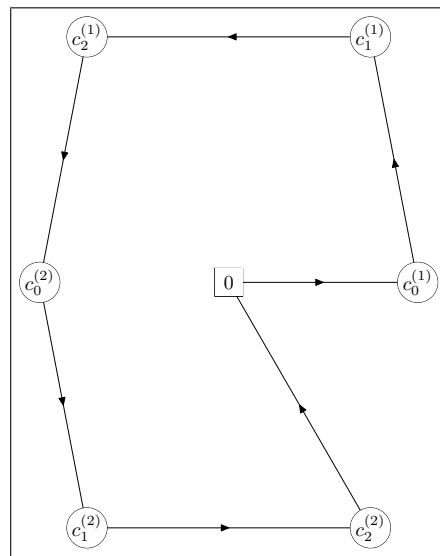
In the next theorem, we compare the $\text{VRPD}_{m,\alpha}$ to the min-max VRP with a fleet of m trucks and no drones.



(a) Problem



(b) Feasible $VRPD_{m,\alpha}$ solution



(c) Optimal TSP solution

Figure 5.10: A worst-case $VRPD_{m,\alpha}$ example with $k = 2$

Theorem 17. *If the triangle inequality is valid,*

$$\frac{Z(\text{VRP}^*)}{Z(\text{VRPD}_{m,\alpha})} \leq \alpha k + 1,$$

and the bound is tight.

Proof of Theorem 17. The proof relies on the same decomposition used in the proof of Theorem 16. Denote the set of customers served by the i^{th} truck or a drone on the i^{th} truck by S_i . The route in the optimal $\text{VRPD}_{m,\alpha}$ solution that serves customers in S_i is feasible to the subproblem $\text{VRPD}_{1,\alpha}^{(i)}$. We denote the TSP on S_i by $\text{TSP}^{(i)}$ and reproduce inequality (5.26) below.

$$Z(\text{TSP}^{(i)}) \leq (\alpha k + 1)Z^f(\text{VRPD}_{1,\alpha}^{(i)}). \quad (5.32)$$

The optimal objective function value of the min-max VRP is never greater than the maximum of the $Z(\text{TSP}^{(i)})$ s; otherwise we have a better VRP^* solution consisting of the routes from the optimal $\text{TSP}^{(i)}$ solutions.

$$Z(\text{VRP}^*) \leq \max\{Z(\text{TSP}^{(1)}), Z(\text{TSP}^{(2)}), \dots, Z(\text{TSP}^{(k)})\} \quad (5.33)$$

$$\leq (\alpha k + 1) \max_i \{Z^f(\text{VRPD}_{1,\alpha}^{(i)})\} \quad (5.34)$$

$$= (\alpha k + 1)Z(\text{VRPD}_{m,\alpha}). \quad (5.35)$$

Rearranging the terms, we have the inequality in Theorem 17.

To show that the bound is tight, we consider the same example of $m(k + 1)$

customers as in the proof of Theorem 16. In the optimal VRP solution, we serve the customers $c_j^{(i)}, \forall j \in J$, by the i^{th} truck. All routes have the same duration and $Z(\text{VRP}^*) = 2(1 + \alpha k)$ is the optimal objective function value because if $Z(\text{VRP}^*) < 2(1 + \alpha k)$, we will have a TSP solution over all the $m(k+1)$ customers and the depot with $Z(\text{TSP}) < 2m(1 + \alpha k)$. A feasible $\text{VRPD}_{m,\alpha}$ solution described in the proof of Theorem 16 has $Z^f(\text{VRPD}_{m,\alpha}) = 2$. Therefore, in this example,

$$\frac{Z(\text{VRP}^*)}{Z(\text{VRPD}_{m,\alpha})} \geq \frac{Z(\text{VRP}^*)}{Z^f(\text{VRPD}_{m,\alpha})} = \frac{2(1 + \alpha k)}{2} = 1 + \alpha k. \quad (5.36)$$

□

The next theorem compares $\text{VRPD}_{m,\alpha}$ and $\text{VRPD}_{m,\beta}$, i.e., VRPD with different drone speeds. The idea is to address the following question: If a more advanced (and faster) set of drones becomes available, how much time can we save in delivering all packages?

Theorem 18. *Let $\alpha < \beta$. If the triangle inequality is valid, we have*

$$\frac{Z(\text{VRPD}_{m,\alpha})}{Z(\text{VRPD}_{m,\beta})} \leq \frac{\beta}{\alpha},$$

and the bound is tight.

To prove Theorem 18, we first introduce a lemma that is true for all regular feasible solutions of VRPD, i.e., a truck leaves a pick-up node as soon as it picks up the drone. Suppose an ant crawls onto the truck just before it is dispatched from the depot. The ant can crawl from a drone to the truck or from the truck to a drone,

only when the drone is on the truck. It stays on one of the vehicles (the truck or a drone) until the fleet is back to the depot.

Lemma 1. *For every regular feasible solution to the VRPD, there is a strategy for the ant to always stay on a vehicle that is in motion.*

Proof of Lemma 1. The ant crawls onto the truck just before the truck leaves from the depot. Whenever a drone is about to launch, the ant has a choice to crawl onto this drone or to stay on the truck. If, at the pick-up node of this drone, the truck has to wait, the ant chooses to crawl onto the drone; otherwise, it stays on the truck. In a regular feasible solution, the truck and the drone never both wait at the pick-up node. The ant crawls back to the truck whenever the drone is picked up if the ant is on the drone. Following this strategy, the ant will never stay on a vehicle that is waiting. □

We illustrate the ant's strategy using the example in Figure 5.1. When the truck is dispatched from the depot, the blue drone is launched. Since the truck will not wait at customer 4 where the blue drone is picked up, the ant chooses to stay on the truck. At customer 1, the red drone is launched for the first time. Since the truck will have to wait at customer 5 to pick up the red drone, the ant crawls onto the drone. When the truck picks up the red drone at customer 5, the ant crawls back to the truck. The red drone is launched for the second time at 5, but the ant stays on the truck this time because the truck does not have to wait at the pick-up node 4. The ant stay on the truck until it is back at the depot. The ant route is 0(on the truck) \rightarrow 1(crawls onto the red drone) \rightarrow 2(on the red drone) \rightarrow

5(crawls back onto the truck) \rightarrow 3(on the truck) \rightarrow 4(on the truck) \rightarrow 0(on the truck).

There is no waiting time on this route. In addition, the ant route can be partitioned according to the vehicle that the ant stays on. In the proceeding example, the elements of partition are $0 \rightarrow 1$ on the truck, $1 \rightarrow 2 \rightarrow 5$ on the drone, and $5 \rightarrow 3 \rightarrow 4 \rightarrow 0$ on the truck.

With Lemma 1 proved, we now prove Theorem 18.

Proof of Theorem 18. We start with a fleet with only one truck with k drones and show first

$$\frac{Z(\text{VRPD}_{1,\alpha})}{Z(\text{VRPD}_{1,\beta})} \leq \frac{\beta}{\alpha}. \quad (5.37)$$

Suppose we have an optimal $\text{VRPD}_{1,\beta}$ solution. We construct a feasible $\text{VRPD}_{1,\alpha}$ solution by following the same routing plan, but serving the customers with the α drones. In this $\text{VRPD}_{1,\alpha}$ solution, there is a strategy for the ant to always stay on a moving vehicle by Lemma 1. The ant never waits, so its travel time is the duration of the ant route (R_α), which is also the objective value of the solution to the $\text{VRPD}_{1,\alpha}$. The ant route can be partitioned into segments based on the vehicle the ant is on. On the other hand, if the ant chooses the same path (R_β) in the optimal $\text{VRPD}_{1,\beta}$ solution, there may be waiting times. R_β has the same length as R_α but different duration because of shorter travel times and possible waiting times. R_β can be partitioned in exactly the same way as R_α . For every element of the partition, if the path is traveled with the truck speed, the travel time on that path in both the $\text{VRPD}_{1,\alpha}$ and $\text{VRPD}_{1,\beta}$ solutions are equal; if the path is traveled by the drone, the travel time of that path in the $\text{VRPD}_{1,\alpha}$ solution is no more than

$\frac{\beta}{\alpha}$ times the travel time of the path in the $\text{VRPD}_{1,\beta}$ solution. Therefore, the total travel time by the ant in the $\text{VRPD}_{1,\alpha}$ solution is no more than $\frac{\beta}{\alpha}$ times the travel time in the $\text{VRPD}_{1,\beta}$ solution. Because of possible waiting times on route R_β and because there is no waiting time on route R_α , the duration of R_α is no more than $\frac{\beta}{\alpha}$ times the duration of R_β . Hence, inequality (5.37) holds.

To generalize inequality (5.37) to problems with multiple trucks, we partition the $\text{VRPD}_{m,\beta}$ into m subproblems of $\text{VRPD}_{1,\beta}$ according to the optimal $\text{VRPD}_{m,\beta}$ solution. Let S_i be the set of customers served by either the i^{th} truck or a drone on the i^{th} truck, where $i \in I = \{1, 2, \dots, m\}$. The problem of serving all customers in S_i using one truck and k β drones is the i^{th} subproblem, denoted by $\text{VRPD}_{1,\beta}^{(i)}$. We assume the i^{th} route in the optimal $\text{VRPD}_{m,\beta}$ solution also solves the subproblem $\text{VRPD}_{1,\beta}^{(i)}$ optimally. (If not, we can always replace the i^{th} route of the $\text{VRPD}_{m,\beta}$ solution with the optimal solution to the $\text{VRPD}_{1,\beta}^{(i)}$ without increasing the objective function value of the $\text{VRPD}_{m,\beta}$ solution.) We solve the i^{th} subproblem using the α drones to obtain an optimal solution whose objective function value is denoted by $Z(\text{VRPD}_{1,\alpha}^{(i)})$. By inequality (5.37), we have

$$Z(\text{VRPD}_{1,\alpha}^{(i)}) \leq \frac{\beta}{\alpha} Z(\text{VRPD}_{1,\beta}^{(i)}) \quad (5.38)$$

$$\max_{i \in I} Z(\text{VRPD}_{1,\alpha}^{(i)}) \leq \frac{\beta}{\alpha} \max_{i \in I} Z(\text{VRPD}_{1,\beta}^{(i)}) = \frac{\beta}{\alpha} Z(\text{VRPD}_{m,\beta}). \quad (5.39)$$

We put the optimal solutions to the m subproblems $\text{VRPD}_{1,\alpha}^{(i)}$ together to form a

feasible solution to the $\text{VRPD}_{m,\alpha}$. This yields the desired inequality:

$$Z(\text{VRPD}_{m,\alpha}) \leq Z^f(\text{VRPD}_{m,\alpha}) = \max_{i \in I} Z(\text{VRPD}_{1,\alpha}^{(i)}) \leq \frac{\beta}{\alpha} Z(\text{VRPD}_{m,\beta}). \quad (5.40)$$

To show the bound is tight, we consider two cases. If $1 \leq \alpha < \beta$, Let customer c_0 be the only customer, which is at a distance of 1 from the depot. Since, the drones travel faster than the truck in both $\text{VRPD}_{1,\alpha}$ and $\text{VRPD}_{1,\beta}$, it is optimal to have a drone to serve c_0 . $Z(\text{VRPD}_{1,\alpha}) = \frac{1}{\alpha}$ and $Z(\text{VRPD}_{1,\beta}) = \frac{1}{\beta}$. Therefore, $\frac{Z(\text{VRPD}_{1,\alpha})}{Z(\text{VRPD}_{1,\beta})} = \frac{\beta}{\alpha}$ in this example.

If $\alpha < 1$, we consider an example with the number of drones per truck $k \geq \frac{1}{\alpha}$. Let the number of customers be $k + 1$. Customer c_0 is at a distance of 1 from the depot and customers c_1 to c_k are at a distance of β from the depot. The distance between c_0 and c_j with $j > 0$ is $1 + \beta$ and the distance between c_i and c_j with $i, j > 0$ is 2β . A feasible solution, denoted by S_α , to $\text{VRPD}_{1,\alpha}$ is to serve c_0 by the truck and c_1 to c_k by the drones. The objective function value of S_α is $\frac{2\beta}{\alpha}$. $\frac{2\beta}{\alpha}$ is also a lower bound of all feasible solutions to $\text{VRPD}_{1,\alpha}$. If a customer c_j with $j > 0$ is served by a drone, it is on a route with duration at least $\frac{2\beta}{\alpha}$. If all customers c_j with $j > 0$ are served by the truck, the duration of the truck route is at least $2k\beta \geq \frac{2\beta}{\alpha}$. Therefore, S_α is also the optimal solution and $Z(\text{VRPD}_{1,\alpha}) = \frac{2\beta}{\alpha}$. A feasible solution to the $\text{VRPD}_{1,\beta}$ is to have the truck serving c_0 and the drones serving c_j with $j > 0$ and the objective function value is $Z^f(\text{VRPD}_{1,\beta}) = 2$. Therefore, in this example,

$$\frac{Z(\text{VRPD}_{1,\alpha})}{Z(\text{VRPD}_{1,\beta})} \geq \frac{Z(\text{VRPD}_{1,\alpha})}{Z^f(\text{VRPD}_{1,\beta})} = \frac{\beta}{\alpha}$$

□

Remark 10. If we can replace our current set of drones with an advanced set of drones which travel twice as fast, we can reduce the delivery completion time by up to 50%.

5.4 Extending our model

So far, in this paper, we have ignored cost, assumed that the truck and the drone follow the same distance metric, and ignored the limited battery life of a drone. In this section, we begin to relax these simplifications and provide some initial results for others to build upon.

The next theorem takes into account explicitly the limited battery life (in time units), U , of a drone, which we essentially ignored in the previous section. A lower bound on $Z(\text{VRPD}_{1,\alpha})$ is given by Theorem 19.

Theorem 19. *If the triangle inequality is valid, then*

$$Z(\text{VRPD}_{1,\alpha}) \geq Z(\text{TSP}) - nU\alpha, \quad (5.41)$$

where n is the number of customers served by drones in the optimal $\text{VRPD}_{1,\alpha}$ solution and U is the battery life of a drone.

Remark 11. The maximal amount we can save by adding drones to trucks, i.e., $nU\alpha$, is directly proportional to drone range and the number of drone deployments. In other words, long range drones and high utilization rates both could help reduce

costs.

Remark 12. Theorem 19 gives a lower bound to $Z(\text{VRPD}_{1,\alpha})$. An upper bound on $Z(\text{VRPD}_{1,\alpha})$ is $Z(\text{TSP})$. In the worst case, none of the drones are deployed. This could happen when customers are located far apart and the drone range is small.

Proof of Theorem 19. We construct a feasible TSP solution from the optimal $\text{VRPD}_{1,\alpha}$ solution using the same procedure presented in the proof of Theorem 15. We insert the customers served by drones one by one onto the truck route whose duration equals $Z(\text{VRPD}_{1,\alpha})$. If a drone is launched at node i to service customer k and is then picked up at node j , the distance covered by the drone is $L_{ik} + L_{kj} \leq \alpha U$. If $L_{ik} \leq L_{kj}$, we insert k just after node i on the truck route. If $L_{ik} > L_{kj}$, we insert k just after node j on the truck route. The increase in the duration of the truck route is no more than αU if the triangle inequality is valid. After all n customers served by the drone are added, the increase in duration is no more than $n\alpha U$, i.e., $Z^f(\text{TSP}) \leq Z(\text{VRPD}_{1,\alpha}) + n\alpha U$. Since $Z(\text{TSP}) \leq Z^f(\text{TSP})$, we have

$$Z(\text{VRPD}_{1,\alpha}) \geq Z(\text{TSP}) - nU\alpha$$

after rearranging the terms. □

Remark 13. The inequality $Z(\text{VRPD}_{1,\alpha}) \geq \frac{Z(\text{TSP})}{1+\alpha k}$ from Theorem 15 is still valid if the drones have limited battery life. Considering both Theorems 15 and 19, we have $Z(\text{VRPD}_{1,\alpha}) \geq \max\{\frac{Z(\text{TSP})}{1+\alpha k}, Z(\text{TSP}) - nU\alpha\}$.

In the above theorems, the drones and the trucks follow the same distance

metric. In practice, we expect the drones to (typically) travel via the crow-fly distance and the trucks to be restricted to the street network. Therefore, the above worst-case ratios are conservative in practice. Of course, this dichotomy ignores the reality of high-rise buildings and other barriers. We show what happens to the worst-case result if the drone and the truck follow different distance metrics in the following theorem. The distance matrices followed by a truck and a drone are denoted by Q_t and Q_d , respectively. The $(i, j)^{\text{th}}$ entry of Q_t (Q_d), denoted by $Q_t(i, j)$ ($Q_d(i, j)$), is the distance traveled by the truck (drone) from node i to node j . Denote the duration of the optimal TSP solution by $Z(\text{TSP}, Q_t)$ and the optimal VRPD $_{1,\alpha}$ solution by $Z(\text{VRPD}_{1,\alpha}, Q_t, Q_d)$.

Theorem 20. *Let B be the least upper bound on $\frac{Q_t(i,j)}{Q_d(i,j)}$, $\forall(i, j)$, and $B \geq 1$, then*

$$\frac{Z(\text{TSP}, Q_t)}{Z(\text{VRPD}_{m,\alpha}, Q_t, Q_d)} \leq Bm(\alpha k + 1).$$

Remark 14. If the truck is restricted to the street network and the drone travels via the crow-fly distance, $B \geq 1$. In effect, if the crow-fly distance is much more direct than the road network, in places, i.e., B is large, then we can potentially save even more by utilizing drones.

Proof of Theorem 20. Let Q_* be another distance metric defined by $Q_* = Q_t/B$. Since $B \geq 1$, we have $Q_*(i, j) \leq Q_t(i, j)$, $\forall(i, j)$. Since $Q_t(i, j)/Q_d(i, j) \leq B$, we have $Q_*(i, j) = Q_t(i, j)/B \leq Q_d(i, j)$, $\forall(i, j)$. Therefore,

$$Z(\text{VRPD}_{m,\alpha}, Q_*, Q_*) \leq Z(\text{VRPD}_{m,\alpha}, Q_t, Q_d) \tag{5.42}$$

because at worst, the same routes can be utilized and traversed more quickly. Yet

$$Z(\text{VRPD}_{m,\alpha}, Q_*, Q_*) = Z(\text{VRPD}_{m,\alpha}, Q_t, Q_t)/B \quad (5.43)$$

because these two quantities are derived from the same problem, except for a scalar multiple of B in both of the distance metrics.

Previously we showed in Theorem 16 that

$$Z(\text{TSP}, Q_t) \leq m(\alpha k + 1)Z(\text{VRPD}_{m,\alpha}, Q_t, Q_t), \quad (5.44)$$

so from (5.43) and (5.44)

$$Z(\text{TSP}, Q_t) \leq B(m(\alpha k + 1))Z(\text{VRPD}_{m,\alpha}, Q_*, Q_*), \quad (5.45)$$

and now by (5.42)

$$Z(\text{TSP}, Q_t) \leq B(m(\alpha k + 1))Z(\text{VRPD}_{m,\alpha}, Q_*, Q_*) \leq B(m(\alpha k + 1))Z(\text{VRPD}_{m,\alpha}, Q_t, Q_t), \quad (5.46)$$

which yields the desired result. \square

The next example illustrates, not surprisingly, that when trucks and drones follow different distance metrics, we can do better than the bound in Theorem 15. In Figure 5.11, there are seven customers located on two concentric circles with radii one and two. There are four edges of length one that link the two circles (see Figure

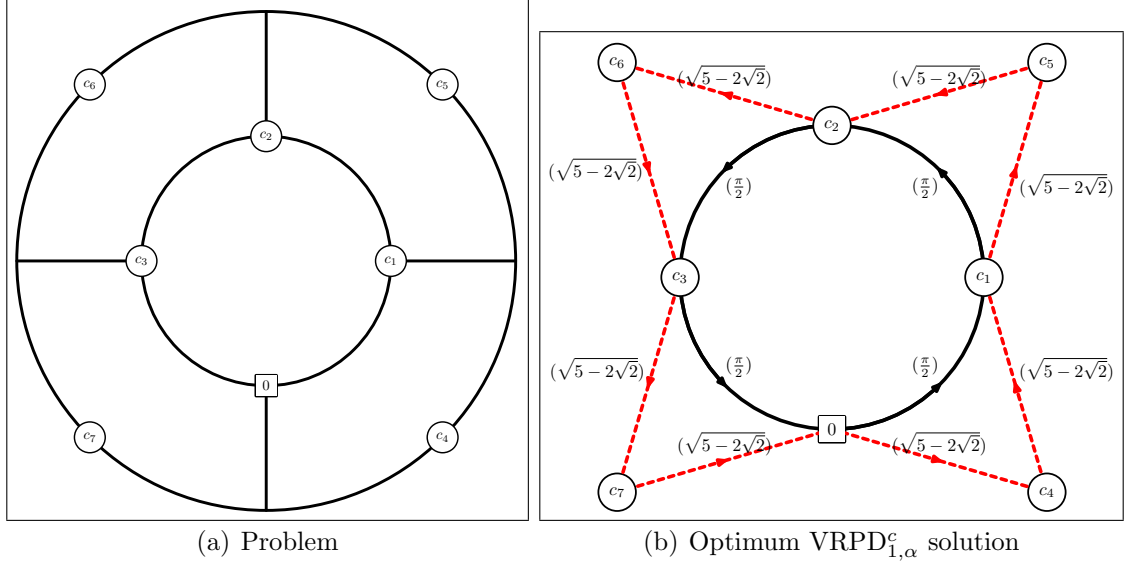


Figure 5.11: Truck and drone follow different distance metrics

Node	Polar coordinates		Distance from the depot	
	Radial	Angular	Edge restriction	Crow-fly
0	1	$-\pi/2$	0	0
c_1	1	0	$\pi/2$	$\sqrt{2}$
c_2	1	$\pi/2$	π	2
c_3	1	π	$\pi/2$	$\sqrt{2}$
c_4	2	$-\pi/4$	$1 + \pi/2$	$5 - 2\sqrt{2}$
c_5	2	$\pi/4$	$1 + \pi$	$5 + 2\sqrt{2}$
c_6	2	$3\pi/4$	$1 + \pi$	$5 + 2\sqrt{2}$
c_7	2	$-3\pi/4$	$1 + \pi/2$	$5 - 2\sqrt{2}$

Table 5.1: Positions of the depot and the customers in Figure 5.11(a)

5.11(a)). The seven customers are served by one truck carrying one drone. The speed of the truck is one and the speed of the drone is $\alpha = \frac{4}{\pi}\sqrt{5 - 2\sqrt{2}} \approx 1.876$. The polar coordinates of the depot (node 0) and the seven customers and their distances from the depot are given in Table 5.1.

We assume the drones can fly as the crow flies, but the truck is restricted to the edges shown in Figure 5.11(a). For example, the distance between customer c_1 and the depot is $\frac{\pi}{2} \approx 1.571$ for the truck, but $\sqrt{2} \approx 1.414$ for the drone using

the coordinates given in Table 5.1. The crow-fly distance between points (r_1, θ_1) and (r_2, θ_2) is calculated by $\sqrt{r_1^2 + r_2^2 - 2r_1r_2 \cos(\theta_1 - \theta_2)}$. We denote the optimal objective function value by $Z(\text{VRPD}_{1,\alpha}^c)$. From a geometric point of view, we serve the four customers on the outer circle by the drone and the three customers on the inner circle by the truck. The optimal solution is shown in Figure 5.11(b). The drone is dispatched from the depot to serve customer c_4 while the truck travels to serve c_1 . The two vehicles arrive at c_1 at the same time when the drone is immediately launched to serve c_5 , and so on. Eventually, the two vehicles arrive at the depot simultaneously with $Z(\text{VRPD}_{1,\alpha}^c) = 2\pi \approx 6.283$.

If we serve all the customers using only the truck, $Z(\text{TSP}) = 2 + \frac{11}{2}\pi \approx 19.279$. The path followed by the truck is $0 \rightarrow c_1 \rightarrow c_5 \rightarrow c_4 \rightarrow c_7 \rightarrow c_6 \rightarrow c_2 \rightarrow c_3 \rightarrow 0$ (optimal solution obtained using Gurobi solver [52]). In this example, we have $\frac{Z(\text{TSP})}{Z(\text{VRPD}_{1,\alpha}^c)} = \frac{2 + \frac{11}{2}\pi}{2\pi} \approx 3.068 > 1 + \alpha k \approx 2.876$. Incidentally, if the drone also follows only the edges shown in Figure 5.11(a), we think the optimal solution is $Z(\text{VRPD}_{1,\alpha}) = \frac{\pi(2+\pi)}{\sqrt{5-2\sqrt{2}}} \approx 10.961$. The routes are similar to the routes in the optimal solution in which the drone flies as the crow flies. The drone is dispatched from the depot to serve customer c_4 while the truck travels to serve c_1 . The truck arrives at c_1 earlier and waits for the drone for time $\frac{\pi(2+\pi)}{4\sqrt{5-2\sqrt{2}}} - \frac{\pi}{2}$. The drone is immediately launched to serve c_5 , and so on. The ratio of objective function values is about 1.759, less than 2.876.

While minimizing the completion time is the primary objective, a company may want to look at aspects of economic cost as well. In the next theorem, we combine the completion time and the variable costs of using the truck and drone to

form a new objective function, denoted by Y . Therefore, the new objective function value of the optimal TSP solution is calculated by $Y(TSP) = Z(TSP) + \theta X(TSP)$, where $X(TSP)$ denotes the variable cost of truck usage and θ gives weights to the two components of the objective function. When $\theta = 0$, we are minimizing the completion time. When θ is very large, we are minimizing the sum of the variable costs. The new objective function value of the optimal VRPD $_{1,\alpha}$ solution is calculated by $Y(\text{VRPD}_{1,\alpha}) = Z(\text{VRPD}_{1,\alpha}) + \theta X(\text{VRPD}_{1,\alpha})$, where $X(\text{VRPD}_{1,\alpha}) = X_t + X_d$, the sum of truck and drone usage costs. We assume the cost per unit time of the drone is a times the cost per unit time of the truck. a is expected to be much less than 1. The drone usage cost is incurred only when the drone is in the air. We ignore the fixed costs for now.

Theorem 21. *If the triangle inequality is valid, then*

$$Y(\text{VRPD}_{1,\alpha}) \geq Y(TSP) - \left[\frac{\alpha}{a} + \left(\frac{\alpha}{a} - 1 \right) \theta \right] X_d,$$

where X_d is the variable cost of k drones in the optimal VRPD $_{1,\alpha}$ solution.

Remark 15. The coefficient $\left[\frac{\alpha}{a} + \left(\frac{\alpha}{a} - 1 \right) \theta \right]$ is positive if $\alpha > a$. The potential savings from using a drone is large if α , θ , and X_d are large while a is small. We also point out the similar structure of the inequalities in Theorems 19 and 21 and in Theorems 16 and 20.

Remark 16. An upper bound on $Y(\text{VRPD}_{1,\alpha})$ is $Y(TSP)$.

Proof of Theorem 21. Without loss of generality, we assume the truck speed is 1

and the drone speed is α . We further assume that the truck usage cost is 1 per unit time and the drone usage cost is a per unit time, so that $X(\text{TSP}) = 1 \times Z(\text{TSP})$. If not, we can modify the parameter θ to normalize the usage costs of the vehicles. Note also that $Y(\text{TSP}) = Z(\text{TSP}) + \theta X(\text{TSP}) = (1 + \theta)Z(\text{TSP})$. Therefore, a TSP solution that minimizes duration also minimizes the total cost Y .

We want to find a lower bound for $Y(\text{VRPD}_{1,\alpha})$ in terms of $Y(\text{TSP})$, similar to what we did in Theorem 19. Given an optimal $\text{VRPD}_{1,\alpha}$ solution with duration $Z(\text{VRPD}_{1,\alpha})$, we can construct a feasible TSP solution with duration no more than $(1 + \alpha k)Z(\text{VRPD}_{1,\alpha})$ using the construction process described in the proof of Theorem 15. Therefore, an upper bound of $Z(\text{TSP})$ is given by

$$Z(\text{TSP}) \leq (1 + \alpha k)Z(\text{VRPD}_{1,\alpha}). \quad (5.47)$$

Using the same construction process, we can show that an upper bound of the truck usage cost is given by

$$X(\text{TSP}) \leq X_t + \frac{X_d}{a}\alpha, \quad (5.48)$$

where X_t and X_d are the truck and drone usage costs of the optimal $\text{VRPD}_{1,\alpha}$ solution. The factor $\frac{X_d}{a}$ gives the sum of drone usage time. Multiplying it by the drone speed α gives the maximum total distance covered by the k drones. Since the truck has unit speed and unit usage cost, the term $\frac{X_d}{a}\alpha$ also gives the additional truck usage cost when we convert the optimal $\text{VRPD}_{1,\alpha}$ to a feasible TSP solution.

In inequalities (5.47) and (5.48), $Z(\text{TSP}) = X(\text{TSP})$, and $1 \times Z(\text{VRPD}_{1,\alpha}) = X_t$. Comparing these two equations, a tighter upper bound for $Z(\text{TSP})$ is $X_t + \frac{X_d}{a}\alpha$ because $\frac{X_d}{ak} \leq \frac{X_t}{1}$, as the average usage time per drone is never greater than the usage time of the truck.

Now,

$$\begin{aligned}
Y(\text{TSP}) &= (1 + \theta)Z(\text{TSP}) \\
&\leq (1 + \theta) \left(X_t + \frac{\alpha}{a} X_d \right) \\
&= X_t + \theta(X_t + X_d) + \left[\frac{\alpha}{a} + \left(\frac{\alpha}{a} - 1 \right) \theta \right] X_d \\
&= Y(\text{VRPD}_{1,\alpha}) + \left[\frac{\alpha}{a} + \left(\frac{\alpha}{a} - 1 \right) \theta \right] X_d
\end{aligned}$$

which yields the desired result. □

5.5 Conclusions and future work

The idea of delivering packages by drones (from trucks) as well as directly from trucks, as is the common practice, is intriguing and is being seriously considered by numerous prominent companies in the U.S. and in Europe. There are, however, numerous technological and regulatory obstacles to overcome. In order for the commercialization of this idea to make sense, the potential savings in delivery completion time must be considerable.

After describing the VRPD and defining notation, we prove several worst-case theorems. Each result reveals the amount of time that could be saved, in the best

case, as a result of using trucks and drones rather than trucks alone in delivering packages to customers. For example, suppose a drone travels 50% faster than a truck, there are m trucks, and at most two drones per truck. Theorem 17 tells us that, in the best case, we can reduce delivery completion time by 75%.

For each of the first seven theorems, we proved worst-case bounds and showed that these bounds are tight. Next, we extended our model in three key directions. First, we explicitly included a limited battery life for the drones. Second, we took into account that trucks travel over a street network, whereas drones travel from one point to another as the crow flies. Third, we sought to incorporate cost, in addition to delivery completion time, into our model. For each of these extensions, we proved an additional inequality.

These extensions represent an initial attempt to add greater realism to the basic model. There is much more work to be done in terms of worst-case analysis. For example, can Theorems 19 and 21 be generalized to the m -vehicle case? In addition, there is a need for smart exact and heuristic approaches to solve the VRPD and simulation studies that aim to determine the expected benefits of using drones and trucks to deliver packages rather than trucks alone.

Overall, we think the VRPD represents a very exciting new direction in logistics. We expect to see substantial progress on this problem in both the academic literature and in practice over the next decade. Furthermore, we expect the academic and practitioner communities to feed off of one another. What we have shown represent bounds on maximal savings. Further research could give us better indications of actual savings in real-life settings.

Chapter 6: The Min-Max Close-Enough Vehicle Routing Problem

6.1 Introduction

We have seen many cases where advancements in technology motivate new problems in operations research. The notion of close-enough routing is one of these new problems. Traditionally, both the simpler Traveling Salesman Problem (TSP) and the more complex Vehicle Routing Problem (VRP) require cities and customers to be visited exactly at their locations. For example, utility companies send their workers to read the meters at every household. With radio frequency identification (RFID) technology, meters can be read from a distance. Instead of visiting every customer, workers need only get close enough to a customer to read the meter. Another application of close-enough routing problem arises when a pilot (or a drone) surveys several ground targets. The drone does not have to fly directly above the targets but only has to get close enough to survey them.

The basic form of close-enough routing, the Close-Enough Traveling Salesman Problem (CETSP), was introduced by Gulczynski et al. [51]. The CETSP is, typically, defined on a Euclidean plane. The salesman must start from and end at the depot. Every customer has a service range. A customer has been visited when the salesman comes within the customer's service range. The objective is to visit

all customers and return to the depot in the shortest distance traveled. When all customer service ranges are equal to zero, the CETSP reduces to the TSP. A positive service range changes the geometry of the problem. The TSP can be described as finding the shortest Hamiltonian cycle in a complete graph. However, in the CETSP, the nodes of the routes are not known in advance. A CETSP solver must not only determine the sequence in which the customers are visited, but also the locations at which these customers are served. Since Gulczynski et al.'s work on heuristics for the CETSP, several papers have appeared in the literature. Three papers have focused on heuristics [24, 70, 85] and two papers have developed exact approaches and lower bounds [24, 32].

A natural extension to the CETSP is the Close-Enough Vehicle Routing Problem (CEVRP). Instead of only one route traveled by one salesman, a number of routes are traveled by a fleet of vehicles that make deliveries to meet the demand of customers. The vehicles do not have to visit the customers at their locations; they only need to get close enough to the customers. The total demands delivered on a route cannot exceed the capacity of a truck. The CEVRP can model package delivery when customers are willing to travel some distance to pick up their packages. For example, in disaster routing, we can drop rescue packages near the affected villages. Mennell [70] developed Steiner-zone-based heuristics to solve the CEVRP. Steiner zones are explained in Section 6.2.2.

We propose a new variant of the CEVRP called the min-max Close-Enough Vehicle Routing Problem (MMCEVRP). Instead of minimizing the total distance traveled by the fleet, we minimize the distance of the the longest route. In other

words, we focus on the completion time. When a task requires several routes to be traveled in parallel, the task is finished only when the last route is completed. For example, if we launch several drones to survey the destruction on major roads after a natural disaster, then the survey is completed only when the last drone returns to its base. Some complex problems can be formulated using the MMCEVRP as a subproblem. For example, suppose that drones are used to take readings from meters. The drones are loaded onto a truck. We may want to park the truck in a particular neighborhood and then dispatch the drones to take the readings. Only when the last drone returns can the truck leave and reposition to a different neighborhood. The min-max objective can also be used to balance the route lengths. If the length of the longest route is minimized, the variability of the route lengths tends to be small.

In the MMCEVRP, we have to fix the number of vehicles in the fleet in advance; otherwise, the optimal solution simply requires that the number of vehicles equals the number of customers and each vehicle serves one specific customer. In addition, we do not consider the capacity constraint because most applications of close-enough routing problems pertain to service rather than the delivery of physical commodities.

The rest of the chapter is organized as follows. In Section 6.2, we describe the MMCEVRP in the Euclidean plane and explain the concept of Steiner zones. In Section 6.3, we develop our heuristic algorithm (denoted by MMSZ) for the MMCEVRP. In Section 6.4, we present the performance of MMSZ on CETSP and MMCEVRP instances. Finally, in Section 6.5, we give our concluding remarks and mention directions for future work.

6.2 MMCEVRP

6.2.1 Problem description

The MMCEVRP is defined on a Euclidean plane. The set of points, $V = \{v_0, v_1, v_2, \dots, v_n\}$, gives the locations of the depot (v_0) and the customers ($v_i, i > 0$). Customer i has service range r_i . For customer i , there is a disk centered at v_i with radius r_i . We want to construct K cycles (routes) that pass through v_0 such that all disks defined by the customers are serviced by at least one of the routes. The objective is to minimize the longest distance of the K routes.

An example of the MMCEVRP with 11 customers is shown in Figure 6.1. The depot is at the bottom left labeled D . The circles represent the disks defined by the 11 customers. Assuming the fleet has two vehicles, we show two feasible routes (one with a solid red line, one with a dashed green line).

6.2.2 Steiner zone

If a route passes through a disk defined by a customer, then that customer is served. If a route passes through an overlap between two disks, both customers are served. If we can identify the overlapping regions, and then pick a point from each of these regions and disks defined by customers that are not already accounted for by the overlaps, the problem becomes a standard routing problem. This is the motivation of what we call Steiner-zone-based methods.

A Steiner zone is the overlap of disks. We define the disks themselves to be

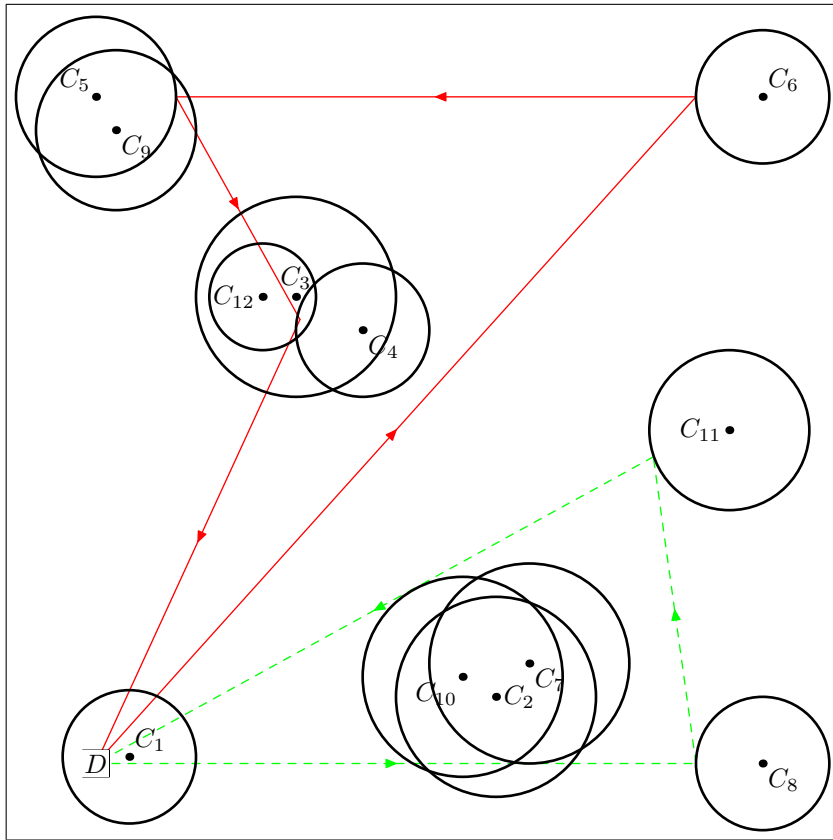


Figure 6.1: An MMCEVRP example with 11 customers and routes for two vehicles

special cases of Steiner zones. If a Steiner zone is contained in at most k disks, it has degree k . Therefore, a disk that is not contained in any other disk has degree 1. Intuitively, Steiner zones of high degree are desirable because a route that passes through it serves multiple customers at the same time. We note that a Steiner zone with very high degree usually has a small area, which limits our choice of a point from it (we term the point a Steiner point) in both the construction and improvement procedures in Section 6.3.

In Figure 6.2, we show examples of Steiner zones. Their degrees are given in the captions of the subgraphs. Observe that a degree k Steiner zone is enclosed by at most k arcs. We use the set notation to denote the Steiner zones. For example, $\{C_4, C_5\}$ denotes a Steiner zone that is contained in the disks defined by C_4 and C_5 and not other customers.

The boundary of a Steiner zone consists of one or more arcs. In general, if the boundary has more than one arc, we define the center of the Steiner zone to be the average of the endpoints of these arcs, i.e., the x (y) coordinate of the center is the average of the x (y) coordinates of the endpoints. In the special case where the Steiner zone is bounded by a circle, we define its center to be the center of the circle. All Steiner zones are convex because they are formed by the intersection of convex disks. Therefore, a center point of a Steiner zone always lies in the zone. In Figures 6.2(a) and 6.2(d), the centers of Steiner zone $\{C_2, C_3\}$ and $\{C_6, C_7, C_8\}$ are marked by an x.

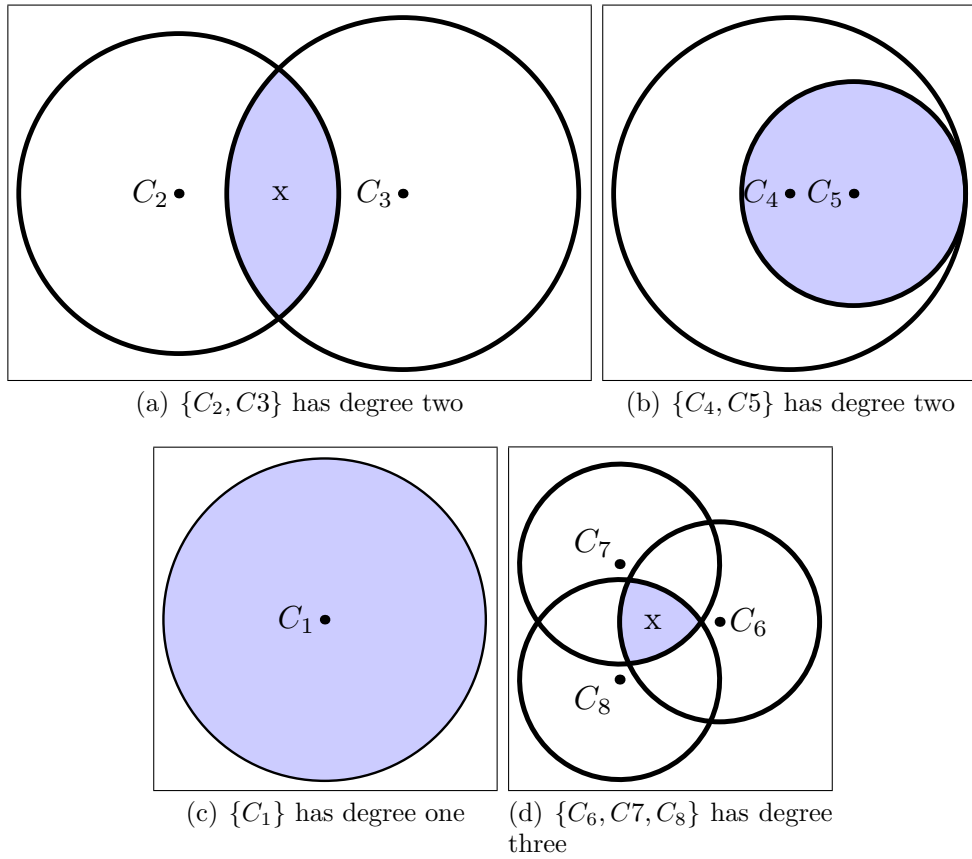


Figure 6.2: Steiner zones of various degrees

6.3 Algorithm

MMSZ is a hybrid composite algorithm that combines both tour construction and tour improvement phases. The construction phase has four steps. The improvement phase has intra-route and inter-route moves. An overview of the algorithm is given in Table 6.2.

6.3.1 Construction procedures

6.3.1.1 Customer pruning

We observe that not all customers need be considered explicitly to construct a feasible solution. For example, in Figure 6.3, there are 11 customers with various radii. The depot is represented by the square labeled D on the bottom left. We can eliminate customer C_3 because its disk contains the disk defined by C_{12} ; any route that serves C_{12} also serves C_3 . Similarly, we can eliminate customer C_1 on the bottom left because the depot is within its service range.

We may also remove customer C_9 . If all service ranges are zero, there always exists an optimal solution with all routes lying within the convex hull defined by V , the locations of the depot and the customers. If not, we can identify a path starting from the first time and ending at the second time when the route crosses the boundary. Since all routes start and end at the depot, which is in the convex hull, such a path always exists. Replace the path with a straight-line segment. The solution is feasible because no customers lie outside the convex hull. The solution

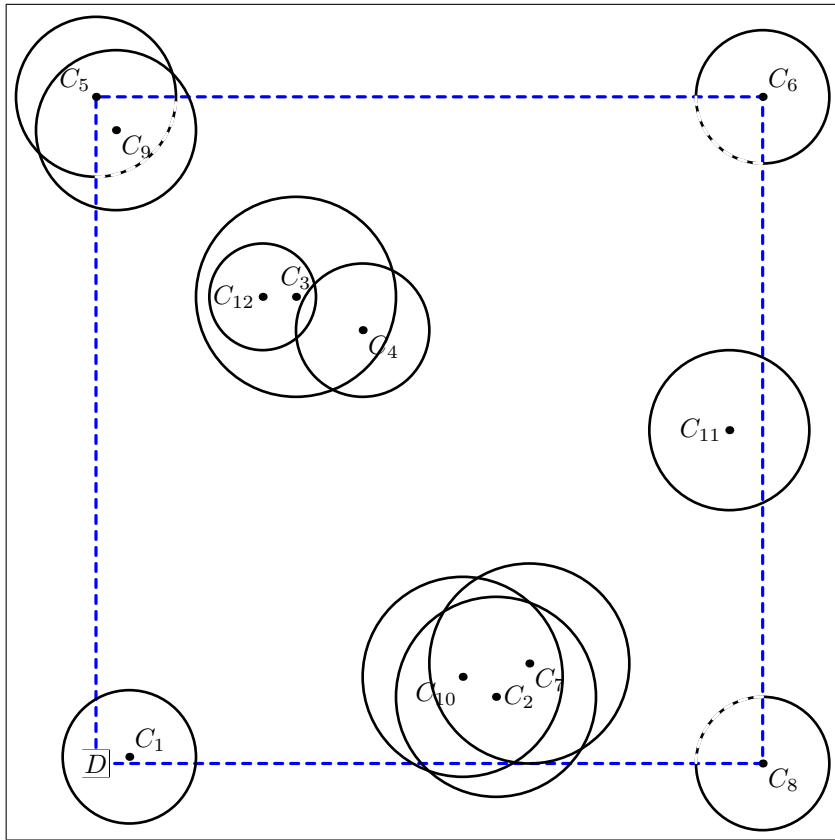


Figure 6.3: Customer pruning

is never worse because the triangle inequality holds on a Euclidean graph.

We can apply the same concept when some service ranges are positive. We hypothesize that there always exists an optimal solution with all routes in the convex hull defined by the depot and customer locations. The convex hull is drawn using the dashed line in Figure 6.3. A rigorous proof is required because it is possible that a route visits a customer (for example, C_{11}) outside the convex hull (although we believe such a route is not optimal).

The convex hull intersects the circles defined by the boundary customers, i.e., C_5 , C_6 , and C_8 , at the dashed arcs. In an optimal solution, if a route visits a boundary customer, it will visit a point on the arc. Therefore, any customer that defines a disk containing the dashed arcs can be removed (for example, C_9).

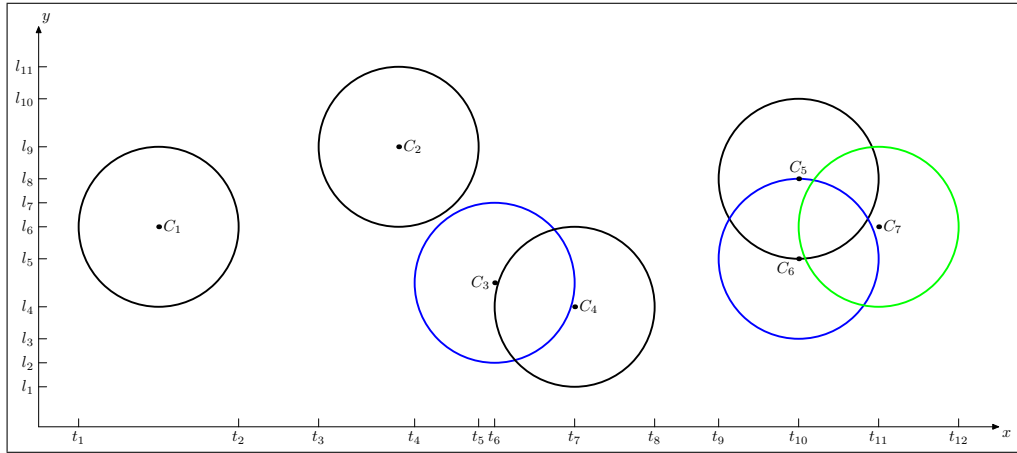
To summarize, a customer may be removed if it defines a disk that contains (A) the depot or (B) a disk defined by another customer. From our computational experience, a pre-processing procedure that considers these two pruning criteria both reduces total running time and improves solution quality. A customer may also be removed by (C) the convex hull argument; however, the effects are mixed. In general, removal of a customer by (C) reduces running time, but it may or may not improve solution quality (solution quality could be worse). Removal by (C) requires further research and a more rigorous argument. In Section 6.4, we report only results with customer pruning based on criteria (A) and (B).

6.3.1.2 Steiner zone construction

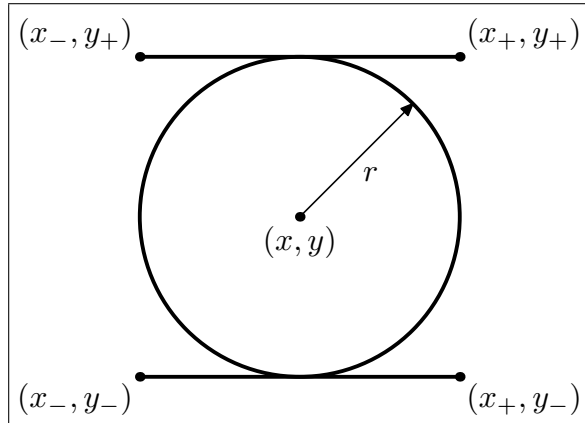
A naive approach to construct the Steiner zones would examine every subset of customers and determine if the disks they define overlap. This method has an exponential running time. One way to reduce the running time is limiting the degree of Steiner zones constructed to at most three, as suggested in [70]. However, we do not want to limit the search space of Steiner zones, so we implement a sweep line algorithm [83]. From our computational experience, this algorithm is fast.

The sweep line algorithm is illustrated with seven customers shown in Figure 6.4(a). The labels t_1 to t_{12} on the horizontal axis are x values such that $t_1 < t_2 < \dots < t_{12}$. Similarly, the labels l_1 to l_{11} on the vertical axis are y values such that $l_1 < l_2 < \dots < l_{11}$. Every customer is represented by a circle, which is then approximated by a pair of horizontal line segments (Figure 6.4(b)). If the center of the circle is at (x, y) and the radius is r , the two line segments are $\overline{(x_-, y_-)(x_+, y_-)}$ and $\overline{(x_-, y_+)(x_+, y_+)}$, where $x_{\pm} = x \pm r$ and $y_{\pm} = y \pm r$. Therefore, the seven customers in Figure 6.4(a) can be approximated by seven pairs of line segments in Figure 6.4(c).

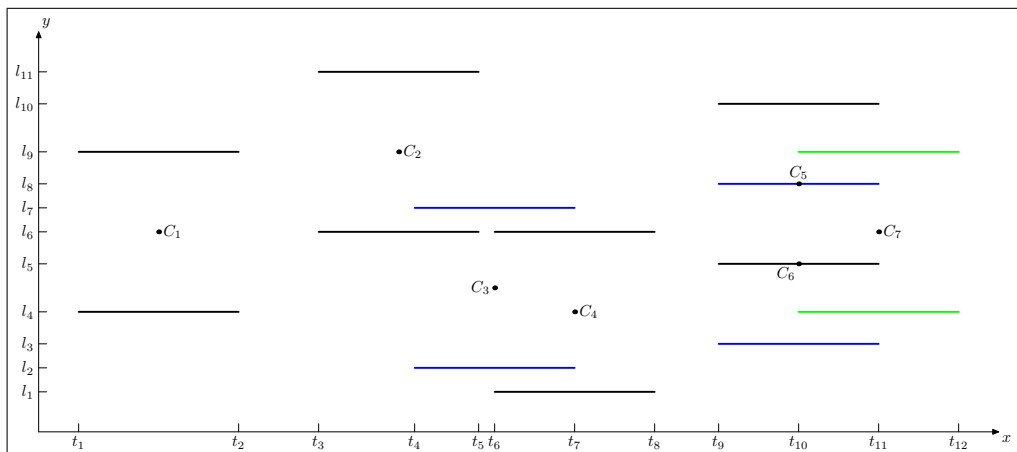
Imagine a vertical line that sweeps from left to right so that the horizontal axis represents time. Every pair of horizontal line segments that approximates a customer at (x, y) will cut the sweep line and register an interval $[y_-, y_+]$ from time x_- to time x_+ . Whenever the sweep line detects an overlap of registered intervals (we term it a child interval), it will calculate possible Steiner zones. If a new Steiner zone is found, the child interval is also registered, and is not removed until one of



(a) Customer locations



(b) Customer approximation



(c) Line segments representation

Figure 6.4: Sweep line algorithm

the parents is removed.

Table 6.1: Status of the sweep line

Time	Registered interval	Steiner zone
$[t_1, t_2]$	$[l_4, l_9]$	$\{C_1\}$
$[t_2, t_3]$	none	none
$[t_3, t_4]$	$[l_6, l_{11}]$	$\{C_2\}$
$[t_4, t_5]$	$[l_6, l_{11}]$ $[l_2, l_7]$	$\{C_2\}$ $\{C_3\}$
$[t_5, t_6]$	$[l_2, l_7]$	$\{C_3\}$
$[t_6, t_7]$	$[l_2, l_7]$ $[l_1, l_6]$ $[l_2, l_6]$	$\{C_3\}$ $\{C_4\}$ $\{C_3, C_4\}$
$[t_7, t_8]$	$[l_1, l_6]$	$\{C_4\}$
$[t_8, t_9]$	none	none
$[t_9, t_{10}]$	$[l_5, l_{10}]$ $[l_3, l_8]$ $[l_5, l_8]$	$\{C_5\}$ $\{C_6\}$ $\{C_5, C_6\}$
$[t_{10}, t_{11}]$	$[l_5, l_{10}]$ $[l_3, l_8]$ $[l_4, l_9]$ $[l_5, l_9]$ $[l_4, l_8]$ $[l_5, l_8]$	$\{C_5\}$ $\{C_6\}$ $\{C_7\}$ $\{C_5, C_7\}$ $\{C_6, C_7\}$ $\{C_5, C_6, C_7\}$
$[t_{11}, t_{12}]$	$[l_4, l_9]$	$\{C_7\}$

The status of the sweep line as it sweeps across the customers in Figure 6.4(c) is recorded in Table 6.1. The first column gives the time interval. The second column gives the registered interval over each time interval. The third column gives the Steiner zones corresponding to the registered intervals. If there is more than one Steiner zone corresponding to an interval, we record only the interval with the highest degree. Over the time interval $[t_4, t_5]$, although the registered intervals $[l_6, l_{11}]$ and $[l_2, l_7]$ overlap, upon checking, the disks defined by customers C_2 and C_3

do not overlap, so the child interval $[l_6, l_7]$ is not registered on the sweep line. Over the time interval $[t_{10}, t_{11}]$, the registered interval $[l_5, l_8]$ points to two Steiner zones $(\{C_5, C_6\}, \{C_5, C_6, C_7\})$. Only the Steiner zone $\{C_5, C_6, C_7\}$ is registered because it has degree three, while the Steiner zone $\{C_5, C_6\}$ has degree two.

6.3.1.3 Set covering

After we have determined the set of Steiner zones, we solve a Set Covering Problem (SCP) that determines the fewest Steiner zones to cover all customers. Specifically, the following Binary Integer Program (BIP1) is solved.

$$(BIP1) \quad \min \quad \sum_{j \in M} x_j \quad (6.1)$$

$$\text{s.t.} \quad \sum_{j \in M} s_{ij} x_j \geq 1 \quad \forall i \in N \quad (6.2)$$

$$x_j \in \{0, 1\} \quad \forall j \in M \quad (6.3)$$

where $M = \{0, 1, \dots, m\}$ is the set of indices for the Steiner zones and $N = \{0, 1, \dots, n\}$ is the set of indices for the customers. The binary decision variable x_j equals 1 when Steiner zone j is selected. In the objective function (6.1), we minimize the number of Steiner zones selected. In constraints (6.2), the binary parameter s_{ij} equals 1 when Steiner zone j is contained in the disk defined by customer i ; therefore, customer i is served by visiting Steiner zone j . The constraints force every customer to be served. Constraints (6.3) define a binary decision variable.

We observe that the optimal solution is often not unique. For example, if $n = 4$ and we have four Steiner zones of degree at least two ($\{1, 2\}$, $\{1, 2, 3\}$, $\{2, 3\}$, $\{2, 3, 4\}$), both $\{1, 2\}$ & $\{3, 4\}$ and $\{1, 2, 3\}$ & $\{2, 3, 4\}$ cover all four customers with two Steiner zones. The combination $\{1, 2\}$ and $\{3, 4\}$ is desirable because the union of the two low-degree Steiner zones contains the union of the two high-degree Steiner zones.

In view of the above observations, we modify BIP1 with a new objective function (6.4) and an additional constraint (6.5). We denote the modified model by BIP2.

$$(BIP2) \quad \min \quad \sum_{j \in M} d_j x_j \quad (6.4)$$

$$\text{s.t} \quad \sum_{j \in M} x_j \leq L \quad (6.5)$$

$$\sum_{j \in M} s_{ij} x_j \geq 1 \quad \forall i \in N \quad (6.6)$$

$$x_j \in \{0, 1\} \quad \forall j \in M \quad (6.7)$$

In the objective function (6.4), d_j is the degree of Steiner zone j . The objective function minimizes the total degree of the selected Steiner zones. In constraints (6.5), L is the optimal objective function value found in solving BIP1.

Both BIPs are solved using the general purpose optimization software Gurobi [53]. Even though the SCP is NP complete, our computational experience shows that both BIPs are solved quickly in all test instances. If the problem size is too large for a solution to be produced in a reasonable amount of time, the following three modifications may be used:

1. Use an exact solver specifically designed to solve the SCP;
2. Reduce m , the number of Steiner zones considered; for example, by excluding some degree two or degree three Steiner zones;
3. Use a heuristic solver for the SCP instead of an exact solver.

6.3.1.4 MMVRP solver

We choose a Steiner point from every Steiner zone. We do not make arbitrary choices, but identify the Steiner point that is closest to the depot. These Steiner points together with the depot constitute a min-max VRP that is solved using the MMD solver developed by Wang et al. [95]. An initial feasible solution to the MMCEVRP is produced.

6.3.2 Improvement procedures

The key difference between the standard VRP and the CEVRP lies in the location where a customer can be served. In the standard VRP, there is a unique location where a customer has to be visited whereas, in the CEVRP, a customer can be served at any point in the disk defined by that customer. As long as the radius of the disk is greater than zero, the number of choices is infinite. These choices increase the complexity of the routing problem but they also lead to savings. Both the intra-route and inter-route improvement procedures seek to exploit the choices of the locations to visit.

6.3.2.1 Intra-route improvement

For a specific route, we want to shorten its length by re-selecting Steiner points. An optimal choice may be found using second order cone programming [70], however this procedure is time consuming. We apply a greedy heuristic, GREEDYSR, that alternates between selection of Steiner points and routing of these points.

We examine the Steiner points in the sequence that they are visited on a specific route. For every Steiner point q_0 , we fix its predecessor p and successor s , and choose a point q from the Steiner zone where q_0 is located to minimize $d(p, q) + d(q, s)$, where $d(p, q)$ denotes the Euclidean distance from p to q . In particular, if the line segment \overline{ps} crosses the Steiner zone, there are infinite number of choices, and we choose one of the two points at the boundaries arbitrarily.

Figure 6.5 illustrates one iteration of the selection process. Let a route serve two customers C_1 at $(1, 1)$ and C_2 at $(2, 0)$. Both customers have a service range of 0.25. The depot is at the origin. Initially, as shown in Figure 6.5(a), the route visits points $A_1(0.8232233, 0.8232233)$ and $B_1(1.75, 0)$ that are within the respective disks and are closest to the depot. The length of this route is about 4.15. To improve the selection of Steiner points, we first fix points D and B_1 on the route, and choose a point A on the disk defined by C_1 , such that $d(D, A) + d(A, B_1)$ is minimized. The point is $A = A_2(0.984492, 0.750481)$ as shown in Figure 6.5(b). Next, we fix points A_2 and D on the route, and choose a point B on the disk defined by C_2 , such that $d(A_2, B) + d(B, D)$ is minimized. The point is $B_2(1.763626, 0.0814086)$. The new route has length 4.03.

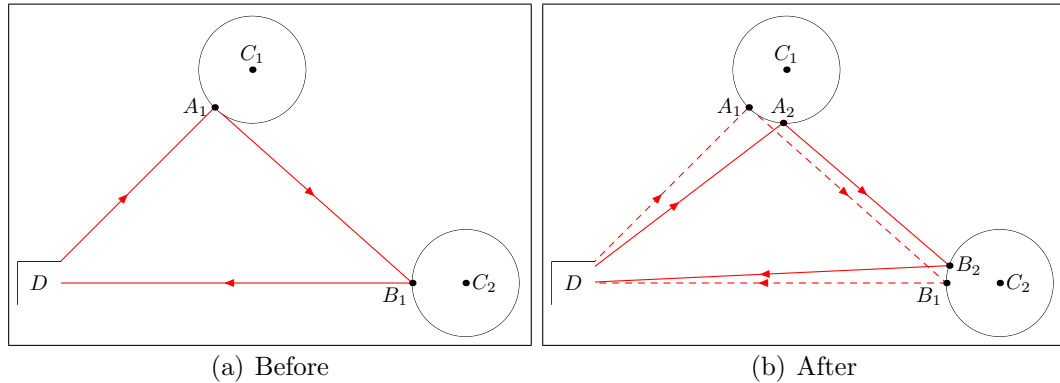


Figure 6.5: One pass of the selection process

We repeat the selection process until no improvement can be found. The Lin-Kernighan-Helsgaun (LKH) TSP solver [56] is called to optimize the routing. The improvement procedure alternates between the Steiner points selection process and the LKH solver until no improvement can be found.

Next, we perturb the route by a random selection of Steiner points. Each Steiner point has a probability of 0.5 to be replaced with the center point of its Steiner zone. We expect the new route to increase in length. We apply the GREEDYSR to search for a new local minimum. The routing should precede the selection process this time; otherwise we may undo the perturbation. If the new route is shorter, it replaces the old route. In our implementation, perturbation is carried out 10 times.

6.3.2.2 Inter-route improvement

The construction procedures and the intra-route improvement procedures depend on the choice of Steiner zones from solving BIP1 and BIP2. However, such a choice may not be optimal. We use two strategies to break away from a local

optimum.

The first strategy does not consider any Steiner zone of degree greater than one. For every customer location, we find its closest point (called a foot) on the feasible routes. Ties are broken arbitrarily. The feet together with the depot form a min-max VRP that can be solved using the MMD solver. The solution remains feasible because it visits all feet. It is at least as good as the original solution that visits all feet. The intra-route improvement procedures are then applied to decrease the objective function value.

The second strategy uses new Steiner zones. In the current version of MMSZ, we compute the feet as described in the first strategy. These points serve as candidate Steiner zone points. For each foot, we identify the customers with disks that contain the point in order to generate a new set of Steiner zones. From the new set, we select the least number of Steiner zones using BIP1 and BIP2. The MMD solver solves the min-max VRP on the selected points.

The second strategy may be modified by considering other points on the routes that are different from the feet. We can construct new Steiner zones using the feasible routes as a guide. Further research may develop insight on how to choose the new Steiner points.

In Table 6.2, we give an overview of the MMSZ algorithm.

Table 6.2: Overview of MMSZ

Algorithm 1

Construction phase

1. Customer pruning
Remove customers with disks that contain the depot or disks defined by other customers
2. Steiner zone construction
Use sweep line algorithm
3. Set covering
Solve BIP_1 and BIP_2
4. Solution initialization
Use the min-max VRP solver MMD

Improvement phase

5. Intra-route improvement
 - 5a **For** every route in the solution
 Do
 Alternate between Steiner point selection and re-routing
 While there is improvement
 - 5b **Do** 10 times
 Perturb Steiner point selection
 Do
 Alternate between re-routing and Steiner point selection
 While there is improvement
 If route length shortened
 Update route
 Endif
 End**Endfor**
 6. Inter-route improvement
Do
 - 6a Select feet for all customers on its nearest route
 Use the min-max VRP solver MMD
 Apply Intra-route improvement
 - 6b Select a subset of feet that covers all customers
 Use the min-max VRP solver MMD
 Apply Intra-route improvement**while** there is improvement
-

6.4 Computational results

Because the MMCEVRP is a new problem that has not been studied in the literature, there are no benchmark instances. We modify existing CETSP and CEVRP instances to produce benchmark instances. We test the performance of MMSZ using 14 instances taken from [70]. The number of customers ranges from 99 to 1000. Some instances have customer locations that are uniformly distributed; some have locations that are clustered. The instances can be found in the Appendix. We implement MMSZ using C++ and perform our computational experiments on a Linux machine with a 2.2GHz processor and 4G RAM. The running time of an instance is the average of 10 runs.

6.4.1 CETSP

In this section, we report the performance of MMSZ on CETSP. When there is one route, the MMD solver in MMSZ reduces to a LKH solver. We compare MMSZ to the heuristic solvers developed in [70]. The results are presented in Table 6.3. The first column gives the instance names. The second column gives the best solution produced by these heuristics. The third column gives the gap (%) between the results produced by MMSZ and the best solutions. The fourth to seventh columns give the gap (%) between the seven heuristics developed in [70] and the best solutions. In the last three rows, we calculate the average gap, the average running time per instance, and the number of best solutions produced. Mennell [70] developed 10 heuristics; the three heuristics with an average gap greater than 10% and no best solutions are

not reported in Table 6.3.

MMSZ finds four new best solutions. In terms of average gap, MMSZ is not the best among the heuristics; MMSZ's average gap of 3.22% is reasonable given its short running time compared to the other algorithms (note these algorithms were run on different machines). SZ_1 is faster than MMSZ but produces an average gap of 7.78%. SZ_1 produces three results that have a deviation of 10% or more from the best solution. The results of MMSZ on these 14 instances indicate that MMSZ needs improvement. The fact that MMSZ has a short running time makes it a promising heuristic.

6.4.2 MMCEVRP

We present the results of MMSZ on the MMCEVRP in Table 6.4. The customer locations and service ranges are exactly the same as those in the CETSP instances. We assume that there are six routes in each instance. The first column in Table 6.4 gives the names of the test instances. The second and the third columns give the objective function values and running times produced by MMSZ. The average running time is 140.5 seconds. In the fourth and fifth columns, we solve each instance as a min-max VRP using MMD, i.e., assuming all customer service ranges are zero. Comparing the second and the fourth columns, the difference in the objective function values produced by MMSZ and MMD is the benefit we obtain from close-enough routing. The percentage savings is computed in the sixth column. The average savings is 27.6%. Comparing the third and the fifth

Table 6.3: Results produced by MMSZ and seven heuristics on 14 CETSP instances

Instance	Best	Gap (%)							SZ1
		MMSZ	HYBRID2	HYBRID1	SZ2	SZ ₃₅₀₋₅₉	SZ3	GTSP2	
kroD100rdmRad	141.83	6.03	1.72	6.83	1.80	2.24	1.02	0.00	2.81
rat195rdmRad	68.22	2.02	0.86	0.91	0.64	0.07	0.00	2.87	7.75
lin318rdmRad	2081.66	4.92	3.80	3.98	4.52	2.63	5.09	0.00	10.99
rd400rdmRad	1252.38	7.88	0.00	0.67	1.89	1.41	1.70	0.37	2.16
pcb442rdmRad	233.331	0.00	0.80	1.71	4.35	1.93	5.46	7.67	9.70
d493rdmRad	140.12	1.70	0.00	0.41	1.40	9.40	12.17	14.50	7.90
dsj1000rdmRad	653.37	1.65	0.39	1.07	0.00	9.58	12.67	20.81	9.05
team1_100rdmRad	388.54	5.33	0.46	0.58	0.62	0.14	0.00	0.00	5.66
team2_200rdmRad	622.74	6.70	3.22	3.27	5.31	3.51	2.30	0.00	7.17
team3_300rdmRad	381.83	3.36	4.60	4.76	3.87	0.00	4.31	15.67	11.04
team4_400rdmRad	1011.77	5.54	1.44	1.69	1.39	0.00	0.90	0.15	2.54
team5_499rdmRad	453.78	0.00	0.58	0.90	0.40	4.94	0.12	16.49	9.43
team6_500rdmRad	657.168	0.00	1.37	1.44	3.17	3.42	4.23	11.23	14.69
bonus1000rdmRad	983.166	0.00	1.34	1.40	0.96	3.25	5.08	6.78	8.00
Average gap		3.22	1.47	2.12	2.17	3.04	3.93	6.90	7.78
Average running time (s)		2.45	1371.60	1050.80	28.90	31217.20	3088.90	1600769.00	1.07
Number of best solutions		4	2	0	1	2	2	3	0

columns, we observe that MMSZ generally takes less computational time to solve an MMCEVRP instance than MMD takes to solve the corresponding min-max VRP instance. Most likely, this is due to the customer pruning strategies. Even though MMSZ calls MMD several times, the instances solved are smaller than the min-max VRP. Further research is required to construct lower bounds on these MMCEVRP instances to examine the performance of the MMSZ algorithm.

6.5 Conclusions and future work

In this chapter, we proposed a new problem, the MMCEVRP, by combining the work on the CETSP, the CEVRP, and the min-max VRP. We developed a heuristic, MMSZ, based on the idea of Steiner zones and showed that it performed reasonably well on CETSP instances.

There are several modifications that can be considered such as using the convex hull argument in customer pruning and using the Steiner zone selection in the inter-route improvement procedures. We hope that these modifications will improve the MMSZ solver. We would like to run the solver on additional CETSP instances and develop lower bounds on the MMCEVRP instances.

Table 6.4: Results produced by MMSZ on 14 MMCEVRP instances

Instance	MMSZ		MMD (service range = 0)			Savings (%)
	Objective function value	Time (s)	Objective function value	Time (s)		
kroD100rdmRad	77.39	49.5	84.13	31	8.0%	
rat195rdmRad	53.49	16.7	72.76	112	26.5%	
lin318rdRad	875.05	62.3	1280.77	201	31.7%	
rd400rdmRad	333.49	599.1	379.64	542	12.2%	
pcb442rdmRad	97.00	89.2	162.89	537	40.5%	
d493rdmRad	82.78	61.0	127.4	1359	35.0%	
bonus1000rdmRad	274.28	344.4	485.12	7650	43.5%	
team1_100rdmRad	192.90	18.6	207.74	49	7.1%	
team2_200rdmRad	283.94	69.2	356.41	126	20.3%	
team3_300rdmRad	177.14	20.8	277.33	454	36.1%	
team4_400rdmRad	336.41	442.1	400.37	705	16.0%	
team5_499rdmRad	195.42	20.4	367.63	1869	46.8%	
team6_500rdmRad	284.97	79.0	382.86	1207	25.6%	
dsj1000rdmRad	288.49	94.2	455.38	7065	36.6%	
Average		140.5		1565	27.6%	

Chapter 7: Conclusions and future work

In this dissertation, we studied several variants of the VRP with the min-max objective function. Instead of minimizing the total distance traveled by all the vehicles, we minimize the distance of the longest route.

We used both theoretical and computational approaches. We performed worst-case analyses that compared optimal solutions to the min-max and min-sum problems. We showed that the optimal solutions with respect to one objective function can be very poor with respect to the other objective function. This observation motivated our development of heuristics that solved the min-max VRPs.

We studied the MMMDVRP and developed a heuristic algorithm (MD). We compared MD to two alternative heuristics that we developed and to an existing method from the literature on a set of 20 test instances. MD produced 15 best solutions and was the top performer. Additional computational experiments on instances with uniform and non-uniform distributions of customers, varying customer-to-vehicle ratios, and real-world data further demonstrated MD's effectiveness in producing high-quality results.

We generalized the MMMDVRP to the MMSDMDV-MSTR by incorporating customer service times, service splits, and minimum service requirements. We de-

veloped a heuristic (MDS) for this problem. We demonstrated the effectiveness of MDS on 21 instances whose near optimal solutions can be estimated using geometry. We also investigated the savings from split service and the split patterns as we varied the required service times, the average number of customers per route, and the minimum service time requirements.

We proposed the VRPD. The problem was motivated by several influential companies currently investigating the use of commercial drones for package delivery. We performed worst-case analyses to reveal the amount of delivery time that could be saved at most as a result of using a fleet with trucks and drones instead of using a traditional fleet with only trucks. The maximum speed up is a function of the number of drones loaded onto one truck and the speed of a drone relative to the speed of a truck.

We proposed the MMCEVRP which is motivated by RFID technology. We developed a heuristic (MMSZ) for this problem. On 14 CETSP instances from the literature, MMSZ produced four new best solutions. MMSZ had fast running times and produced results that were comparable in quality to the results of the existing heuristics for the CETSP. We also generated 14 new MMCEVRP instances and used MMSZ to demonstrate the savings that could be obtained when vehicles are required only to get close enough to the customers.

We raised new research questions that can be explored in future work. First, we compared the min-max and min-sum objective solutions from a worst-case perspective. What happens in average cases? One approach would be to solve the benchmark VRP instances with the min-max objective function and compare the

solutions to the best-known min-sum solutions. However, almost all benchmark VRP instances involve the delivery of goods instead of services. Therefore, we would need to modify MD and MDS to handle the delivery of goods. Second, we showed the benefit from using drones in the VRPD from a theoretical point of view. What happens in practice? Can we run a simulation of the VRPD? This requires a computational approach for the VRPD. Third, we have already mentioned several modifications that can be considered to improve the MDSZ algorithm for the CETSP and MMCEVRP. We would like to demonstrate the effectiveness of MDSZ over a larger set of test instances. Finally, real-life routing is more complicated than merely deciding to use a min-sum or min-max objective function. Routing may involve a combination of the two objective functions. We need to consider constructing routes that minimize the total distances but are balanced at the same time. Besides having a weighted sum in the objective function, a unifying scheme might consider minimizing the p -norm of the route lengths, or equivalently, to minimize $L_1^p + L_2^2 + \dots + L_m^p$, where L_1, L_2, \dots, L_m are the lengths of the routes. It would be worthwhile to explore how the value of the parameter p changes the solutions.

Appendix A: The MD algorithm illustration

In this appendix, we illustrate the MD algorithm using an instance with three depots, with each depot having one vehicle and 10 customers. (We denote this problem by MM1. The coordinates of the customers and depots are given in the online appendix.) The locations of customers and depots are shown in Figure A.1. Customers are represented by circles and depots are represented by stars.

A.1 Initialization

Customers 1, 9, 5, and 2 are assigned to depot 1. Customers 7, 3, and 4 are assigned to depot 2. Customers 10, 6, and 8 are assigned to depot 3. The LKH solver generates a TSP on each route. This gives the initial solution that is shown in Figure A.2.

The number next to a line segment is the length between neighboring nodes. The number in parentheses next to a depot is the total length of the route passing through that depot (170.778 for depot 1, 143.072 for depot 2, and 219.02 for depot 3).

A.2 Local search

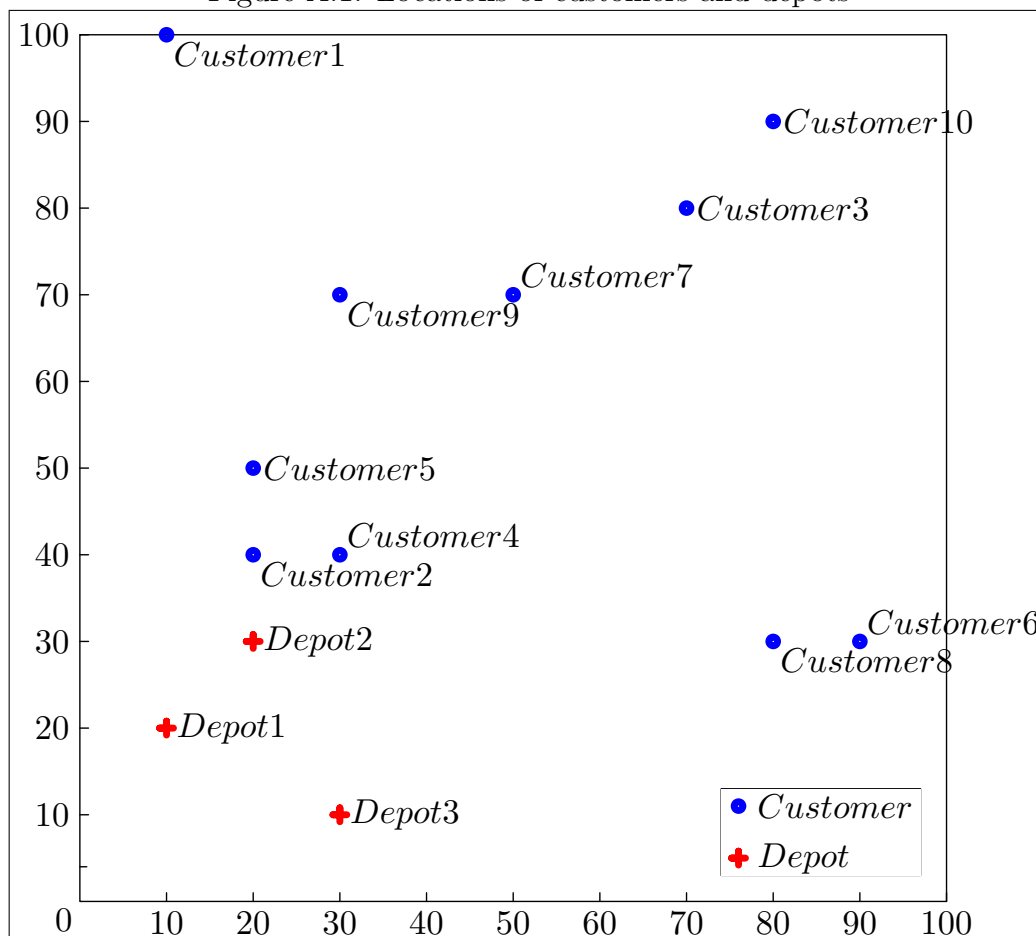
The maximal route passes through depot 3 and has a length of 219.02. There are three customers on this route. The savings produced by removing a customer from this route are given in Table [A.1](#).

The customer with the largest savings (customer 10) is removed from the maximal route. It may be inserted onto the route passing through depot 1 or onto the route passing through depot 2. The increase in route length is estimated by inserting customer 10 between every pair of adjacent nodes on the route. These costs are given in Table [A.2](#).

Customer 10 is inserted in the least-cost way (27.837) between customer 7 and customer 3 on route 2 that passes through depot 2. The TSP solution on routes 2 and 3 are calculated again using the LKH solver. The following solution is produced after iteration 1 (see Figure [A.3](#)). Route 1 passes through depot 1 with customers 1, 9, 5, and 2 and a length of 170.778. Route 2 passes through depot 2 with customers 7, 10, 3, and 4 and a length of 170.909. Route 3 passes through depot 3 with customers 8 and 6 and a length of 127.098.

The objective function value decreased from 219.02 to 170.909, so the procedure continues. The maximal route is the second route with four customers. The savings from removing a customer are given in Table [A.3](#).

Figure A.1: Locations of customers and depots



Customer 10 is removed and inserted onto route 1 or route 3. The insertion costs are given in Table A.2 and Table A.4.

If customer 10 is inserted onto route 3, the estimated increase in route length is 91.922. If it is inserted onto route 1, the estimated increase in route length is 88.507 (see Table A.2). So we try to insert customer 10 onto route 1. After solving

Table A.1: Savings if a customer is removed from route 3

Customer removed	Savings
Customer 10	91.922
Customer 6	10.282
Customer 8	0.606

Figure A.2: Initial solution

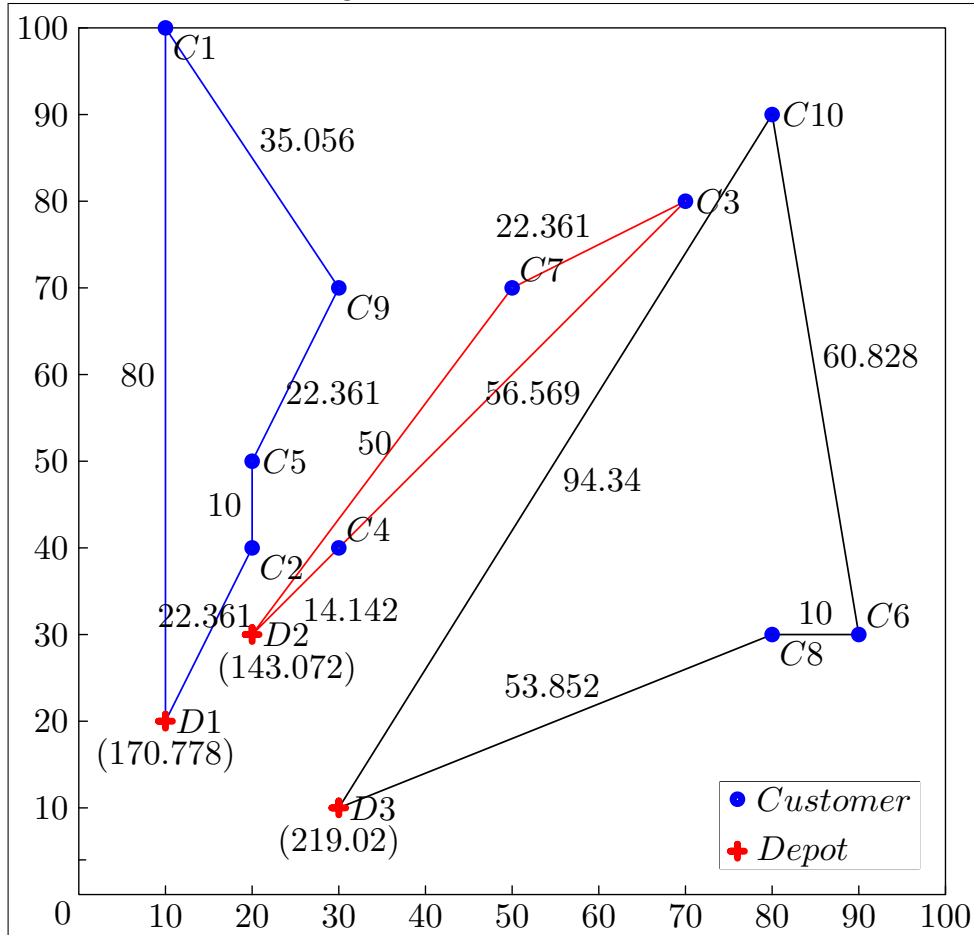


Table A.2: Cost of inserting customer 10 onto routes 1 and 2

Route	Position of insertion between nodes	Cost of insertion
Passing through depot 1	depot and customer 1	89.706
	Customer 1 and 9	88.507
	Customer 9 and 5	103.602
	Customer 5 and 2	140.214
	Customer 2 and depot	154.734
Passing through depot 2	Depot and customer 7	70.908
	Customer 7 and customer 3	27.837
	Customer 3 and customer 4	28.284
	Customer 4 and depot	141.421

Figure A.3: Iteration 1

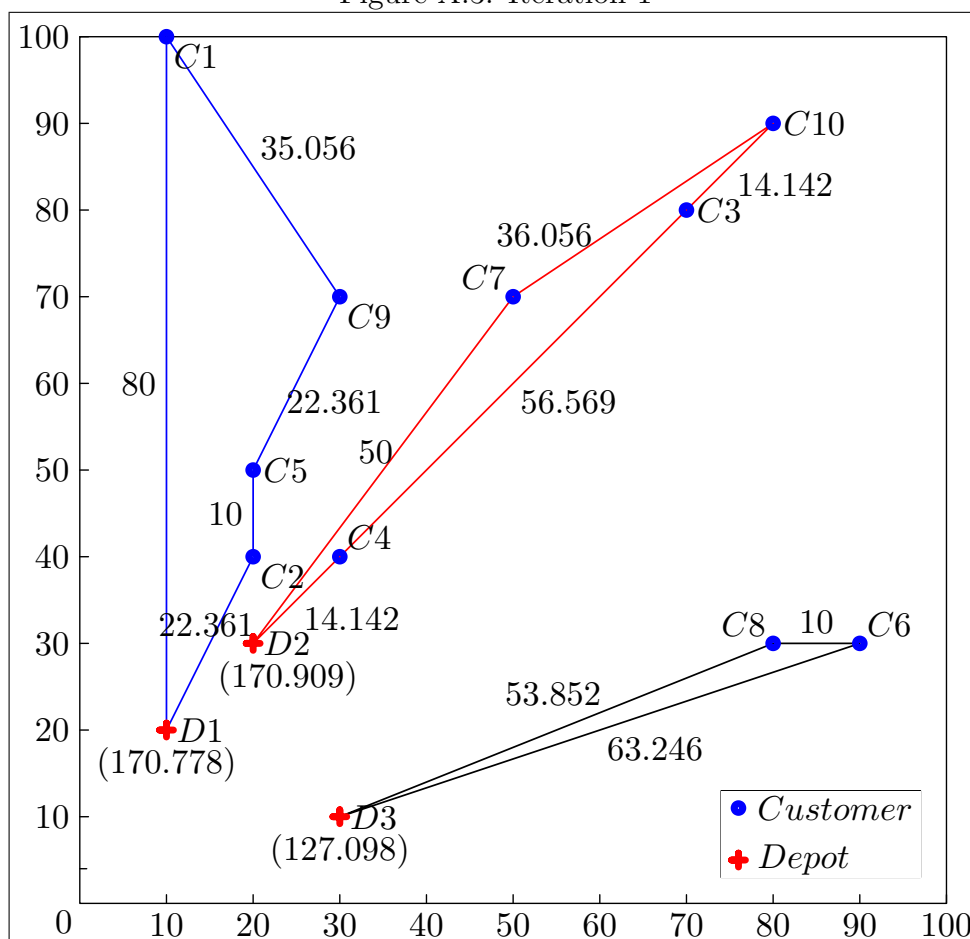


Table A.3: Savings if a customer is removed from route 2

Customer removed	Savings
Customer 7	1.203
Customer 10	27.837
Customer 3	0
Customer 4	0

Table A.4: Cost of inserting customer 10 onto route 3

Route	Position of insertion between nodes	Cost of insertion
Passing through depot 3	Depot and customer 8	100.488
	Customer 8 and 6	110.828
	Customer 6 and depot	91.922

the TSP on routes 1 and 2 using the LKH solver, the new objective function value is 238.877, which is greater than 170.909. There is no improvement if customer 10 is removed from the maximal route (i.e., route 2)

We go back to Table [A.3](#) and consider removing customer 7. The increase in route length is estimated by inserting customer 7 between every pair of adjacent nodes on routes 1 and 3. These costs are given in Table [A.5](#).

Customer 7 is inserted in the least-cost way between customers 9 and 5 on route 1. After solving the TSP on routes 1 and 2 using the LKH solver, the new objective function value is 203.438, which is greater than 170.909. The solution is not updated.

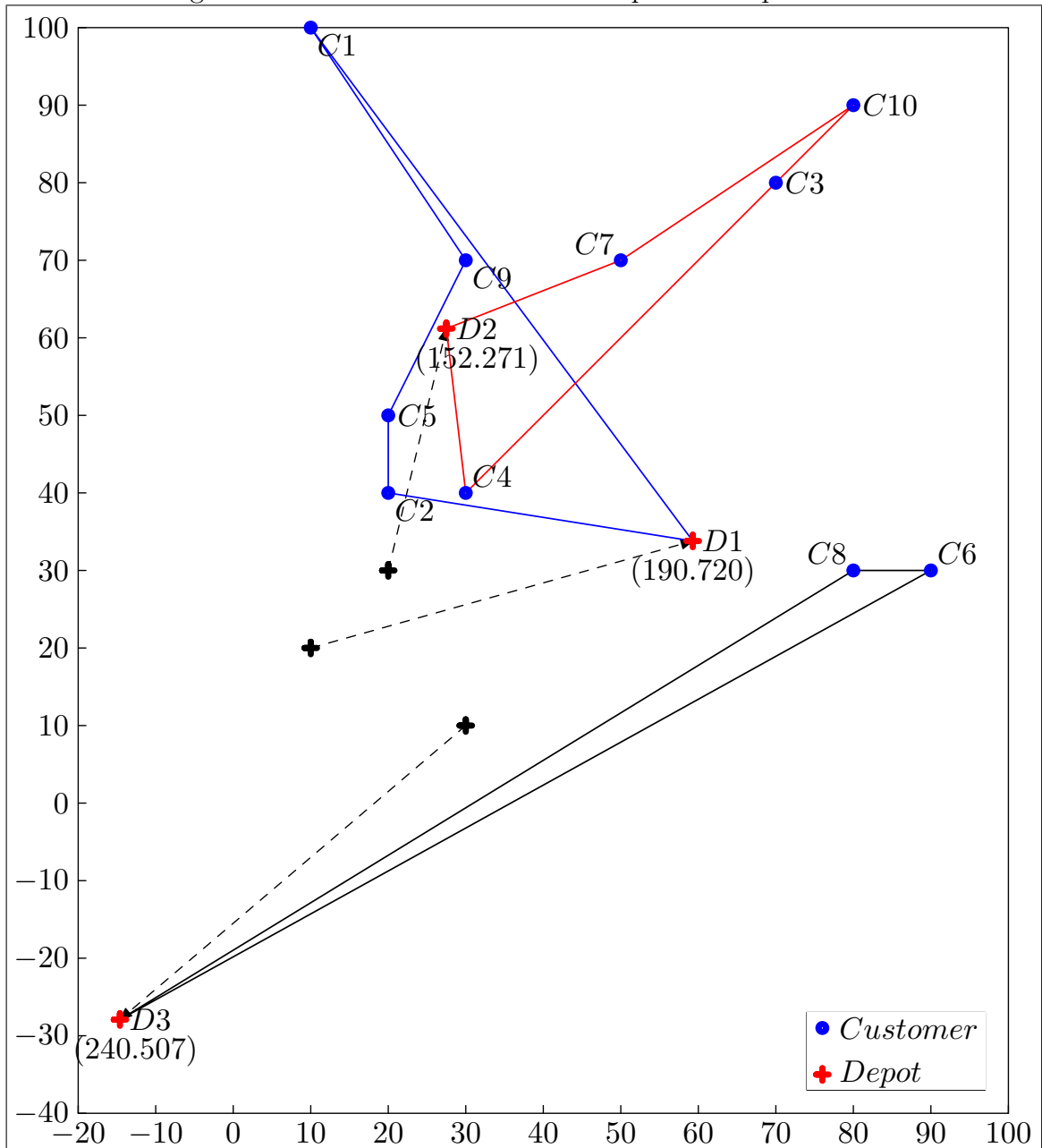
We go back to Table [A.3](#) and consider removing customers 3 and 4. Neither removal produces a smaller objective function value, so the solution with the objective function value of 170.909 (Figure [A.3](#)) is retained.

A.2.1 Improvement by perturbation

For each of the three depots, we compute the average of the distances to its preceding and succeeding customers. This is the radius of the first perturbation. The angle of the first perturbation is generated randomly. The new positions of the depots after perturbation are given in Table [A.6](#). The sequence of nodes on each route is unchanged and the feasible solution to the new problem is shown in Figure [A.4](#). The objective function value is 240.507.

We apply our local improvement procedure to the problem with the perturbed

Figure A.4: A feasible solution to the perturbed problem



positions of the depots. When the local improvement procedure ends, we have a solution with an objective function value of 175.466. This solution is shown in Figure [A.5](#).

The depots are then set to their original positions with the sequence of nodes on each route given by the perturbed solution (see Figure [A.6](#)). This solution is feasible and has an objective function value 227.925. We apply the local improvement procedure to this solution and obtain another feasible solution with objective function value 226.275 in Figure [A.7](#). The first perturbation does not result in a better solution, and we continue with the second to the fifth with the angles of perturbations shown in Table [A.7](#). None of these improves the current solution, so MD stops. The final solution has an objective function value of 170.909.

Table A.5: Cost of inserting customer 7 onto routes 1 and 3

Route	Position of insertion between nodes	Cost of insertion
Passing through depot 1	Depot and customer 1	34.031
	Customer 1 and 9	33.945
	Customer 9 and 5	33.695
	Customer 5 and 2	68.482
	Customer 2 and depot	84.097
Passing through depot 3	Depot and customer 8	59.394
	Customer 8 and customer 6	96.569
	Customer 6 and depot	56.569

Figure A.5: Solution to the perturbed problem after local search

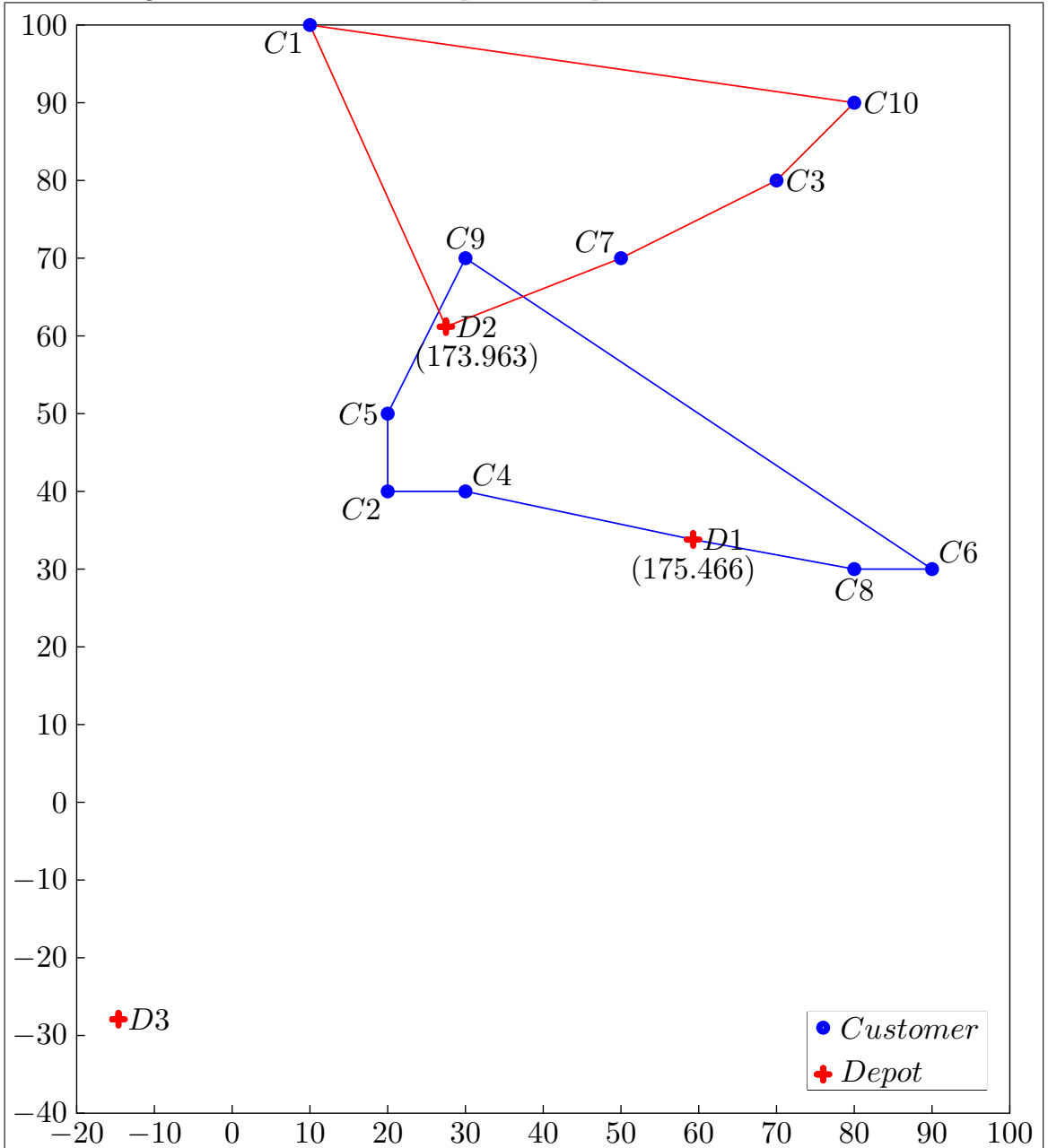


Figure A.6: A feasible solution to the original problem

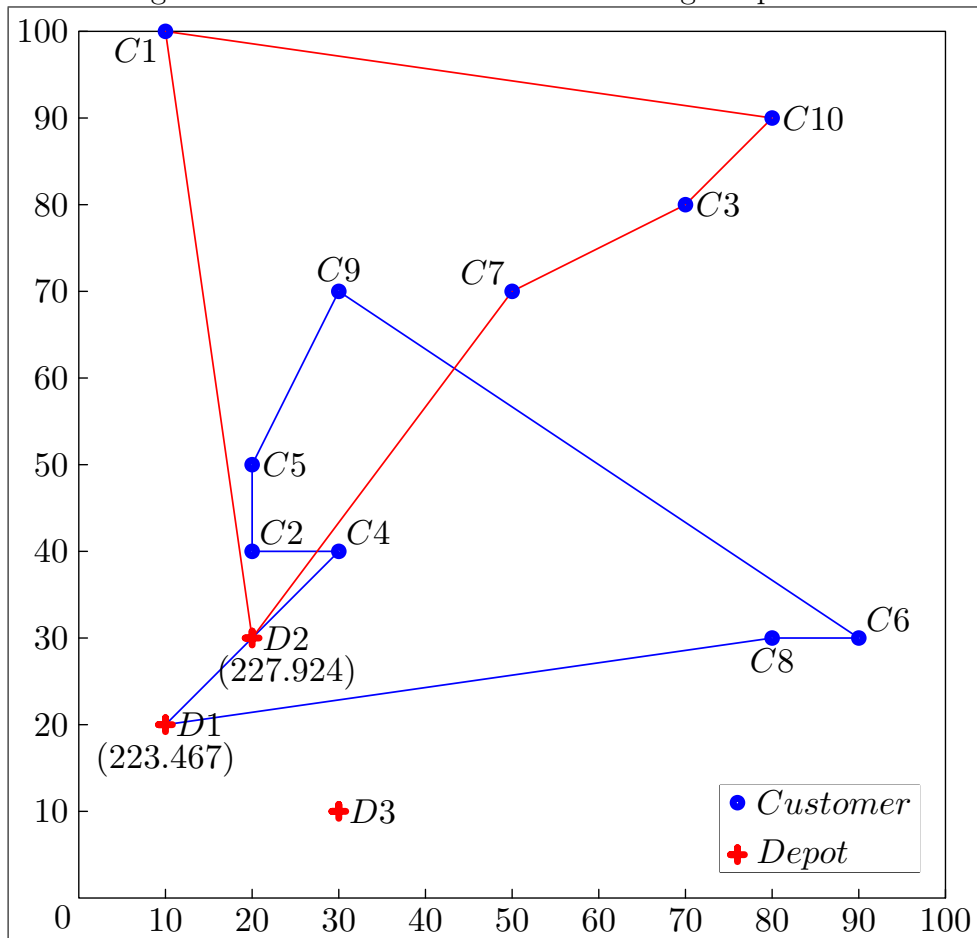


Figure A.7: The feasible solution generated after one perturbation

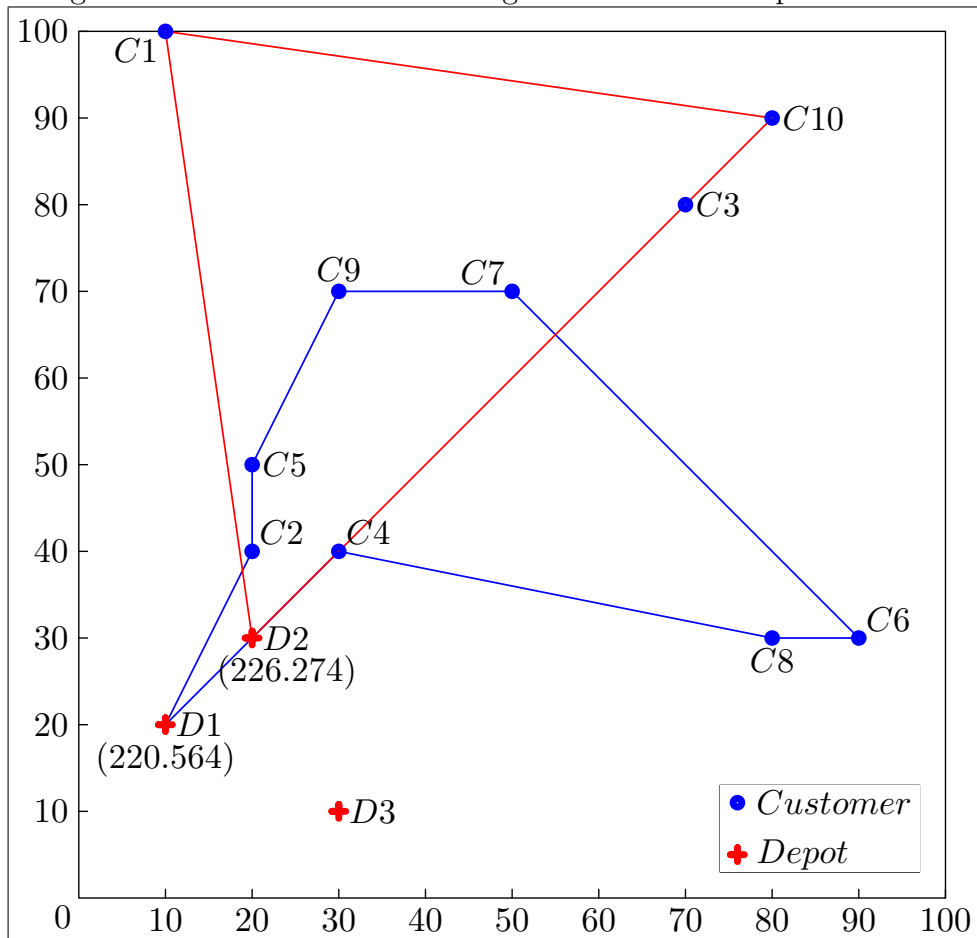


Table A.6: Depot perturbation

Depot number	Original position	Preceding and succeeding customers	Sum of distances	Perturbation radius	Perturbation angle (degree)	Position after perturbation
1	(10, 20)	1 and 2	102.361	51.181	15.642	(59.285, 33.799)
2	(20, 30)	7 and 4	64.142	32.071	76.490	(27.492, 61.184)
3	(30, 10)	8 and 6	117.098	58.549	220.360	(-14.614, -27.915)

Table A.7: Angles of each perturbation

Depot number	Angle (degree)				
	1st perturbation	2nd perturbation	3rd perturbation	4th perturbation	5th perturbation
1	15.642	159.642	303.642	87.642	231.642
2	76.490	220.490	4.490	148.490	292.490
3	220.360	4.360	148.360	292.360	76.360

Appendix B: Min-Max Multi-Depot Vehicle Routing Problem test instances

In this appendix, we present the problem data for the Min-Max Multi-Depot Vehicle Routing Problem defined in Chapters 3 and 4. There are 43 instances. Each instance is presented in two Tables. For example, instance MS1 is given in Tables B.2 and B.1. The first tables presents information of the depots. The first column gives the indices of the depots. The second and third columns gives the x and y coordinates. The fourth column gives the number of vehicles available at the depot. The second table presents the customer information. The first column gives the indices. The first column gives the indices of the depots. The second and third columns gives the x and y coordinates. The fourth column gives the service time required by the customer in short service scenario. For moderate and long service scenarios, multiply the service time in the fourth column by 10 and 100, respectively. For problems with no service as defined in Chapter 3, assume the service time to be zero.

Table B.1: Depot locations and number of vehicles for MS1

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	10.0000	20.0000	1
2	20.0000	30.0000	1
3	30.0000	10.0000	1

Table B.2: Customer locations and service time for MS1

Customer index	x-coordinate	y-coordinate	Service time (short)
1	10.0000	100.0000	8.3325
2	20.0000	40.0000	9.1521
3	70.0000	80.0000	2.1429
4	30.0000	40.0000	9.2204
5	20.0000	50.0000	6.6912
6	90.0000	30.0000	1.8779
7	50.0000	70.0000	3.5065
8	80.0000	30.0000	5.9219
9	30.0000	70.0000	9.6176
10	80.0000	90.0000	9.6840

Table B.3: Depot locations and number of vehicles for MS2

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	21.2888	52.2043	1
2	59.2391	43.7700	1
3	22.9666	68.5444	1
4	39.1410	46.6052	1
5	68.7562	47.9356	1
6	39.5161	7.6577	1
7	68.0789	73.3489	1
8	55.8174	17.9064	1
9	57.6268	24.4486	1
10	63.9899	9.8381	1

Table B.4: Customer locations and service time for MS2

Customer index	x-coordinate	y-coordinate	Service time (short)
1	42.3717	21.0719	2.4185
2	38.1346	96.6976	9.7353
3	96.0173	63.5615	9.6145
4	53.2372	42.5230	5.3684
5	52.9380	22.6214	8.2025
6	97.0738	93.2507	2.2770
7	24.2893	74.2582	4.7959
8	25.6262	51.3310	9.2416
9	77.1841	54.1750	8.1299
10	93.4500	21.4326	9.6354
11	56.0222	80.0675	6.9017
12	41.3510	62.7991	1.3214
13	96.8513	9.0680	8.6422
14	74.4064	81.2102	9.4059
15	71.9163	9.6782	7.1086
16	75.8901	19.2165	7.8197
17	94.1169	6.3931	7.6882
18	6.6357	49.6881	4.5300
19	97.5356	46.1870	6.8993
20	33.5305	87.3451	2.5407
21	83.3950	76.1189	7.3544
22	24.7385	68.3413	1.2865
23	77.2984	31.9094	3.4923
24	73.3318	36.2518	1.4155
25	11.6293	86.7636	1.8742
26	4.2015	35.9457	8.4111

Continued on next page

Table B.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
27	71.5816	31.5702	7.2535
28	19.9927	89.6961	3.8539
29	71.3789	67.9739	9.5520
30	33.9053	59.6417	1.3100
31	64.4098	88.2395	4.9487
32	54.5410	37.1641	4.4340
33	83.3633	72.3460	7.8897
34	0.0955	24.5134	8.1568
35	33.6509	99.5646	2.6819
36	83.5126	57.9980	5.4079
37	48.1385	42.7319	5.0103
38	79.1647	30.6400	6.8168
39	23.7766	93.6280	7.3843
40	93.7347	75.9613	7.7922
41	77.7377	68.3942	3.4842
42	96.2453	92.2266	7.1173
43	22.4053	96.7950	6.8959
44	91.3288	44.2740	2.4635
45	65.5203	76.4083	2.0710
46	42.4624	99.5223	5.4853
47	68.3758	10.9553	9.6377
48	2.6470	6.0943	4.0635
49	9.8981	69.9627	6.2674
50	77.7062	11.3505	3.0143
51	34.0485	8.0255	7.7614
52	59.4066	19.0212	3.2959
53	92.3058	65.8970	5.5536
54	62.2910	14.8163	7.2917
55	9.6147	66.5420	9.0181
56	16.7153	71.4803	9.6336
57	38.2046	77.6560	5.9249
58	85.6429	85.8575	2.2476
59	12.6112	73.1837	2.3436
60	2.3018	9.1639	3.3176
61	10.2421	34.7997	8.5665
62	44.8135	31.9384	3.2885
63	75.6650	80.1556	8.3286
64	19.5197	67.8249	3.1917
65	25.5492	17.8588	9.3634
66	55.0357	69.9585	4.1499
67	29.5891	11.0002	2.7694

Continued on next page

Table B.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
68	25.2060	73.4743	3.2598
69	90.6318	23.8128	6.5444
70	30.0720	54.3313	5.2596
71	38.8312	40.4830	4.1649
72	13.4515	86.0942	8.4775
73	58.9769	89.9728	6.2674
74	72.3640	36.8535	5.9475
75	54.9162	94.0927	9.2547
76	5.5910	24.2092	3.5726
77	85.7959	7.7676	7.8148
78	46.0143	48.2620	7.7836
79	78.4601	71.5383	4.4240
80	90.9931	20.7262	6.1104
81	68.2374	60.4949	1.6827
82	36.9523	11.6687	1.4856
83	14.5552	86.0910	5.7772
84	64.5500	94.7755	8.0125
85	8.1966	50.9360	9.4061
86	39.9162	67.2787	2.1692
87	50.5978	30.7904	6.1194
88	76.1888	88.4342	5.2245
89	9.2827	95.3463	1.1071
90	84.8672	51.5999	4.0341
91	93.0101	8.3152	2.4596
92	13.7636	5.3947	8.1486
93	33.2069	42.0601	3.8009
94	74.8078	0.1772	5.7568
95	54.1435	82.3773	2.4908
96	62.9500	84.0450	6.4178
97	65.7024	1.4281	3.3667
98	65.0223	34.0155	6.8867
99	29.9930	61.0280	7.2029
100	46.5959	60.3401	7.7334
101	63.3036	29.0540	5.0549
102	18.4229	35.1736	1.7544
103	54.2073	78.8436	3.0608
104	64.0933	83.3867	9.2200
105	52.0235	74.2476	2.3714
106	72.7472	24.2331	8.4324
107	37.8189	46.6308	5.8451
108	75.6411	57.9820	9.9652

Continued on next page

Table B.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
109	26.0032	64.0590	1.7036
110	69.0846	56.5915	4.9841
111	81.2258	17.8132	1.9599
112	22.2669	62.8717	9.6571
113	40.2015	97.7549	1.0417
114	82.4689	3.1487	7.9742
115	83.5833	36.7082	8.3557
116	65.2170	31.8721	8.8183
117	12.9822	84.7061	1.7599
118	10.4784	4.7148	4.5980
119	6.3152	46.9795	3.3388
120	81.1699	23.6665	8.2006
121	66.9589	82.7761	4.8827
122	65.4007	14.9655	9.1958
123	56.7773	93.9456	2.6366
124	36.6892	91.7089	3.3742
125	27.1541	15.1045	2.3099
126	36.9662	21.7908	2.2246
127	69.8461	40.8888	8.8236
128	89.6409	4.7775	6.2173
129	11.2503	53.0036	5.9487
130	44.7073	8.2384	2.3046
131	31.4107	44.4389	8.6773
132	87.2632	32.3204	6.5985
133	80.8371	68.7854	4.1586
134	82.3874	95.1422	5.6192
135	6.4314	18.0002	4.6163
136	81.8890	86.6141	1.6837
137	53.8426	47.3724	3.1592
138	90.7878	94.5270	2.1099
139	40.1263	46.6021	2.6552
140	57.7198	39.6023	3.1596
141	48.3229	72.1113	4.7554
142	95.6106	87.1121	1.4469
143	90.0032	5.0789	9.1244
144	40.8929	37.4761	9.5031
145	72.9129	89.6216	5.4178
146	48.5348	35.8281	5.4033
147	56.0211	2.5580	4.0395
148	28.9788	4.9546	9.1005
149	68.6327	6.1254	4.3232

Continued on next page

Table B.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
150	65.6304	24.0635	2.0008
151	88.6036	33.5977	8.0223
152	30.7436	46.4527	4.5076
153	9.3165	25.3369	3.1752
154	3.0666	40.7277	4.6352
155	96.3846	0.2616	1.8681
156	35.8780	59.9087	2.1878
157	45.3830	92.6853	9.4785
158	10.1330	9.0371	9.6052
159	95.6642	72.6462	6.1769
160	89.8242	16.3304	1.5380
161	40.2470	20.8568	3.1130
162	73.7383	5.9784	4.1784
163	75.7725	25.7072	8.3907
164	57.3396	2.9404	1.1386
165	88.9068	25.3356	1.3872
166	89.5288	2.1035	2.5209
167	11.8599	54.6317	6.8420
168	90.6514	23.5580	7.5855
169	62.7801	69.5762	6.8297
170	27.3630	0.4912	5.0583
171	68.9240	25.0002	5.9231
172	77.4322	34.2250	3.6669
173	50.2278	81.4333	7.7022
174	5.4367	0.6760	2.7006
175	56.4215	48.4245	7.1810
176	98.7090	90.5716	2.6516
177	50.1543	18.6850	4.3164
178	88.3348	65.7118	6.6306
179	87.4595	13.4362	8.0220
180	61.7789	80.8280	1.7301
181	96.1064	33.0440	9.3645
182	72.6070	0.5962	7.9814
183	29.1658	76.7126	5.3811
184	46.6497	74.4982	4.9227
185	94.3889	55.5933	5.0211
186	9.4327	24.7474	3.7571
187	1.1900	17.7821	5.5766
188	37.2270	81.8080	5.5969
189	35.4200	17.4567	8.3586
190	8.2033	7.4115	8.1535

Continued on next page

Table B.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
191	31.0937	21.1644	6.7989
192	25.5754	37.6355	4.4075
193	10.4812	41.1446	8.3042
194	29.0293	32.4128	5.7954
195	49.8504	47.0981	4.1565
196	82.0490	56.4202	9.4510
197	30.7409	52.8335	8.8835
198	77.1465	79.3498	5.9514
199	20.2639	69.4421	6.6023
200	93.9600	5.4612	6.2834

Table B.5: Depot locations and number of vehicles for MS3

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	51.7495	16.6061	1
2	5.9168	24.4048	1
3	45.3517	22.9581	1
4	71.5177	97.2638	1
5	16.3892	54.9787	1

Table B.6: Customer locations and service time for MS3

Customer index	x-coordinate	y-coordinate	Service time (short)
1	65.9347	13.9814	2.8697
2	7.6244	79.7171	3.7112
3	6.5731	62.8122	5.2383
4	42.2126	69.4265	3.0744
5	38.8115	92.4552	8.5988
6	68.7263	35.3737	2.7529
7	32.2607	47.2219	3.0333
8	98.7039	45.2264	2.5364
9	95.5273	40.0173	3.0490
10	9.2997	19.1013	4.9213
11	20.6722	74.7603	3.7999
12	63.5399	49.9023	9.3104
13	63.2667	62.8860	4.8719
14	80.9434	60.7898	2.6633
15	0.7111	18.6862	9.1439
16	49.9912	84.8929	9.8177
17	24.3640	91.6986	4.9498
18	79.4765	71.4256	2.0001
19	83.0204	62.8923	3.3226
20	81.1405	38.7679	4.6785
21	54.5647	93.7111	6.3541
22	21.4328	75.5154	3.3599
23	49.7063	9.2986	6.4256
24	15.3895	7.5649	7.4009
25	42.4834	69.3362	2.9957
26	88.3003	33.2948	2.0568
27	1.1494	40.3969	3.6701
28	90.2812	50.2277	3.8690
29	3.1320	61.1400	4.8175
30	53.3081	6.7816	5.5707
31	30.1657	90.0306	1.7696

Continued on next page

Table B.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
32	35.3248	64.7544	3.3623
33	9.2645	35.1265	8.2091
34	57.8233	16.9696	1.2630
35	82.6313	99.5440	9.3597
36	41.6470	99.8797	7.5730
37	29.9607	93.4010	5.3975
38	62.0015	85.0375	6.2067
39	40.6180	57.5657	3.1356
40	1.1030	58.3901	5.1296
41	25.7348	22.9469	9.6678
42	57.3268	65.9794	5.9213
43	6.2108	9.7641	5.6902
44	23.1410	95.9846	3.0843
45	24.5214	87.9156	5.4001
46	61.6664	48.5627	6.6165
47	63.3129	13.9200	7.1122
48	65.2097	95.2913	4.5596
49	24.0897	71.1530	4.3069
50	5.3875	27.0574	9.8918
51	11.8316	61.7139	1.3396
52	96.2430	87.4157	8.9665
53	63.2148	56.4725	9.2196
54	97.8891	68.7579	8.1657
55	14.3761	28.7705	1.8884
56	24.7022	8.4721	3.3568
57	42.5798	37.2627	4.0182
58	39.4624	87.0338	7.1176
59	47.7660	36.1793	2.2290
60	48.4300	27.0830	7.4910
61	20.6074	80.9024	1.9609
62	49.4130	58.4027	6.8838
63	56.4975	49.2220	5.4476
64	14.8381	35.4672	8.0115
65	24.3911	30.8156	7.4353
66	98.7911	66.0646	9.1335
67	23.1601	66.5199	9.0183
68	95.7599	83.5580	4.0075
69	38.8064	69.4215	7.2887
70	28.5808	48.0228	2.7803
71	20.1051	36.5955	1.2749
72	49.0074	93.3398	7.6967

Continued on next page

Table B.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
73	46.7727	41.8866	5.5002
74	57.2927	85.0163	5.3193
75	16.4220	39.6474	9.1425
76	11.9291	62.9770	6.4888
77	24.9008	1.1356	6.5590
78	34.0818	97.8530	8.7350
79	57.7463	69.6665	8.2494
80	56.5399	50.5062	6.1905
81	87.9296	84.1013	2.6463
82	22.2513	80.8307	3.1594
83	76.8688	35.6211	8.9786
84	1.9344	40.5730	1.2581
85	71.1380	53.4484	5.4091
86	22.1543	46.6015	2.5113
87	93.5079	78.1585	9.8081
88	75.0565	84.1438	7.4143
89	93.1089	19.1518	5.5042
90	64.6096	38.4546	5.2398
91	25.7552	42.4601	1.5366
92	68.1301	36.0579	7.1377
93	63.4657	43.5454	1.3819
94	82.9543	23.0787	1.6430
95	31.7206	40.8781	5.6948
96	83.3590	53.4587	1.8706
97	78.5742	32.2458	8.3633
98	5.9935	93.3967	8.3579
99	29.4875	76.6433	7.5020
100	73.1582	50.9890	2.3488
101	12.9750	91.4705	6.9364
102	50.7740	20.7177	5.6674
103	34.7406	97.4828	9.7568
104	31.2918	43.4434	6.8409
105	38.7898	52.2879	8.2030
106	16.3543	40.9691	5.0842
107	35.0749	94.9436	4.8915
108	7.0657	53.7740	8.4278
109	40.2958	43.4379	1.7512
110	4.3994	95.2502	2.1985
111	25.7205	83.9927	2.5605
112	54.3179	76.0495	4.5184
113	75.8951	33.2688	8.4824

Continued on next page

Table B.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
114	90.7364	26.4182	8.2303
115	53.7900	66.3277	1.5442
116	83.7320	19.9492	4.5933
117	51.0974	19.2698	5.7419
118	90.1519	15.8271	4.7512
119	59.2997	9.5270	6.9117
120	12.4853	54.0009	6.6518
121	25.2374	17.1285	3.6279
122	86.0886	28.7830	4.8849
123	91.0325	61.9415	1.1394
124	7.4769	42.3282	9.8566
125	52.0687	36.4475	2.5045
126	84.5190	28.8201	1.9559
127	8.0212	39.0486	4.3517
128	62.9930	82.6206	2.7831
129	6.7775	4.9362	5.4072
130	29.4878	39.9111	4.0554
131	24.9314	55.4772	9.5647
132	58.6656	84.2038	9.2830
133	33.5036	91.2324	1.4741
134	34.5026	90.5755	7.6407
135	96.5250	79.2366	3.4221
136	61.2938	1.8262	4.8055
137	63.0190	90.4577	5.9308
138	14.8569	60.4558	9.4846
139	34.8968	54.5496	4.7597
140	67.4349	22.2294	9.8475
141	21.3657	58.3887	3.7131
142	61.6199	43.6148	7.3099
143	67.4303	46.9643	6.9970
144	96.4090	58.2727	5.8521
145	98.1139	82.3507	7.2829
146	65.6092	66.0335	6.9988
147	96.3105	16.0012	2.6032
148	17.0134	60.1479	2.1521
149	17.3919	30.1151	9.9917
150	41.0605	12.9844	2.5401
151	43.9775	47.6483	1.2934
152	99.4172	71.7430	6.0508
153	95.2514	86.9517	8.9368
154	94.8587	1.9623	7.0226

Continued on next page

Table B.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
155	1.9617	65.3235	2.7139
156	64.4344	72.3402	4.3202
157	14.0724	13.0591	5.1465
158	35.7299	4.4767	9.8347
159	63.1400	29.3383	2.4076
160	66.4236	10.1468	8.6997
161	70.8748	73.1358	6.8029
162	90.7964	42.7851	4.3864
163	91.6963	25.3390	2.7183
164	57.7239	0.5453	4.8543
165	44.1691	65.2593	5.3382
166	18.4609	35.5386	2.0855
167	42.3110	81.7361	6.3056
168	53.2011	90.0074	3.0357
169	30.2541	69.9039	4.4616
170	94.3200	66.3982	6.2469
171	5.6019	70.3227	3.2663
172	26.2895	88.9624	3.6140
173	24.1409	12.3061	6.5538
174	14.5428	44.7442	3.3875
175	31.6316	48.0949	8.4194
176	76.4449	58.9633	9.8440
177	10.7543	86.1450	7.5722
178	77.3199	5.7134	4.0949
179	50.8148	92.5009	6.2566
180	0.7758	39.1215	1.9699
181	70.2742	90.5410	9.1568
182	89.1321	84.3112	8.9169
183	17.1201	99.3738	8.3598
184	30.5219	25.5909	3.3466
185	90.4901	2.5831	6.3492
186	42.8127	70.7142	1.2026
187	43.5558	38.2540	4.8273
188	50.2604	51.9665	3.8145
189	28.5803	22.1361	2.4534
190	39.6735	91.1996	2.6089
191	96.3475	72.3820	4.8060
192	84.0355	64.1584	1.8481
193	35.3905	49.3433	6.3867
194	41.6860	20.0757	5.2383
195	89.4717	11.4777	7.2635

Continued on next page

Table B.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
196	55.3785	60.3113	7.2990
197	80.6704	36.7337	6.7468
198	19.6683	31.9498	1.3024
199	67.8038	62.8998	1.6193
200	77.6332	90.0649	3.8764

Table B.7: Depot locations and number of vehicles for MS4

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	63.6348	72.0529	1
2	53.2735	39.9964	1
3	20.8717	39.4036	1
4	67.3728	41.1502	1
5	24.1908	14.9744	1

Table B.8: Customer locations and service time for MS4

Customer index	x-coordinate	y-coordinate	Service time (short)
1	41.0432	46.1949	5.7778
2	72.6150	166.6222	6.8900
3	100.6177	76.6355	4.6686
4	89.9108	21.6288	8.3798
5	129.7186	73.1642	7.4652
6	89.0872	33.1108	9.7178
7	45.4358	89.9866	5.7820
8	129.4441	130.5741	3.9263
9	33.3562	16.0214	1.9507
10	89.9108	76.9025	6.4986
11	26.2183	78.5047	8.0092
12	51.7502	21.3618	4.8111
13	77.8312	125.5007	1.8174
14	7.1380	47.5300	3.3982
15	25.3946	117.7570	2.3829
16	81.6747	49.1322	3.5290
17	105.8339	118.2911	4.9608
18	31.7090	3.7383	5.7443
19	15.5113	35.7810	5.1168
20	153.3288	189.5861	8.8783
21	13.3105	60.0757	5.6625
22	72.0659	17.6235	9.4926
23	147.2889	140.4539	6.7394
24	102.8140	63.0174	9.6192
25	38.5724	20.0267	3.1664
26	48.7303	6.9426	7.0851
27	42.6905	46.4619	3.6016
28	95.9506	151.6689	7.0463
29	100.6177	101.4686	7.2563
30	138.2292	170.3605	1.6119
31	45.4358	15.2203	3.2931

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
32	25.3946	58.7450	3.0164
33	19.3548	32.8438	7.0105
34	8.6479	43.5247	8.5995
35	117.6390	142.8571	4.1002
36	23.1984	69.4259	8.0247
37	30.6108	24.0320	7.0780
38	45.1613	15.4873	1.0604
39	113.5209	63.2844	6.4195
40	64.9279	18.9586	4.4809
41	28.4146	12.2830	9.2439
42	101.1668	76.1015	1.0104
43	58.8881	44.8598	5.1620
44	63.2807	28.0374	4.8191
45	34.7289	73.1642	5.1482
46	33.3562	5.3405	7.9314
47	1.7845	55.5407	3.9022
48	75.6349	44.0587	8.0627
49	42.9650	127.3698	5.2422
50	41.3178	7.7437	1.3219
51	105.8339	75.3004	2.5829
52	114.8936	70.2270	7.4958
53	70.9632	52.8660	5.2614
54	64.9279	67.5567	2.3745
55	39.3960	71.8291	4.0701
56	24.0220	17.6235	6.4665
57	0.0000	58.2109	2.7257
58	40.2196	22.9640	7.6458
59	7.2752	50.4673	3.1856
60	91.2835	51.8024	9.2568
61	66.3006	65.9546	3.4216
62	79.4784	80.1068	7.8895
63	36.9252	9.0788	2.6980
64	73.4386	60.3471	3.5875
65	79.4784	65.1535	1.8200
66	122.3061	64.0854	6.1859
67	143.4454	176.2350	7.1503
68	29.7872	32.5768	5.9193
69	48.7303	14.6862	4.8316
70	44.6122	26.7023	6.8000
71	108.5793	80.9079	6.8286
72	75.0858	31.5087	7.1112

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
73	66.5752	25.9012	6.7221
74	41.5923	88.3845	9.5066
75	72.3404	33.3778	2.8804
76	24.2965	41.9226	7.3835
77	66.3006	71.0280	3.1261
78	90.7344	116.4219	2.0746
79	13.5896	35.5140	6.4657
80	52.5738	33.6449	5.0512
81	122.5806	165.2870	5.1285
82	83.5964	77.1696	6.9575
83	72.6150	21.8959	7.9326
84	79.4784	135.9146	4.1520
85	77.8312	39.2523	6.9581
86	38.5724	1.3351	4.7454
87	71.2423	22.1629	8.5774
88	86.8909	16.2884	8.4963
89	2.3336	51.5354	3.3080
90	57.2409	42.7236	6.5211
91	97.3233	100.4005	6.2402
92	47.0830	19.4927	5.8667
93	111.3246	169.2924	8.8295
94	95.6760	167.6903	3.3830
95	92.9307	108.1442	3.8627
96	58.3391	69.6929	2.0729
97	70.6932	42.4566	9.4585
98	39.6706	124.1656	6.8100
99	8.7348	37.8149	5.3152
100	92.6561	82.7770	6.7539
101	120.6589	61.4152	5.9024
102	65.2025	66.4887	6.8258
103	39.3960	23.7650	5.8950
104	70.6932	49.3992	7.4894
105	16.6095	54.7397	5.7025
106	92.3816	52.3364	9.9433
107	52.0247	25.3672	2.9681
108	80.0275	104.6729	1.9522
109	35.0034	81.7089	1.9873
110	170.8991	145.7944	1.5723
111	69.5951	22.4299	4.6412
112	67.3988	49.6662	5.0354
113	51.2011	55.8077	4.2923

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
114	88.8126	70.4940	7.8715
115	21.5511	115.8879	6.6511
116	58.8881	32.0427	7.9478
117	78.9293	106.5421	9.3957
118	143.1709	186.1148	9.7547
119	80.8511	68.0908	2.7283
120	126.9732	143.6582	2.2499
121	108.0302	120.4272	7.2664
122	169.5264	146.5955	1.8444
123	106.9321	193.3244	5.7286
124	102.5395	103.8718	5.7731
125	117.1906	60.6898	8.7503
126	70.9677	45.1268	5.3637
127	14.6877	39.7864	4.5411
128	57.7900	28.5714	7.0429
129	36.6507	23.4980	7.6713
130	33.9053	4.5394	5.6805
131	118.7371	79.0387	4.1294
132	88.5381	47.7971	2.3500
133	56.1382	62.7503	6.2748
134	17.4331	41.1215	3.3593
135	69.3205	44.5928	1.4001
136	138.7783	152.2029	7.7944
137	106.6575	125.7677	3.1851
138	91.1004	39.1989	4.9816
139	119.2862	66.7557	7.1902
140	97.3233	105.4740	4.2331
141	157.7213	200.0000	7.6271
142	13.3150	51.0013	4.5524
143	75.3603	82.5100	7.1507
144	96.2251	65.4206	7.3364
145	28.9636	17.3565	4.9807
146	62.7316	67.0227	1.1762
147	57.2409	37.3832	3.9777
148	124.2279	128.1709	4.8188
149	33.3562	89.4526	3.4324
150	60.8099	91.8558	2.7735
151	41.0432	12.5501	8.3955
152	110.7756	122.2964	4.8693
153	121.4825	150.0668	8.9899
154	56.6918	123.6315	4.5206

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
155	134.6603	138.3178	7.9220
156	44.0631	45.9279	4.5711
157	77.8312	90.7877	8.2766
158	63.2807	131.3752	7.7957
159	88.6250	36.7334	4.3966
160	64.3789	64.0854	2.9442
161	13.0405	38.4513	8.1137
162	46.5340	33.9119	9.5437
163	63.0062	25.6342	3.9481
164	74.2622	72.8972	7.0414
165	8.6479	43.7917	4.9478
166	83.5964	102.2697	8.5015
167	78.6548	80.3738	7.9197
168	63.5552	27.7704	2.5053
169	74.8113	109.2123	8.7578
170	122.8552	73.4312	9.9088
171	32.2581	47.2630	5.6298
172	66.5752	21.0948	8.9585
173	42.1414	113.4846	6.2922
174	42.9650	15.7543	2.3928
175	73.1640	20.2937	2.7988
176	57.7900	61.1482	4.6626
177	70.4187	20.5607	7.7384
178	32.5326	36.5821	8.4303
179	75.3603	17.8905	8.1097
180	36.1016	0.0000	3.8667
181	121.7570	77.9706	5.8066
182	91.0089	84.3792	1.8096
183	40.2196	65.6876	2.0054
184	50.1030	28.8385	2.2266
185	50.6520	48.0641	7.1079
186	113.7909	70.7610	5.4566
187	52.2992	40.3204	2.7074
188	53.9465	60.6142	5.4551
189	117.3644	71.2951	2.3285
190	90.4598	71.5621	1.4948
191	144.8181	139.9199	8.6564
192	31.9835	29.9065	6.0450
193	21.8257	63.2844	9.3665
194	56.1428	56.8758	7.2700
195	94.3034	74.7664	6.2451

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
196	44.0631	84.1121	8.3386
197	90.7344	96.3952	8.9111
198	26.4928	29.6395	9.9002
199	45.7104	24.8331	1.0047
200	63.5552	13.0841	8.7889
201	49.8284	2.6702	6.5131
202	99.7941	60.0801	9.9096
203	157.7213	142.0561	5.7491
204	63.2807	87.5834	5.3157
205	55.0446	81.9760	8.2121
206	108.0302	69.4259	3.0506
207	42.1414	32.3097	5.4828
208	109.6774	68.8919	9.1077
209	92.9307	67.2897	6.1720
210	27.0419	66.2216	8.6066
211	117.0899	127.9039	7.6478
212	28.6891	24.5661	6.2739
213	21.5511	30.7076	3.2206
214	12.2169	43.2577	6.9977
215	65.7515	83.5781	1.7513
216	65.7515	112.1495	6.6336
217	109.6774	148.4646	6.9485
218	99.2450	99.5995	7.5678
219	82.2237	133.2443	9.0168
220	66.3006	37.9172	9.8407
221	88.5976	39.9599	7.9213
222	114.6191	63.8184	6.2330
223	44.0631	53.6716	9.3548
224	51.4756	14.4192	6.2208
225	99.5196	76.3685	1.1528
226	91.0089	34.1789	2.0877
227	109.9520	73.9653	8.7644
228	42.4159	97.1963	5.3587
229	103.1068	113.8852	8.6037
230	16.8840	71.2951	2.8846
231	192.3130	172.7637	5.9706
232	108.5793	79.3057	6.6690
233	23.4729	30.9746	1.2879
234	123.1297	160.7477	6.5324
235	108.5793	123.0975	4.2617
236	31.7090	70.7610	1.4458

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
237	25.3946	30.4406	5.4061
238	13.8641	59.0120	2.7326
239	113.2464	65.6876	2.1078
240	65.4770	16.8224	2.8494
241	105.0103	57.6769	2.3186
242	52.5738	22.6969	2.7016
243	44.0631	21.6288	1.3839
244	123.8161	65.0200	6.7168
245	119.2862	141.2550	3.5368
246	152.5051	139.1188	5.8474
247	194.7838	178.1041	7.2565
248	58.6136	37.1162	5.4920
249	104.4612	84.9132	5.8222
250	2.0590	49.0654	5.0066
251	83.3219	95.8611	2.1154
252	143.7200	159.4125	5.4132
253	8.9224	42.1896	8.6770
254	46.5340	40.5875	8.8653
255	56.4173	25.1001	3.4326
256	102.5395	171.6956	2.8762
257	114.6191	153.8051	6.0848
258	11.9423	63.0174	6.7628
259	104.1867	61.9493	4.7533
260	64.9279	34.9800	2.8538
261	123.4043	78.5047	9.5314
262	61.6335	122.8304	1.7386
263	64.1043	62.4833	1.9514
264	51.7502	39.5194	2.2784
265	44.0631	131.9092	2.4981
266	190.3912	168.3578	6.5886
267	100.8922	155.6742	6.1634
268	22.6493	59.2746	1.4687
269	63.5552	53.9386	9.3808
270	8.6479	42.3231	7.5580
271	58.8881	13.8852	7.6406
272	53.6719	14.9533	1.5706
273	114.3445	75.5674	8.7440
274	152.5051	134.3124	9.4096
275	91.2835	124.4326	9.8596
276	30.3363	64.6195	8.7304
277	54.7701	19.2256	8.0700

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
278	109.1283	116.9559	5.6204
279	63.8298	34.7130	2.5984
280	47.3576	26.4352	4.5873
281	94.8524	111.3485	2.2054
282	135.2093	161.8158	1.2780
283	69.5951	54.4682	9.4523
284	67.3988	69.1589	3.7118
285	103.6376	163.1509	3.6598
286	64.6534	64.8865	3.9964
287	48.4557	68.6248	5.2036
288	32.2581	48.8652	6.8338
289	25.9437	24.2991	1.2271
290	62.1826	31.7757	8.5799
291	30.8854	11.7490	6.0313
292	95.9506	130.0401	8.6869
293	91.8325	74.4993	4.1309
294	124.2279	126.3017	5.0142
295	28.6891	129.2390	1.4882
296	164.0357	150.6008	2.5940
297	76.4585	44.3258	6.9653
298	117.6390	127.6368	3.9775
299	55.0446	128.7049	9.0864
300	72.0659	55.0067	2.0634
301	49.5539	81.4419	9.8958
302	11.9423	48.3311	5.8598
303	162.6630	156.7423	7.3623
304	31.1599	31.2417	9.9954
305	73.4386	18.4246	3.5906
306	47.0830	10.1469	4.7307
307	31.1599	42.9907	5.1836
308	34.4544	66.7557	7.8756
309	53.9465	26.1682	8.3638
310	64.1043	63.5514	1.9020
311	93.7543	59.5461	2.6031
312	30.8854	23.2310	4.2367
313	103.6376	72.6302	1.5103
314	105.8339	73.6983	5.6970
315	81.4001	77.4366	4.0226
316	94.5779	95.0601	2.5810
317	112.1391	119.3280	2.8805
318	92.1071	48.3311	9.1464

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
319	152.7797	144.4593	7.0785
320	90.5605	35.8790	5.2162
321	114.8936	64.6195	9.2092
322	72.6150	18.1575	1.9361
323	98.9705	74.2323	7.7099
324	78.1057	136.7156	7.6264
325	45.4358	11.2150	6.0568
326	116.2663	120.9613	2.6577
327	19.6294	61.4152	6.3749
328	73.7131	145.2603	3.6994
329	34.4544	34.1789	2.2071
330	61.3590	59.8131	2.9134
331	19.6294	72.0961	9.0545
332	14.4132	33.1108	1.6431
333	95.6760	56.0748	3.1824
334	112.1482	121.4953	1.4838
335	123.4043	124.9666	4.9755
336	124.5024	72.0961	1.1195
337	71.2423	48.5981	9.0747
338	3.9808	51.8024	2.7699
339	33.9053	67.8238	1.8403
340	55.0446	119.8932	3.7663
341	59.9863	92.6569	5.1045
342	43.5141	149.2657	1.9150
343	121.2080	34.4459	9.9585
344	120.3844	78.7717	3.9888
345	84.4200	79.8398	3.6761
346	54.7701	41.6555	1.5584
347	70.6932	82.2430	3.6842
348	200.0000	183.1776	1.4172
349	71.5168	114.8198	5.5489
350	68.7714	18.6916	7.8528
351	70.6932	60.8812	6.6796
352	125.6005	69.9599	1.8090
353	40.2196	53.4045	1.7278
354	18.5312	58.4780	7.9952
355	46.8085	12.8171	9.1462
356	41.3178	29.1055	5.8039
357	63.2807	85.9813	1.9824
358	29.2382	65.4206	8.4323
359	59.7117	13.3511	4.0429

Continued on next page

Table B.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
360	3.2944	50.5340	3.6458
361	53.1229	10.6809	7.7168
362	41.3178	45.3939	1.0930
363	22.3702	56.6088	1.4360
364	37.7488	68.3578	7.0112
365	115.9918	59.2790	6.4312
366	59.4372	28.3044	5.7349
367	7.2752	51.2684	7.5674
368	72.8895	62.2163	7.3653
369	89.0872	86.7824	8.0324
370	103.0885	80.6409	3.5918
371	34.1798	13.6182	7.2328
372	102.8140	158.3445	6.0100
373	31.1599	98.5314	4.5687
374	104.9417	110.3783	1.5543
375	31.9835	26.9693	8.0216
376	39.3960	77.7036	4.0383
377	5.7653	47.7303	6.4708
378	49.2793	9.6128	7.6713
379	28.6891	86.5154	1.9433
380	92.1071	41.3885	2.1510
381	73.7131	13.6182	5.9459
382	165.9574	174.3658	5.3671
383	30.0618	46.7290	9.0143
384	45.4358	115.3538	8.1906
385	33.9007	93.4579	7.6091
386	66.5752	112.9506	1.4620
387	46.8085	19.7597	1.6560
388	27.8655	63.8184	1.7967
389	26.4928	67.2897	8.1852
390	38.2979	30.1736	9.4871
391	33.6307	132.7103	7.1534
392	37.7488	27.2363	2.1887
393	77.5566	85.4473	7.5045
394	40.7687	17.0895	1.9932
395	92.1071	43.7917	2.0574

Table B.9: Depot locations and number of vehicles for MS5

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	33.7083	39.2445	1
2	57.5542	64.0354	1
3	61.0117	5.1591	1
4	95.1798	96.9469	1
5	78.8370	30.4870	1
6	25.7830	87.4796	1
7	58.1238	41.5663	1
8	56.5414	54.3891	1
9	78.1262	31.0382	1
10	86.8901	68.5936	1

Table B.10: Customer locations and service time for MS5

Customer index	x-coordinate	y-coordinate	Service time (short)
1	41.0432	46.1949	6.7665
2	72.6150	166.6222	3.9593
3	100.6177	76.6355	6.8843
4	89.9108	21.6288	7.7422
5	129.7186	73.1642	6.2487
6	89.0872	33.1108	7.6603
7	45.4358	89.9866	3.1134
8	129.4441	130.5741	7.6146
9	33.3562	16.0214	9.7354
10	89.9108	76.9025	8.8024
11	26.2183	78.5047	1.7761
12	51.7502	21.3618	4.2979
13	77.8312	125.5007	4.3228
14	7.1380	47.5300	7.1653
15	25.3946	117.7570	6.3815
16	81.6747	49.1322	8.1043
17	105.8339	118.2911	4.3089
18	31.7090	3.7383	2.8543
19	15.5113	35.7810	1.7800
20	153.3288	189.5861	7.9474
21	13.3105	60.0757	2.8511
22	72.0659	17.6235	4.4944
23	147.2889	140.4539	5.9660
24	102.8140	63.0174	3.0606
25	38.5724	20.0267	6.7775
26	48.7303	6.9426	5.3603

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
27	42.6905	46.4619	2.3666
28	95.9506	151.6689	8.0374
29	100.6177	101.4686	1.9055
30	138.2292	170.3605	3.6466
31	45.4358	15.2203	3.1364
32	25.3946	58.7450	5.7779
33	19.3548	32.8438	1.8235
34	8.6479	43.5247	4.6478
35	117.6390	142.8571	1.9436
36	23.1984	69.4259	2.0106
37	30.6108	24.0320	8.0599
38	45.1613	15.4873	3.6241
39	113.5209	63.2844	6.4318
40	64.9279	18.9586	9.6798
41	28.4146	12.2830	4.8924
42	101.1668	76.1015	7.2528
43	58.8881	44.8598	7.8229
44	63.2807	28.0374	4.8938
45	34.7289	73.1642	6.8995
46	33.3562	5.3405	1.9878
47	1.7845	55.5407	9.4038
48	75.6349	44.0587	2.6871
49	42.9650	127.3698	3.3956
50	41.3178	7.7437	8.1805
51	105.8339	75.3004	5.3884
52	114.8936	70.2270	7.9206
53	70.9632	52.8660	4.5641
54	64.9279	67.5567	3.4564
55	39.3960	71.8291	1.3351
56	24.0220	17.6235	7.0597
57	0.0000	58.2109	4.8661
58	40.2196	22.9640	5.0657
59	7.2752	50.4673	6.4887
60	91.2835	51.8024	1.5346
61	66.3006	65.9546	3.8423
62	79.4784	80.1068	7.9545
63	36.9252	9.0788	7.2679
64	73.4386	60.3471	2.1280
65	79.4784	65.1535	2.1714
66	122.3061	64.0854	1.8312
67	143.4454	176.2350	1.0704

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
68	29.7872	32.5768	4.8080
69	48.7303	14.6862	6.9002
70	44.6122	26.7023	7.5063
71	108.5793	80.9079	5.7809
72	75.0858	31.5087	1.9794
73	66.5752	25.9012	6.6859
74	41.5923	88.3845	2.1385
75	72.3404	33.3778	2.2087
76	24.2965	41.9226	1.8873
77	66.3006	71.0280	2.2782
78	90.7344	116.4219	2.5143
79	13.5896	35.5140	2.7662
80	52.5738	33.6449	3.8573
81	122.5806	165.2870	3.8479
82	83.5964	77.1696	2.9581
83	72.6150	21.8959	3.2594
84	79.4784	135.9146	9.0363
85	77.8312	39.2523	7.3290
86	38.5724	1.3351	6.0016
87	71.2423	22.1629	2.6599
88	86.8909	16.2884	2.9083
89	2.3336	51.5354	1.6961
90	57.2409	42.7236	9.2242
91	97.3233	100.4005	7.3604
92	47.0830	19.4927	6.0201
93	111.3246	169.2924	3.8209
94	95.6760	167.6903	2.4958
95	92.9307	108.1442	6.6025
96	58.3391	69.6929	9.8914
97	70.6932	42.4566	2.5339
98	39.6706	124.1656	3.3201
99	8.7348	37.8149	4.5712
100	92.6561	82.7770	1.6660
101	120.6589	61.4152	7.1569
102	65.2025	66.4887	4.6215
103	39.3960	23.7650	9.8455
104	70.6932	49.3992	4.6197
105	16.6095	54.7397	6.5860
106	92.3816	52.3364	2.3893
107	52.0247	25.3672	4.4321
108	80.0275	104.6729	2.4502

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
109	35.0034	81.7089	7.8230
110	170.8991	145.7944	8.8400
111	69.5951	22.4299	4.1570
112	67.3988	49.6662	7.1698
113	51.2011	55.8077	3.6473
114	88.8126	70.4940	5.7757
115	21.5511	115.8879	8.4918
116	58.8881	32.0427	6.3774
117	78.9293	106.5421	4.0178
118	143.1709	186.1148	3.6930
119	80.8511	68.0908	5.0733
120	126.9732	143.6582	4.8038
121	108.0302	120.4272	4.2365
122	169.5264	146.5955	6.0249
123	106.9321	193.3244	7.6829
124	102.5395	103.8718	4.8190
125	117.1906	60.6898	4.8642
126	70.9677	45.1268	2.1239
127	14.6877	39.7864	1.2199
128	57.7900	28.5714	3.6117
129	36.6507	23.4980	3.8577
130	33.9053	4.5394	6.8832
131	118.7371	79.0387	9.6124
132	88.5381	47.7971	9.4216
133	56.1382	62.7503	5.1210
134	17.4331	41.1215	3.1643
135	69.3205	44.5928	7.8751
136	138.7783	152.2029	7.8339
137	106.6575	125.7677	7.6658
138	91.1004	39.1989	7.6932
139	119.2862	66.7557	1.9533
140	97.3233	105.4740	7.1340
141	157.7213	200.0000	5.1693
142	13.3150	51.0013	2.9095
143	75.3603	82.5100	1.8867
144	96.2251	65.4206	8.4122
145	28.9636	17.3565	2.5751
146	62.7316	67.0227	2.4721
147	57.2409	37.3832	6.9939
148	124.2279	128.1709	9.0495
149	33.3562	89.4526	5.6490

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
150	60.8099	91.8558	7.3243
151	41.0432	12.5501	2.3823
152	110.7756	122.2964	9.5811
153	121.4825	150.0668	5.8680
154	56.6918	123.6315	7.1176
155	134.6603	138.3178	1.3291
156	44.0631	45.9279	8.2828
157	77.8312	90.7877	7.7376
158	63.2807	131.3752	2.0817
159	88.6250	36.7334	5.7254
160	64.3789	64.0854	3.9325
161	13.0405	38.4513	5.9180
162	46.5340	33.9119	4.5899
163	63.0062	25.6342	4.7358
164	74.2622	72.8972	2.6266
165	8.6479	43.7917	3.2985
166	83.5964	102.2697	1.1848
167	78.6548	80.3738	9.3131
168	63.5552	27.7704	6.8833
169	74.8113	109.2123	9.3935
170	122.8552	73.4312	2.4716
171	32.2581	47.2630	9.2899
172	66.5752	21.0948	8.1519
173	42.1414	113.4846	6.1965
174	42.9650	15.7543	4.9603
175	73.1640	20.2937	3.3185
176	57.7900	61.1482	7.7675
177	70.4187	20.5607	3.0580
178	32.5326	36.5821	1.5777
179	75.3603	17.8905	7.9060
180	36.1016	0.0000	7.0408
181	121.7570	77.9706	7.4369
182	91.0089	84.3792	6.7785
183	40.2196	65.6876	4.7714
184	50.1030	28.8385	4.5169
185	50.6520	48.0641	8.3453
186	113.7909	70.7610	3.8569
187	52.2992	40.3204	8.3309
188	53.9465	60.6142	8.1017
189	117.3644	71.2951	8.6704
190	90.4598	71.5621	5.5507

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
191	144.8181	139.9199	6.7210
192	31.9835	29.9065	9.5580
193	21.8257	63.2844	4.9957
194	56.1428	56.8758	1.5402
195	94.3034	74.7664	8.8007
196	44.0631	84.1121	6.6807
197	90.7344	96.3952	4.1957
198	26.4928	29.6395	9.9730
199	45.7104	24.8331	3.0175
200	63.5552	13.0841	6.8721
201	49.8284	2.6702	6.4449
202	99.7941	60.0801	4.4852
203	157.7213	142.0561	2.2797
204	63.2807	87.5834	1.2262
205	55.0446	81.9760	4.7900
206	108.0302	69.4259	2.6569
207	42.1414	32.3097	7.5320
208	109.6774	68.8919	4.3333
209	92.9307	67.2897	8.5740
210	27.0419	66.2216	7.6081
211	117.0899	127.9039	6.1392
212	28.6891	24.5661	2.5917
213	21.5511	30.7076	9.6165
214	12.2169	43.2577	3.3879
215	65.7515	83.5781	9.3212
216	65.7515	112.1495	3.0139
217	109.6774	148.4646	4.3621
218	99.2450	99.5995	1.7875
219	82.2237	133.2443	6.7610
220	66.3006	37.9172	2.6256
221	88.5976	39.9599	1.4055
222	114.6191	63.8184	7.5086
223	44.0631	53.6716	4.1269
224	51.4756	14.4192	6.9456
225	99.5196	76.3685	4.4548
226	91.0089	34.1789	6.6461
227	109.9520	73.9653	1.1948
228	42.4159	97.1963	9.1951
229	103.1068	113.8852	8.2050
230	16.8840	71.2951	7.7126
231	192.3130	172.7637	8.3180

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
232	108.5793	79.3057	4.4498
233	23.4729	30.9746	6.5555
234	123.1297	160.7477	6.1795
235	108.5793	123.0975	5.7705
236	31.7090	70.7610	3.4756
237	25.3946	30.4406	3.2377
238	13.8641	59.0120	5.0647
239	113.2464	65.6876	3.0494
240	65.4770	16.8224	8.2400
241	105.0103	57.6769	9.8749
242	52.5738	22.6969	1.2699
243	44.0631	21.6288	5.8210
244	123.8161	65.0200	1.7837
245	119.2862	141.2550	8.2188
246	152.5051	139.1188	9.9023
247	194.7838	178.1041	1.6025
248	58.6136	37.1162	9.4546
249	104.4612	84.9132	1.1636
250	2.0590	49.0654	7.1545
251	83.3219	95.8611	8.0536
252	143.7200	159.4125	5.8072
253	8.9224	42.1896	8.9682
254	46.5340	40.5875	9.0910
255	56.4173	25.1001	6.6334
256	102.5395	171.6956	2.2408
257	114.6191	153.8051	2.9602
258	11.9423	63.0174	2.6393
259	104.1867	61.9493	1.3764
260	64.9279	34.9800	1.9625
261	123.4043	78.5047	6.5480
262	61.6335	122.8304	9.4569
263	64.1043	62.4833	4.1901
264	51.7502	39.5194	4.6957
265	44.0631	131.9092	9.8591
266	190.3912	168.3578	9.5102
267	100.8922	155.6742	7.0898
268	22.6493	59.2746	9.8947
269	63.5552	53.9386	7.9015
270	8.6479	42.3231	4.0303
271	58.8881	13.8852	6.9614
272	53.6719	14.9533	3.1975

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
273	114.3445	75.5674	3.6596
274	152.5051	134.3124	7.1216
275	91.2835	124.4326	5.7506
276	30.3363	64.6195	4.7043
277	54.7701	19.2256	6.4237
278	109.1283	116.9559	7.7547
279	63.8298	34.7130	6.2518
280	47.3576	26.4352	5.9661
281	94.8524	111.3485	6.2521
282	135.2093	161.8158	5.6064
283	69.5951	54.4682	1.7433
284	67.3988	69.1589	7.4761
285	103.6376	163.1509	9.9654
286	64.6534	64.8865	4.1908
287	48.4557	68.6248	9.7413
288	32.2581	48.8652	4.1180
289	25.9437	24.2991	8.9789
290	62.1826	31.7757	5.0923
291	30.8854	11.7490	4.7208
292	95.9506	130.0401	2.9596
293	91.8325	74.4993	2.1309
294	124.2279	126.3017	3.7802
295	28.6891	129.2390	7.5349
296	164.0357	150.6008	8.0458
297	76.4585	44.3258	7.2441
298	117.6390	127.6368	1.0882
299	55.0446	128.7049	8.5889
300	72.0659	55.0067	9.3010
301	49.5539	81.4419	7.9386
302	11.9423	48.3311	1.3839
303	162.6630	156.7423	4.4037
304	31.1599	31.2417	7.3391
305	73.4386	18.4246	7.5656
306	47.0830	10.1469	3.0185
307	31.1599	42.9907	3.4215
308	34.4544	66.7557	7.0573
309	53.9465	26.1682	5.2974
310	64.1043	63.5514	6.6134
311	93.7543	59.5461	3.1280
312	30.8854	23.2310	2.5941
313	103.6376	72.6302	8.4668

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
314	105.8339	73.6983	7.9023
315	81.4001	77.4366	9.4103
316	94.5779	95.0601	1.9710
317	112.1391	119.3280	2.6400
318	92.1071	48.3311	1.8919
319	152.7797	144.4593	5.4079
320	90.5605	35.8790	2.7392
321	114.8936	64.6195	9.0630
322	72.6150	18.1575	1.8918
323	98.9705	74.2323	1.3975
324	78.1057	136.7156	6.0157
325	45.4358	11.2150	7.9525
326	116.2663	120.9613	3.8075
327	19.6294	61.4152	2.6108
328	73.7131	145.2603	4.0506
329	34.4544	34.1789	2.8913
330	61.3590	59.8131	5.5914
331	19.6294	72.0961	9.1573
332	14.4132	33.1108	6.6603
333	95.6760	56.0748	1.9138
334	112.1482	121.4953	4.5177
335	123.4043	124.9666	1.4915
336	124.5024	72.0961	5.5115
337	71.2423	48.5981	4.8855
338	3.9808	51.8024	9.9780
339	33.9053	67.8238	8.3044
340	55.0446	119.8932	5.3709
341	59.9863	92.6569	9.0500
342	43.5141	149.2657	2.2379
343	121.2080	34.4459	4.5100
344	120.3844	78.7717	9.3462
345	84.4200	79.8398	9.2574
346	54.7701	41.6555	7.4222
347	70.6932	82.2430	6.5650
348	200.0000	183.1776	4.0896
349	71.5168	114.8198	9.4242
350	68.7714	18.6916	2.1230
351	70.6932	60.8812	7.5753
352	125.6005	69.9599	6.8183
353	40.2196	53.4045	8.4984
354	18.5312	58.4780	4.5845

Continued on next page

Table B.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
355	46.8085	12.8171	7.7484
356	41.3178	29.1055	8.5170
357	63.2807	85.9813	3.9021
358	29.2382	65.4206	5.9704
359	59.7117	13.3511	9.8122
360	3.2944	50.5340	5.9438
361	53.1229	10.6809	3.9738
362	41.3178	45.3939	6.5752
363	22.3702	56.6088	4.2457
364	37.7488	68.3578	7.8086
365	115.9918	59.2790	4.7251
366	59.4372	28.3044	5.4311
367	7.2752	51.2684	7.2527
368	72.8895	62.2163	9.7546
369	89.0872	86.7824	3.9498
370	103.0885	80.6409	8.5402
371	34.1798	13.6182	7.6517
372	102.8140	158.3445	9.5876
373	31.1599	98.5314	1.2873
374	104.9417	110.3783	4.2118
375	31.9835	26.9693	6.9639
376	39.3960	77.7036	3.5335
377	5.7653	47.7303	3.0734
378	49.2793	9.6128	7.4002
379	28.6891	86.5154	6.6212
380	92.1071	41.3885	6.3155
381	73.7131	13.6182	6.9439
382	165.9574	174.3658	1.4280
383	30.0618	46.7290	4.1391
384	45.4358	115.3538	5.0621
385	33.9007	93.4579	3.1681
386	66.5752	112.9506	7.4354
387	46.8085	19.7597	8.7056
388	27.8655	63.8184	3.5336
389	26.4928	67.2897	7.5795
390	38.2979	30.1736	2.2399

Table B.11: Depot locations and number of vehicles for MS6

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	25.0000	25.0000	1
2	75.0000	25.0000	1
3	75.0000	75.0000	1
4	25.0000	75.0000	1

Table B.12: Customer locations and service time for MS6

Customer index	x-coordinate	y-coordinate	Service time (short)
1	35.0000	25.0000	8.5305
2	34.9799	25.6342	2.2474
3	34.9195	26.2659	6.2939
4	34.8193	26.8925	4.2954
5	34.6795	27.5115	8.2608
6	34.5007	28.1203	5.5340
7	34.2837	28.7166	5.4063
8	34.0293	29.2979	8.8934
9	33.7385	29.8620	4.1783
10	33.4125	30.4064	5.0450
11	33.0527	30.9291	9.6718
12	32.6604	31.4279	1.3807
13	32.2373	31.9008	9.7566
14	31.7851	32.3459	2.7029
15	31.3055	32.7615	7.0041
16	30.8006	33.1458	6.2780
17	30.2723	33.4973	7.0760
18	29.7227	33.8145	4.2492
19	29.1542	34.0963	6.5825
20	28.5689	34.3415	8.3004
21	27.9692	34.5490	1.1733
22	27.3576	34.7181	1.7549
23	26.7365	34.8481	9.7732
24	26.1084	34.9384	6.8621
25	25.4758	34.9887	3.0811
26	24.8413	34.9987	4.6314
27	24.2075	34.9685	2.0982
28	23.5769	34.8982	3.4159
29	22.9519	34.7880	3.3206
30	22.3353	34.6384	3.9850
31	21.7293	34.4500	2.3701
32	21.1365	34.2235	4.1321

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	20.5593	33.9599	2.0949
34	20.0000	33.6603	8.9574
35	19.4608	33.3257	1.8485
36	18.9439	32.9576	9.3704
37	18.4514	32.5575	4.5912
38	17.9853	32.1269	1.4266
39	17.5474	31.6677	4.0814
40	17.1395	31.1816	7.6237
41	16.7632	30.6706	8.1521
42	16.4202	30.1368	5.9042
43	16.1116	29.5823	7.1760
44	15.8389	29.0093	9.0427
45	15.6031	28.4202	1.4931
46	15.4051	27.8173	3.7330
47	15.2457	27.2031	1.4157
48	15.1256	26.5800	2.7593
49	15.0453	25.9506	7.4815
50	15.0050	25.3173	7.4958
51	15.0050	24.6827	8.9002
52	15.0453	24.0494	6.2419
53	15.1256	23.4200	1.6362
54	15.2457	22.7969	9.3047
55	15.4051	22.1827	8.2033
56	15.6031	21.5798	3.5735
57	15.8389	20.9907	5.8930
58	16.1116	20.4177	9.8630
59	16.4202	19.8632	7.4411
60	16.7632	19.3294	8.5507
61	17.1395	18.8184	4.8993
62	17.5474	18.3323	5.2356
63	17.9853	17.8731	6.0464
64	18.4514	17.4425	3.4218
65	18.9439	17.0424	7.7412
66	19.4608	16.6743	5.5350
67	20.0000	16.3397	6.8213
68	20.5593	16.0401	3.7697
69	21.1365	15.7765	2.2485
70	21.7293	15.5500	5.2802
71	22.3353	15.3616	4.2621
72	22.9519	15.2120	8.0930
73	23.5769	15.1018	8.0227

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	24.2075	15.0315	7.0166
75	24.8413	15.0013	2.2015
76	25.4758	15.0113	1.1940
77	26.1084	15.0616	6.0386
78	26.7365	15.1519	3.7074
79	27.3576	15.2819	9.4547
80	27.9692	15.4510	9.8281
81	28.5689	15.6585	3.5796
82	29.1542	15.9037	8.2074
83	29.7227	16.1855	9.0650
84	30.2723	16.5027	6.3777
85	30.8006	16.8542	8.9562
86	31.3055	17.2385	9.4936
87	31.7851	17.6541	5.9424
88	32.2373	18.0992	7.5555
89	32.6604	18.5721	6.1908
90	33.0527	19.0709	1.2327
91	33.4125	19.5936	5.0188
92	33.7385	20.1380	6.8167
93	34.0293	20.7021	5.6908
94	34.2837	21.2834	4.3508
95	34.5007	21.8797	9.4342
96	34.6795	22.4885	8.4658
97	34.8193	23.1075	8.6418
98	34.9195	23.7341	4.3528
99	34.9799	24.3658	6.3387
100	35.0000	25.0000	8.8530
101	85.0000	25.0000	9.4015
102	84.9799	25.6342	7.0162
103	84.9195	26.2659	2.8610
104	84.8193	26.8925	6.8847
105	84.6795	27.5115	1.6485
106	84.5007	28.1203	4.6605
107	84.2837	28.7166	7.0024
108	84.0293	29.2979	9.4035
109	83.7385	29.8620	8.2986
110	83.4125	30.4064	5.3609
111	83.0527	30.9291	7.8107
112	82.6604	31.4279	4.7534
113	82.2373	31.9008	9.7461
114	81.7851	32.3459	9.8918

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	81.3055	32.7615	8.7773
116	80.8006	33.1458	4.5000
117	80.2723	33.4973	5.0927
118	79.7227	33.8145	3.2202
119	79.1542	34.0963	8.0598
120	78.5689	34.3415	8.9455
121	77.9692	34.5490	9.2234
122	77.3576	34.7181	6.0246
123	76.7365	34.8481	6.3898
124	76.1084	34.9384	2.3399
125	75.4758	34.9887	9.0974
126	74.8413	34.9987	5.0535
127	74.2075	34.9685	2.8511
128	73.5769	34.8982	9.0969
129	72.9519	34.7880	7.8633
130	72.3353	34.6384	8.9424
131	71.7293	34.4500	3.5646
132	71.1365	34.2235	7.0590
133	70.5593	33.9599	6.9785
134	70.0000	33.6603	2.1053
135	69.4608	33.3257	4.6659
136	68.9439	32.9576	3.4776
137	68.4514	32.5575	7.4500
138	67.9853	32.1269	3.5505
139	67.5474	31.6677	9.0658
140	67.1395	31.1816	8.4392
141	66.7632	30.6706	4.5102
142	66.4202	30.1368	5.4811
143	66.1116	29.5823	7.2532
144	65.8389	29.0093	8.5093
145	65.6031	28.4202	6.4867
146	65.4051	27.8173	6.1726
147	65.2457	27.2031	3.9344
148	65.1256	26.5800	5.1078
149	65.0453	25.9506	7.4242
150	65.0050	25.3173	8.9596
151	65.0050	24.6827	7.4877
152	65.0453	24.0494	1.1675
153	65.1256	23.4200	7.0730
154	65.2457	22.7969	4.9466
155	65.4051	22.1827	4.9404

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	65.6031	21.5798	2.0533
157	65.8389	20.9907	8.3321
158	66.1116	20.4177	3.9237
159	66.4202	19.8632	3.2161
160	66.7632	19.3294	4.0844
161	67.1395	18.8184	4.3812
162	67.5474	18.3323	5.9190
163	67.9853	17.8731	6.0573
164	68.4514	17.4425	4.5624
165	68.9439	17.0424	4.5832
166	69.4608	16.6743	5.6383
167	70.0000	16.3397	6.9178
168	70.5593	16.0401	9.5582
169	71.1365	15.7765	7.5011
170	71.7293	15.5500	4.6007
171	72.3353	15.3616	8.4868
172	72.9519	15.2120	2.2090
173	73.5769	15.1018	1.5442
174	74.2075	15.0315	1.7582
175	74.8413	15.0013	2.4751
176	75.4758	15.0113	3.9180
177	76.1084	15.0616	3.7155
178	76.7365	15.1519	1.1051
179	77.3576	15.2819	5.8591
180	77.9692	15.4510	1.8584
181	78.5689	15.6585	2.3186
182	79.1542	15.9037	6.6803
183	79.7227	16.1855	8.7339
184	80.2723	16.5027	9.7680
185	80.8006	16.8542	6.1375
186	81.3055	17.2385	9.9717
187	81.7851	17.6541	5.9819
188	82.2373	18.0992	5.6391
189	82.6604	18.5721	3.9761
190	83.0527	19.0709	4.8700
191	83.4125	19.5936	5.4263
192	83.7385	20.1380	1.6393
193	84.0293	20.7021	8.9897
194	84.2837	21.2834	1.5817
195	84.5007	21.8797	4.9257
196	84.6795	22.4885	8.4397

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	84.8193	23.1075	4.5508
198	84.9195	23.7341	6.5213
199	84.9799	24.3658	8.3678
200	85.0000	25.0000	8.9761
201	85.0000	75.0000	9.3800
202	84.9799	75.6342	2.7171
203	84.9195	76.2659	3.3272
204	84.8193	76.8925	9.0808
205	84.6795	77.5115	6.3403
206	84.5007	78.1203	5.5346
207	84.2837	78.7166	6.5153
208	84.0293	79.2979	8.3748
209	83.7385	79.8620	5.7870
210	83.4125	80.4064	2.8187
211	83.0527	80.9291	5.0850
212	82.6604	81.4279	4.8512
213	82.2373	81.9008	9.6945
214	81.7851	82.3459	6.5805
215	81.3055	82.7615	7.2585
216	80.8006	83.1458	7.4815
217	80.2723	83.4973	4.1221
218	79.7227	83.8145	5.6529
219	79.1542	84.0963	6.0103
220	78.5689	84.3415	2.4085
221	77.9692	84.5490	6.0585
222	77.3576	84.7181	7.2532
223	76.7365	84.8481	4.8381
224	76.1084	84.9384	8.5264
225	75.4758	84.9887	7.5825
226	74.8413	84.9987	4.2403
227	74.2075	84.9685	5.0879
228	73.5769	84.8982	4.4775
229	72.9519	84.7880	7.9800
230	72.3353	84.6384	7.6084
231	71.7293	84.4500	4.8725
232	71.1365	84.2235	7.2438
233	70.5593	83.9599	9.5069
234	70.0000	83.6603	8.0581
235	69.4608	83.3257	7.3501
236	68.9439	82.9576	1.9840
237	68.4514	82.5575	4.5094

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	67.9853	82.1269	6.3181
239	67.5474	81.6677	5.1344
240	67.1395	81.1816	1.4531
241	66.7632	80.6706	3.0582
242	66.4202	80.1368	8.5077
243	66.1116	79.5823	1.1408
244	65.8389	79.0093	8.7734
245	65.6031	78.4202	1.7026
246	65.4051	77.8173	7.0214
247	65.2457	77.2031	5.5019
248	65.1256	76.5800	2.9619
249	65.0453	75.9506	6.1445
250	65.0050	75.3173	2.0997
251	65.0050	74.6827	7.0405
252	65.0453	74.0494	6.3963
253	65.1256	73.4200	1.5038
254	65.2457	72.7969	1.5071
255	65.4051	72.1827	2.3725
256	65.6031	71.5798	1.1766
257	65.8389	70.9907	4.9166
258	66.1116	70.4177	8.4900
259	66.4202	69.8632	6.5565
260	66.7632	69.3294	5.6812
261	67.1395	68.8184	8.7748
262	67.5474	68.3323	1.8793
263	67.9853	67.8731	9.1725
264	68.4514	67.4425	1.9722
265	68.9439	67.0424	5.6530
266	69.4608	66.6743	2.2884
267	70.0000	66.3397	6.0343
268	70.5593	66.0401	1.0412
269	71.1365	65.7765	7.9001
270	71.7293	65.5500	8.6384
271	72.3353	65.3616	9.2514
272	72.9519	65.2120	9.8827
273	73.5769	65.1018	5.5462
274	74.2075	65.0315	3.4428
275	74.8413	65.0013	1.9068
276	75.4758	65.0113	5.5706
277	76.1084	65.0616	6.2705
278	76.7365	65.1519	7.8660

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	77.3576	65.2819	1.7467
280	77.9692	65.4510	6.9544
281	78.5689	65.6585	5.6528
282	79.1542	65.9037	2.5394
283	79.7227	66.1855	9.4470
284	80.2723	66.5027	6.3143
285	80.8006	66.8542	4.9657
286	81.3055	67.2385	9.4773
287	81.7851	67.6541	6.9032
288	82.2373	68.0992	5.0675
289	82.6604	68.5721	8.5573
290	83.0527	69.0709	5.7936
291	83.4125	69.5936	5.9850
292	83.7385	70.1380	7.1206
293	84.0293	70.7021	4.3047
294	84.2837	71.2834	3.1536
295	84.5007	71.8797	6.2103
296	84.6795	72.4885	8.8020
297	84.8193	73.1075	4.6610
298	84.9195	73.7341	2.0135
299	84.9799	74.3658	4.9946
300	85.0000	75.0000	3.7017
301	35.0000	75.0000	4.6125
302	34.9799	75.6342	8.5003
303	34.9195	76.2659	4.6327
304	34.8193	76.8925	4.5116
305	34.6795	77.5115	4.2440
306	34.5007	78.1203	2.2623
307	34.2837	78.7166	3.3412
308	34.0293	79.2979	1.7813
309	33.7385	79.8620	4.8646
310	33.4125	80.4064	3.3155
311	33.0527	80.9291	3.6780
312	32.6604	81.4279	4.8237
313	32.2373	81.9008	2.0729
314	31.7851	82.3459	5.4556
315	31.3055	82.7615	7.3577
316	30.8006	83.1458	3.1922
317	30.2723	83.4973	8.0656
318	29.7227	83.8145	1.6668
319	29.1542	84.0963	4.5450

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	28.5689	84.3415	1.0305
321	27.9692	84.5490	2.9861
322	27.3576	84.7181	1.0117
323	26.7365	84.8481	2.7026
324	26.1084	84.9384	2.2824
325	25.4758	84.9887	3.4127
326	24.8413	84.9987	2.5740
327	24.2075	84.9685	2.2478
328	23.5769	84.8982	6.3900
329	22.9519	84.7880	9.1095
330	22.3353	84.6384	9.4544
331	21.7293	84.4500	2.9907
332	21.1365	84.2235	5.3440
333	20.5593	83.9599	4.3841
334	20.0000	83.6603	5.7140
335	19.4608	83.3257	3.3839
336	18.9439	82.9576	1.6152
337	18.4514	82.5575	4.9269
338	17.9853	82.1269	2.5647
339	17.5474	81.6677	1.2350
340	17.1395	81.1816	9.5921
341	16.7632	80.6706	4.8754
342	16.4202	80.1368	9.6540
343	16.1116	79.5823	7.8617
344	15.8389	79.0093	1.0661
345	15.6031	78.4202	7.1203
346	15.4051	77.8173	7.3536
347	15.2457	77.2031	6.8062
348	15.1256	76.5800	5.9708
349	15.0453	75.9506	2.9630
350	15.0050	75.3173	7.9513
351	15.0050	74.6827	3.0523
352	15.0453	74.0494	4.3378
353	15.1256	73.4200	9.0184
354	15.2457	72.7969	8.7074
355	15.4051	72.1827	4.6219
356	15.6031	71.5798	3.8622
357	15.8389	70.9907	6.4777
358	16.1116	70.4177	9.1918
359	16.4202	69.8632	9.1819
360	16.7632	69.3294	6.3243

Continued on next page

Table B.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	17.1395	68.8184	3.9931
362	17.5474	68.3323	8.6776
363	17.9853	67.8731	4.9816
364	18.4514	67.4425	9.1392
365	18.9439	67.0424	1.2986
366	19.4608	66.6743	5.7918
367	20.0000	66.3397	7.4485
368	20.5593	66.0401	2.6137
369	21.1365	65.7765	4.0288
370	21.7293	65.5500	2.6894
371	22.3353	65.3616	3.8973
372	22.9519	65.2120	4.6347
373	23.5769	65.1018	5.9371
374	24.2075	65.0315	1.4386
375	24.8413	65.0013	5.9746
376	25.4758	65.0113	3.4733
377	26.1084	65.0616	3.1735
378	26.7365	65.1519	3.1883
379	27.3576	65.2819	2.3874
380	27.9692	65.4510	9.6077
381	28.5689	65.6585	9.4210
382	29.1542	65.9037	8.3684
383	29.7227	66.1855	7.5544
384	30.2723	66.5027	2.5823
385	30.8006	66.8542	4.2433
386	31.3055	67.2385	2.6991
387	31.7851	67.6541	1.0108
388	32.2373	68.0992	3.8478
389	32.6604	68.5721	7.2966
390	33.0527	69.0709	6.6273
391	33.4125	69.5936	5.8876
392	33.7385	70.1380	4.9513
393	34.0293	70.7021	3.5868
394	34.2837	71.2834	5.5149
395	34.5007	71.8797	7.8539
396	34.6795	72.4885	7.8617
397	34.8193	73.1075	6.1845
398	34.9195	73.7341	7.7290
399	34.9799	74.3658	6.8098
400	35.0000	75.0000	2.1090

Table B.13: Depot locations and number of vehicles for MS7

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	37.0000	64.0000	3

Table B.14: Customer locations and service time for MS7

Customer index	x-coordinate	y-coordinate	Service time (short)
1	65.5741	48.9764	5.5396
2	3.5712	44.5586	4.1254
3	84.9129	64.6313	1.8293
4	93.3993	70.9365	2.3306
5	67.8735	75.4687	2.7835
6	75.7740	27.6025	7.0504
7	74.3132	67.9703	4.8836
8	39.2227	65.5098	7.2496
9	65.5478	16.2612	3.3111
10	17.1187	11.8998	1.0878
11	70.6046	49.8364	5.7905
12	3.1833	95.9744	3.5145
13	27.6923	34.0386	9.5161
14	4.6171	58.5268	9.1580
15	9.7132	22.3812	4.5342
16	82.3458	75.1267	1.2237
17	69.4829	25.5095	7.0429
18	31.7099	50.5957	8.5345
19	95.0222	69.9077	9.7435
20	3.4446	89.0903	1.5124
21	43.8744	95.9291	5.0529
22	38.1558	54.7216	6.2422
23	76.5517	13.8624	7.1797
24	79.5200	14.9294	7.4749
25	18.6873	25.7508	6.8504

Table B.15: Depot locations and number of vehicles for MS8

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	26.9062	28.7498	2
2	76.5500	9.1113	2
3	18.8662	57.6209	2

Table B.16: Customer locations and service time for MS8

Customer index	x-coordinate	y-coordinate	Service time (short)
1	84.0717	10.6762	7.5422
2	25.4282	65.3757	4.3646
3	81.4285	49.4174	6.2342
4	24.3525	77.9052	2.0451
5	92.9264	71.5037	1.5189
6	34.9984	90.3721	9.8179
7	19.6595	89.0923	3.5634
8	25.1084	33.4163	6.3548
9	61.6045	69.8746	9.6594
10	47.3289	19.7810	2.6720
11	35.1660	3.0541	2.7374
12	83.0829	74.4074	4.0748
13	58.5264	50.0022	9.3961
14	54.9724	47.9922	4.5160
15	91.7194	90.4722	3.4590
16	28.5839	60.9867	2.3675
17	75.7200	61.7666	4.5740
18	75.3729	85.9442	4.3725
19	38.0446	80.5489	2.1800
20	56.7822	57.6722	4.9154
21	7.5854	18.2922	1.8236
22	5.3950	23.9932	6.5316
23	53.0798	88.6512	1.0988
24	77.9167	2.8674	6.1593
25	93.4011	48.9901	8.1076
26	12.9906	16.7927	3.1183
27	56.8824	97.8681	5.0322
28	46.9391	71.2694	6.1242
29	1.1902	50.0472	1.5526
30	33.7123	47.1088	5.4666
31	16.2182	5.9619	6.7808
32	79.4285	68.1972	2.9914
33	31.1215	4.2431	8.5335

Continued on next page

Table B.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	52.8533	7.1445	9.7397
35	16.5649	52.1650	8.6174
36	60.1982	9.6730	5.5540
37	26.2971	81.8149	3.5099
38	65.4079	81.7547	7.7196
39	68.9215	72.2440	3.1324
40	74.8152	14.9865	9.6161
41	45.0542	65.9605	6.5823
42	8.3821	51.8595	6.4024
43	22.8977	97.2975	2.5534
44	91.3337	64.8991	1.8131
45	15.2378	80.0331	3.2974
46	82.5817	45.3798	8.7271
47	53.8342	43.2392	9.1996
48	99.6135	82.5314	7.2967
49	7.8176	8.3470	7.5266
50	44.2678	13.3171	3.0690
51	10.6653	17.3389	6.1845
52	96.1898	39.0938	8.2957
53	0.4634	83.1380	4.6346
54	77.4910	80.3364	9.8960
55	81.7303	6.0471	1.8100
56	86.8695	39.9258	3.8885
57	8.4436	52.6876	5.6027
58	39.9783	41.6799	1.5455
59	25.9870	65.6860	7.5312
60	80.0068	62.7973	6.0090
61	43.1414	29.1984	5.7642
62	91.0648	43.1651	8.4698
63	18.1847	1.5487	8.7288
64	26.3803	98.4064	8.1013
65	14.5539	16.7168	3.8605
66	13.6069	10.6216	5.0699
67	86.9292	37.2410	7.7701
68	57.9705	19.8118	1.9888
69	54.9860	48.9688	1.9877
70	14.4955	33.9493	3.4290
71	85.3031	95.1630	5.7217
72	62.2055	92.0332	9.7539
73	35.0952	5.2677	7.3937
74	51.3250	73.7858	3.8067

Continued on next page

Table B.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	40.1808	26.9119	3.6231
76	7.5967	42.2836	8.6532
77	23.9916	54.7871	9.2048
78	12.3319	94.2737	6.7535
79	18.3908	41.7744	3.2983
80	23.9953	98.3052	1.7980
81	41.7267	30.1455	8.5443
82	4.9654	70.1099	6.2625
83	90.2716	66.6339	9.5330
84	94.4787	53.9126	1.5493
85	49.0864	69.8106	6.2618
86	48.9253	66.6528	3.5660
87	33.7719	17.8132	8.4496
88	90.0054	12.8014	2.7189
89	36.9247	99.9080	4.9828
90	11.1203	17.1121	4.5407
91	78.0252	3.2601	8.4392
92	38.9739	56.1200	7.0918
93	24.1691	88.1867	2.8684
94	40.3912	66.9175	3.8629
95	9.6455	19.0433	2.2043
96	13.1973	36.8917	7.0432
97	94.2051	46.0726	6.1389
98	95.6135	98.1638	2.5279
99	57.5209	15.6405	2.3289
100	5.9780	85.5523	5.2847
101	23.4780	64.4765	9.1729
102	35.3159	37.6272	5.9696
103	82.1194	19.0924	1.2965
104	1.5403	42.8253	1.4848
105	4.3024	48.2022	8.2456
106	16.8990	12.0612	5.0624
107	64.9115	58.9507	4.4438
108	73.1722	22.6188	8.1068
109	64.7746	38.4619	4.2786
110	45.0924	58.2986	5.7911
111	54.7009	25.1806	7.4049
112	29.6321	29.0441	8.8433
113	74.4693	61.7091	3.9582
114	18.8955	26.5281	6.8511
115	68.6775	82.4376	9.7735

Continued on next page

Table B.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	18.3511	98.2663	1.6837
117	36.8485	73.0249	6.2832
118	62.5619	34.3877	4.7250
119	78.0227	58.4069	3.7822
120	8.1126	10.7769	3.3745
121	92.9386	90.6308	7.8289
122	77.5713	87.9654	9.9569
123	48.6792	81.7761	2.6791
124	43.5859	26.0728	8.0303
125	44.6784	59.4356	2.7622
126	30.6349	2.2513	9.9312
127	50.8509	42.5259	8.2204
128	51.0772	31.2719	4.8180
129	81.7628	16.1485	7.5598
130	79.4831	17.8766	5.4852
131	64.4318	42.2886	8.2809
132	37.8609	9.4229	4.2086
133	81.1580	59.8524	1.6592
134	53.2826	47.0924	6.3189
135	35.0727	69.5949	9.1917
136	93.9002	69.9888	2.7439
137	87.5943	63.8531	4.8913
138	55.0156	3.3604	7.7424
139	62.2475	6.8806	1.3527
140	58.7045	31.9600	9.5169
141	20.7742	53.0864	7.8731
142	30.1246	65.4446	6.0294
143	47.0923	40.7619	2.6546
144	23.0488	81.9981	5.4815
145	84.4309	71.8359	5.6606
146	19.4764	96.8649	9.9482
147	22.5922	53.1334	8.6937
148	17.0708	32.5146	9.6616
149	22.7664	10.5629	7.1105
150	43.5699	61.0959	4.6315
151	31.1102	77.8802	9.4148
152	92.3380	42.3453	5.3154
153	43.0207	9.0823	3.0861
154	18.4816	26.6471	4.5666
155	90.4881	15.3657	7.3457
156	97.9748	28.1005	6.0270

Continued on next page

Table B.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	43.8870	44.0085	7.8097
158	11.1119	52.7143	9.9593
159	25.8065	45.7424	9.6619
160	40.8720	87.5372	5.8156
161	59.4896	51.8052	9.6748
162	26.2212	94.3623	2.0406
163	60.2843	63.7709	1.4630
164	71.1216	95.7694	3.7391
165	22.1747	24.0707	6.2217
166	11.7418	67.6122	5.7787
167	29.6676	28.9065	9.1109
168	31.8778	67.1808	5.8650
169	42.4167	69.5140	4.8878
170	50.7858	6.7993	5.8840
171	8.5516	25.4790	7.4117
172	26.2482	22.4040	1.1501
173	80.1015	66.7833	8.2083
174	2.9220	84.4392	2.2826
175	92.8854	34.4462	5.3063
176	73.0331	78.0520	3.3115
177	48.8609	67.5332	4.3218
178	57.8525	0.6715	6.9559
179	23.7284	60.2170	2.5265
180	45.8849	38.6771	3.5091
181	96.3089	91.5991	2.7840
182	54.6806	0.1151	2.7556
183	52.1136	46.2449	3.9416
184	23.1594	42.4349	8.9230
185	48.8898	46.0916	5.2399
186	62.4060	77.0160	4.6357
187	67.9136	32.2472	2.6131
188	39.5515	78.4739	9.7203
189	36.7437	47.1357	4.6671
190	98.7982	3.5763	8.6004
191	3.7739	17.5874	6.5379
192	88.5168	72.1758	4.3895
193	91.3287	47.3486	8.8946
194	79.6184	15.2721	8.0637
195	9.8712	34.1125	5.1846
196	26.1871	60.7389	8.3258
197	33.5357	19.1745	9.0860

Continued on next page

Table B.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	67.9728	73.8427	4.8631
199	13.6553	24.2850	4.0090
200	72.1227	91.7424	6.3698

Table B.17: Depot locations and number of vehicles for MS9

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	60.3296	84.8597	3
2	78.3266	5.0646	2
3	11.3931	46.6202	2
4	97.8564	32.5653	1

Table B.18: Customer locations and service time for MS9

Customer index	x-coordinate	y-coordinate	Service time (short)
1	56.0562	26.1645	9.1179
2	38.2674	49.4950	7.3186
3	52.3018	58.7149	4.3971
4	70.2185	52.1100	7.6146
5	45.0966	30.7025	9.5869
6	38.5638	30.6025	5.8853
7	35.7138	60.8385	5.8610
8	53.0924	48.1828	3.8000
9	61.9613	45.1720	1.6411
10	73.2240	66.4526	2.6378
11	43.6292	40.0442	1.8369
12	45.1862	51.6930	5.1714
13	33.8185	55.2226	1.0840
14	65.8856	60.2485	9.2352
15	41.7793	39.3206	6.7847
16	36.0966	54.4665	1.0128
17	74.0606	84.3558	1.2735
18	54.4269	31.0878	2.8762
19	53.0906	55.4247	5.0947
20	28.4918	47.1279	2.1454
21	49.0570	39.6614	1.0778
22	50.2878	39.6002	7.5437
23	27.2536	56.2237	4.1870
24	39.6315	78.9453	8.0240
25	37.0725	40.0772	4.9299
26	50.3980	56.7620	4.9290
27	28.4720	43.0117	1.4429
28	58.4147	74.7071	1.4467
29	68.3554	56.8083	1.8199
30	38.5178	48.2762	6.3463
31	42.7329	57.7484	3.1698
32	50.0948	49.9302	8.5723

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	60.0465	63.8400	8.7149
34	50.3145	47.6801	9.6725
35	48.5292	35.9823	5.4001
36	35.9598	53.0806	2.9828
37	39.5500	69.5130	3.0359
38	51.6198	35.0422	5.8311
39	66.8979	46.9707	7.8590
40	50.9771	62.5604	4.1281
41	25.6282	25.9984	5.1511
42	49.0437	57.8181	6.7539
43	41.5411	59.4120	9.2560
44	39.3706	52.6685	2.4542
45	39.7259	40.3721	7.4407
46	30.2890	49.9108	6.1996
47	38.2742	51.1648	4.8997
48	31.6512	61.6906	8.9582
49	37.6434	58.2940	4.5375
50	44.5324	45.6221	2.6108
51	45.3477	70.2485	6.7000
52	39.7763	49.3646	6.6160
53	40.6770	39.8413	3.9515
54	43.3384	44.5198	8.2267
55	49.4040	60.7326	9.9953
56	61.1662	52.4402	9.8288
57	51.7156	61.1108	2.1433
58	38.7618	50.8653	3.0902
59	51.4002	81.0853	1.2127
60	39.3495	29.1795	6.4669
61	17.4180	44.8009	1.9973
62	9.3252	48.9472	4.6671
63	18.3772	51.1156	8.9567
64	39.4696	68.2018	5.9332
65	34.0053	52.7432	4.3210
66	32.5691	48.5640	2.8751
67	43.4380	50.8575	4.9685
68	33.4431	59.3937	9.6058
69	33.8498	41.3822	2.1162
70	51.5661	55.6352	5.2369
71	54.0334	30.4372	8.7121
72	77.6655	49.0151	1.3905
73	47.1772	38.2276	7.2246

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	43.6903	41.8392	9.8109
75	34.6552	53.5316	3.5494
76	40.0684	35.9365	2.2040
77	42.1353	37.6378	7.1675
78	17.7746	31.0518	9.1851
79	39.1806	22.1436	6.4978
80	53.5649	48.1060	9.0998
81	34.7034	64.5343	2.7409
82	49.9176	47.7258	7.7898
83	57.0206	47.0756	4.1163
84	58.2449	36.9158	4.7676
85	53.9549	69.7915	2.4015
86	10.5737	46.8823	8.3710
87	34.7946	66.1752	6.6243
88	55.7356	54.5248	7.6470
89	48.4954	46.7118	8.2460
90	42.9265	63.5268	1.6050
91	49.0988	62.2804	9.5571
92	59.0010	48.6070	5.4782
93	45.0539	66.1994	7.7963
94	32.0196	72.2662	7.6816
95	40.2834	49.1798	8.4802
96	39.8887	46.8040	2.4085
97	55.6678	55.0580	5.1158
98	48.7473	54.3970	6.5629
99	50.6789	60.0939	9.3897
100	44.9691	46.8051	8.5158
101	37.6819	58.9389	9.0588
102	43.7306	63.1075	6.2427
103	45.9529	52.2194	6.2447
104	22.8840	51.9162	8.6943
105	45.4124	34.3209	1.3138
106	56.1083	35.3400	8.9688
107	41.2832	31.7320	4.6696
108	65.3200	34.4464	1.3274
109	50.8642	48.0613	7.7153
110	36.8522	29.8136	2.3935
111	40.6579	78.0758	2.2952
112	38.9257	59.2410	6.4536
113	46.3017	24.1544	3.2903
114	53.6384	35.5681	3.9174

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	38.6870	48.6601	4.6161
116	49.4064	28.5890	4.6574
117	67.9327	44.2513	4.4757
118	56.1642	63.6375	6.4882
119	54.6466	47.9515	2.5020
120	31.2170	49.1595	2.6928
121	35.2257	37.4801	1.8517
122	46.3222	43.0542	3.9087
123	41.4193	33.1055	7.9264
124	19.6422	54.5526	3.1071
125	21.2225	44.3474	7.6633
126	57.5170	59.7921	7.2354
127	32.0268	65.4655	8.4167
128	72.5478	63.4650	8.4518
129	11.1145	49.5645	3.6403
130	49.2681	43.7002	3.7843
131	42.8661	34.6998	5.7073
132	32.0537	51.4814	3.9277
133	48.6332	61.9934	8.4866
134	31.5164	45.7384	8.2927
135	55.1398	47.8335	6.0130
136	43.8124	57.7038	3.3667
137	19.4373	60.7990	7.1251
138	8.2179	32.2886	3.1029
139	38.8024	52.4994	5.1078
140	59.2258	52.4478	4.4611
141	45.4453	48.1108	5.8474
142	43.6321	61.1598	9.9253
143	52.6822	45.4476	7.7970
144	22.9513	39.6726	9.8241
145	63.2195	53.4501	3.1130
146	30.0878	55.7475	5.7570
147	43.3966	47.2812	1.4629
148	37.6633	59.9515	7.8119
149	44.9937	31.0247	6.4178
150	15.0783	36.5635	8.7145
151	64.6271	11.5979	9.8945
152	50.6544	56.5176	9.3654
153	71.5704	37.6122	4.6856
154	63.0953	46.8359	1.0031
155	43.0212	62.6158	5.8679

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	29.4422	50.6377	2.8696
157	18.0156	44.4946	2.9736
158	43.0996	39.3941	3.9323
159	45.9880	46.9954	1.8635
160	57.7974	57.5366	7.7278
161	29.2717	31.0468	7.7366
162	54.2114	49.1456	5.8897
163	43.8776	59.7799	4.0432
164	31.8045	32.2409	8.4910
165	53.9166	58.3671	5.9731
166	46.6522	58.5405	9.6179
167	39.4985	38.9733	9.0355
168	69.6756	31.1936	4.2085
169	51.5606	55.4142	5.9176
170	41.2818	60.1032	4.1201
171	46.8208	57.2367	6.6052
172	44.1007	59.5356	8.1696
173	45.3370	35.2234	7.7129
174	49.3370	57.2981	2.1298
175	34.2355	42.7499	8.4015
176	31.4711	42.9829	1.2264
177	48.0093	30.5513	4.7299
178	69.7870	63.7526	7.5827
179	38.4740	52.1882	8.0324
180	28.3897	62.5451	4.3056
181	39.4493	68.8876	7.7038
182	35.9426	35.7845	9.0304
183	38.1808	58.0377	3.1834
184	49.6503	49.8405	2.1664
185	40.9999	61.4282	3.0256
186	34.3664	63.8462	4.1501
187	36.5176	60.2559	3.5838
188	23.9639	39.7799	9.3474
189	30.5783	48.4189	1.4618
190	22.6714	53.3018	6.3340
191	35.4859	89.4816	2.4661
192	27.3557	65.3327	8.5457
193	32.7549	79.0079	2.5080
194	38.5478	55.1812	5.5198
195	25.7080	52.6479	9.9940
196	42.5805	57.6646	4.1987

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	47.7196	43.4028	1.4237
198	29.0967	65.5200	2.9229
199	58.7703	48.0296	4.5806
200	20.1985	32.8300	4.0030
201	37.2601	60.8855	3.0664
202	21.6473	30.3933	9.4251
203	37.9339	26.9468	7.1487
204	23.9441	53.6051	9.6590
205	34.6452	38.1136	4.9418
206	32.2756	38.6158	9.4630
207	25.9285	47.9756	1.0525
208	13.3591	43.8887	6.4928
209	50.9294	47.2152	8.2097
210	71.4306	53.4008	3.0968
211	74.6190	35.3934	9.3922
212	35.8260	34.6971	7.8694
213	42.2000	23.7565	8.4380
214	36.2036	45.1220	6.1612
215	43.9421	58.3035	8.1332
216	29.7319	41.2217	3.9614
217	15.4362	56.2666	3.0112
218	42.3365	56.7539	3.8115
219	25.3553	62.3844	6.2607
220	15.6795	62.3672	8.4692
221	76.7750	41.3895	3.6142
222	39.5236	39.2895	4.6230
223	48.6269	50.6049	8.7585
224	59.8924	41.6893	6.5327
225	18.7892	68.1593	9.9207
226	48.7593	67.2481	2.8333
227	50.0249	51.1892	8.4449
228	44.0438	44.6609	7.0828
229	45.1114	56.3851	3.2405
230	35.3151	41.7966	5.2821
231	53.1866	48.4373	4.5917
232	30.7151	43.3692	6.3949
233	31.4802	51.3198	8.2047
234	53.2191	64.1044	1.9456
235	66.9506	59.2810	8.3930
236	37.3372	64.2950	8.5698
237	35.6417	38.5661	4.1906

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	48.6868	52.2475	4.8706
239	58.1765	37.7082	6.1502
240	56.6855	54.8104	7.3074
241	46.7164	54.0712	7.6822
242	33.7942	66.2039	7.8210
243	51.8538	63.7404	4.5022
244	41.7252	58.1653	4.8637
245	62.5278	43.6866	9.6071
246	22.7398	44.0501	6.1567
247	44.8747	24.3555	8.6475
248	61.2817	44.3962	3.4871
249	35.7866	30.6100	6.6009
250	33.9311	61.6228	6.2953
251	29.5195	61.2742	9.6712
252	38.8754	51.7286	1.7731
253	39.9925	45.2699	5.5045
254	44.8106	51.7883	5.6943
255	30.2379	70.0630	1.8115
256	44.0363	66.8640	9.1420
257	34.2304	44.3945	8.9595
258	37.5896	52.1051	4.9509
259	30.8833	35.9938	8.0355
260	38.8218	55.0091	2.3362
261	93.8553	59.2383	6.5783
262	91.5362	61.2506	3.3456
263	59.2417	30.8598	5.0109
264	54.1037	56.3078	8.5960
265	24.5980	39.1973	2.7658
266	34.5058	45.2931	3.7347
267	34.0085	59.8501	5.3497
268	50.5043	53.7276	4.0403
269	49.7570	47.9532	8.1864
270	44.4068	57.5842	9.8874
271	37.9959	70.4312	2.4314
272	29.6307	42.2063	3.1319
273	42.9332	33.1237	7.3201
274	59.1307	35.4720	4.3792
275	48.9623	38.1965	9.7633
276	45.4433	41.6099	9.7508
277	52.2497	57.2085	6.7933
278	51.2035	23.9279	8.7409

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	19.7650	52.9495	4.6170
280	43.1253	40.2697	6.6874
281	36.7720	63.7445	9.8671
282	13.7996	39.3054	6.0353
283	23.8778	50.0945	9.4023
284	38.2873	38.2802	7.4831
285	54.6490	41.4805	5.3563
286	39.5815	46.7483	6.7513
287	46.6036	47.1401	8.9887
288	30.0289	43.4398	2.7886
289	12.0385	64.1040	4.5583
290	44.1988	56.8767	9.9296
291	29.2688	73.1893	4.6212
292	59.6084	46.5338	6.9297
293	67.6442	63.3329	9.1121
294	37.5472	23.7595	9.9584
295	59.8981	57.9810	6.8785
296	56.4807	54.6433	1.9759
297	22.6422	45.3228	1.3250
298	42.3806	58.6919	6.5628
299	46.5874	60.9704	6.1043
300	50.3285	62.9201	9.6577
301	52.5255	55.2474	7.7149
302	52.4914	57.5134	6.9626
303	52.5486	41.5748	5.7098
304	38.3917	36.3103	3.3390
305	48.2749	46.6548	9.6579
306	10.6729	52.3319	5.8618
307	26.1664	61.8868	1.2724
308	60.0281	40.1185	7.2668
309	33.4180	43.8815	5.6774
310	47.5366	87.1809	1.5313
311	64.4018	42.2177	9.0103
312	30.1584	74.0038	3.9718
313	29.1531	62.0144	3.0673
314	35.8183	43.0275	2.0255
315	49.1580	48.6681	3.7983
316	39.9319	47.3105	3.0559
317	28.8885	55.9186	6.8680
318	20.3865	67.0705	1.5954
319	37.5677	29.5275	3.4789

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	39.6979	75.2966	3.5364
321	35.2112	59.7224	8.9206
322	39.1147	43.1387	4.9990
323	27.2084	48.4249	7.8032
324	50.7033	53.7448	6.4297
325	11.7911	53.7021	8.0494
326	44.9231	65.0098	2.0254
327	52.4148	63.6272	9.8071
328	30.7310	45.5162	8.6374
329	42.0416	48.3759	1.4558
330	47.0255	59.1717	5.1958
331	34.0769	51.5041	3.9309
332	42.6622	64.2041	6.6718
333	48.7445	41.4153	3.0727
334	29.4693	55.8960	6.2190
335	54.7880	53.6043	6.4284
336	58.4934	67.3982	6.3989
337	47.4454	33.1812	5.0359
338	43.0730	50.0093	1.3188
339	26.2215	50.6687	5.6243
340	49.9263	20.7262	4.6696
341	25.4879	65.6012	1.9724
342	65.5827	85.1154	5.1389
343	50.3782	47.0977	5.0579
344	46.6403	53.5879	5.9603
345	37.2343	44.1924	8.2486
346	11.7670	54.8040	7.3077
347	25.7764	45.2522	8.8501
348	48.0761	48.7278	1.4697
349	77.3206	70.2269	2.9771
350	53.4321	39.4096	5.1368
351	47.2821	42.8015	9.6268
352	35.1145	49.0511	8.1104
353	44.6040	48.3441	5.0669
354	56.6040	67.9914	4.0009
355	39.2289	75.3908	1.5319
356	69.8822	37.7725	7.6681
357	25.4249	41.9872	5.5612
358	37.4823	56.5059	2.7993
359	43.6061	45.2413	4.8447
360	14.9438	74.9106	2.5182

Continued on next page

Table B.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	50.9346	70.4484	7.7653
362	43.9685	56.9877	4.3152
363	44.0100	57.0455	9.4764
364	54.2101	45.7700	1.1546
365	57.7670	59.5456	8.4615
366	54.3169	64.0930	6.6393
367	36.1597	51.7696	5.8487
368	42.1915	74.1017	6.8546
369	47.9065	58.3830	7.5397
370	24.9028	48.6236	1.8504
371	28.0567	54.6370	8.8982
372	36.7577	63.7074	1.1293
373	43.9667	45.0230	3.6487
374	68.4419	48.9317	2.6192
375	54.2466	79.6661	9.3366
376	36.5357	44.0760	1.6136
377	33.8701	61.8293	6.2298
378	64.7685	60.2270	6.7344
379	81.9077	69.8621	6.8614
380	45.2491	56.5751	8.7816
381	36.0162	19.1850	1.5036
382	22.6764	39.3434	8.3517
383	56.7855	56.3967	5.7603
384	46.9960	53.2222	7.2492
385	59.5058	74.5306	2.9116
386	29.8756	67.5789	5.8895
387	46.2939	56.2104	7.3227
388	33.5136	51.0354	9.6079
389	61.0708	30.6440	5.0009
390	34.9830	73.2895	1.7686
391	41.6084	51.6753	1.5161
392	37.8883	30.6750	6.6651
393	57.0566	55.4160	8.1656
394	48.9777	51.2869	7.2207
395	28.5116	42.8707	4.1078
396	33.8187	56.1633	9.5214
397	27.9184	41.1561	5.6817
398	50.0815	33.1497	9.5843
399	47.5993	28.0712	1.6624
400	19.4941	45.4524	2.8633

Table B.19: Depot locations and number of vehicles for MS10

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	57.7414	97.9788	1
2	58.8255	81.6171	1
3	15.1868	80.7170	1
4	67.7835	79.3016	1
5	9.3111	83.4786	1

Table B.20: Customer locations and service time for MS10

Customer index	x-coordinate	y-coordinate	Service time (short)
1	13.9101	73.3572	7.9753
2	80.1760	11.0916	9.2277
3	25.1768	43.4769	8.0430
4	75.2904	55.9157	3.6598
5	14.9107	27.7160	2.3666
6	13.9866	57.7608	8.6312
7	66.8281	78.6792	8.0637
8	72.8494	26.6905	3.4375
9	52.0159	8.0015	3.0503
10	37.8769	66.7042	3.8892
11	35.0886	65.4607	8.4661
12	33.8570	7.0006	8.3996
13	8.6564	8.8704	6.1361
14	13.4911	22.1040	6.1465
15	94.2045	16.9353	3.5742
16	98.0828	99.7183	7.2922
17	36.3779	50.3678	8.1663
18	4.7367	83.0884	4.9743
19	90.9440	8.7179	5.0159
20	10.0580	91.2066	5.1910
21	5.1369	74.8024	3.5114
22	61.8200	11.2874	7.0784
23	76.2004	29.4551	9.1330
24	86.1616	39.0946	9.1767
25	37.6759	81.9315	7.7248
26	68.4753	39.7109	3.3446
27	1.0803	97.7365	7.2067
28	57.8439	75.4148	2.1865
29	51.6434	44.3531	2.1115
30	25.3183	36.4009	2.7181

Continued on next page

Table B.20 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	71.2754	86.6030	2.3116
32	71.9774	61.1971	6.2654
33	86.9030	28.6301	1.6603
34	51.6930	44.2035	8.4009
35	84.0120	40.2920	7.5061
36	12.7584	93.3000	9.3327
37	48.8197	12.1854	5.4337
38	33.3632	88.6730	6.8939
39	2.0502	6.8694	9.0111
40	56.5288	26.7518	5.8467
41	62.6645	63.2938	3.5398
42	97.4316	3.1550	9.7836
43	34.8002	87.5025	1.3278
44	82.5828	62.3307	3.9362
45	30.5917	9.0164	9.7571
46	95.6239	15.3623	4.2853
47	19.6524	7.1491	3.7823
48	39.7401	33.8837	2.0882
49	40.6499	27.3435	9.2419
50	33.0560	92.3707	2.2193

Table B.21: Depot locations and number of vehicles for MS11

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	5.1399	99.2428	1
2	40.9326	95.2956	1
3	94.5372	31.1508	1
4	59.1796	77.8629	1
5	12.2829	47.9044	1
6	15.4306	42.8746	1
7	22.3423	39.6704	1
8	90.7130	67.6403	1
9	82.5080	71.2048	1
10	94.8137	99.3811	1

Table B.22: Customer locations and service time for MS11

Customer index	x-coordinate	y-coordinate	Service time (short)
1	2.6674	57.5368	3.9891
2	3.5652	9.7947	9.0773
3	64.3782	86.9809	5.4968
4	81.2668	30.1085	6.5376
5	38.8833	66.9797	6.2482
6	8.4198	99.1974	7.2843
7	35.5116	70.2578	1.2640
8	1.4450	21.0481	5.7509
9	46.7375	95.4999	1.2887
10	72.8599	69.7781	8.4443
11	72.3784	60.0850	4.0599
12	57.5165	57.6609	8.6204
13	44.2243	42.6026	3.2146
14	32.4027	81.6076	6.2334
15	3.6741	58.1288	9.4391
16	82.4656	77.2154	1.4301
17	48.4269	5.7463	1.4858
18	46.2789	53.8695	1.1856
19	35.9623	88.0525	7.1333
20	70.9636	89.8417	6.3877
21	94.2521	67.7323	2.0263
22	37.9749	51.0343	8.1662
23	43.8165	87.8222	6.5607
24	84.3402	88.0361	1.6319
25	27.9308	41.6597	1.6235

Continued on next page

Table B.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
26	24.1490	75.0759	2.2241
27	7.9304	98.9051	8.1000
28	7.9270	47.9617	1.8316
29	82.8677	62.3566	3.1408
30	11.9271	16.8022	3.1928
31	5.3021	88.9436	1.9434
32	62.8386	12.0909	8.7252
33	71.8067	60.0299	7.2838
34	47.3595	69.9011	7.6037
35	96.8337	35.9944	6.8548
36	77.2015	56.4388	5.6464
37	30.7836	57.0001	3.9375
38	57.5944	66.9409	6.9560
39	85.2369	7.7982	2.0581
40	59.5812	51.4278	2.3304
41	82.9913	42.8144	1.1779
42	81.7100	29.3103	9.6786
43	46.3333	14.9322	9.7334
44	88.9017	84.1730	2.1147
45	44.6931	86.9811	5.2067
46	99.2755	97.7289	6.9102
47	59.5808	71.0659	3.6117
48	81.4165	69.7454	7.7908
49	88.7809	8.3062	6.0231
50	40.0024	3.1112	4.8501
51	97.1473	77.9183	3.4047
52	86.8116	41.3687	7.7836
53	8.7943	88.9695	9.0854
54	24.7970	27.9276	7.5560
55	84.7975	95.6279	4.6615
56	26.8378	60.2501	9.4448
57	0.6183	77.2996	3.2988
58	31.4865	79.5838	5.7985
59	81.0160	74.7446	9.5928
60	12.6118	14.5703	3.4097
61	67.3843	59.7275	3.2508
62	29.6429	24.8321	9.3491
63	68.1019	0.2224	1.6172
64	42.6812	18.6048	3.6946
65	11.8274	43.8759	6.3243
66	76.8099	80.7740	2.8297

Continued on next page

Table B.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
67	58.5799	46.5256	6.7229
68	76.1654	74.0685	8.1853
69	62.8008	96.0086	5.5153
70	27.8368	6.6571	6.8573
71	17.1257	49.7518	8.1636
72	16.0127	62.3515	3.1004
73	80.3727	76.5584	6.4076
74	61.4369	55.4403	2.0122
75	11.3839	46.1961	5.6419
76	18.7029	94.9898	8.5406
77	60.6554	47.3963	9.2871
78	44.6592	75.2075	5.4841
79	22.1432	93.8007	3.4985
80	27.9252	59.8272	6.8727
81	35.5684	47.4444	9.2557
82	27.5665	35.0596	5.5886
83	73.4136	41.8614	9.7677
84	10.7109	40.7034	2.7755
85	51.8309	45.5369	2.0007
86	75.8132	67.8294	3.6762
87	19.0193	82.6729	4.5678
88	90.9900	63.7608	4.7868
89	66.1143	18.9957	3.8033
90	56.6582	91.9704	7.2446
91	54.3360	34.2368	1.8268
92	21.5530	69.9487	4.6188
93	50.6242	71.2903	3.6566
94	90.8622	16.4965	3.7585
95	52.8936	90.2401	1.9501
96	49.4804	15.4084	6.3444
97	97.4544	22.3874	3.5445
98	71.4946	46.4983	2.3970
99	33.2944	21.7388	1.0059
100	93.8843	51.0154	3.5524

Table B.23: Depot locations and number of vehicles for MS12

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	79.2328	89.5452	1
2	65.4914	31.7236	1
3	39.5365	95.5817	1
4	34.0986	8.7049	1
5	19.3701	56.3395	1
6	17.7701	86.8037	1
7	33.4280	12.8627	1
8	96.7222	91.5623	1
9	15.8952	51.3489	1
10	12.1682	11.7241	1
11	87.2591	8.6689	1
12	9.7448	94.3246	1
13	40.1110	54.9028	1
14	77.7212	51.7343	1
15	30.5305	18.7454	1

Table B.24: Customer locations and service time for MS12

Customer index	x-coordinate	y-coordinate	Service time (short)
1	84.8838	76.7164	5.9573
2	7.4965	61.4920	8.8381
3	34.6679	15.1291	1.3803
4	54.1668	83.9111	9.1425
5	71.9803	17.3691	2.1788
6	88.1973	83.3605	8.5036
7	80.4918	78.1370	8.2042
8	39.8681	71.7369	9.2609
9	71.6123	47.2104	2.2357
10	59.3099	30.8544	5.5426
11	91.9977	67.7132	4.6446
12	36.0995	60.8741	2.5621
13	87.6580	29.3219	6.1767
14	79.0508	83.5840	6.4560
15	39.9935	26.8413	2.9300
16	97.4063	29.6483	5.6794
17	47.3952	38.0316	9.9027
18	62.8858	68.1348	5.4092
19	63.9848	50.3475	7.2539
20	92.4296	49.5073	4.7028

Continued on next page

Table B.24 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
21	51.4633	5.7136	1.3130
22	35.9821	47.3741	3.6355
23	98.6112	45.6489	8.2130
24	37.2214	44.0584	4.1185
25	24.1912	83.8965	1.7498
26	98.4222	23.6235	5.6000
27	88.9401	19.1235	4.3015
28	51.6035	71.6161	7.6553
29	21.6915	32.4501	5.7227
30	84.4665	10.0158	8.2407
31	20.4530	54.6944	8.3522
32	71.8650	39.1058	2.7052
33	37.9119	46.0879	2.1132
34	31.6365	76.0468	8.3890
35	80.3795	95.7029	6.7411
36	13.7151	83.3024	1.1451
37	28.2269	93.9429	9.0636
38	93.5620	65.4148	5.6384
39	73.3356	91.8315	5.9007
40	25.2357	27.8333	6.4580
41	70.8616	45.0372	7.8439
42	44.2847	33.8453	8.6981
43	12.6414	40.0331	4.4458
44	56.6498	38.4749	1.7618
45	13.7892	62.2959	7.6049
46	99.4235	90.3701	3.9879
47	20.5406	13.3576	8.5577
48	16.1358	31.9299	4.3455
49	11.2159	17.2428	8.4539
50	89.8153	72.3215	2.5887
51	29.9263	96.9070	2.1657
52	2.4689	54.0433	8.9190
53	78.0181	63.7164	1.3967
54	70.2509	98.4452	7.1805
55	90.3480	65.8928	7.6040
56	93.4307	31.6856	4.9346
57	50.4669	29.9761	4.4186
58	25.4714	58.0236	9.8169
59	9.3391	48.1903	4.5909
60	90.5070	91.6805	4.9617
61	92.4821	12.5090	2.4113

Continued on next page

Table B.24 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
62	43.9733	5.2424	3.9343
63	63.9823	65.2836	3.8266
64	47.6791	63.2134	9.0505
65	21.8455	38.0676	3.2232
66	33.3453	89.7187	3.7961
67	18.7407	5.8015	4.6798
68	33.8638	21.3627	7.3721
69	53.9213	20.3135	2.2927
70	95.9540	38.5715	8.8419
71	33.0622	34.3493	1.7484
72	87.7187	2.9828	5.1556
73	74.5795	78.0242	1.2735
74	36.9616	4.4396	7.7788
75	2.9581	15.7177	7.3004
76	57.3854	90.3904	2.9306
77	93.4200	75.2448	7.1191
78	91.8947	52.9195	6.0156
79	30.2341	54.4974	8.6561
80	4.5993	90.5775	6.0271
81	57.2539	0.2591	9.1160
82	89.6137	71.4522	4.7757
83	39.3908	16.0302	4.2232
84	14.3409	36.0827	5.4009
85	6.5196	73.9671	3.3037
86	27.2358	39.8498	9.3625
87	66.3161	94.2627	5.2008
88	53.2208	44.8656	3.2861
89	18.6890	96.5921	4.8810
90	51.5501	19.5253	7.3228
91	7.8789	77.3108	4.6210
92	57.3898	82.2491	2.6366
93	52.5279	4.5997	8.7063
94	32.9479	13.4850	6.2578
95	46.0387	92.3910	4.3622
96	92.3387	68.6517	2.9953
97	26.0633	85.1518	2.9709
98	89.3198	81.0635	5.7001
99	93.9919	67.4228	4.9008
100	23.2644	8.2232	7.6717

Table B.25: Depot locations and number of vehicles for MS13

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	75.3025	45.3429	1
2	48.1377	48.4770	1
3	95.4844	48.4203	1
4	16.0127	28.1074	1
5	53.3086	76.7624	1
6	79.4255	68.3671	1
7	42.6890	44.5856	1
8	31.4857	55.3484	1
9	61.2524	61.1174	1
10	1.7678	6.4381	1

Table B.26: Customer locations and service time for MS13

Customer index	x-coordinate	y-coordinate	Service time (short)
1	38.4046	81.9824	1.6340
2	15.7315	88.0233	8.6260
3	71.6633	59.7598	7.1189
4	82.8184	92.5286	2.2299
5	51.2924	86.5152	8.7256
6	5.6883	79.3977	2.7985
7	73.0230	93.2013	6.4661
8	29.1937	56.7226	5.8874
9	88.8814	27.3759	2.4609
10	44.7806	3.2031	1.0509
11	65.1449	21.8420	7.9434
12	19.7955	12.8206	7.8831
13	34.9659	23.1896	4.7896
14	30.1467	75.1538	1.5113
15	34.9174	11.4795	6.2717
16	89.6056	41.6898	2.5674
17	64.2363	48.0861	7.5575
18	86.0558	76.5752	5.8086
19	13.3779	9.2853	3.2776
20	47.8741	11.2863	9.2535
21	27.3411	20.1287	7.8238
22	58.1609	83.2626	8.9833
23	15.1083	48.2931	1.6192
24	1.0940	58.2560	2.6518
25	43.7077	46.5662	7.6337

Continued on next page

Table B.26 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
26	81.8049	64.1693	7.2704
27	38.6612	1.7803	7.9929
28	81.1967	69.0865	5.5171
29	78.5434	7.6852	4.8295
30	14.1194	47.7202	6.5011
31	6.9957	13.2942	8.7019
32	23.6076	90.4177	7.0372
33	13.5709	5.0989	5.7123
34	51.3808	86.1329	3.6893
35	81.0218	0.1233	7.3357
36	41.6035	50.9610	4.4345
37	42.0985	84.3904	6.1092
38	95.0245	26.8292	8.9907
39	82.9276	94.7960	8.5865
40	61.1001	63.8211	9.0892
41	64.0161	93.5116	9.4510
42	86.8000	90.4675	8.3389
43	74.8358	73.4878	1.0122
44	7.2096	38.8988	1.0278
45	28.3765	93.6475	1.7872
46	67.9808	49.8622	3.3465
47	52.7609	34.8022	1.2052
48	19.3448	66.0084	4.8168
49	13.7742	57.1662	4.0696
50	19.8092	39.2005	5.8722
51	92.3349	83.4178	9.3355
52	75.0160	36.0487	3.6865
53	93.9900	0.8925	4.0428
54	11.3533	12.8318	8.7353
55	86.9494	98.7228	4.0643
56	40.6627	53.1273	2.2431
57	70.5614	82.2435	5.5702
58	15.5556	89.2311	8.7099
59	30.2592	53.8919	4.4588
60	95.4580	82.7336	7.2612
61	78.0448	77.2385	6.6511
62	12.5153	81.1148	5.0535
63	60.5574	87.3184	5.2626
64	19.2593	28.2841	9.5474
65	60.1699	31.0673	1.7515
66	92.3424	70.8875	3.5185

Continued on next page

Table B.26 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
67	65.8284	83.0132	5.0231
68	49.1116	64.1517	6.2881
69	26.7149	87.6817	8.8987
70	0.5501	86.8896	5.2219
71	40.7605	78.5222	4.9368
72	5.9845	45.5789	7.7157
73	9.1087	9.0935	5.2112
74	26.1522	26.4278	8.7474
75	92.9512	87.7384	5.1986
76	16.2000	44.5277	5.4829
77	86.8666	55.6758	5.3869
78	65.9508	23.9985	3.0652
79	33.4629	2.8775	1.7700
80	6.8542	39.1089	1.6064
81	15.4129	93.6924	8.9955
82	36.2408	96.4002	3.0985
83	83.7933	46.4083	8.7544
84	78.4464	53.0032	7.4056
85	32.7664	75.1074	8.8553
86	28.1587	45.0526	9.4420
87	33.4650	19.5776	2.2572
88	81.6511	37.1952	4.5451
89	79.2793	87.1983	9.8251
90	20.9674	24.6748	6.8031
91	34.5006	25.7683	9.0677
92	61.0463	56.4980	5.3401
93	80.8030	23.8069	1.1268
94	21.5873	20.6731	6.6059
95	6.0116	80.9983	3.0799
96	56.5336	91.7677	5.7469
97	14.7862	33.8864	7.5249
98	85.4760	18.2345	6.4667
99	28.7712	32.9070	6.2953
100	31.8631	75.5483	4.9009
101	5.2765	98.1078	3.1976
102	11.3527	84.5170	4.8606
103	49.0543	58.0095	1.0916
104	49.2519	14.8817	6.4794
105	0.7589	93.8698	9.6218
106	32.3446	70.8335	1.8590
107	10.4311	27.1163	1.3203

Continued on next page

Table B.26 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
108	71.6200	53.8359	8.9761
109	56.8327	56.5314	3.2225
110	70.3127	46.6551	1.0802
111	76.2664	6.3306	8.3343
112	95.1919	17.9179	2.2645
113	69.4616	17.7301	8.9188
114	56.9940	45.0039	1.8584
115	43.5692	34.3838	4.1730
116	34.5676	56.3986	6.3408
117	21.1172	32.2013	6.2666
118	56.1776	41.2997	7.0091
119	21.4503	45.3095	6.8322
120	63.8317	2.9586	4.9003
121	52.2746	19.0441	2.2578
122	29.4720	70.5819	7.7674
123	11.2972	24.6521	3.1761
124	73.7633	18.8298	6.8541
125	94.1852	78.3202	8.7164
126	94.5175	23.2220	1.7593
127	75.5635	29.6525	9.7488
128	55.5291	4.6170	1.2831
129	87.5019	70.9775	8.5186
130	32.5093	84.9996	8.5214
131	75.1625	44.7553	1.4487
132	45.3528	88.4267	5.9130
133	22.2157	68.2814	9.4885
134	42.8586	83.8519	3.8933
135	8.0592	26.3103	8.2582
136	43.7028	32.1639	6.4126
137	86.9149	73.9457	8.1066
138	6.8397	72.7802	8.1927
139	97.0996	62.3384	1.4461
140	33.7546	0.3840	3.5488
141	72.8519	88.4373	6.8811
142	84.5155	88.0378	5.4069
143	84.2709	49.3070	9.7557
144	93.1851	27.5528	7.7364
145	43.3289	45.8167	6.1106
146	5.4162	45.0135	3.6907
147	36.1782	26.8808	3.3050
148	85.6894	60.2161	8.9791

Continued on next page

Table B.26 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
149	90.7921	45.7708	5.0212
150	94.3764	79.9694	8.3439

Table B.27: Depot locations and number of vehicles for MS14

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	50.9477	11.0443	1
2	52.9504	34.4700	1
3	37.2480	20.3357	1
4	13.5668	46.6052	1
5	55.9797	89.9157	1
6	5.2539	42.6109	1
7	8.3353	4.2426	1
8	97.9748	7.9603	1
9	45.6481	42.1063	1
10	36.1703	62.9647	1

Table B.28: Customer locations and service time for MS14

Customer index	x-coordinate	y-coordinate	Service time (short)
1	34.0682	47.7248	1.8850
2	73.1047	91.1516	8.7363
3	58.9121	0.0285	1.2487
4	87.3705	21.1197	9.0924
5	22.4711	54.2240	9.0994
6	94.9757	60.5166	5.7170
7	50.5346	35.6386	2.0818
8	58.6995	12.2596	2.6001
9	78.7107	92.4724	7.3550
10	60.6314	45.0438	8.4822
11	27.5973	16.4567	1.3135
12	20.9587	93.3727	7.8205
13	63.8576	33.9486	9.6140
14	5.0658	54.9143	4.0858
15	23.5190	62.7872	6.7442
16	50.9214	61.4709	4.0871
17	71.8875	51.9026	2.9482
18	23.5131	14.4930	8.0758
19	68.9906	57.1562	7.5078
20	39.5743	57.3022	3.5096
21	45.4098	14.0397	6.2419
22	34.9428	13.4217	4.7891
23	8.8914	72.1064	1.8286
24	64.3515	66.8602	1.2162
25	63.9235	48.7290	5.4203

Continued on next page

Table B.28 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
26	89.0775	64.9199	3.5044
27	83.5526	6.9878	4.0578
28	19.8948	94.3572	3.5861
29	48.2615	47.9180	2.5381
30	74.6043	37.9257	4.5934
31	51.0344	56.2950	7.2788
32	16.1966	11.0337	2.8331
33	96.9306	73.7059	6.9969
34	22.9774	73.0330	4.9876
35	24.1708	18.4982	4.8997
36	50.0251	20.2014	2.5772
37	85.0863	98.6389	2.7388
38	85.7453	7.2576	6.5478
39	63.0492	38.3593	3.4211
40	59.3343	46.0343	6.0371
41	43.8832	27.7129	9.5031
42	8.9289	9.2281	7.4302
43	31.1514	8.5463	7.1130
44	82.0607	49.9539	9.6344
45	20.3401	44.0501	7.9780
46	41.6228	92.5386	6.4695
47	59.4766	94.2454	9.5320
48	12.1474	24.4952	1.5368
49	14.3340	28.2829	3.4184
50	82.5198	3.0400	9.8801
51	55.9053	86.0957	7.9499
52	19.6033	67.9961	5.2782
53	26.0766	31.8231	7.1281
54	46.7499	96.5846	4.7524
55	71.6791	57.1251	4.4213
56	54.7767	67.0669	2.9194
57	79.5080	7.2774	4.4464
58	94.2238	5.3281	1.2670
59	33.5589	31.9823	5.2509
60	73.8772	65.4969	4.0004
61	66.3296	41.5111	9.7826
62	8.2097	24.3938	5.9990
63	84.7047	44.3410	8.6167
64	5.5759	0.9972	4.6726
65	10.8237	47.9729	5.1582
66	1.3048	64.3192	8.4368

Continued on next page

Table B.28 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
67	3.4662	92.4457	9.9208
68	26.5897	45.6692	5.7155
69	3.9818	14.8053	9.3289
70	7.2103	49.2107	7.6512
71	44.4772	22.8131	6.1069
72	12.1012	4.0364	9.7190
73	62.9775	37.6335	8.4205
74	78.9437	90.2753	9.6365
75	32.4933	15.4110	6.8171
76	6.0002	34.8458	4.4162
77	74.2784	47.0526	5.2892
78	21.4135	50.6707	9.2070
79	9.6196	54.2071	1.1337
80	35.6511	60.1855	2.4102
81	69.8125	10.7143	5.2441
82	13.7772	75.1515	5.8869
83	3.4487	4.7172	1.5372
84	86.5825	87.6240	6.9223
85	96.8178	25.7666	9.0067
86	73.2148	93.3628	1.9867
87	6.0559	26.6090	4.9400
88	84.3849	32.2155	3.5221
89	61.3738	44.6251	9.8672
90	36.2290	34.6663	6.4788
91	86.6690	71.7504	3.2837
92	85.8173	58.2244	2.1935
93	44.4085	90.2696	5.9050
94	26.5976	79.4241	8.4502
95	5.2205	48.9509	8.5331
96	71.1852	93.6590	8.5001
97	65.1925	64.1101	2.8334
98	2.4963	16.9525	5.8998
99	54.5672	78.4591	8.8745
100	22.8351	76.6663	2.0890
101	14.9282	55.5932	8.7072
102	11.8268	90.2985	9.0980
103	18.4141	0.8639	2.9608
104	24.9133	16.0063	1.6928
105	35.3673	46.4992	5.2679
106	26.3691	61.7522	8.5152
107	44.5311	67.5322	5.2245

Continued on next page

Table B.28 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
108	46.7969	0.7669	4.7239
109	51.1808	94.4520	5.5247
110	42.0698	27.5375	2.1290
111	16.9687	57.7956	2.1906
112	0.0295	1.9687	8.8343
113	68.5550	23.7139	6.4266
114	77.6316	3.1725	3.3877
115	59.3658	4.7617	8.7832
116	39.3476	63.0482	1.5230
117	4.7282	92.8014	5.1198
118	64.4047	25.3419	7.4999
119	67.8625	43.8807	4.0510
120	8.8041	38.5523	4.6110
121	42.2692	10.5689	5.7428
122	34.2623	53.7708	9.0481
123	21.0132	59.1484	8.0052
124	70.4211	95.1834	1.6243
125	35.1593	16.0609	3.5091
126	67.8446	64.9370	4.4143
127	77.7020	82.5812	8.7821
128	76.7738	3.5974	4.7796
129	72.4167	97.0257	3.1589
130	49.9858	39.2246	6.3789
131	33.9372	80.6794	5.3146
132	73.7536	47.9707	9.0869
133	40.6698	57.4196	9.4124
134	5.0236	40.8764	8.3610
135	50.1057	93.7172	7.3802
136	49.5534	33.2394	7.6890
137	72.8798	17.3133	9.0974
138	68.7816	5.0080	1.5872
139	27.0168	88.3460	4.0232
140	70.9288	51.9753	1.0390
141	30.5717	94.9801	8.4529
142	20.1278	76.7067	5.5669
143	33.4082	2.7198	4.2955
144	54.6521	8.8647	3.0398
145	96.2750	8.0197	5.8135
146	51.5600	79.1613	3.6054
147	73.3446	24.5464	1.6153
148	70.6524	62.0514	1.7647

Continued on next page

Table B.28 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
149	89.0745	40.7637	1.6151
150	23.4481	43.8167	4.6883
151	52.9067	3.3222	2.1104
152	79.3450	56.2426	4.9871
153	2.5190	90.6573	9.0905
154	14.9375	71.2760	4.1828
155	97.3608	32.5911	2.0816
156	9.5061	68.6444	6.1220
157	75.4307	60.8648	8.8753
158	72.2382	84.5703	4.1372
159	81.5137	51.5252	1.3773
160	97.3707	22.7095	2.2811
161	16.4119	0.7236	1.6893
162	21.7680	34.6486	7.6647
163	15.1729	16.5658	5.1087
164	4.1410	8.0079	7.0142
165	88.2381	83.2683	7.2932
166	15.4246	97.3957	6.1422
167	51.8210	67.8655	6.6582
168	97.9325	31.5769	8.8999
169	17.1000	52.7683	6.9612
170	17.3423	33.9339	8.8787
171	23.0803	40.6514	5.2077
172	71.5006	53.6792	2.2720
173	17.2084	75.7755	1.6132
174	79.3838	96.0459	7.4282
175	39.3794	22.1355	3.7719
176	98.9994	63.0437	7.0405
177	34.5886	84.4377	6.8718
178	57.5531	2.8326	5.7794
179	41.4077	71.4274	7.4360
180	86.0199	4.3968	5.5433
181	75.2088	85.0030	5.3920
182	55.3456	62.0369	5.4805
183	83.0181	25.5402	9.4238
184	2.2514	44.7884	4.5035
185	51.6314	17.9253	2.0543
186	54.2119	35.2360	3.1638
187	86.1579	7.8450	7.1642
188	77.9652	11.2370	8.5533
189	86.4454	21.9861	9.7313

Continued on next page

Table B.28 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
190	29.6715	81.9656	2.9365
191	91.4258	5.3710	7.8431
192	7.3030	28.2665	6.2569
193	36.0603	33.5689	4.6266
194	83.5813	72.9290	5.5904
195	39.3918	69.7007	5.4608
196	31.1664	40.7809	6.8623
197	51.4351	60.1450	7.6934
198	10.8848	31.1384	3.7176
199	60.4039	63.8843	1.8065
200	61.7219	62.2465	8.4337

Table B.29: Depot locations and number of vehicles for MS15

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	82.7138	46.0477	1
2	62.3415	2.4759	1
3	69.7335	36.2333	1
4	85.4939	74.6624	1
5	67.5608	20.6114	1
6	72.2931	92.8864	1
7	92.9658	37.0591	1
8	1.6773	90.2385	1
9	60.9782	1.0761	1
10	40.5933	66.9059	1
11	1.3957	22.3919	1
12	12.5167	40.1077	1
13	4.4000	16.5540	1
14	90.8243	26.1612	1
15	4.9054	22.6277	1

Table B.30: Customer locations and service time for MS15

Customer index	x-coordinate	y-coordinate	Service time (short)
1	52.6191	41.9685	4.5063
2	45.4754	94.4392	7.9777
3	74.5108	21.1852	2.6143
4	43.7398	97.2133	1.9843
5	54.8130	23.5469	9.1464
6	9.3981	93.4518	8.8872
7	30.4627	88.1543	9.9981
8	21.3497	90.3259	8.7783
9	50.6712	70.8485	1.3319
10	20.4348	62.6591	5.9021
11	72.6632	27.3688	9.9785
12	29.3073	59.1189	5.5991
13	35.1586	16.9864	8.8616
14	79.7836	71.3801	1.6320
15	17.5590	51.5580	9.8878
16	73.1566	63.5009	9.3044
17	24.2365	83.7488	6.0783
18	35.9603	41.9824	4.8832
19	80.6551	63.5321	4.0406
20	3.8360	57.0699	7.4865

Continued on next page

Table B.30 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
21	70.6084	51.0100	1.1229
22	92.5684	32.9466	4.3665
23	95.7143	52.3347	9.3042
24	85.5912	53.1489	5.9183
25	79.8043	93.4029	5.2650
26	16.4660	5.4815	5.4688
27	0.9393	70.1807	3.7807
28	8.6167	50.2172	9.5575
29	33.4376	55.2349	9.8379
30	95.1178	24.3973	5.6221
31	2.2754	5.1771	9.9333
32	77.4854	10.6673	5.1026
33	39.1151	11.4094	4.8344
34	73.3815	53.9032	2.9189
35	48.6522	13.1238	2.7392
36	10.1803	67.6535	8.4948
37	24.9967	65.3466	7.5397
38	35.8891	71.8359	5.7677
39	88.7415	91.6172	8.4617
40	39.2293	23.4555	5.6069
41	67.4695	50.8875	5.9677
42	27.7345	40.0228	2.9196
43	84.3636	54.1670	6.2904
44	47.7457	82.3342	2.2849
45	89.7487	52.6801	1.4700
46	46.6371	17.2711	7.1498
47	11.2998	55.9483	6.4770
48	91.1164	70.0526	2.9769
49	76.6736	15.8703	4.6565
50	13.2314	43.3857	6.6692
51	85.0772	83.2705	5.9978
52	72.2032	56.0467	2.1482
53	50.6660	61.4987	2.5228
54	65.5667	46.0642	1.0090
55	89.1753	45.4488	4.7635
56	88.8252	22.9161	5.3964
57	77.7470	17.9931	2.4388
58	41.9711	7.3758	7.0015
59	56.0199	2.2425	1.1613
60	70.0990	13.2425	2.0771
61	14.0448	72.7218	9.5691

Continued on next page

Table B.30 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
62	76.5040	43.2792	9.7827
63	44.8577	71.0036	1.2782
64	63.4764	1.6535	5.4449
65	39.8621	64.9684	8.7645
66	70.0038	57.5809	3.1859
67	78.3498	13.9306	8.5084
68	49.6652	63.9250	8.3223
69	79.8168	40.5893	6.6608
70	14.6513	7.3171	1.0201
71	97.2576	89.6088	4.4175
72	21.6487	43.0584	9.1397
73	50.5662	94.3031	7.1232
74	31.1862	30.3139	4.4094
75	40.2148	72.4127	6.6876
76	7.8520	82.4206	3.1894
77	28.1037	54.1722	6.1427
78	84.8573	67.3412	9.8356
79	83.2829	46.1439	8.6471
80	21.3707	9.4002	3.5510
81	30.5034	51.4731	7.1421
82	5.9127	52.5096	4.2231
83	49.6670	61.6561	9.8823
84	9.4147	50.8664	1.7559
85	28.8266	62.6359	3.2528
86	52.0959	24.2776	8.3021
87	24.6714	21.3666	1.7598
88	52.4989	93.2445	5.7813
89	0.0216	71.4865	8.2056
90	60.6740	87.9242	7.6494
91	42.6572	5.5312	2.2750
92	32.6130	45.9128	4.9410
93	45.8415	68.8961	4.1534
94	89.0975	8.0184	5.3065
95	14.0619	23.7447	6.2866
96	5.5848	7.3990	2.3123
97	89.4689	2.4026	9.1480
98	83.0803	19.4479	6.7617
99	12.9668	61.3517	2.4665
100	30.3434	50.0500	6.0932
101	95.7392	36.2198	9.3845
102	5.1894	34.9276	8.0479

Continued on next page

Table B.30 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
103	77.4386	93.1591	7.1712
104	50.3188	87.5076	5.1960
105	22.9283	65.3519	3.3429
106	0.8506	88.7309	6.1234
107	74.6547	27.5570	3.2389
108	69.7549	81.2539	3.8737
109	0.3831	92.7308	9.1972
110	66.0206	46.8375	8.9670
111	3.1405	85.0647	8.1513
112	39.8171	97.8265	9.3323
113	21.8759	53.7081	2.6096
114	82.1511	21.8348	5.6579
115	86.4652	26.7599	6.6430
116	66.0394	90.0181	9.2186
117	9.9822	10.9677	6.9757
118	88.3171	71.0194	4.5027
119	85.9947	76.5775	7.6601
120	8.7871	0.6287	8.3587
121	3.8823	84.5070	6.4031
122	29.0958	0.2111	1.7650
123	94.3212	66.1206	9.3012
124	40.6678	60.7921	1.4824
125	37.3480	22.3083	5.7432
126	68.9022	33.5125	2.0697
127	39.7022	18.4480	4.4213
128	32.3493	36.0395	8.3155
129	73.0854	48.2812	3.1969
130	23.1858	67.5851	8.9598
131	26.8343	75.5826	7.4138
132	82.3748	37.4737	4.4033
133	28.9639	91.2783	3.2403
134	78.6753	23.1210	3.2757
135	60.5930	3.5129	7.9052
136	72.4255	19.1041	1.4488
137	49.9148	10.6091	7.1676
138	17.8161	33.5842	6.5825
139	80.7403	76.5902	7.7202
140	4.0684	83.4964	9.7953
141	29.9519	71.3710	4.4552
142	71.8089	74.4422	3.3419
143	64.8999	13.8708	8.8972

Continued on next page

Table B.30 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
144	59.5550	40.8846	8.2549
145	93.6151	88.7777	5.1501
146	56.4706	15.4694	1.8187
147	48.5860	54.5062	6.0784
148	60.0572	60.8617	2.6864
149	77.1968	46.1180	5.7852
150	15.6894	8.6627	4.1953
151	73.6769	54.0661	3.8331
152	85.0173	6.5706	7.5407
153	94.4269	50.7296	5.6420
154	99.0855	95.8065	8.1158
155	39.0393	91.1629	2.8404
156	41.9616	27.5429	7.1030
157	75.9690	12.0248	1.4724
158	67.0435	11.7439	8.2106
159	40.4143	40.4541	7.1071
160	88.6360	99.7240	9.5141
161	6.1133	22.7405	1.8240
162	1.8487	29.7179	9.1759
163	47.5989	24.5366	5.5896
164	39.2928	99.8526	6.5341
165	62.6853	19.6622	3.8446
166	47.1226	62.8252	1.6974
167	22.1875	72.8184	8.6555
168	77.1351	34.9442	2.3007
169	73.3761	62.7602	4.3344
170	82.0011	5.3531	6.6015
171	29.0746	78.0673	9.9780
172	21.2930	23.3376	5.6561
173	33.7055	32.4291	9.9146
174	51.0144	42.2676	3.0388
175	20.0273	42.8808	4.5820
176	35.0940	16.7854	7.2691
177	41.7122	96.6105	1.5818
178	21.2701	73.7416	7.7290
179	96.0120	15.8647	4.7836
180	25.3234	75.2734	8.3019
181	60.2012	9.2748	4.4164
182	5.8580	64.8614	3.8716
183	49.4950	22.7149	9.8745
184	80.6352	43.6651	7.4636

Continued on next page

Table B.30 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
185	38.8180	39.5433	4.7187
186	60.6827	6.6797	1.8877
187	79.1451	50.8395	7.6110
188	74.9905	72.0357	6.7358
189	56.8547	92.9759	1.6646
190	49.4238	63.7829	2.0846
191	51.7639	11.2372	9.8344
192	87.3649	93.6142	5.4712
193	92.5130	62.0842	1.2017
194	29.1919	79.4782	1.4845
195	71.6016	94.5143	2.2679
196	70.4746	43.4996	9.0413
197	32.0214	20.2160	5.1924
198	31.8399	94.8296	6.0477
199	35.9972	25.2442	5.4501
200	54.1179	0.1149	1.6101

Table B.31: Depot locations and number of vehicles for MS16

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	30.5941	53.0751	1
2	71.2459	75.9094	1
3	49.7526	30.0855	1
4	6.4983	56.9495	1
5	8.5534	0.6741	1
6	23.0418	72.7248	1
7	86.8254	98.0680	1
8	15.3820	92.0042	1
9	92.9129	43.1917	1
10	33.9653	46.9081	1
11	4.1665	31.9300	1
12	5.1632	3.3848	1
13	68.2048	78.9141	1
14	89.3803	93.3408	1
15	90.3510	8.5425	1
16	6.9326	91.7872	1
17	78.5355	47.5713	1
18	23.3435	77.3246	1
19	33.8876	78.3497	1
20	77.7837	3.7876	1

Table B.32: Customer locations and service time for MS16

Customer index	x-coordinate	y-coordinate	Service time (short)
1	83.6273	13.4138	9.0788
2	25.3914	32.1400	3.5971
3	78.0193	64.2589	3.4214
4	81.2506	67.3135	6.3477
5	98.5365	65.5603	5.2829
6	72.4040	24.7084	4.3148
7	22.9113	12.4256	6.9005
8	15.9973	93.2218	9.4438
9	63.3852	69.6086	6.5838
10	82.0131	95.3983	3.5456
11	82.0259	61.3463	2.8466
12	71.9662	72.6297	4.9522
13	77.2423	47.2813	1.2453
14	6.8482	81.6732	8.8857
15	69.1949	72.7783	6.4908

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
16	88.8836	27.0925	2.8323
17	75.9363	35.2158	5.6793
18	97.2073	13.9324	1.4844
19	37.1875	63.0829	8.7597
20	5.8579	56.7421	4.9864
21	72.1451	7.6372	5.9321
22	46.3058	87.1420	6.1017
23	11.0376	27.4157	7.1236
24	28.6049	59.1674	4.3424
25	47.4359	22.9871	1.7041
26	50.6120	15.0409	5.1072
27	52.4789	20.9920	1.4306
28	64.2384	56.4531	7.6443
29	58.3572	11.1331	1.3420
30	85.0996	44.6561	9.5882
31	85.4822	17.7285	7.6814
32	61.7680	70.5119	9.4370
33	68.3814	35.3039	5.6203
34	52.4318	89.1144	3.1681
35	49.6775	51.9680	3.3397
36	35.8253	60.1015	7.8308
37	28.5674	87.8569	9.9401
38	78.8281	24.4384	4.2104
39	27.8982	1.2551	7.7757
40	3.3948	96.1300	1.9904
41	15.1250	36.3034	6.3734
42	5.9394	55.7092	4.8754
43	88.4695	67.5221	7.5765
44	65.2163	4.9816	3.3506
45	30.4307	21.6877	1.8533
46	12.3870	67.7737	5.0587
47	93.8755	59.6624	6.7607
48	99.2395	14.8774	2.1883
49	20.1747	55.9261	5.0754
50	57.6672	73.0361	6.8698
51	74.8502	36.1978	8.4430
52	52.7801	93.4878	3.7727
53	75.2836	99.0340	4.6213
54	78.4849	71.9893	8.9581
55	17.9508	65.4987	7.3052
56	43.6256	56.2842	3.1769

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
57	33.1336	67.6886	7.8385
58	67.9275	48.8686	3.6183
59	82.0844	27.7066	3.4969
60	81.1331	69.2565	1.0550
61	54.1045	65.8366	4.3724
62	68.4049	69.5436	4.9324
63	41.0557	5.3107	3.7387
64	35.5577	69.0316	3.6177
65	85.6898	71.4025	3.1826
66	4.0079	25.6822	9.4302
67	54.7535	47.2767	8.7417
68	26.2973	81.3231	4.5751
69	85.8985	75.3718	5.3148
70	14.5887	90.9521	6.0850
71	23.0548	78.2805	5.4066
72	92.3024	9.0596	3.4283
73	55.2752	73.1954	9.9077
74	76.9321	3.4239	2.6531
75	72.6873	76.9977	8.7549
76	43.7713	10.6540	1.2937
77	21.0285	24.1021	3.9876
78	52.1351	56.2473	7.7387
79	9.0336	91.5313	6.7993
80	88.9070	3.4448	2.5231
81	66.7487	19.5637	9.5698
82	66.6791	31.1933	5.8894
83	3.7761	89.2717	3.2627
84	71.9952	90.4974	6.2072
85	81.1435	76.9257	9.2393
86	72.4261	70.2054	9.0604
87	21.5199	37.9402	5.3426
88	78.0268	49.6084	4.9847
89	45.1968	74.0316	3.8058
90	90.1915	28.1185	1.4978
91	41.8902	2.7138	7.7841
92	38.2491	96.4877	2.1875
93	7.2397	60.4587	4.2033
94	33.4091	56.1719	4.5628
95	68.7402	49.8904	8.9697
96	85.2551	18.7859	1.1912
97	50.7309	48.6177	8.5967

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
98	42.3945	6.5442	3.5926
99	62.9568	34.1208	3.2531
100	28.9318	60.7920	5.3954
101	33.6669	27.5734	7.5613
102	51.6900	90.0075	2.8235
103	70.5938	22.0113	2.9465
104	28.9810	62.9220	9.7870
105	16.4195	71.4924	6.3391
106	35.5511	62.0014	3.7396
107	10.1090	0.0441	9.7093
108	47.1034	18.1602	9.0637
109	28.4684	64.2044	2.7102
110	76.8534	84.3855	1.0162
111	3.5429	12.4015	7.4059
112	52.3437	64.7618	8.8095
113	6.4394	13.0585	2.0648
114	38.7566	30.1491	1.3512
115	37.6659	82.6570	6.3838
116	52.3649	98.6209	6.4388
117	74.8536	47.7087	5.6479
118	30.4541	79.6311	1.0676
119	62.2527	62.8181	7.2004
120	78.3454	91.7540	9.5142
121	51.0584	36.4480	8.8618
122	23.8503	67.0573	2.0195
123	96.8738	44.6289	4.1911
124	5.3979	77.7150	3.1774
125	77.1972	40.4756	6.0430
126	95.4528	31.1688	6.5145
127	56.2504	17.1436	3.7073
128	70.2530	66.6227	8.1833
129	59.0035	72.9626	8.1608
130	32.9469	48.8609	8.0298
131	58.0126	39.7254	4.1599
132	45.6109	69.8326	1.4887
133	26.6090	52.0006	7.3783
134	88.2168	61.8112	9.9364
135	46.5590	34.4391	2.4623
136	34.1952	51.6429	2.0221
137	86.3692	17.1102	9.2159
138	68.4147	49.7452	5.3349

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
139	32.1115	87.2089	8.6663
140	4.1623	84.9397	8.2892
141	9.4374	68.3027	2.6808
142	14.2798	76.9184	3.2248
143	7.6083	24.9397	1.4877
144	99.6860	27.9478	6.4807
145	99.8070	89.5055	7.9951
146	9.7580	74.9350	5.5996
147	29.5423	94.3449	1.2498
148	7.4823	37.6382	9.9135
149	72.2519	82.7073	5.5085
150	84.5874	19.5925	3.9880
151	41.8889	65.3375	2.5649
152	42.0836	21.0795	6.6307
153	96.1056	74.9380	6.1762
154	4.7442	76.3263	7.7589
155	86.3227	73.6764	2.3817
156	30.4649	22.8298	4.2111
157	13.1091	47.4383	2.2956
158	34.5838	61.8314	8.6555
159	28.9813	23.2079	4.0408
160	99.1615	22.3869	3.4768
161	40.5411	98.9728	1.0541
162	82.7164	32.3630	8.2172
163	55.5244	7.9538	5.4767
164	72.1747	2.7638	5.8406
165	21.7502	42.7484	8.8382
166	67.1286	7.3023	7.5056
167	9.5841	78.9739	7.0128
168	14.2781	41.3731	2.6095
169	46.8255	17.1118	5.9545
170	12.9453	35.6296	9.6389
171	66.5920	54.0189	6.3642
172	24.1543	34.9451	8.2771
173	78.6979	57.4980	9.8608
174	66.0186	23.5142	8.9733
175	84.0606	51.0532	2.9245
176	89.0851	93.3506	1.3117
177	43.5979	42.3752	5.0601
178	79.8357	18.5118	1.1242
179	35.8177	32.5795	5.2634

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
180	29.0567	54.0114	9.5608
181	13.2049	55.6515	3.2406
182	29.6228	60.0637	4.4778
183	13.4185	5.0335	4.8829
184	66.3954	92.7492	8.4780
185	64.8759	52.1568	8.4218
186	38.1936	59.3168	5.0770
187	82.4117	4.8602	4.4250
188	40.7519	31.8646	9.3328
189	40.7603	31.2755	7.6676
190	84.3031	48.8249	7.6387
191	67.6528	40.6287	9.5222
192	23.7067	15.3257	5.5909
193	13.6666	87.4145	8.1269
194	36.9112	89.0138	5.0696
195	61.2510	46.4154	8.6428
196	46.5676	55.5598	4.5139
197	10.4211	68.6089	7.6454
198	55.3354	81.3035	9.7879
199	75.1216	87.6230	5.7097
200	20.9624	54.6080	4.8692
201	72.5237	23.4034	2.8644
202	88.7311	43.9713	3.9106
203	31.7848	21.1602	1.9978
204	23.8851	31.7062	4.3769
205	5.3005	69.8511	3.9691
206	28.3050	0.4145	4.0789
207	96.1946	11.1278	8.3541
208	59.5213	25.6654	5.7852
209	12.5944	50.5640	5.6901
210	33.7481	35.2143	7.9688
211	43.6707	82.0170	2.0824
212	46.4840	3.5376	6.6291
213	19.8928	55.2643	4.1198
214	31.2437	99.6854	4.0116
215	61.4243	28.6419	6.1715
216	84.2377	34.3819	8.7754
217	34.4674	24.5274	2.7871
218	65.0229	22.1678	7.0521
219	82.6152	58.6575	9.1165
220	63.9230	60.2019	2.7924

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
221	27.9889	28.4304	3.6846
222	68.1264	96.4126	5.4687
223	67.0078	58.8176	9.0091
224	64.5547	43.1629	5.5127
225	80.6805	25.8366	3.4930
226	7.1452	54.1601	5.8056
227	60.5724	82.1745	6.1682
228	30.7538	1.8671	4.7152
229	69.9887	0.0693	1.1329
230	21.0559	95.1881	7.3249
231	17.1636	78.8707	5.5607
232	4.1477	6.7218	4.4314
233	23.4573	58.9159	1.5844
234	62.1966	93.4178	4.2272
235	99.4877	72.9679	3.1083
236	47.7832	11.3415	2.8315
237	94.5501	54.7822	8.3240
238	29.8136	37.1847	4.5409
239	37.3291	0.6609	1.4822
240	28.0092	65.8637	4.3755
241	22.6651	72.8266	7.9749
242	10.9719	82.9271	2.4877
243	52.6815	5.5271	9.2100
244	68.5546	12.3668	3.8729
245	86.3801	42.7940	3.9680
246	3.2580	48.3365	2.8381
247	32.0232	68.9513	7.9049
248	15.2189	43.8155	1.6298
249	36.2978	16.3159	9.5503
250	30.8702	13.2865	2.4239
251	13.8538	0.2071	3.5780
252	51.8378	71.9086	7.1842
253	70.3343	36.6122	2.2703
254	40.9914	14.5009	5.6088
255	97.6691	67.1912	7.4919
256	72.3245	7.9443	9.3596
257	59.3197	89.3727	7.5889
258	36.1890	42.7059	7.7486
259	41.4369	57.9219	4.6659
260	80.3465	80.6668	3.1554
261	70.7753	55.5773	5.6877

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
262	21.9454	14.3563	2.9717
263	99.6323	15.9648	8.5815
264	82.4775	64.9636	6.9664
265	92.9664	76.1384	8.3461
266	50.8914	89.1876	8.1449
267	53.7478	90.2929	5.2219
268	47.9874	74.5592	3.7857
269	31.7078	4.7780	7.1882
270	99.3214	19.0511	9.8817
271	96.8150	84.6854	7.9294
272	81.4333	26.5603	8.4662
273	38.2692	44.4779	7.3548
274	9.0227	18.4100	6.3580
275	13.5141	74.8350	7.7759
276	45.5964	26.1417	5.4705
277	49.9855	3.0949	8.7862
278	35.6861	25.8744	1.6122
279	82.7003	97.4909	9.7169
280	56.9921	62.2335	1.8888
281	58.5904	11.4813	5.9228
282	35.3933	68.1641	4.6267
283	69.6625	4.8603	1.9634
284	15.5309	57.5336	7.5175
285	96.1699	68.6401	6.5231
286	19.8193	83.7089	8.0467
287	79.0636	60.1657	6.0996
288	87.9582	71.5423	8.3019
289	53.4913	33.5876	6.1910
290	28.1810	24.3498	9.4963
291	7.8989	4.8129	8.8431
292	99.0843	92.7817	5.5684
293	30.5336	14.6126	8.0994
294	20.0885	23.9020	5.2573
295	28.8278	27.6707	8.4592
296	28.2919	91.4633	3.9023
297	37.8837	87.0358	9.7853
298	27.5112	24.9717	3.5039
299	52.4671	58.5451	1.6555
300	78.9537	68.9615	7.7610
301	59.2400	14.2448	8.4807
302	46.1638	9.4883	9.3010

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
303	3.9206	21.5729	3.9432
304	48.2431	87.4577	8.2366
305	51.1400	49.8845	5.8443
306	48.5021	13.4619	5.1697
307	60.1092	58.3302	8.3868
308	30.3268	59.5625	9.5672
309	70.6812	21.8147	1.6865
310	40.6076	52.0709	7.3780
311	2.5503	35.0184	3.1143
312	82.4370	36.1829	4.5901
313	75.6241	20.0929	3.4131
314	87.8341	49.8174	8.4926
315	22.2303	78.5249	9.9584
316	17.3134	37.9571	6.8478
317	21.5612	93.2677	7.3356
318	89.0336	57.2262	9.3907
319	80.7219	64.1863	7.1889
320	32.2264	37.8729	6.1152
321	70.8655	93.2131	4.4276
322	48.7394	62.2542	6.7112
323	9.9905	44.9324	4.2691
324	64.4508	71.9840	4.6686
325	91.2805	86.6334	4.3183
326	22.9310	63.7123	5.2156
327	59.9455	20.4294	5.5307
328	5.6518	46.7243	9.1948
329	1.8068	95.7587	2.8579
330	55.4073	36.8310	4.0474
331	60.2711	28.2750	6.1671
332	58.3277	26.7562	5.3824
333	85.7517	6.3572	3.3600
334	71.8649	38.9343	6.2163
335	86.4947	10.9066	8.9049
336	0.4961	75.3147	1.5486
337	67.2604	50.5242	4.9679
338	77.2338	91.9815	1.7583
339	68.7893	17.2141	6.0691
340	41.1953	88.1958	5.8538
341	5.3899	0.7962	7.9125
342	37.7046	26.7336	3.0978
343	22.3171	46.2730	6.2863

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
344	10.3852	16.0249	5.1308
345	44.5516	71.1385	8.7488
346	73.6901	65.3564	6.9475
347	65.3271	76.6332	4.1849
348	70.3674	54.9928	4.1247
349	87.2967	68.1229	3.2835
350	36.9236	22.7567	9.5728
351	19.3340	62.8886	3.6838
352	50.5989	94.3380	2.4257
353	53.2623	47.0560	4.2517
354	73.1320	49.4925	7.6747
355	34.8167	86.6775	7.3531
356	72.5305	0.5953	7.3080
357	81.0881	60.0507	1.0560
358	27.5374	27.3986	4.3691
359	27.0413	16.1304	9.1135
360	33.1666	59.8931	3.8651
361	9.9130	71.5914	6.3737
362	50.2947	83.0994	3.6802
363	75.7520	96.5808	2.1251
364	14.5749	95.9650	4.4952
365	65.9084	6.4964	8.3592
366	90.6467	33.8136	9.8306
367	59.7386	60.9382	8.7579
368	23.3337	19.1122	1.7544
369	73.0851	25.7067	4.0394
370	85.0063	92.5547	3.1252
371	36.6237	84.3547	3.8602
372	21.9630	74.4138	9.8600
373	11.6501	57.5202	5.9343
374	55.4393	68.7866	7.7433
375	42.4683	91.1837	8.5767
376	44.5172	92.9185	2.5020
377	33.0563	4.4128	9.1279
378	23.7857	81.5201	1.9461
379	85.6897	40.5950	7.7058
380	35.8244	90.0965	7.5643
381	9.0875	96.2033	7.4572
382	88.8327	60.0698	2.2009
383	26.2022	60.5780	5.0121
384	66.0621	31.5406	5.5791

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
385	47.3200	89.2316	5.7744
386	37.1157	36.0147	8.7375
387	63.1419	86.2332	7.0995
388	70.8833	44.7124	8.2525
389	84.4786	20.0179	5.7812
390	2.9731	30.7646	9.6031
391	83.5732	0.0635	1.6001
392	11.0115	57.8047	5.8737
393	25.0147	10.5918	3.5349
394	90.1421	94.5503	5.3281
395	42.2903	94.1672	7.1638
396	46.6450	83.4614	2.8743
397	2.7744	83.9566	6.4734
398	99.9635	66.3509	3.9356
399	87.1309	14.3425	8.9276
400	12.4625	81.2300	2.2006
401	69.6480	68.0498	1.9217
402	85.6216	60.1203	9.6321
403	94.8601	2.4498	2.3761
404	13.8291	36.1770	2.3728
405	75.8103	82.6972	2.4000
406	73.3446	39.8728	1.8061
407	22.2534	76.2698	5.0898
408	27.2640	9.4955	7.0201
409	90.0841	48.2271	8.4817
410	4.9400	30.0808	8.1121
411	46.7135	84.1755	7.4144
412	72.6552	94.8797	5.2534
413	72.5001	25.6608	7.3773
414	70.0004	5.6050	9.6225
415	27.4118	20.4262	5.5520
416	99.8883	18.4695	3.7455
417	41.8041	27.5795	8.1083
418	7.6958	58.5219	3.1275
419	50.9499	70.5852	3.1087
420	79.2801	22.9321	5.1823
421	87.1855	44.5900	6.5745
422	31.5241	72.3181	6.5380
423	38.4946	52.4527	2.1036
424	93.1367	39.9355	2.1141
425	6.4939	66.9043	3.5601

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
426	58.6540	41.0171	7.6216
427	85.7887	56.2696	4.7018
428	48.5789	42.5327	8.4608
429	87.3613	58.1622	9.4160
430	5.9912	38.0970	4.5916
431	28.0485	97.4925	1.4699
432	11.0064	8.1281	6.1407
433	14.5471	71.3322	7.7290
434	60.9363	18.2524	3.8822
435	47.8568	51.2964	5.4364
436	86.3848	63.8632	2.9949
437	34.0932	32.1014	9.4535
438	79.8495	15.0627	5.3407
439	77.4927	85.5940	5.8600
440	46.0189	85.4591	2.9895
441	36.8783	70.8467	1.8635
442	30.4860	37.8482	1.5415
443	85.0130	9.8284	8.3756
444	4.0364	38.3813	7.9433
445	30.1841	12.5245	2.7613
446	83.1498	22.1172	9.0561
447	2.7342	65.1652	7.1587
448	2.7634	28.4505	6.9116
449	1.5746	49.0644	9.9134
450	23.0410	44.3664	1.3032
451	12.6614	81.9575	4.8183
452	7.2701	19.8952	5.4099
453	48.7939	5.4821	6.2515
454	13.6214	32.0200	1.7494
455	28.1430	54.5708	6.9414
456	55.2356	19.4002	1.4707
457	12.1351	2.7756	6.0115
458	21.1733	40.9677	7.4082
459	24.7317	1.8912	5.3912
460	91.3518	53.6560	6.5584
461	65.1253	7.1775	2.9240
462	87.0338	54.6654	6.8109
463	93.8043	14.6098	4.4258
464	8.8729	24.6039	1.9334
465	32.5083	19.5743	4.3976
466	90.9627	98.7790	3.3657

Continued on next page

Table B.32 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
467	45.4574	21.4868	3.1716
468	2.1161	36.8042	6.6063
469	98.7262	96.0385	5.7063
470	11.0076	17.6528	4.7191
471	47.4674	23.5248	2.9601
472	62.0475	85.0245	8.7270
473	40.1033	76.5287	8.7491
474	60.9001	36.6935	3.5555
475	95.1030	86.8446	6.5385
476	3.8282	89.5959	8.0154
477	42.4845	82.9588	9.5936
478	19.5832	75.1997	9.2764
479	33.2656	71.5682	4.4633
480	54.1069	19.3536	2.4638
481	52.3277	59.1760	8.1708
482	85.8211	38.8465	2.0244
483	83.7580	4.6413	2.4294
484	58.4855	39.4074	4.2025
485	41.6375	76.9052	8.6298
486	42.4323	17.3147	6.2450
487	7.1230	71.3003	6.2756
488	89.0572	56.6626	9.3325
489	69.3810	66.0685	6.1757
490	6.5244	63.3813	1.0898
491	97.5718	3.4284	8.2844
492	87.2843	84.4262	6.4793
493	4.6176	85.6129	5.3192
494	43.5048	2.5544	3.4160
495	90.3892	30.2877	3.3229
496	8.5737	60.6761	5.3291
497	79.5302	89.2820	3.0461
498	45.9480	42.2346	1.4374
499	77.6448	15.9174	2.5232
500	84.5341	42.0531	3.3260

Table B.33: Depot locations and number of vehicles for MS17

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	40.0000	50.0000	2
2	60.0000	50.0000	2

Table B.34: Customer locations and service time for MS17

Customer index	x-coordinate	y-coordinate	Service time (short)
1	73.8564	69.4413	2.7812
2	51.5279	70.2137	6.4512
3	63.0879	58.0923	8.4133
4	47.1635	67.1003	8.2955
5	47.9687	64.5121	8.2201
6	58.6256	43.6374	7.3730
7	56.9470	57.1482	8.7344
8	35.9968	45.0145	8.0298
9	30.8413	35.0022	2.8342
10	36.2767	60.5791	9.9401
11	32.3028	51.1242	1.8426
12	50.7446	46.8813	6.8556
13	44.8594	54.8621	2.9366
14	45.3999	66.4616	3.1949
15	32.9880	56.5489	4.0572
16	59.7446	53.2425	2.7808
17	55.4926	54.6631	5.5615
18	48.8797	50.8537	9.5568
19	62.7648	37.0922	4.5515
20	39.0753	63.1130	6.2602
21	55.1838	73.4818	6.4588
22	54.3555	41.0984	7.4318
23	54.3657	82.1293	4.6138
24	40.8844	47.0625	8.7282
25	54.0855	45.9375	9.2844
26	43.5640	35.0400	7.7576
27	38.7944	36.7944	3.5703
28	34.9591	34.1171	8.1713
29	62.9727	55.8984	2.2849
30	39.4257	76.6171	5.5410
31	47.8386	58.7912	6.4962
32	34.8918	64.2367	7.3342
33	46.2859	72.3641	4.4501

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	9.5995	8.3411	7.5582
35	36.4130	47.2073	8.9856
36	32.1695	55.8836	1.5026
37	37.3194	61.9542	2.2439
38	47.3342	28.2525	8.7676
39	45.9332	33.2355	4.7957
40	74.3050	63.1781	4.7018
41	42.8528	48.0571	9.6323
42	46.8746	59.2182	7.7522
43	30.3836	33.9893	9.8290
44	44.0327	22.7700	3.1016
45	33.2753	62.6867	1.8660
46	50.3787	69.8885	4.4612
47	60.6636	77.2010	5.5025
48	55.0532	24.4635	6.1323
49	41.2422	27.7191	9.7897
50	29.6182	25.4359	5.4357
51	68.2502	49.3056	4.6079
52	75.6255	39.7415	9.9549
53	51.5063	71.9026	3.3490
54	37.6262	25.7489	6.9879
55	64.9721	20.9608	9.6783
56	42.5918	53.4217	7.0404
57	44.1274	69.8822	3.6926
58	61.0797	36.6196	5.7801
59	32.6848	28.9061	1.0132
60	25.5406	47.5111	8.9541
61	55.2585	22.7259	4.6395
62	55.0092	50.2891	3.7109
63	51.1893	63.8065	9.5552
64	56.2086	53.6290	5.1458
65	63.5280	18.1793	3.5888
66	62.1306	41.0530	1.7616
67	42.8929	44.9661	6.2396
68	60.1247	80.2264	2.3776
69	52.1656	65.2475	1.6578
70	43.6807	49.0487	6.2251
71	35.0837	71.8227	3.5831
72	58.0871	32.5877	4.2573
73	45.5797	44.1956	7.5234
74	50.5804	73.5427	8.7248

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	40.0882	75.0397	4.1312
76	30.6186	62.1729	9.6557
77	52.1448	58.1792	9.5821
78	49.2233	40.2312	2.8543
79	64.9878	62.4150	7.9142
80	60.0213	36.1974	6.5398
81	63.1663	59.5753	9.2703
82	40.6390	54.6974	6.4228
83	38.2959	68.9884	7.3192
84	34.1364	42.9022	7.6931
85	56.2248	60.6023	4.4659
86	84.8635	63.2196	3.2635
87	59.0947	35.0270	1.3308
88	40.3367	52.6041	5.2491
89	60.4579	76.6209	6.8057
90	35.8959	51.8740	3.5107
91	32.1941	44.8563	5.6607
92	58.9680	57.6110	3.2110
93	40.2762	45.4150	3.6776
94	53.9498	57.3857	6.8543
95	67.5817	47.7539	9.0225
96	55.0141	49.6945	8.7500
97	61.6208	57.6798	2.8892
98	29.9275	72.7053	4.5918
99	58.2692	57.5312	8.9909
100	76.7313	77.4731	3.3088
101	56.7642	16.1940	9.7012
102	30.7390	42.5124	6.5724
103	47.4607	53.9332	2.4881
104	43.7504	36.0805	8.4358
105	54.7878	28.7341	6.9012
106	55.1504	60.2839	5.9181
107	55.0687	60.2117	3.2620
108	45.4527	54.8230	1.3614
109	42.5091	56.5886	3.1004
110	42.6301	35.4906	4.2500
111	60.6693	41.7052	6.7011
112	26.8374	48.2221	9.8749
113	47.4087	38.5362	2.8644
114	53.3797	55.5313	7.8138
115	41.8404	89.4204	8.9770

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	55.9653	41.9628	5.2501
117	49.1085	60.7908	2.4302
118	38.2712	32.7596	8.2983
119	52.0170	72.3259	5.2886
120	46.6477	33.8477	2.0466
121	44.8766	53.4786	8.8815
122	41.1085	39.6901	6.7167
123	50.7681	58.5336	1.8755
124	26.9234	50.1892	9.1760
125	45.0208	49.2669	1.3151
126	43.2056	99.1515	1.3577
127	38.6013	39.4992	9.8971
128	58.1587	49.2187	7.1756
129	40.8216	94.7171	4.3902
130	56.7579	30.8885	5.5389
131	62.1980	59.2166	7.8715
132	48.0391	32.0590	1.4399
133	53.4725	67.1773	7.5333
134	57.9940	55.4588	7.3120
135	48.9878	60.8687	5.1300
136	56.7609	45.3523	6.2407
137	34.2179	54.0865	4.0518
138	63.8803	74.5419	2.5356
139	37.6305	12.0816	4.5927
140	27.1396	22.7785	9.2780
141	67.3062	56.9245	3.0344
142	49.2159	39.0872	4.2491
143	55.6115	45.0609	3.9211
144	45.4593	25.0514	1.7522
145	37.2427	34.9194	5.6140
146	11.5876	43.2636	8.4958
147	57.8285	37.9034	9.1415
148	46.4164	35.5586	7.5124
149	47.5332	42.9692	4.4470
150	55.0701	34.2889	3.6822
151	32.2581	72.3647	7.2254
152	40.8819	33.5261	8.9241
153	64.3416	80.2990	9.3209
154	57.4733	43.7594	1.7313
155	33.9840	25.8043	5.3441
156	22.4592	39.6886	2.1544

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	42.8594	65.5750	3.2762
158	52.6750	67.5988	8.9557
159	61.7797	52.6705	2.7665
160	51.1716	54.7900	2.0922
161	35.9711	60.5484	5.8933
162	53.8270	25.6826	3.8316
163	35.3458	40.3048	4.4384
164	37.9879	19.4975	8.1239
165	41.8283	42.5149	8.5526
166	34.6326	65.8212	7.1221
167	46.6129	61.9574	4.7523
168	38.7506	88.1305	6.7860
169	46.4289	52.7788	2.9267
170	44.2197	14.0585	6.5554
171	44.8777	78.1567	7.0767
172	43.7058	71.3713	6.4092
173	65.4162	40.2895	4.1168
174	57.6288	53.7102	4.2796
175	50.7384	62.9909	2.5433
176	31.6632	56.4118	8.1583
177	29.6775	61.6061	5.4340
178	25.4406	48.1214	4.1916
179	82.5649	49.3529	7.9756
180	62.1547	51.4681	3.1312
181	53.2123	36.8391	8.6035
182	37.8220	73.7160	8.3487
183	35.6704	50.1055	8.6161
184	56.8455	61.4413	4.3317
185	69.5635	35.7511	4.4491
186	28.8332	32.0794	8.7520
187	44.3825	48.4839	5.1752
188	48.9463	45.7871	6.1349
189	25.1000	69.9137	7.2578
190	60.5156	60.1011	9.6483
191	44.8168	59.0086	5.9168
192	73.9023	25.9177	6.7292
193	45.1138	33.8718	6.1380
194	55.1148	53.3675	9.3440
195	35.7196	44.2020	8.7739
196	42.1892	71.5015	2.5286
197	35.3910	72.3526	2.6083

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	54.9072	40.3200	3.1915
199	66.2730	64.5856	7.7660
200	42.5795	73.2575	2.7922
201	55.4547	55.3498	9.8465
202	43.6955	77.0564	7.3867
203	51.2763	67.7072	2.5789
204	64.9531	53.5684	8.7247
205	51.5035	64.6134	9.1847
206	37.0395	53.2401	9.6550
207	39.2862	43.0851	6.1354
208	47.8766	55.9743	6.0659
209	47.6041	50.6037	2.5900
210	39.1773	43.9228	5.6231
211	52.2583	79.5170	5.9362
212	65.8316	53.6879	2.4875
213	46.8604	95.5063	5.4450
214	47.4429	45.0639	5.8161
215	22.4810	59.4049	2.7893
216	40.3186	76.3770	6.6085
217	32.5841	95.4872	1.2368
218	45.1721	55.0594	3.8691
219	56.5698	36.8290	5.7970
220	69.0409	63.3897	3.9410
221	72.4812	28.0016	6.4197
222	48.5389	45.4359	4.2574
223	45.9975	54.5311	2.2143
224	60.2190	74.8259	9.2243
225	56.1270	73.9524	6.7650
226	59.5656	49.5406	6.9290
227	59.7285	65.3989	7.0780
228	31.4962	44.6453	7.7010
229	56.7545	61.0187	8.5796
230	48.8558	81.9216	5.6499
231	40.4968	52.6127	2.3668
232	41.3301	44.9911	4.4260
233	66.0182	41.6661	8.3892
234	39.8783	61.9412	2.5423
235	34.5398	72.2881	3.9698
236	52.6836	85.4280	9.6982
237	75.1346	50.9008	8.2566
238	50.3194	52.7173	2.9997

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	53.8537	39.4549	9.9980
240	38.2719	76.8665	1.5736
241	70.9277	48.7425	4.8293
242	51.5624	42.1127	4.6390
243	56.6263	86.4040	4.6026
244	38.0991	63.4980	2.0073
245	60.6755	61.9390	4.8188
246	54.8643	33.2405	6.5219
247	35.5500	57.2331	9.8926
248	50.4968	58.6691	2.9791
249	44.3675	31.7959	4.1867
250	51.3656	46.2368	3.3962
251	46.8681	43.2513	3.6235
252	47.6262	58.7977	2.6955
253	37.0886	33.2173	1.2057
254	45.9589	68.1504	5.0446
255	59.5816	79.7479	3.1928
256	71.8084	44.9374	8.8185
257	35.4935	49.8551	5.7575
258	79.7176	58.4439	9.2272
259	69.0760	70.0542	9.7654
260	52.1063	58.7003	6.2688
261	46.2349	56.6174	2.0708
262	41.2668	41.9532	9.3388
263	60.4096	46.1417	6.3420
264	41.3174	60.2231	8.9525
265	44.2265	78.0475	4.8203
266	61.0452	59.4732	6.4653
267	55.4493	29.8995	1.6369
268	61.2093	57.2177	9.3230
269	56.3092	48.4647	6.7787
270	44.9888	45.9324	1.9405
271	43.5769	46.3469	7.3020
272	59.9546	35.3372	4.5622
273	41.6101	44.6533	1.7641
274	64.8332	36.9264	2.9303
275	59.8838	43.9173	3.2392
276	53.5965	51.9545	3.0399
277	50.0403	52.9057	7.3270
278	54.5702	46.4057	7.7874
279	94.0835	47.4565	5.9256

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	48.5945	50.5615	5.9814
281	30.5426	57.6380	6.6752
282	73.9388	71.3605	9.8691
283	57.6231	60.3348	6.7085
284	41.9011	45.2221	6.4041
285	82.7167	59.9669	9.1827
286	56.8869	45.9078	6.1375
287	53.6775	20.3210	4.0188
288	40.2770	10.8793	9.6143
289	36.6884	21.4401	4.9593
290	27.8948	46.0479	6.4139
291	44.7135	39.6729	7.4824
292	36.8362	37.9973	7.1090
293	58.0969	50.6776	2.9148
294	46.0296	39.0170	1.7346
295	72.1124	39.4914	3.4703
296	68.8823	60.1604	8.8077
297	52.0501	63.0389	6.0342
298	46.4655	90.6097	5.1816
299	64.4021	55.0401	4.8727
300	35.6687	50.9720	7.9659
301	58.4212	40.4311	6.8853
302	41.6361	46.7465	6.9196
303	44.9960	49.1578	2.4492
304	41.6025	20.7371	4.8914
305	57.1954	45.7107	5.5458
306	40.2738	62.4924	4.3780
307	36.7055	40.4873	5.3234
308	56.9122	58.2372	4.0818
309	44.7071	66.5240	7.9943
310	54.5198	67.9523	4.4555
311	45.6014	62.9474	7.4040
312	53.3693	12.3360	5.3284
313	17.9444	40.5937	7.5626
314	55.8233	65.0249	9.4380
315	73.1695	56.5779	5.6553
316	62.9911	50.0809	9.1276
317	61.3862	57.2820	2.9637
318	47.0034	68.8345	8.8590
319	52.2625	52.5628	1.7442
320	53.0531	37.3562	5.1886

Continued on next page

Table B.34 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
321	51.2049	46.9973	1.1974
322	39.6191	46.5368	8.2745
323	45.5968	64.9458	2.6129
324	47.8153	56.8718	2.4885
325	43.9918	59.1253	2.6344
326	60.4605	52.4639	7.2229
327	81.7294	43.9622	2.9239
328	33.4583	51.0190	3.6829
329	51.6043	53.6118	7.9150
330	31.9703	26.6980	5.5104
331	66.2814	52.9812	9.1852
332	67.6239	65.4597	1.5207
333	29.2182	48.1637	4.9308
334	74.2961	76.2066	6.1503
335	36.4413	59.3415	6.0856
336	52.8352	42.9943	8.4143
337	63.7366	47.4342	2.1349
338	51.8399	45.4134	3.7011
339	78.6958	54.0187	1.0191
340	84.4070	62.5781	9.5600
341	51.7290	45.1348	7.8967
342	26.1617	57.6408	7.7617
343	45.4376	79.2548	2.2498
344	39.3986	65.5248	4.1439
345	40.4406	63.7544	2.3621
346	35.9038	36.4199	5.4705
347	50.9774	41.0966	8.2779
348	76.3329	54.0425	6.6958
349	41.0519	48.3225	7.1956
350	46.4936	22.9159	6.7561

Table B.35: Depot locations and number of vehicles for MS18

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	20.0000	80.0000	1
2	80.0000	20.0000	3

Table B.36: Customer locations and service time for MS18

Customer index	x-coordinate	y-coordinate	Service time (short)
1	7.8069	12.7266	7.5639
2	66.9043	0.8648	8.7386
3	50.0211	72.7080	6.6426
4	21.7994	35.4116	2.6253
5	57.1616	78.0446	6.1598
6	12.2189	43.6657	2.4721
7	67.1166	43.6555	9.1545
8	59.9586	4.9213	1.6961
9	5.5976	4.9632	4.0468
10	5.6343	9.1100	6.2256
11	15.2501	59.4037	5.2771
12	1.9621	24.1084	8.2479
13	43.5176	84.1369	5.7770
14	83.2221	85.7213	3.0458
15	61.7390	96.3612	7.3854
16	52.0129	48.8900	2.3377
17	86.3868	22.0310	6.9230
18	9.7698	22.6209	6.7058
19	90.8052	53.6788	3.0638
20	10.8017	76.2110	2.6401
21	51.6997	34.7567	2.4972
22	14.3156	46.1232	2.3465
23	55.9371	63.9324	2.8247
24	0.4580	91.7336	9.5946
25	76.6682	16.1573	1.1432
26	84.8709	71.5635	9.6176
27	91.6821	57.7739	1.2312
28	98.6968	43.3299	9.7400
29	50.5133	88.4243	3.6784
30	27.1422	39.3052	5.7257
31	10.0751	17.8975	8.7611
32	50.7849	63.3334	9.0676
33	58.5609	62.4001	2.7011

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	76.2887	32.7942	6.9465
35	8.2963	80.2965	9.4711
36	66.1596	99.9478	9.7814
37	51.6979	98.0978	1.9714
38	17.1048	12.7037	2.6101
39	93.8558	23.2240	7.7190
40	59.0483	2.3632	1.4452
41	44.0635	60.7433	1.6416
42	94.1919	11.0809	5.4021
43	65.5914	40.7460	8.6490
44	45.1946	88.4077	9.9734
45	83.9697	54.8133	1.0395
46	53.2624	36.9003	5.8835
47	55.3887	20.8346	8.7521
48	68.0066	44.0943	9.1823
49	36.7190	95.6196	8.6082
50	23.9291	12.4026	8.9099
51	57.8923	47.0763	7.7156
52	86.6887	85.6896	2.0574
53	40.6777	4.3390	5.5812
54	11.2615	69.1625	2.5195
55	44.3846	97.8985	8.4800
56	30.0184	28.3268	9.3521
57	40.1387	13.3780	2.5254
58	83.3364	68.5280	8.9536
59	40.3629	90.9455	4.4908
60	39.0176	61.0869	4.4431
61	36.0449	89.9983	3.4431
62	14.0255	19.3434	8.8109
63	26.0130	75.4425	7.6735
64	8.6815	34.6261	5.0309
65	42.9397	41.8625	7.3867
66	25.7283	15.5720	9.4990
67	29.7555	81.9001	2.5671
68	42.4858	62.4924	3.2014
69	11.9207	73.8560	6.7684
70	49.5067	80.5112	8.2775
71	70.6407	6.7223	8.6803
72	24.3573	95.0790	4.5831
73	78.5070	49.7577	2.0394
74	7.4090	75.5146	1.7225

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	39.3883	74.2405	4.2442
76	0.3394	83.1130	8.4601
77	22.0677	15.6502	2.9315
78	0.1301	45.7309	8.1194
79	18.9180	61.8100	6.8922
80	14.2484	93.2183	1.2353
81	26.8076	83.5088	8.0720
82	17.4892	89.5424	9.3031
83	13.8649	58.2519	5.4308
84	59.8886	58.2747	8.5061
85	90.1058	85.4926	2.1822
86	93.9380	3.4866	7.8381
87	22.1184	88.5420	9.3316
88	48.2671	40.7731	8.4944
89	37.6011	3.6382	3.3346
90	52.3780	74.6148	2.9172
91	26.4873	15.4829	5.7008
92	6.8357	14.3908	4.5762
93	43.6327	60.5959	5.3120
94	17.3853	25.4481	9.9451
95	2.6107	32.4154	6.4403
96	95.4678	40.1791	9.5042
97	43.0597	40.6373	5.4140
98	96.1559	38.6191	4.9415
99	76.2414	60.9802	7.9539
100	0.7349	16.6891	7.6966
101	68.0039	18.8092	4.9861
102	70.5951	9.4629	1.4770
103	64.5129	32.3186	1.7904
104	55.2310	76.9597	8.1819
105	21.8109	23.4118	6.9002
106	77.2366	74.0365	1.2910
107	22.8028	69.2818	6.0136
108	37.0865	82.4078	7.4782
109	89.0929	82.7978	1.9937
110	85.6377	29.3368	2.9498
111	40.2434	30.9369	8.2992
112	31.8019	52.3030	2.2480
113	60.8635	32.5299	8.9371
114	91.0195	83.1843	9.3120
115	90.9098	81.0295	1.1148

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	59.1594	55.6998	4.3944
117	33.2571	26.2964	2.5103
118	85.3064	68.0566	5.8620
119	44.2398	23.3653	1.9150
120	90.4355	45.6425	1.3534
121	3.3179	38.4567	9.3991
122	53.2426	53.8601	9.7443
123	71.6497	99.1704	4.2484
124	17.9302	75.5220	6.7978
125	33.6533	98.0455	1.6115
126	18.7713	23.4783	2.8712
127	32.1927	52.8559	1.3564
128	40.3857	5.1436	5.2242
129	54.8566	75.6875	2.3509
130	4.8739	60.1980	9.9218
131	55.2732	85.7169	4.8436
132	27.4811	98.8277	9.5983
133	24.1502	92.9484	7.5182
134	24.3145	40.9515	6.2280
135	15.4159	0.0341	5.8623
136	95.6416	54.0878	7.3490
137	93.5661	20.7731	1.0453
138	81.8714	21.9284	8.0426
139	72.8262	32.5806	9.3417
140	17.5812	9.5949	1.0747
141	36.0371	74.7534	8.4217
142	18.8790	74.8509	7.9060
143	0.1198	54.3299	9.9742
144	31.6420	33.8132	3.0489
145	69.9617	83.2334	9.2759
146	62.5255	55.2572	6.7780
147	54.3062	95.7543	1.9479
148	43.9037	89.2833	3.4134
149	28.7427	35.6504	7.8746
150	50.1659	54.6402	8.2496
151	76.1546	34.6682	1.9383
152	76.2408	62.2803	5.2278
153	57.6056	79.6625	2.9716
154	74.7663	74.5875	9.3044
155	64.5535	12.5536	3.8829
156	12.3220	82.2394	8.7179

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	50.4398	2.5151	3.3386
158	34.7261	41.4429	8.9026
159	9.2148	73.1407	2.6944
160	14.7849	78.1374	7.8327
161	19.8170	36.7286	1.2852
162	67.2270	74.4868	6.7811
163	43.1511	89.2267	6.1018
164	69.4404	24.2603	4.3877
165	25.6785	12.9597	2.9129
166	0.9759	22.5068	8.1294
167	53.2283	35.0014	2.3090
168	27.9392	28.7085	5.4023
169	94.6230	92.7488	1.1156
170	90.6443	5.1314	2.6795
171	39.2685	59.2667	5.3671
172	2.4855	16.2899	8.5440
173	67.1437	83.8406	2.2695
174	83.7171	16.7561	7.5900
175	97.1500	50.2201	7.2196
176	5.6933	99.9329	1.3104
177	45.0324	35.5407	5.3997
178	58.2470	4.7078	9.7425
179	68.6638	21.3661	2.0121
180	71.9433	39.7839	7.6889
181	65.0041	33.3668	6.7469
182	72.6915	22.9603	6.3476
183	37.3848	93.6120	5.4876
184	58.1582	68.3189	6.1107
185	11.6119	96.2114	4.8385
186	5.7654	43.7973	1.6862
187	97.9765	94.0337	3.6153
188	28.4824	0.5834	6.0520
189	59.4974	61.0307	6.7000
190	96.2161	80.1076	9.3770
191	18.5778	23.2982	9.7999
192	19.3040	93.2469	1.8424
193	34.1644	76.3263	6.9556
194	93.2898	82.6450	6.4250
195	39.0668	57.3464	5.2644
196	27.3217	79.2582	4.2063
197	15.1947	32.9041	5.2802

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	39.7109	22.3462	7.0392
199	37.4722	31.2386	9.6368
200	13.1115	58.4523	1.8018
201	43.5041	82.9914	8.1797
202	9.1513	29.0462	6.3170
203	61.4627	40.2554	9.2098
204	1.0979	86.2057	1.9102
205	57.3260	61.4740	3.6397
206	78.9730	99.1188	1.4643
207	23.5367	20.3699	5.5372
208	44.8020	82.7209	7.9154
209	56.9358	67.5862	3.5469
210	6.1401	24.8949	3.0282
211	49.6289	47.5786	3.9816
212	64.2315	39.9075	5.0793
213	22.1266	59.9438	7.6365
214	83.7056	80.0523	5.5890
215	97.1075	10.5069	4.4426
216	84.6373	82.1442	9.1493
217	50.5999	84.1086	9.6873
218	27.8876	35.4506	6.6544
219	74.6617	43.0069	2.1883
220	23.6930	57.2239	6.5647
221	95.7345	70.0825	4.4472
222	62.0260	74.2470	9.9207
223	60.0262	75.7884	3.5814
224	17.2605	38.9129	7.3557
225	9.0347	42.9302	5.8169
226	25.5262	95.6345	2.7389
227	85.8571	57.2971	7.2049
228	91.1067	84.9722	1.4541
229	69.9634	27.6345	2.6599
230	72.5182	62.2324	1.4109
231	22.9886	58.8362	8.9654
232	57.6053	96.3468	8.5581
233	81.0628	8.5903	2.0634
234	40.3843	50.0499	4.6937
235	98.8439	52.1590	2.0821
236	8.9999	9.0166	6.1488
237	32.0941	90.4666	9.5445
238	51.1409	88.4389	3.3075

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	6.0606	43.8990	9.9088
240	72.5688	78.1723	4.1483
241	55.6556	14.8465	2.8767
242	52.9360	61.9816	6.9924
243	82.9982	26.0624	9.7601
244	85.8759	44.5656	6.6043
245	78.9029	84.4000	1.5718
246	31.7833	19.6205	4.3616
247	45.2207	30.3852	2.4963
248	75.2228	48.3295	3.0815
249	10.9862	33.7812	1.4699
250	10.9742	79.8486	9.1158
251	26.9884	98.7488	8.1396
252	52.4637	15.9048	4.3571
253	97.2651	23.6880	8.4885
254	71.0409	70.2237	7.7845
255	31.1860	37.5472	6.5968
256	29.1457	97.3705	4.5468
257	85.0357	97.2306	4.2335
258	91.1647	64.3698	1.7997
259	63.9276	86.0099	4.0751
260	25.5370	40.1883	5.9380
261	8.8666	63.1931	5.1449
262	83.8256	98.5237	6.8091
263	58.4719	55.9477	5.6217
264	94.8109	93.3592	8.3298
265	6.1029	72.0343	1.8746
266	58.4641	48.4039	5.1734
267	28.5108	63.9031	6.3084
268	82.7732	88.7637	2.6845
269	19.0986	19.8737	6.5020
270	44.2530	39.5366	1.4675
271	39.3412	99.2175	6.1815
272	82.6574	40.2352	8.5811
273	67.6871	65.8856	5.4975
274	20.7603	90.1348	4.9512
275	31.8105	99.5382	2.3415
276	13.3811	65.3163	1.2545
277	67.1463	10.8436	7.8100
278	57.0991	3.6114	8.1650
279	16.9767	61.8091	3.6420

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	14.7656	56.7144	2.0369
281	47.6080	96.1965	4.3758
282	90.8102	74.6105	8.4600
283	55.2175	66.2516	8.5760
284	3.2940	52.3313	6.9871
285	5.3863	25.9894	9.6413
286	80.5063	96.1994	9.4881
287	45.1375	54.0204	2.0143
288	38.2646	3.0270	6.8346
289	78.9644	69.6314	5.3272
290	36.4287	51.9716	1.5987
291	53.2350	5.9031	9.0799
292	71.1657	89.0036	5.4751
293	87.1477	33.0202	7.9417
294	32.8690	22.9701	1.5433
295	65.0118	11.3949	3.3621
296	97.4836	31.0923	6.8596
297	7.5967	22.8432	2.2024
298	58.7019	65.1997	6.7469
299	41.3886	6.6160	4.4645
300	30.9136	27.5431	7.8913
301	26.3834	28.1820	6.8762
302	75.8766	88.0066	4.4334
303	99.5216	44.4330	3.7002
304	18.6571	75.5914	4.0613
305	78.1145	60.3296	9.2703
306	19.5798	78.3266	5.1064
307	99.2359	11.3931	4.9825
308	80.2262	97.8564	5.0877
309	42.4227	84.8597	9.5075
310	72.8864	5.0646	2.9721
311	49.8354	46.6202	8.9416
312	80.8990	32.5653	1.1789
313	35.6509	63.0205	4.0759
314	7.3243	23.0299	7.8942
315	59.0991	57.9885	4.0852
316	91.0188	60.3156	6.5693
317	19.3766	59.9879	5.0772
318	43.2368	44.8428	1.0915
319	74.9160	3.5423	6.3917
320	3.9184	51.3815	6.4141

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
321	94.6325	40.7730	6.8448
322	76.3673	10.8046	4.0845
323	55.8821	45.9876	5.4397
324	18.3843	45.0883	7.3160
325	49.7949	55.1140	8.9902
326	51.7846	80.5404	1.4955
327	99.4243	70.0850	1.8853
328	85.4852	87.2236	6.8480
329	96.2404	5.2192	7.8766
330	67.8941	21.9681	9.8916
331	40.3501	45.9642	2.1279
332	93.4979	95.8534	4.2803
333	47.9485	79.0045	7.0861
334	23.1792	45.1875	4.3818
335	39.6290	33.3428	8.7711
336	70.5077	5.9095	3.6278
337	55.8559	74.0905	2.2013
338	75.6631	50.6795	7.0539
339	99.5481	19.9925	2.8233
340	96.2431	42.7194	8.8166
341	53.5067	16.8690	7.7604
342	96.3870	75.1695	4.7744
343	11.5626	36.8351	1.0021
344	5.1448	94.1818	2.3452
345	30.4349	1.7173	3.4645
346	58.0192	82.9056	8.8518
347	53.0964	62.6591	6.4113
348	90.1208	53.8747	3.8907
349	54.0550	65.0508	3.5586
350	43.1981	72.6630	4.9178
351	54.2667	9.4489	9.1338
352	71.2415	87.7574	9.3260
353	1.6675	1.4362	5.5476
354	80.0921	29.4303	6.6482
355	14.2509	17.9915	7.4734
356	47.8474	92.6294	1.2152
357	25.6835	6.8180	6.1744
358	36.9092	58.1093	1.4188
359	66.1765	63.7151	4.8028
360	16.9609	65.1269	5.2096
361	27.8784	86.4622	1.2037

Continued on next page

Table B.36 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
362	19.8222	5.5953	1.5857
363	19.5072	81.6855	9.3156
364	32.6840	52.8922	5.8073
365	88.0338	69.4351	4.3012
366	47.1102	21.2405	4.2755
367	40.3969	54.3280	2.3624
368	17.9231	70.2520	2.3465
369	96.8925	95.6435	4.1572
370	40.7456	44.4542	4.0237
371	84.4487	8.5398	8.0563
372	61.5325	5.7340	5.3807
373	37.6611	62.9450	5.1832
374	87.7182	79.6179	2.1813
375	78.4852	69.1191	8.9775
376	46.4954	34.5308	7.0710
377	81.3977	94.6817	8.5164
378	89.8444	52.0190	6.9084
379	42.9239	95.3813	9.8553
380	33.4329	7.3596	9.8181
381	59.6647	20.7032	3.2514
382	90.1991	77.5028	6.6211
383	70.2066	91.4188	7.5542
384	37.7455	78.2551	5.4835
385	73.4956	29.5534	8.6485
386	95.4103	15.1846	2.7183
387	54.2813	84.7911	2.1173
388	54.0106	78.4855	1.0251
389	31.1110	27.0832	2.3766
390	7.1235	22.7811	5.8074
391	18.1980	32.1023	5.5957
392	9.2989	82.9562	4.4669
393	46.3489	82.2182	3.7954
394	0.9333	57.0683	1.0320
395	91.5026	57.1830	8.3372
396	64.2742	28.6018	6.7458
397	0.1419	69.9134	5.0351
398	3.0385	79.6258	3.1968
399	20.8470	44.1589	8.2305
400	45.4966	44.6216	8.4157

Table B.37: Depot locations and number of vehicles for MS19

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	20.0000	70.0000	1
2	70.0000	20.0000	1
3	10.0000	10.0000	2

Table B.38: Customer locations and service time for MS19

Customer index	x-coordinate	y-coordinate	Service time (short)
1	12.6820	37.7550	8.6697
2	7.8183	6.0331	5.2053
3	9.5451	30.8690	9.7363
4	69.9089	71.5373	8.5712
5	9.7705	8.9562	1.7069
6	29.5166	11.2224	3.1384
7	26.3677	10.8578	8.3581
8	7.9879	3.1220	4.6525
9	55.8517	45.1865	5.1968
10	34.4087	10.1366	9.5638
11	20.5853	23.9799	9.6850
12	13.3106	9.1599	7.8876
13	29.5222	29.7540	6.1708
14	20.7833	10.7837	9.2433
15	29.2525	25.5736	5.4589
16	2.1943	2.2791	2.4941
17	10.4478	23.6190	3.9340
18	43.3033	9.7144	3.6679
19	10.9586	7.1034	6.0247
20	83.6020	40.3118	1.6073
21	6.1281	9.7035	1.6208
22	100.0000	5.8614	2.5011
23	23.8943	7.9978	9.5269
24	9.9201	43.5462	8.2998
25	80.7923	56.7733	7.3941
26	20.8241	5.0362	9.7322
27	43.6629	0.5026	9.9858
28	13.4801	7.1360	9.8871
29	41.3824	2.3649	2.3508
30	23.9513	12.4183	9.6263
31	3.1340	19.4567	5.7741
32	100.0000	77.0249	1.6668

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	9.6341	12.7845	3.8064
34	31.6006	6.1659	9.0565
35	4.9184	5.0207	8.5129
36	30.5951	37.5054	1.0211
37	23.5338	7.7685	6.7619
38	1.2539	9.7315	8.2286
39	4.5005	0.7075	3.2062
40	2.9073	22.1926	1.5771
41	1.7448	74.2873	3.3683
42	51.1288	28.8581	1.9245
43	26.3683	28.8987	5.3535
44	8.4355	17.6945	4.7700
45	11.7441	72.2255	4.4316
46	4.5495	58.8515	8.9809
47	37.7960	35.7741	4.7850
48	28.5390	6.1336	3.5546
49	37.9231	3.5152	1.4336
50	89.3572	11.7908	2.9725
51	9.6339	27.5261	3.1526
52	31.2811	32.6180	1.2633
53	87.0135	86.0708	7.3208
54	31.4299	3.5007	1.0687
55	54.4664	34.8938	6.4983
56	65.9083	0.3671	4.6728
57	13.5745	51.4740	3.2405
58	100.0000	15.7330	6.8721
59	4.2548	24.2821	3.8825
60	67.9291	6.0909	1.9330
61	18.1367	2.2456	5.8201
62	45.4419	25.4633	2.4838
63	21.5712	2.3291	8.9509
64	3.6818	53.1902	6.9981
65	10.5242	83.9336	8.6297
66	0.9562	2.5091	7.8639
67	23.1737	1.7944	8.2631
68	22.1726	13.1910	6.6966
69	6.2351	71.8609	7.3938
70	2.5771	3.1346	7.1980
71	10.0376	4.0772	3.8885
72	44.0974	14.1083	5.7848
73	28.5029	19.3814	8.8587

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	32.6219	67.3518	1.4909
75	36.6554	23.9791	5.5036
76	8.8280	7.5140	4.8949
77	29.3223	16.2365	9.1385
78	0.6620	17.4912	6.6717
79	3.6999	4.6523	9.8473
80	11.9600	100.0000	6.2668
81	3.2116	33.2896	8.5657
82	29.5134	48.8156	5.2193
83	11.7023	85.3035	5.9070
84	11.3933	31.0061	2.6119
85	29.9997	2.8050	6.7102
86	13.4912	45.3341	9.6666
87	55.7157	0.2771	5.8061
88	5.6284	50.7563	5.3165
89	3.3344	19.0196	8.1430
90	10.8594	24.8455	1.8344
91	72.4791	10.4804	8.9272
92	1.5852	3.3793	1.0349
93	71.1995	30.5300	5.6038
94	34.7430	32.4731	7.1062
95	24.5129	62.8663	6.0917
96	22.0757	42.0038	5.3061
97	45.0173	6.8606	3.8846
98	1.4944	2.3685	6.4142
99	51.3847	10.9772	9.2184
100	7.0131	16.4711	7.1427
101	11.1511	8.8600	9.5206
102	29.5540	77.4861	1.8918
103	53.9148	2.9063	5.5993
104	1.1367	9.9144	1.9912
105	4.8351	45.0645	5.9074
106	47.0644	17.2008	7.1991
107	23.3556	15.7863	2.3268
108	19.2635	11.7900	7.9980
109	7.6014	0.9019	4.5915
110	3.3196	14.0892	9.0847
111	0.6626	13.7187	3.7634
112	8.0783	1.6138	1.5495
113	11.8336	69.6935	2.9752
114	4.2966	10.4259	1.7455

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	24.3187	57.7156	9.5536
116	2.6707	12.4120	1.1473
117	5.9323	5.4429	2.0320
118	2.3908	85.8053	1.1117
119	21.6037	16.2554	2.9460
120	66.2728	30.2961	1.1028
121	2.4259	10.3633	6.7820
122	12.2454	12.8659	5.6529
123	7.1808	69.6981	3.2099
124	13.6008	2.8807	2.7437
125	0.1373	1.1947	1.8178
126	44.9142	42.7486	4.3160
127	8.6037	65.2464	1.0701
128	44.7886	0.3010	6.4243
129	63.3532	21.2213	5.3097
130	11.3896	6.8944	3.7731
131	14.8787	1.9987	7.7000
132	6.4604	3.4208	8.5541
133	72.5640	0.9331	3.3619
134	76.6311	30.3708	5.6281
135	13.5102	8.5609	5.0210
136	6.8036	2.6035	4.0709
137	42.1498	3.3611	8.5523
138	15.5922	4.7004	9.8424
139	13.8914	83.6610	6.6382
140	12.5657	2.4642	2.6315
141	79.9820	11.6331	2.1072
142	32.7220	13.9394	6.2197
143	43.0164	7.5890	3.9568
144	15.9793	16.9209	3.4137
145	7.6946	3.6307	5.9522
146	2.1489	49.1103	2.6247
147	87.1702	10.4966	7.1064
148	4.8330	13.0643	1.5012
149	4.1397	16.6691	1.3065
150	18.8950	35.2012	3.5787
151	24.8348	0.6713	1.6965
152	64.5453	2.1876	9.1052
153	44.3052	10.6924	8.6195
154	9.9387	55.0681	4.5613
155	13.1853	16.6078	2.5229

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	10.0946	18.2945	4.8741
157	19.9483	67.1431	4.7460
158	5.8316	23.6145	7.5589
159	19.6426	5.4165	4.6583
160	2.7882	5.9991	9.5663
161	65.5847	53.0113	9.2079
162	11.3361	22.1697	9.5627
163	5.3106	5.6391	4.1140
164	28.4002	34.3868	3.6122
165	15.5872	13.2979	8.9803
166	3.5945	82.6017	2.8903
167	15.6739	9.5817	2.1779
168	5.7790	4.7542	5.6846
169	13.3509	8.9201	9.1492
170	3.1531	26.1193	4.6228
171	20.3447	17.8773	2.9419
172	59.3349	31.4583	1.7087
173	1.8278	33.1092	9.3975
174	21.7726	6.6994	6.4258
175	16.0280	13.4301	4.3974
176	9.2424	15.4716	6.9844
177	72.6668	0.2342	8.1297
178	26.9401	6.5615	4.0014
179	5.8050	13.3567	7.2339
180	100.0000	5.8661	2.8343
181	72.8760	14.9948	9.6284
182	32.3590	64.2878	7.4065
183	25.7170	18.6470	2.5022
184	6.1777	4.0710	4.9850
185	41.6707	22.7155	6.6969
186	22.5055	36.0137	9.3697
187	9.1337	15.3358	5.7640
188	4.6739	24.9303	6.6383
189	15.1204	6.9096	7.1274
190	2.2936	6.5654	9.3088
191	2.1491	26.5106	2.3755
192	12.0098	0.8272	4.6515
193	2.3448	25.8342	3.8123
194	2.8051	41.1015	7.2451
195	26.5841	59.9070	9.0162
196	0.0905	29.0201	5.4160

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	2.9059	1.0637	8.2524
198	25.2777	11.2172	3.9380
199	6.1189	39.2386	5.9489
200	27.8439	27.4812	4.4991
201	46.3344	26.7495	9.0715
202	7.5451	2.7777	7.0851
203	11.4821	17.1215	8.4556
204	12.7747	14.3964	1.9908
205	35.6194	5.9138	3.5130
206	31.6155	26.1793	7.9087
207	5.6181	37.8327	2.9445
208	13.3206	4.8751	1.3066
209	29.9537	64.4118	4.9290
210	30.4255	62.4694	9.4318
211	37.2686	29.3025	3.3588
212	17.0581	3.9019	6.1277
213	14.2716	18.6480	4.2360
214	66.8790	28.1570	1.2415
215	45.2120	19.4108	5.5038
216	16.8082	9.8567	8.4431
217	15.3335	13.8755	3.3308
218	16.8319	4.2749	1.4130
219	52.6105	64.4843	3.2182
220	46.4877	33.6913	6.9466
221	22.3421	9.3652	3.9647
222	9.1446	20.9544	6.9355
223	6.1868	28.1964	1.1170
224	11.2996	76.9387	7.4626
225	13.5405	29.2511	4.5201
226	0.6398	21.2964	1.3015
227	15.8890	12.1301	4.6541
228	31.0877	35.3658	7.4468
229	40.7144	4.2189	9.2920
230	38.3846	3.1165	9.8561
231	20.6576	1.8612	9.8508
232	14.1871	14.3782	9.0668
233	2.2048	29.8517	8.7913
234	28.7926	6.5294	8.2086
235	31.7330	16.9703	5.9948
236	11.9953	12.2517	4.7698
237	37.8027	9.4009	2.1441

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	44.0040	61.9516	6.8916
239	100.0000	8.4180	8.7757
240	16.5250	30.2348	3.4714
241	100.0000	36.3974	8.5615
242	14.6746	28.6863	1.6368
243	14.6866	31.6446	4.4091
244	65.1829	34.6010	3.4135
245	23.1012	52.2788	2.3763
246	6.4627	10.0813	6.6790
247	13.9420	31.9682	3.8474
248	22.7162	34.9017	9.6320
249	16.1890	14.1071	5.4881
250	23.3814	74.2284	7.6475
251	67.5672	4.8649	1.1148
252	6.2591	82.4578	6.4482
253	6.7195	32.9967	6.1881
254	14.1175	29.9175	8.2664
255	12.1752	10.3007	6.8947
256	13.2387	11.7198	8.9041
257	12.0872	8.4800	9.1214
258	35.7011	32.1988	2.3701
259	5.8588	0.0981	2.7332
260	8.7160	30.0622	8.1188
261	7.5995	17.2655	1.5463
262	49.4370	50.5629	4.5084
263	100.0000	2.7019	3.6997
264	7.5778	35.8933	7.6076
265	5.2438	67.5430	1.9379
266	14.2856	25.1538	8.1332
267	72.2024	0.2764	8.0446
268	28.2451	38.7763	5.7916
269	1.7173	31.1603	3.2802
270	3.9820	17.1003	1.6386
271	9.3938	11.5283	6.6322
272	44.7085	23.3370	1.2221
273	9.6539	9.6430	1.5584
274	63.2783	50.9991	2.1665
275	14.4507	66.3966	5.0555
276	19.4653	77.3151	7.0510
277	10.1967	14.7680	8.7050
278	20.8612	2.8904	5.4860

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	87.0850	13.3697	1.4391
280	20.3880	15.7991	3.8245
281	19.0321	10.9999	6.7747
282	100.0000	22.4424	8.0775
283	13.0408	33.5450	3.6024
284	29.9638	12.3898	5.4808
285	4.7810	11.4406	8.3659
286	2.1957	6.8849	6.3562
287	32.9796	36.3222	5.8278
288	30.4335	31.0570	3.9779
289	59.5208	94.6371	4.7052
290	8.0109	30.8233	8.1461
291	8.3009	25.9556	4.0889
292	11.9159	10.7838	5.1635
293	24.4465	12.4559	4.3104
294	11.5243	6.9873	7.1161
295	16.4789	3.0722	6.1100
296	10.7616	2.7593	6.8660
297	3.4455	63.7518	5.4200
298	27.6395	16.0675	4.5861
299	14.6053	77.4467	5.2974
300	88.8465	5.6847	1.5993
301	31.4831	97.1466	4.6993
302	23.5507	14.2859	9.7218
303	26.7438	85.6912	8.0265
304	14.2384	76.2052	7.5612
305	19.3852	76.0262	7.8909
306	83.3386	45.9418	7.8092
307	74.5104	38.4084	8.5894
308	74.3855	10.7429	7.9314
309	26.5942	45.5472	9.8079
310	11.3418	14.7247	2.0022
311	4.8981	29.3592	4.5647
312	27.6120	38.0417	5.4285
313	65.7360	92.4546	3.3229
314	62.6701	19.3468	1.3327
315	57.4108	65.5051	9.7694
316	20.0358	39.4229	7.5378
317	40.9374	19.3486	2.3317
318	28.4314	3.1735	2.3311
319	83.4083	80.1822	7.3434

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	75.7352	31.3325	4.4289
321	86.5908	74.6942	1.6877
322	41.6935	59.0634	4.6976
323	74.2514	29.6429	2.2869
324	6.9935	81.5503	8.1903
325	95.8454	89.2513	9.3722
326	68.7191	58.9583	1.0425
327	26.0030	81.5188	6.8504
328	73.5626	55.5128	7.1068
329	47.8618	81.4574	3.2826
330	87.1375	3.8354	8.5886
331	32.2553	84.8485	3.6456
332	56.1023	11.4486	1.2417
333	24.5850	15.1174	1.8398
334	13.4488	72.8034	8.1810
335	23.7612	20.1974	7.4026
336	36.3673	73.8008	8.0507
337	68.8089	86.7171	6.6153
338	3.9020	20.9039	8.4287
339	68.8734	72.8760	1.3152
340	26.0818	61.3300	4.6493
341	85.6589	51.2972	3.2470
342	54.6114	95.9335	5.3281
343	46.0499	18.4444	8.9276
344	15.2666	20.0738	3.5262
345	25.5789	65.9121	6.3923
346	39.1646	73.9105	1.2360
347	96.4607	37.4368	2.3968
348	51.9424	97.6080	8.5052
349	12.0884	3.5211	2.7540
350	91.4895	32.8246	8.4681
351	45.6607	65.0959	4.0427
352	90.4683	3.9350	7.0400
353	29.1900	13.5622	1.4713
354	78.2189	23.8739	7.6088
355	5.5907	85.9359	5.4953
356	21.3044	91.4478	9.4897
357	77.6544	0.7608	3.6080
358	69.6810	24.6182	4.3890
359	90.7883	60.9730	2.0238
360	60.8883	98.4514	9.6837

Continued on next page

Table B.38 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	54.4557	97.9311	4.8926
362	75.3118	61.9195	1.7611
363	87.7259	94.8318	7.4501
364	89.3774	37.3761	5.5611
365	85.5831	22.7565	3.9528
366	68.3244	56.8183	7.7817
367	40.7614	56.0081	8.5241
368	4.7855	28.1103	3.2834
369	23.8428	87.2199	5.8098
370	1.3959	84.5637	4.9165
371	38.1700	64.7979	2.4193
372	90.7123	72.3669	6.4043
373	30.3596	26.6740	9.4371
374	86.7330	12.1991	1.9698
375	14.7173	15.0853	9.0998
376	30.9913	66.7906	5.9542
377	41.8244	33.6551	4.8462
378	21.0176	61.7685	2.3714
379	76.7455	77.5326	3.2279
380	24.2546	73.2936	5.0263
381	88.6141	73.6284	5.7951
382	29.7543	5.9901	4.1919
383	19.0678	22.7051	7.9580
384	72.4119	46.6279	8.9351
385	95.6810	89.8958	7.6068
386	90.1467	54.4241	4.6579
387	70.0584	5.7137	6.4376
388	81.3472	79.4493	6.7699
389	86.6425	77.4849	2.1472
390	88.8213	50.9021	5.4657
391	23.0451	2.5752	3.7942
392	62.6476	97.5528	6.2072
393	24.3942	24.2368	9.4925
394	44.2680	90.1012	4.8425
395	78.2786	44.8384	1.2982
396	71.5829	6.2794	9.3649
397	24.4633	9.9259	9.3248
398	73.7832	36.8498	4.2248
399	90.7812	51.3531	3.3399
400	84.2232	38.0071	8.0817

Table B.39: Depot locations and number of vehicles for MS20

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	25.6060	1.6149	1
2	30.0000	30.0000	2
3	70.0000	70.0000	2

Table B.40: Customer locations and service time for MS20

Customer index	x-coordinate	y-coordinate	Service time (short)
1	4.2018	36.5997	5.6042
2	17.1602	39.2858	6.0627
3	52.7356	35.3461	7.1631
4	44.0164	41.4880	1.8316
5	14.4179	33.3959	8.8532
6	52.8884	23.8118	9.4864
7	27.2686	45.9001	1.8693
8	30.6371	30.7543	8.6129
9	37.1386	28.7998	9.1846
10	32.5833	12.5864	1.1021
11	64.7317	42.0604	5.7131
12	31.0256	18.5135	6.8531
13	32.0664	42.9399	4.4663
14	25.6741	10.7300	6.8437
15	8.4971	33.4598	7.8657
16	35.8140	23.9867	6.1812
17	38.3398	28.6541	6.6873
18	38.2171	9.0215	3.5038
19	39.3133	21.6025	8.5585
20	45.0584	44.3805	4.8415
21	18.3947	64.5842	6.6846
22	38.3871	40.4169	8.5012
23	39.0688	2.2105	3.4317
24	23.3464	22.9831	4.6072
25	29.5895	36.2596	5.9883
26	17.7956	19.6608	4.9948
27	35.8404	60.9155	1.8135
28	24.8826	29.0918	7.6994
29	58.7577	49.2761	1.2935
30	36.9916	34.2850	4.8677
31	25.4193	31.0962	1.3354
32	19.1042	57.5082	9.7822

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	1.0000	11.9495	5.7011
34	33.3619	22.5401	9.1867
35	18.2371	6.4420	4.4492
36	33.4853	34.1546	8.9601
37	7.4295	36.4559	3.2952
38	41.7407	38.0011	9.1814
39	19.9933	45.9441	9.0510
40	36.0906	10.6709	4.5867
41	18.5207	51.4470	6.6252
42	28.9498	2.2946	6.1084
43	48.1555	38.1287	9.0506
44	31.0259	0.9940	2.9275
45	34.8522	42.1337	1.0347
46	48.7670	33.6994	8.9252
47	23.3411	48.0565	3.1161
48	36.8956	40.1752	3.2038
49	45.9998	49.3303	6.7683
50	47.1081	21.0803	3.7407
51	39.5031	6.1646	8.4306
52	70.1808	1.0000	8.9532
53	10.9101	60.4333	9.5084
54	17.3579	47.0016	4.5172
55	34.4009	41.4462	8.2119
56	23.1983	37.8937	2.4140
57	37.3757	15.3048	6.6265
58	9.3782	32.0551	7.2909
59	31.1935	26.0003	1.7728
60	42.8258	36.8273	5.7806
61	14.8478	21.5168	8.9971
62	24.8780	67.0746	3.3730
63	1.0000	11.3143	3.1131
64	17.4946	41.7573	8.5569
65	34.5788	39.8622	5.4599
66	49.3897	25.7832	2.3713
67	48.8168	75.9203	3.0769
68	33.8530	23.4514	6.9216
69	20.9420	28.0715	6.0665
70	8.5099	62.7814	3.6265
71	41.8643	55.4148	6.6007
72	35.6718	7.6526	7.4431
73	21.5751	46.7418	3.5266

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	26.3221	36.3800	4.7105
75	31.0761	38.1466	4.2599
76	18.5178	21.6122	8.0325
77	19.7962	10.2288	2.2194
78	25.7427	9.4795	9.1186
79	21.4979	12.3690	3.6067
80	50.8109	20.8986	5.4960
81	33.5060	12.3039	8.0523
82	38.6620	45.1187	7.0936
83	62.3390	33.7020	2.3483
84	24.4542	33.3709	7.2696
85	25.5830	11.7220	2.1611
86	10.2557	40.9440	9.5135
87	37.0405	1.0000	8.9777
88	22.7030	20.3513	5.6350
89	18.7156	38.9326	7.1147
90	39.7972	60.0346	9.7911
91	9.3039	23.7804	2.1291
92	1.0000	43.0286	7.7702
93	55.1485	63.6988	8.4435
94	50.0119	20.6197	8.0329
95	40.0966	19.4731	2.7179
96	2.3984	64.7104	4.8578
97	23.9212	31.7682	1.1301
98	64.3039	47.1101	3.9276
99	42.2801	34.6173	2.2123
100	19.1989	41.2427	5.0547
101	21.6111	39.8648	6.1505
102	24.5733	36.5552	8.1282
103	25.4264	1.0000	4.7776
104	15.2472	22.0241	5.7928
105	59.9856	23.1952	9.3313
106	44.6384	16.7735	9.0917
107	35.7488	18.3101	5.9035
108	52.9662	22.3562	9.1101
109	15.8206	11.9255	1.4664
110	30.7198	30.6669	8.2774
111	31.5311	18.1156	4.0141
112	12.4404	18.5735	3.0581
113	40.1094	5.5040	8.4016
114	27.0358	43.1720	4.1341

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	49.0969	2.2846	2.4892
116	40.4510	41.9489	1.2532
117	21.3891	29.9530	9.5983
118	51.4771	39.5188	7.1226
119	47.4047	20.2256	8.7451
120	43.5502	38.0543	9.4518
121	43.1607	44.0961	7.1217
122	24.2446	33.3733	9.2568
123	7.9602	32.4499	3.3102
124	39.9992	30.4458	8.9706
125	43.2080	28.0023	9.2804
126	45.1519	32.4457	3.7006
127	14.2751	24.6127	1.6605
128	21.2377	4.0227	7.9066
129	42.0759	45.9993	1.7646
130	41.0076	20.3847	7.5589
131	42.8157	28.5139	5.0310
132	16.9129	27.5304	6.8612
133	42.4870	39.5396	2.5255
134	35.9210	52.5352	5.7830
135	40.8582	1.0000	6.7042
136	1.0000	34.3270	1.1269
137	16.3878	23.9099	5.2333
138	53.1124	9.4374	8.9769
139	46.7406	24.6117	2.0263
140	4.7476	27.5846	4.9829
141	18.9248	63.4662	6.9359
142	1.0000	8.0265	3.6530
143	32.9027	58.9804	9.5533
144	28.2052	30.4159	7.2486
145	19.5624	42.4775	2.8613
146	16.6948	23.5501	5.9929
147	17.0824	14.1971	8.9135
148	3.4815	39.8755	6.0207
149	8.6735	41.7757	7.7710
150	37.2506	43.7922	9.0541
151	33.2950	26.4283	8.5766
152	46.7121	44.8726	2.1777
153	37.8318	27.0132	2.7024
154	27.9967	49.7689	2.3828
155	25.1698	32.1721	1.2601

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	9.5501	26.2656	1.0818
157	20.4951	4.6282	6.3681
158	27.3950	64.4344	6.4814
159	24.6110	40.7937	9.2703
160	2.6859	23.7797	7.6022
161	17.3167	33.0521	3.7103
162	13.5573	25.2406	5.4602
163	35.0304	20.5987	3.3235
164	28.8342	17.6789	7.5957
165	21.7567	6.6307	2.0508
166	14.2944	50.6012	7.7144
167	14.7638	43.0021	8.2881
168	1.0000	27.0720	7.7071
169	50.4943	24.2461	4.0343
170	15.3748	45.0745	6.2589
171	1.0000	2.2791	5.2206
172	24.2523	1.0000	1.7854
173	38.5077	17.1122	8.4585
174	16.7739	15.5612	7.1735
175	25.8551	51.0725	3.4059
176	31.4219	17.1986	9.7254
177	31.2302	4.2888	2.6540
178	46.9592	7.0799	3.6995
179	7.4688	22.5956	4.7007
180	48.6560	40.4680	3.1284
181	51.8310	1.0000	2.7555
182	38.1713	22.1435	7.3484
183	16.2131	18.4730	2.6249
184	11.7700	47.4833	5.7010
185	22.7331	61.0565	3.6655
186	23.5389	38.1246	5.1650
187	34.3477	41.0800	9.3271
188	44.0151	20.4182	2.9430
189	44.4083	14.5860	1.0091
190	45.2059	28.6909	9.1595
191	29.2864	41.3054	7.1204
192	27.7754	63.2071	5.6346
193	32.3259	34.0267	5.6986
194	36.7458	15.3110	1.9263
195	14.9369	15.3833	9.9719
196	40.1105	13.1520	4.2307

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	29.2047	39.6502	6.6272
198	3.3481	35.7266	4.5403
199	20.8271	32.2175	1.0690
200	31.1438	37.2201	5.9076
201	69.0646	77.3671	5.5820
202	64.6178	62.1799	3.2210
203	74.3829	73.4577	1.4086
204	75.8705	64.2169	8.5756
205	59.7133	76.0858	1.4342
206	46.7299	75.6822	3.8469
207	63.4393	71.9451	8.0508
208	58.4249	89.2167	9.7516
209	60.9937	59.3636	6.2782
210	79.7658	67.8599	8.0024
211	62.4135	70.0642	7.5493
212	68.8915	71.8740	6.8589
213	98.7211	77.4477	6.9815
214	70.2304	84.3332	9.4490
215	60.0511	63.3360	5.8157
216	72.1888	71.6392	4.5860
217	55.5788	49.8524	7.0341
218	62.3851	53.4991	4.9648
219	64.5391	71.3395	2.1959
220	70.1182	69.7806	4.9528
221	82.0717	63.7263	5.9288
222	71.5687	54.2798	4.5562
223	68.0493	66.1970	4.5844
224	72.2814	80.9690	7.7621
225	57.9911	73.5898	5.7012
226	74.1075	61.6411	5.4139
227	63.7151	69.5902	1.7981
228	74.9104	80.8101	3.2577
229	66.4415	76.8658	5.0280
230	60.9176	47.1491	6.7416
231	52.7684	72.3562	7.3850
232	71.6035	77.9266	9.9336
233	74.6412	68.3896	9.3898
234	64.1983	58.5480	1.8301
235	56.3478	71.5552	9.5819
236	58.3293	74.4006	2.4652
237	80.3066	65.2813	9.7341

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	62.6042	66.8331	6.3731
239	72.8318	69.8920	3.1620
240	69.8404	74.4226	1.6327
241	79.9664	73.5631	3.7004
242	64.4832	76.3750	8.3219
243	70.1972	67.0347	1.6904
244	87.3394	61.3254	4.1903
245	77.3827	78.0772	2.1881
246	91.9065	76.6529	2.4236
247	72.3452	60.9747	1.5593
248	76.9114	74.8788	7.3166
249	81.0845	76.3785	1.7783
250	79.7799	63.4651	6.5511
251	60.6619	83.9109	2.5639
252	49.4378	71.5197	6.8626
253	75.8314	56.0465	5.4883
254	61.4918	73.1223	3.5606
255	91.3132	81.4637	8.4750
256	75.4400	62.7372	8.3652
257	77.0508	67.5041	9.4435
258	77.2800	83.6568	1.0029
259	81.5499	77.8549	6.7635
260	66.9946	67.5229	1.0662
261	69.3418	65.8327	1.9578
262	72.2263	74.3643	1.9611
263	80.5934	74.8185	4.3040
264	74.9325	73.1404	3.1565
265	64.7851	62.8782	4.1153
266	79.5491	70.7952	3.2466
267	72.7897	75.0733	4.4836
268	59.9754	84.6433	4.7893
269	70.3129	83.5507	6.7607
270	58.6779	68.5668	8.0880
271	62.5699	67.2485	3.4299
272	75.9571	66.8209	8.5958
273	50.9208	89.2139	7.6642
274	55.7005	80.9352	8.4349
275	84.0168	88.1517	2.6397
276	74.2375	71.4266	1.5889
277	76.4629	77.6405	6.4932
278	80.4672	53.1342	7.3140

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	82.5482	57.1889	2.0046
280	73.0182	71.3759	1.8624
281	78.4825	60.7319	6.3805
282	62.4617	54.2955	8.3101
283	67.0331	67.8406	8.3312
284	66.7126	80.2867	1.8049
285	63.1727	64.5674	7.5815
286	64.7526	67.4787	9.1347
287	74.4957	92.7338	5.0701
288	67.6919	87.2376	1.6362
289	71.5461	62.2728	3.1715
290	66.0447	70.1393	7.5868
291	70.6290	47.6220	1.3644
292	79.5832	75.0717	4.8207
293	52.7862	70.9491	5.8619
294	83.6369	73.7984	9.5845
295	75.7169	83.4493	2.8802
296	84.2463	75.7281	2.0470
297	80.6037	55.8990	6.8160
298	57.5233	53.8101	1.9757
299	68.7099	71.8455	9.8515
300	65.3068	63.7068	3.2351
301	55.6229	60.5623	6.4572
302	85.9657	47.5305	8.3503
303	66.5013	62.6333	8.4705
304	67.6009	78.5235	5.4014
305	79.2554	63.4522	7.8466
306	68.6543	69.9450	9.2360
307	68.7316	63.6160	9.1088
308	74.6082	72.2593	2.9281
309	76.6058	68.6349	5.9235
310	78.1571	82.2732	8.0624
311	75.8990	59.1924	2.7500
312	78.3570	73.6465	7.7220
313	66.0095	71.5120	5.2800
314	52.4256	52.5016	6.2493
315	89.7248	73.1456	3.3449
316	64.0644	59.4687	1.7634
317	85.7873	56.5607	3.6832
318	85.4575	69.1952	9.2542
319	79.0443	81.7565	5.2347

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	76.8254	74.9941	3.4252
321	72.0040	85.0558	7.8667
322	68.1962	65.8366	7.9495
323	65.6697	70.0684	1.1917
324	63.6405	75.1080	8.9199
325	64.1417	78.8193	8.1835
326	86.9992	63.1922	3.9175
327	49.4217	65.8585	7.0214
328	67.9391	68.9786	3.6666
329	66.0160	69.3440	9.3696
330	79.1480	73.1007	3.5376
331	72.6254	74.0130	2.5199
332	60.3701	66.2622	7.7065
333	82.9260	72.1275	5.2942
334	85.8779	78.7332	6.8810
335	72.8560	58.0064	9.6992
336	71.1839	64.7918	3.8172
337	73.7968	46.2830	1.6880
338	65.4757	82.7432	8.1227
339	83.9179	80.0402	4.2885
340	51.4345	65.0645	6.2659
341	84.7788	65.0988	2.6500
342	62.2280	91.6454	1.6923
343	61.7832	71.9983	2.3830
344	71.6156	54.0917	8.4419
345	73.4156	82.3353	3.7086
346	75.4898	74.2629	4.4550
347	76.0660	82.3057	6.8567
348	56.5785	83.1113	8.3563
349	77.0262	46.4632	7.8964
350	76.8379	67.4667	4.3676
351	77.0586	93.9092	2.7088
352	71.7876	70.2714	6.8185
353	72.9868	64.4372	1.0324
354	61.5485	70.7602	3.5460
355	69.8888	83.0682	6.7474
356	78.0033	69.1621	6.3287
357	55.0570	85.6977	3.9276
358	66.0657	61.9614	9.9006
359	56.7374	56.9189	2.1091
360	83.3812	62.6098	7.6229

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	74.5669	64.3533	2.4096
362	82.9788	72.0780	4.9118
363	66.2818	89.3002	8.4902
364	75.5776	56.7485	4.2392
365	76.0320	51.6192	1.6861
366	80.2913	61.9231	6.0123
367	72.4720	53.4272	3.4654
368	75.2854	71.6889	2.1885
369	53.6417	69.0762	7.2969
370	82.2771	60.9105	5.3731
371	65.0517	75.6712	2.6444
372	63.1854	55.7114	1.9109
373	53.3516	67.4709	2.8143
374	70.9840	72.6539	2.2127
375	70.7802	67.8396	3.9141
376	73.5082	70.8230	9.5549
377	76.4065	65.6242	5.7892
378	66.9837	64.1214	3.2292
379	80.7399	67.2449	4.9355
380	65.4695	70.1555	7.0218
381	57.9031	64.3663	5.9293
382	65.8768	70.7586	6.4815
383	63.0643	78.5991	8.7682
384	71.5935	48.2003	4.4263
385	74.2891	65.1540	7.7406
386	58.7196	70.8577	2.4103
387	72.9441	69.2767	1.5231
388	64.8784	88.5989	4.0574
389	79.0633	78.9579	8.3546
390	62.6882	75.6286	4.3979
391	69.1334	77.3270	9.7534
392	64.9247	59.6753	6.4479
393	67.4154	76.5832	4.0441
394	75.2514	66.9008	9.3519
395	62.6349	50.3805	9.0858
396	56.1678	48.4706	8.6564
397	60.1792	77.4615	3.3111
398	56.5232	63.5025	3.5695
399	74.7486	69.7633	8.0195
400	72.0386	66.6399	7.3126
401	26.3626	89.0660	5.4326

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
402	26.3116	89.5253	9.7090
403	69.9527	79.4324	5.2855
404	5.6731	53.5218	9.9541
405	78.8717	34.2401	5.4152
406	29.2302	28.0784	5.5311
407	83.9438	47.4461	7.9190
408	48.4634	0.8580	4.4928
409	23.3479	42.4800	5.0793
410	22.0535	71.7987	2.1957
411	31.4285	41.0536	7.8266
412	99.5427	60.4571	6.0871
413	18.9132	59.0882	6.8377
414	85.0491	97.8606	8.1825
415	84.3905	27.5977	2.9840
416	52.8317	4.2786	8.7210
417	66.4871	87.0653	9.1426
418	36.9616	88.7844	3.6282
419	31.7438	37.1951	7.5328
420	81.0324	14.8874	4.0550
421	10.2623	16.9315	3.4541
422	21.2763	16.2823	2.5325
423	44.6422	59.5221	6.9762
424	38.6551	85.1466	5.8227
425	77.4648	4.4113	8.4620
426	47.4231	59.0111	3.4063
427	79.6791	24.7793	2.5854
428	2.4859	21.8489	4.8807
429	99.9140	72.8445	5.2809
430	28.3053	18.3082	8.0670
431	76.7825	10.6938	2.1759
432	3.5064	45.3108	1.4622
433	87.0359	19.3715	6.6476
434	74.2945	37.1959	1.2618
435	10.9293	18.3761	2.2258
436	86.6617	88.6769	7.2510
437	82.1526	21.3487	5.6411
438	0.3792	54.2775	5.8832
439	66.0263	16.5275	8.2764
440	63.2365	44.8273	8.1432
441	21.0481	82.2608	5.5168
442	43.4947	47.2541	3.4897

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
443	93.3109	87.9506	2.0770
444	45.7283	65.6411	8.9794
445	11.0029	54.7909	9.7326
446	67.9891	51.8561	9.4827
447	97.1732	42.5358	6.7432
448	43.5377	81.2119	1.8153
449	23.7959	64.2030	1.6724
450	88.7421	18.4273	2.6421
451	95.2771	99.7704	1.2852
452	39.1655	48.8388	7.5244
453	76.3328	50.9235	2.2974
454	10.0053	76.4176	6.7233
455	22.3862	67.4589	8.1086
456	10.2477	72.5292	6.0963
457	2.1421	22.2260	4.3967
458	51.6928	38.3085	8.3943
459	25.8686	34.6163	3.7439
460	3.3903	84.1848	3.8744
461	74.9682	97.5266	8.0648
462	54.1712	28.2174	5.5336
463	88.1948	97.5571	3.3490
464	56.1391	60.2170	7.5923
465	96.8690	18.6945	2.4665
466	75.2475	46.3329	9.2897
467	94.9283	12.4167	3.0000
468	73.8814	69.9965	1.7525
469	26.3525	75.8415	1.6633
470	8.7485	47.9748	7.9260
471	68.5885	68.3121	8.3591
472	81.0465	71.8050	7.6638
473	15.0807	21.2783	7.8242
474	31.3814	14.0420	9.6508
475	48.7028	48.0692	5.1978
476	70.3631	99.9407	8.0830
477	59.6085	88.0798	4.8031
478	5.4351	3.8926	9.4936
479	97.1161	94.8633	1.0118
480	57.4372	89.2860	9.8314
481	57.4443	21.2325	6.1317
482	57.7154	98.1949	4.1182
483	60.0920	25.4547	6.0175

Continued on next page

Table B.40 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
484	13.6016	62.6856	3.6981
485	3.4933	51.8767	2.4317
486	41.3837	49.4841	6.9873
487	27.2949	24.6604	7.1578
488	68.9648	6.3756	8.1317
489	98.5591	16.8444	4.1376
490	24.6915	66.4876	3.2507
491	76.6348	70.6078	4.1050
492	66.6660	85.8070	3.9577
493	53.6316	26.9826	9.3474
494	90.0525	2.2469	7.8047
495	66.6921	55.8130	3.5941
496	54.3385	19.8975	6.4556
497	8.9272	92.0241	7.8943
498	2.7788	27.5098	8.6154
499	95.9793	22.8960	9.1178
500	73.2243	51.8150	6.3614

Table B.41: Depot locations and number of vehicles for MS21

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	58.2249	11.9215	1
2	54.0739	93.9829	1
3	86.9941	64.5552	1
4	26.4779	47.9463	1
5	31.8074	63.9317	1

Table B.42: Customer locations and service time for MS21

Customer index	x-coordinate	y-coordinate	Service time (short)
1	81.4724	96.3089	1.6168
2	90.5792	54.6806	2.9624
3	12.6987	52.1136	8.8247
4	91.3376	23.1594	4.7280
5	63.2359	48.8898	6.9509
6	9.7540	62.4060	8.0514
7	27.8498	67.9136	3.2310
8	54.6882	39.5515	5.9898
9	95.7507	36.7437	3.0663
10	96.4889	98.7982	1.0622
11	15.7613	3.7739	7.8998
12	97.0593	88.5168	1.1965
13	95.7167	91.3287	4.5379
14	48.5376	79.6184	3.2729
15	80.0280	9.8712	2.8380
16	14.1886	26.1871	6.9605
17	42.1761	33.5357	9.2327
18	91.5736	67.9728	1.0621
19	79.2207	13.6553	7.7178
20	95.9492	72.1227	8.1970
21	65.5741	10.6762	9.1702
22	3.5712	65.3757	9.7712
23	84.9129	49.4174	2.0788
24	93.3993	77.9052	5.6707
25	67.8735	71.5037	8.3978
26	75.7740	90.3721	6.7332
27	74.3132	89.0923	9.5852
28	39.2227	33.4163	9.5223
29	65.5478	69.8746	9.6994
30	17.1187	19.7810	1.6061

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	70.6046	3.0541	4.9378
32	3.1833	74.4074	3.8876
33	27.6923	50.0022	2.2065
34	4.6171	47.9922	2.2113
35	9.7132	90.4722	8.2535
36	82.3458	60.9867	5.7229
37	69.4829	61.7666	9.4983
38	31.7099	85.9442	9.8951
39	95.0222	80.5489	4.6890
40	3.4446	57.6722	4.3407
41	43.8744	18.2922	3.0417
42	38.1558	23.9932	5.0143
43	76.5517	88.6512	3.3960
44	79.5200	2.8674	5.1319
45	18.6873	48.9901	4.8961
46	48.9764	16.7927	3.3366
47	44.5586	97.8681	2.2034
48	64.6313	71.2694	4.7731
49	70.9365	50.0472	5.5617
50	75.4687	47.1088	3.9189
51	27.6025	5.9619	7.1622
52	67.9703	68.1972	4.9878
53	65.5098	4.2431	4.9210
54	16.2612	7.1445	8.1372
55	11.8998	52.1650	8.3400
56	49.8364	9.6730	7.7690
57	95.9744	81.8149	8.1033
58	34.0386	81.7547	5.5114
59	58.5268	72.2440	5.9966
60	22.3812	14.9865	6.6767
61	75.1267	65.9605	1.8819
62	25.5095	51.8595	3.2111
63	50.5957	97.2975	6.5415
64	69.9077	64.8991	3.7446
65	89.0903	80.0331	7.9027
66	95.9291	45.3798	3.4051
67	54.7216	43.2392	1.3556
68	13.8624	82.5314	3.6691
69	14.9294	8.3470	6.0073
70	25.7508	13.3171	9.7217
71	84.0717	17.3389	7.2021

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
72	25.4282	39.0938	7.4609
73	81.4285	83.1380	6.0313
74	24.3525	80.3364	5.8002
75	92.9264	6.0471	8.8815
76	34.9984	39.9258	4.5379
77	19.6595	52.6876	5.1226
78	25.1084	41.6799	2.8742
79	61.6045	65.6860	7.8155
80	47.3289	62.7973	5.9202
81	35.1660	29.1984	4.2165
82	83.0829	43.1651	7.3090
83	58.5264	1.5487	1.9830
84	54.9724	98.4064	1.0595
85	91.7194	16.7168	6.3757
86	28.5839	10.6216	6.9326
87	75.7200	37.2410	6.2201
88	75.3729	19.8118	9.1896
89	38.0446	48.9688	6.7241
90	56.7822	33.9493	5.7301
91	7.5854	95.1630	3.3366
92	5.3950	92.0332	1.4605
93	53.0798	5.2677	7.5876
94	77.9167	73.7858	2.4786
95	93.4011	26.9119	3.5236
96	12.9906	42.2836	3.3348
97	56.8824	54.7871	5.9239
98	46.9391	94.2737	5.8714
99	1.1902	41.7744	8.0930
100	33.7123	98.3052	8.8264
101	16.2182	30.1455	8.0879
102	79.4285	70.1099	9.7249
103	31.1215	66.6339	2.6242
104	52.8533	53.9126	9.3754
105	16.5649	69.8106	1.4064
106	60.1982	66.6528	3.1658
107	26.2971	17.8132	1.0797
108	65.4079	12.8014	7.0443
109	68.9215	99.9080	9.1433
110	74.8152	17.1121	6.1517
111	45.0542	3.2601	2.3992
112	8.3821	56.1200	5.5213

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
113	22.8977	88.1867	6.1096
114	91.3337	66.9175	2.6944
115	15.2378	19.0433	3.9178
116	82.5817	36.8917	7.4443
117	53.8342	46.0726	5.9764
118	99.6135	98.1638	2.2805
119	7.8176	15.6405	4.4233
120	44.2678	85.5523	4.5691
121	10.6653	64.4765	6.1907
122	96.1898	37.6272	1.1746
123	0.4634	19.0924	6.1982
124	77.4910	42.8253	9.3898
125	81.7303	48.2022	1.9619
126	86.8695	12.0612	7.5893
127	8.4436	58.9507	9.7347
128	39.9783	22.6188	6.4800
129	25.9870	38.4619	7.4770
130	80.0068	58.2986	3.7248
131	43.1414	25.1806	5.1312
132	91.0648	29.0441	1.4323
133	18.1847	61.7091	4.4682
134	26.3803	26.5281	4.2554
135	14.5539	82.4376	3.5883
136	13.6069	98.2663	8.3504
137	86.9292	73.0249	5.0548
138	57.9705	34.3877	8.2597
139	54.9860	58.4069	8.1116
140	14.4955	10.7769	3.5466
141	85.3031	90.6308	1.6148
142	62.2055	87.9654	1.4944
143	35.0952	81.7761	6.7377
144	51.3250	26.0728	4.8186
145	40.1808	59.4356	9.1498
146	7.5967	2.2513	4.7559
147	23.9916	42.5259	2.3865
148	12.3319	31.2719	5.8600
149	18.3908	16.1485	9.4338
150	23.9953	17.8766	6.9486
151	41.7267	42.2886	4.5519
152	4.9654	9.4229	3.3309
153	90.2716	59.8524	8.6312

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
154	94.4787	47.0924	9.5055
155	49.0864	69.5949	4.3930
156	48.9253	69.9888	1.6055
157	33.7719	63.8531	2.6342
158	90.0054	3.3604	6.1817
159	36.9247	6.8806	2.6730
160	11.1203	31.9600	3.6230
161	78.0252	53.0864	5.1550
162	38.9739	65.4446	4.1228
163	24.1691	40.7619	3.8635
164	40.3912	81.9981	5.1392
165	9.6455	71.8359	3.1231
166	13.1973	96.8649	1.2498
167	94.2051	53.1334	6.9261
168	95.6135	32.5146	2.4292
169	57.5209	10.5629	8.2240
170	5.9780	61.0959	4.6772
171	23.4780	77.8802	3.9465
172	35.3159	42.3453	7.7141
173	82.1194	9.0823	7.7172
174	1.5403	26.6471	2.5656
175	4.3024	15.3657	2.0579
176	16.8990	28.1005	2.5663
177	64.9115	44.0085	6.6467
178	73.1722	52.7143	8.5770
179	64.7746	45.7424	5.5907
180	45.0924	87.5372	2.4919
181	54.7009	51.8052	7.4287
182	29.6321	94.3623	9.1633
183	74.4693	63.7709	2.9668
184	18.8955	95.7694	8.8387
185	68.6775	24.0707	2.9065
186	18.3511	67.6122	8.5300
187	36.8485	28.9065	8.7337
188	62.5619	67.1808	5.7104
189	78.0227	69.5140	5.2963
190	8.1126	6.7993	9.0089
191	92.9386	25.4790	1.5857
192	77.5713	22.4040	5.5851
193	48.6792	66.7833	6.5872
194	43.5859	84.4392	7.6021

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
195	44.6784	34.4462	3.0700
196	30.6349	78.0520	1.1968
197	50.8509	67.5332	2.2509
198	51.0772	0.6715	7.9256
199	81.7628	60.2170	9.7279
200	79.4831	38.6771	4.4811
201	64.4318	91.5991	9.9409
202	37.8609	0.1151	3.9375
203	81.1580	46.2449	2.2344
204	53.2826	42.4349	4.4628
205	35.0727	46.0916	6.0637
206	93.9002	77.0160	6.7045
207	87.5943	32.2472	5.8745
208	55.0156	78.4739	3.8349
209	62.2475	47.1357	2.4339
210	58.7045	3.5763	2.3735
211	20.7742	17.5874	2.2326
212	30.1246	72.1758	7.3882
213	47.0923	47.3486	5.1838
214	23.0488	15.2721	2.0194
215	84.4309	34.1125	7.3079
216	19.4764	60.7389	2.6199
217	22.5922	19.1745	8.2330
218	17.0708	73.8427	5.6256
219	22.7664	24.2850	5.9359
220	43.5699	91.7424	2.8706
221	31.1102	26.9062	8.0613
222	92.3380	76.5500	5.7384
223	43.0207	18.8662	6.1392
224	18.4816	28.7498	4.7984
225	90.4881	9.1113	7.4904
226	97.9748	57.6209	1.6582
227	43.8870	68.3363	6.3538
228	11.1119	54.6593	8.7578
229	25.8065	42.5729	5.0392
230	40.8720	64.4443	6.8732
231	59.4896	64.7618	3.7313
232	26.2212	67.9017	6.4670
233	60.2843	63.5787	3.5101
234	71.1216	94.5174	8.1961
235	22.1747	20.8935	8.1655

Continued on next page

Table B.42 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
236	11.7418	70.9282	9.5868
237	29.6676	23.6231	4.9990
238	31.8778	11.9396	5.1119
239	42.4167	60.7304	6.3984
240	50.7858	45.0138	8.5836
241	8.5516	45.8725	1.2808
242	26.2482	66.1945	2.6854
243	80.1015	77.0286	9.4923
244	2.9220	35.0218	9.5313
245	92.8854	66.2010	5.0769
246	73.0331	41.6159	8.2975
247	48.8609	84.1929	9.3599
248	57.8525	83.2917	7.0545
249	23.7284	25.6441	4.3510
250	45.8849	61.3461	4.6513

Table B.43: Depot locations and number of vehicles for MS22

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	63.1189	22.4171	1
2	35.5074	65.2451	1
3	99.7003	60.4991	1

Table B.44: Customer locations and service time for MS22

Customer index	x-coordinate	y-coordinate	Service time (short)
1	58.2249	45.6058	8.4429
2	54.0739	10.1669	4.5251
3	86.9941	99.5390	6.5922
4	26.4779	33.2093	9.6864
5	31.8074	29.7347	8.4562
6	11.9215	6.2045	8.3206
7	93.9829	29.8244	9.5959
8	64.5552	4.6351	2.6481
9	47.9463	50.5428	7.0339
10	63.9317	76.1426	7.6204
11	54.4716	63.1070	8.3760
12	64.7311	8.9892	7.1292
13	54.3886	8.0862	3.9705
14	72.1047	77.7241	1.3122
15	52.2495	90.5135	2.0817
16	99.3705	53.3772	3.5534
17	21.8677	10.9154	8.5441
18	10.5798	82.5809	9.1122
19	10.9697	33.8098	5.0495
20	6.3591	29.3973	9.8968
21	40.4580	74.6313	1.3041
22	44.8373	1.0337	8.7351
23	36.5816	4.8447	5.7570
24	76.3505	66.7916	9.7791
25	62.7896	60.3468	8.8950
26	77.1980	52.6102	2.4520
27	93.2854	72.9709	4.1804
28	97.2741	70.7253	1.5221
29	19.2028	78.1377	4.9970
30	13.8874	28.7977	4.9698
31	69.6266	69.2532	3.9403
32	9.3820	55.6670	9.2296

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	52.5404	39.6521	5.4510
34	53.0344	6.1591	7.3921
35	86.1140	78.0176	6.9818
36	48.4853	33.7584	8.4860
37	39.3456	60.7866	3.3223
38	67.1431	74.1254	7.9232
39	74.1258	10.4813	4.6951
40	52.0052	12.7888	1.5009
41	34.7713	54.9540	8.8358
42	14.9997	48.5229	9.7507
43	58.6092	89.0476	2.0528
44	26.2145	79.8960	5.5748
45	4.4454	73.4341	7.8001
46	75.4933	5.1332	1.9899
47	24.2785	7.2885	1.3048
48	44.2402	8.8527	4.9699
49	68.7796	79.8351	2.1681
50	35.9228	94.3008	9.7444
51	73.6340	68.3716	9.4614
52	39.4707	13.2083	9.3981
53	68.3416	72.2725	9.8538
54	70.4047	11.0353	7.2373
55	44.2305	11.7493	7.3223
56	1.9578	64.0718	4.3418
57	33.0858	32.8814	1.5770
58	42.4309	65.3812	4.9911
59	27.0270	74.9131	5.8869
60	19.7054	58.3186	5.8615
61	82.1721	74.0032	8.0766
62	42.9921	23.4827	6.4127
63	88.7771	73.4958	9.5231
64	39.1183	97.0599	6.6810
65	76.9114	86.6930	8.9095
66	39.6792	8.6235	2.1042
67	80.8514	36.6437	8.3219
68	75.5077	36.9199	9.7984
69	37.7396	68.5028	3.0812
70	21.6019	59.7942	9.2146
71	79.0407	78.9364	7.0873
72	94.9304	36.7653	7.5256
73	32.7565	20.6028	7.1721

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	67.1264	8.6667	8.1705
75	43.8645	77.1934	5.7666
76	83.3501	20.5675	7.7918
77	76.8854	38.8272	5.5320
78	16.7254	55.1779	9.1634
79	86.1980	22.8953	2.1125
80	98.9872	64.1941	8.6700
81	51.4423	48.4480	2.5754
82	88.4281	15.1846	7.8775
83	58.8026	78.1932	5.1340
84	15.4752	10.0606	6.4546
85	19.9863	29.4066	4.2764
86	40.6955	23.7373	4.6175
87	74.8706	53.0872	7.5707
88	82.5584	9.1499	9.5962
89	78.9963	40.5315	8.9092
90	31.8524	10.4846	6.4876
91	53.4064	11.2284	9.7099
92	8.9951	78.4428	6.7072
93	11.1706	29.1570	7.9954
94	13.6293	60.3533	9.0865
95	67.8652	96.4423	3.0391
96	49.5177	43.2485	1.9114
97	18.9710	69.4752	8.4543
98	49.5006	75.8099	4.8202
99	14.7608	43.2642	7.5439
100	5.4974	65.5498	9.4307
101	85.0713	10.9755	3.6688
102	56.0560	93.3760	3.8098
103	92.9609	18.7461	5.9473
104	69.6667	26.6179	5.9732
105	58.2791	79.7830	6.7636
106	81.5397	48.7604	6.3698
107	87.9014	76.8958	2.4506
108	98.8912	39.6007	4.7612
109	0.0522	27.2939	4.3215
110	86.5439	3.7235	1.7224
111	61.2566	67.3295	3.1268
112	98.9950	42.9564	9.9491
113	52.7680	45.1739	9.1837
114	47.9523	60.9857	8.1171

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	80.1348	5.9403	2.2163
116	22.7843	31.5811	5.9531
117	49.8094	77.2722	1.4845
118	90.0852	69.6433	7.0890
119	57.4661	12.5332	8.4005
120	84.5178	13.0151	9.2026
121	73.8640	9.2352	2.3248
122	58.5987	0.7820	3.7438
123	24.6735	42.3109	8.0188
124	66.6416	65.5573	5.3851
125	8.3483	72.2923	5.9426
126	62.5960	53.1209	8.9039
127	66.0945	10.8818	9.8946
128	72.9752	63.1766	1.1724
129	89.0752	12.6500	4.1619
130	98.2303	13.4303	5.8118
131	76.9029	9.8594	7.7304
132	58.1446	14.2027	9.7301
133	92.8313	16.8251	7.2563
134	58.0090	19.6249	3.4594
135	1.6983	31.7480	9.5602
136	12.0860	31.6429	9.1690
137	86.2711	21.7563	5.1168
138	48.4297	25.1042	7.5985
139	84.4856	89.2922	6.0242
140	20.9405	70.3223	9.9450
141	55.2291	55.5738	4.5037
142	62.9883	18.4434	8.9351
143	3.1991	21.2031	9.0394
144	61.4713	7.7347	4.4740
145	36.2411	91.3800	7.5480
146	4.9533	70.6715	9.2138
147	48.9570	55.7789	9.1371
148	19.2510	31.3429	1.7331
149	12.3084	16.6204	1.3001
150	20.5494	62.2497	6.1517
151	14.6515	98.7935	1.0836
152	18.9072	17.0432	2.7850
153	4.2652	25.7792	1.1861
154	63.5198	39.6799	8.1304
155	28.1867	7.3995	2.7175

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	53.8597	68.4096	9.5687
157	69.5163	40.2388	7.9320
158	49.9116	98.2835	8.3492
159	53.5801	40.2184	4.8345
160	44.5183	62.0672	3.7020
161	12.3932	15.4370	7.1226
162	49.0357	38.1345	8.7266
163	85.2998	16.1134	8.8461
164	87.3927	75.8112	9.0736
165	27.0294	87.1111	8.5923
166	20.8461	35.0777	5.3664
167	56.4980	68.5536	5.3969
168	64.0312	29.4149	1.5880
169	41.7029	53.0629	5.1128
170	20.5976	83.2423	6.3600
171	94.7933	59.7490	1.9908
172	8.2071	33.5311	4.0941
173	10.5709	29.9225	3.3766
174	14.2041	45.2593	6.2216
175	16.6460	42.2646	4.9185
176	62.0959	35.9606	4.7359
177	57.3710	55.8319	1.4879
178	5.2078	74.2545	3.3373
179	93.1201	42.4335	3.1976
180	72.8662	42.9356	7.3819
181	73.7842	12.4873	6.9297
182	6.3405	2.4434	2.0726
183	86.0441	29.0185	2.1630
184	93.4405	31.7521	1.7017
185	98.4398	65.3690	7.6172
186	85.8939	95.6936	6.0053
187	78.5559	93.5731	8.5093
188	51.3377	45.7886	1.9551
189	17.7602	24.0478	3.3091
190	39.8589	76.3898	1.4871
191	13.3931	75.9327	6.9090
192	3.0890	74.0648	3.4969
193	93.9142	74.3688	7.3822
194	30.1306	10.5920	2.1727
195	29.5534	68.1560	5.7160
196	33.2936	46.3261	1.4130

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	46.7068	21.2163	1.9118
198	64.8198	9.8519	5.2204
199	2.5228	82.3574	7.3958
200	84.2207	17.5010	6.4121
201	55.9033	16.3570	2.8443
202	85.4100	66.5987	6.5691
203	34.7879	89.4389	7.2924
204	44.6027	51.6558	3.8335
205	5.4239	70.2702	8.2431
206	17.7108	15.3590	2.6022
207	66.2808	95.3457	3.1718
208	33.0829	54.0884	6.3526
209	89.8486	67.9734	8.8141
210	11.8155	3.6563	8.3680
211	98.8418	80.9204	6.3108
212	53.9982	74.8619	1.0206
213	70.6917	12.0187	9.5008
214	99.9492	52.5045	8.1323
215	28.7849	32.5834	4.5940
216	41.4523	54.6449	8.8610
217	46.4840	39.8881	7.0696
218	76.3957	41.5093	3.1813
219	81.8204	18.0738	2.5160
220	10.0222	25.5387	8.7501
221	17.8117	2.0536	3.9398
222	35.9635	92.3676	3.9264
223	5.6705	65.3700	4.6016
224	52.1886	93.2614	7.8716
225	33.5849	16.3512	2.4766
226	17.5669	92.1097	7.1946
227	20.8947	79.4658	6.7898
228	90.5154	57.7394	8.3922
229	67.5391	44.0036	4.4069
230	46.8468	25.7614	2.0071
231	91.2132	75.1946	8.7353
232	10.4012	22.8669	7.4186
233	74.5546	6.4187	6.1751
234	73.6267	76.7330	7.6702
235	56.1861	67.1202	7.7830
236	18.4194	71.5213	5.9958
237	59.7211	64.2061	8.2082

Continued on next page

Table B.44 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	29.9937	41.9048	7.0331
239	13.4123	39.0762	5.8160
240	21.2602	81.6140	7.1733
241	89.4942	31.7428	9.5967
242	7.1453	81.4540	6.6498
243	24.2487	78.9074	8.3722
244	5.3754	85.2264	2.7007
245	44.1722	50.5637	7.7633
246	1.3283	63.5661	2.9942
247	89.7191	95.0894	4.7480
248	19.6658	44.3964	8.1179
249	9.3371	6.0019	4.5997
250	30.7367	86.6750	1.4060

Table B.45: Depot locations and number of vehicles for MS23

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	42.7911	69.5390	1
2	96.6053	72.0165	1
3	62.0055	34.6895	1

Table B.46: Customer locations and service time for MS23

Customer index	x-coordinate	y-coordinate	Service time (short)
1	38.7245	4.2298	2.8094
2	14.2187	97.2958	1.3858
3	2.5135	18.9207	6.7525
4	42.1112	66.7120	3.2658
5	18.4100	58.6440	4.7790
6	72.5775	67.5112	2.5465
7	37.0363	36.1022	8.9601
8	84.1560	62.0278	4.0691
9	73.4230	81.1151	2.8461
10	57.1026	1.9257	8.1585
11	17.6855	8.3874	1.2202
12	95.7384	97.4802	1.3580
13	26.5322	65.1350	5.7684
14	92.4581	23.1238	9.4003
15	22.3770	40.3491	6.4199
16	37.3564	12.2021	6.4106
17	8.7500	26.8439	6.7948
18	64.0117	25.7846	9.2974
19	18.0617	33.1665	2.9733
20	4.5051	15.2234	8.9641
21	72.3173	34.8008	1.4394
22	34.7438	12.1658	8.3084
23	66.0617	88.4153	1.2933
24	38.3869	9.4278	4.7354
25	62.7347	93.0041	6.3520
26	2.1650	39.9020	2.7712
27	91.0570	4.7401	8.1648
28	80.0559	34.2374	2.8989
29	74.5847	73.5966	2.5697
30	81.3113	79.4682	6.5246
31	38.3306	54.4906	9.4695
32	61.7279	68.6223	6.9541

Continued on next page

Table B.46 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	57.5495	89.3633	2.9341
34	53.0052	5.4792	9.2223
35	27.5070	30.3661	4.4218
36	24.8629	4.6192	1.3148
37	45.1639	19.5477	3.0461
38	22.7713	72.0166	9.1620
39	80.4450	72.1753	8.8209
40	98.6104	87.7799	6.2422
41	2.9992	58.2433	6.0471
42	53.5664	7.0684	1.0098
43	8.7077	92.2745	2.1418
44	80.2091	80.0372	2.9318
45	98.9145	28.5947	8.4414
46	6.6946	54.3663	4.4885
47	93.9398	98.4776	3.8627
48	1.8178	71.5678	3.3560
49	68.3839	83.8970	3.6687
50	78.3736	43.3261	4.8536
51	53.4138	47.0625	2.7317
52	88.5359	56.0713	6.1073
53	89.9005	26.9092	6.9190
54	62.5938	74.9018	7.1702
55	13.7869	50.3888	4.1837
56	21.7802	64.6810	9.6111
57	18.2141	30.7746	3.1936
58	4.1820	13.8725	7.7344
59	10.6942	47.5573	4.5120
60	61.6443	36.2459	8.6028
61	93.9661	78.8113	4.3479
62	35.4456	78.0296	7.3685
63	41.0629	66.8512	4.1109
64	98.4349	13.3504	8.8944
65	94.5579	2.1556	7.7548
66	67.6645	55.9841	4.9098
67	98.8302	30.0819	4.6059
68	76.6831	93.9410	4.3564
69	33.6699	98.0904	4.9893
70	66.2382	28.6620	4.4228
71	24.4165	80.0820	1.6544
72	29.5507	89.6111	4.9625
73	68.0178	59.7527	6.4587

Continued on next page

Table B.46 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	52.7847	88.4017	3.7431
75	41.1594	94.3732	4.6598
76	60.2638	54.9158	1.9091
77	75.0520	72.8387	5.2919
78	58.3533	57.6758	3.6317
79	55.1793	2.5857	1.1465
80	58.3571	44.6531	8.9597
81	51.1820	64.6302	2.8928
82	8.2593	52.1203	7.1528
83	71.9570	37.2313	2.3895
84	99.6156	93.7135	9.7688
85	35.4534	82.9533	5.5240
86	97.1259	84.9085	9.0227
87	34.6449	37.2534	7.5384
88	88.6544	59.3185	5.4746
89	45.4695	87.2553	6.4649
90	41.3427	93.3502	4.1436
91	21.7732	66.8464	5.7359
92	12.5655	20.6776	8.1722
93	30.8915	65.3851	3.4631
94	72.6104	7.2052	3.6342
95	78.2872	40.6727	4.1334
96	69.3788	66.6932	8.8838
97	0.9802	93.3726	1.8399
98	84.3213	81.0950	2.8601
99	92.2332	48.4548	3.7248
100	77.0954	75.6749	4.1637
101	4.2660	41.7047	7.5407
102	37.8186	97.1786	8.9769
103	70.4340	98.7975	1.4673
104	72.9513	86.4148	1.7070
105	22.4277	38.8884	1.1304
106	26.9055	45.4742	2.7401
107	67.3031	24.6687	1.2366
108	47.7492	78.4423	5.2189
109	62.3716	88.2838	3.1904
110	23.6445	91.3712	9.2793
111	17.7124	55.8285	7.4425
112	82.9643	59.8868	5.3978
113	76.6922	14.8877	1.7027
114	93.4478	89.9713	5.7706

Continued on next page

Table B.46 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	10.7889	45.0394	6.9945
116	18.2228	20.5672	6.4694
117	9.9095	89.9651	4.7760
118	48.9764	76.2586	1.9972
119	19.3245	88.2486	8.3495
120	89.5892	28.4950	3.2437
121	9.9090	67.3226	5.5826
122	4.4166	66.4280	8.2372
123	55.7295	12.2815	5.5885
124	77.2495	40.7318	3.7243
125	31.1940	27.5287	8.7573
126	17.8982	71.6670	1.5165
127	33.8956	28.3384	7.5768
128	21.0146	89.6199	9.1079
129	51.0153	82.6579	5.1764
130	90.6364	39.0027	5.2243
131	62.8924	49.7903	2.3843
132	10.1534	69.4805	9.6562
133	39.0855	83.4369	8.8863
134	5.4617	60.9630	5.3977
135	50.1283	57.4737	4.6637
136	43.1721	32.6042	2.1392
137	99.7560	45.6425	9.3288
138	81.1603	71.3796	1.0502
139	48.5652	88.4405	2.6775
140	89.4448	72.0856	3.9165
141	13.7547	1.8613	1.4517
142	39.0005	67.4776	2.3008
143	92.7356	43.8509	7.5643
144	91.7494	43.7820	5.3405
145	71.3574	11.7037	4.0426
146	61.8337	81.4682	3.1309
147	34.3288	32.4855	5.0578
148	93.6027	24.6228	2.6691
149	12.4774	34.2713	3.9183
150	73.0585	37.5692	3.3757
151	64.6477	54.6554	8.4707
152	83.3152	56.1920	7.2672
153	39.8282	39.5822	4.0018
154	74.9822	39.8131	6.2221
155	83.5221	51.5367	3.5905

Continued on next page

Table B.46 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	32.2460	65.7531	3.3757
157	55.2262	95.0915	3.3391
158	97.9129	72.2349	7.0937
159	54.9309	40.0080	5.6784
160	33.0424	83.1871	1.6908
161	61.9472	13.4338	1.5026
162	36.0637	6.0467	3.3286
163	75.6510	8.4247	4.9593
164	41.3901	16.3898	3.5586
165	49.2345	32.4220	7.1089
166	69.4743	30.1727	9.5462
167	97.2734	1.1681	7.9656
168	32.7755	53.9905	6.7253
169	83.7803	9.5373	7.7822
170	73.9072	14.6515	7.7213
171	95.4174	63.1141	6.2743
172	3.1923	85.9320	7.9575
173	35.6869	97.4222	4.5324
174	66.2654	57.0838	6.4476
175	28.1502	99.6850	3.2269
176	23.0383	55.3542	3.6118
177	71.1129	51.5458	1.1740
178	62.4573	33.0682	4.1258
179	59.0609	43.0002	2.2762
180	66.0438	49.1806	4.7038
181	4.7555	7.1037	2.3776
182	34.8785	88.7739	8.4611
183	45.1341	6.4634	7.6528
184	24.0905	43.6185	1.8898
185	71.5045	82.6630	8.3857
186	85.6182	39.4535	3.0440
187	28.1508	61.3475	1.9625
188	73.1051	81.8641	6.9650
189	13.7763	88.6235	9.5912
190	83.6723	93.1112	8.3311
191	13.8602	19.0785	6.6093
192	58.8209	25.8582	3.9544
193	36.6157	89.7866	3.4963
194	80.6760	59.3362	4.9094
195	50.3781	50.3840	4.1527
196	48.9594	61.2810	8.8998

Continued on next page

Table B.46 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	87.7049	81.9422	1.0554
198	35.3142	53.1889	7.2680
199	44.9444	20.2075	4.0426
200	96.3530	45.3893	3.7449

Table B.47: Depot locations and number of vehicles for MS24

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	79.6179	77.5028	1
2	69.1191	91.4188	1
3	34.5308	78.2551	1
4	94.6817	29.5534	1
5	52.0190	15.1846	1
6	95.3813	84.7911	1
7	7.3596	78.4855	1
8	20.7032	27.0832	1

Table B.48: Customer locations and service time for MS24

Customer index	x-coordinate	y-coordinate	Service time (short)
1	51.6990	87.7182	6.8329
2	55.6695	78.4852	9.2903
3	15.6495	46.4954	9.0377
4	56.2056	81.3977	9.9746
5	69.4803	89.8444	1.6560
6	42.6456	42.9239	2.1666
7	83.6270	33.4329	9.8341
8	73.1387	59.6647	1.8122
9	36.0031	90.1991	7.1754
10	45.4212	70.2066	9.3607
11	38.6390	37.7455	2.2763
12	77.5555	73.4956	8.9597
13	73.4271	95.4103	1.1779
14	43.0278	54.2813	4.0842
15	69.3753	54.0106	3.1448
16	94.5213	31.1110	9.8611
17	78.4233	7.1235	8.6194
18	70.5572	18.1980	8.1506
19	10.9334	9.2989	9.1025
20	38.9931	46.3489	8.0209
21	59.0905	0.9333	8.5286
22	45.9380	91.5026	3.8898
23	5.0340	64.2742	7.6847
24	22.8688	0.1419	6.9804
25	83.4189	3.0385	3.6027
26	1.5645	20.8470	4.0364
27	86.3711	45.4966	9.1777

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
28	7.8069	12.7266	1.2903
29	66.9043	0.8648	7.2672
30	50.0211	72.7080	2.8789
31	21.7994	35.4116	8.4173
32	57.1616	78.0446	2.9641
33	12.2189	43.6657	1.8968
34	67.1166	43.6555	6.5756
35	59.9586	4.9213	1.9343
36	5.5976	4.9632	8.1916
37	5.6343	9.1100	9.1263
38	15.2501	59.4037	3.8126
39	1.9621	24.1084	3.5343
40	43.5176	84.1369	1.0610
41	83.2221	85.7213	5.4628
42	61.7390	96.3612	9.8963
43	52.0129	48.8900	7.6415
44	86.3868	22.0310	3.7965
45	9.7698	22.6209	6.4037
46	90.8052	53.6788	8.0351
47	10.8017	76.2110	2.0038
48	51.6997	34.7567	6.2140
49	14.3156	46.1232	8.8333
50	55.9371	63.9324	7.2080
51	0.4580	91.7336	3.1867
52	76.6682	16.1573	4.0845
53	84.8709	71.5635	5.9090
54	91.6821	57.7739	1.6082
55	98.6968	43.3299	4.6940
56	50.5133	88.4243	3.1376
57	27.1422	39.3052	5.4008
58	10.0751	17.8975	8.2546
59	50.7849	63.3334	4.4006
60	58.5609	62.4001	5.6618
61	76.2887	32.7942	1.8514
62	8.2963	80.2965	9.1819
63	66.1596	99.9478	2.8687
64	51.6979	98.0978	4.4386
65	17.1048	12.7037	6.9425
66	93.8558	23.2240	7.8254
67	59.0483	2.3632	2.5576
68	44.0635	60.7433	5.6564

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
69	94.1919	11.0809	9.9580
70	65.5914	40.7460	7.3685
71	45.1946	88.4077	1.7251
72	83.9697	54.8133	1.3898
73	53.2624	36.9003	5.4204
74	55.3887	20.8346	5.0194
75	68.0066	44.0943	5.3812
76	36.7190	95.6196	2.4930
77	23.9291	12.4026	4.2459
78	57.8923	47.0763	8.9265
79	86.6887	85.6896	7.6992
80	40.6777	4.3390	4.7509
81	11.2615	69.1625	9.1662
82	44.3846	97.8985	1.8488
83	30.0184	28.3268	2.6319
84	40.1387	13.3780	9.5193
85	83.3364	68.5280	1.9076
86	40.3629	90.9455	4.4923
87	39.0176	61.0869	3.6030
88	36.0449	89.9983	1.6578
89	14.0255	19.3434	2.7515
90	26.0130	75.4425	4.7574
91	8.6815	34.6261	3.6363
92	42.9397	41.8625	7.3192
93	25.7283	15.5720	3.1574
94	29.7555	81.9001	9.6353
95	42.4858	62.4924	3.7492
96	11.9207	73.8560	2.3942
97	49.5067	80.5112	5.9996
98	70.6407	6.7223	8.1149
99	24.3573	95.0790	4.9949
100	78.5070	49.7577	9.9624
101	7.4090	75.5146	4.9293
102	39.3883	74.2405	3.7400
103	0.3394	83.1130	3.2186
104	22.0677	15.6502	9.6474
105	0.1301	45.7309	3.0059
106	18.9180	61.8100	4.5605
107	14.2484	93.2183	3.0207
108	26.8076	83.5088	3.4302
109	17.4892	89.5424	4.7660

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
110	13.8649	58.2519	9.9796
111	59.8886	58.2747	9.1993
112	90.1058	85.4926	5.9538
113	93.9380	3.4866	6.3670
114	22.1184	88.5420	1.7123
115	48.2671	40.7731	6.1897
116	37.6011	3.6382	9.0836
117	52.3780	74.6148	5.1698
118	26.4873	15.4829	4.5856
119	6.8357	14.3908	1.9402
120	43.6327	60.5959	6.8701
121	17.3853	25.4481	9.9253
122	2.6107	32.4154	7.1027
123	95.4678	40.1791	4.8563
124	43.0597	40.6373	6.8932
125	96.1559	38.6191	6.2987
126	76.2414	60.9802	7.7055
127	0.7349	16.6891	6.7678
128	68.0039	18.8092	5.5331
129	70.5951	9.4629	9.4424
130	64.5129	32.3186	6.4481
131	55.2310	76.9597	6.7503
132	21.8109	23.4118	7.3239
133	77.2366	74.0365	8.7485
134	22.8028	69.2818	4.4170
135	37.0865	82.4078	7.4091
136	89.0929	82.7978	5.7117
137	85.6377	29.3368	4.2714
138	40.2434	30.9369	4.9121
139	31.8019	52.3030	7.1884
140	60.8635	32.5299	3.0417
141	91.0195	83.1843	9.8110
142	90.9098	81.0295	9.7810
143	59.1594	55.6998	3.6056
144	33.2571	26.2964	4.0459
145	85.3064	68.0566	9.9680
146	44.2398	23.3653	8.1007
147	90.4355	45.6425	8.1543
148	3.3179	38.4567	6.6913
149	53.2426	53.8601	8.3031
150	71.6497	99.1704	5.0328

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
151	17.9302	75.5220	8.4755
152	33.6533	98.0455	2.1400
153	18.7713	23.4783	5.6194
154	32.1927	52.8559	7.4434
155	40.3857	5.1436	3.2333
156	54.8566	75.6875	5.7871
157	4.8739	60.1980	4.4399
158	55.2732	85.7169	8.2159
159	27.4811	98.8277	7.0377
160	24.1502	92.9484	9.8457
161	24.3145	40.9515	9.4314
162	15.4159	0.0341	6.1865
163	95.6416	54.0878	1.7217
164	93.5661	20.7731	4.7244
165	81.8714	21.9284	2.6276
166	72.8262	32.5806	9.9607
167	17.5812	9.5949	5.6835
168	36.0371	74.7534	8.9675
169	18.8790	74.8509	6.8343
170	0.1198	54.3299	5.1963
171	31.6420	33.8132	1.8575
172	69.9617	83.2334	9.7104
173	62.5255	55.2572	6.5810
174	54.3062	95.7543	2.4040
175	43.9037	89.2833	4.5853
176	28.7427	35.6504	8.9425
177	50.1659	54.6402	5.8511
178	76.1546	34.6682	5.8931
179	76.2408	62.2803	4.9821
180	57.6056	79.6625	2.6537
181	74.7663	74.5875	3.2431
182	64.5535	12.5536	3.5660
183	12.3220	82.2394	5.7656
184	50.4398	2.5151	6.0385
185	34.7261	41.4429	4.7363
186	9.2148	73.1407	9.1511
187	14.7849	78.1374	3.7463
188	19.8170	36.7286	6.8479
189	67.2270	74.4868	3.5990
190	43.1511	89.2267	3.2973
191	69.4404	24.2603	4.2236

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
192	25.6785	12.9597	8.2533
193	0.9759	22.5068	5.8503
194	53.2283	35.0014	6.3106
195	27.9392	28.7085	3.0803
196	94.6230	92.7488	1.9175
197	90.6443	5.1314	6.8018
198	39.2685	59.2667	9.8212
199	2.4855	16.2899	1.9155
200	67.1437	83.8406	2.6908
201	83.7171	16.7561	1.0845
202	97.1500	50.2201	8.5447
203	5.6933	99.9329	5.3321
204	45.0324	35.5407	5.2168
205	58.2470	4.7078	9.1769
206	68.6638	21.3661	4.7543
207	71.9433	39.7839	5.8972
208	65.0041	33.3668	7.2911
209	72.6915	22.9603	1.7115
210	37.3848	93.6120	5.5847
211	58.1582	68.3189	5.3821
212	11.6119	96.2114	8.7029
213	5.7654	43.7973	6.5296
214	97.9765	94.0337	2.0567
215	28.4824	0.5834	6.4619
216	59.4974	61.0307	2.4776
217	96.2161	80.1076	4.5912
218	18.5778	23.2982	5.7912
219	19.3040	93.2469	8.8769
220	34.1644	76.3263	6.9313
221	93.2898	82.6450	8.0886
222	39.0668	57.3464	2.1342
223	27.3217	79.2582	5.7248
224	15.1947	32.9041	9.0953
225	39.7109	22.3462	1.9818
226	37.4722	31.2386	6.7111
227	13.1115	58.4523	1.7276
228	43.5041	82.9914	4.7011
229	9.1513	29.0462	7.4137
230	61.4627	40.2554	1.9038
231	1.0979	86.2057	8.2895
232	57.3260	61.4740	6.7403

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
233	78.9730	99.1188	9.0826
234	23.5367	20.3699	6.5964
235	44.8020	82.7209	4.7315
236	56.9358	67.5862	6.8280
237	6.1401	24.8949	5.4034
238	49.6289	47.5786	1.8438
239	64.2315	39.9075	6.7359
240	22.1266	59.9438	9.5524
241	83.7056	80.0523	5.2874
242	97.1075	10.5069	6.4252
243	84.6373	82.1442	6.3233
244	50.5999	84.1086	3.0274
245	27.8876	35.4506	7.0159
246	74.6617	43.0069	2.4090
247	23.6930	57.2239	7.9683
248	95.7345	70.0825	2.9175
249	62.0260	74.2470	2.5221
250	60.0262	75.7884	7.5318
251	17.2605	38.9129	3.3057
252	9.0347	42.9302	2.4649
253	25.5262	95.6345	6.6320
254	85.8571	57.2971	3.2567
255	91.1067	84.9722	3.3668
256	69.9634	27.6345	8.5954
257	72.5182	62.2324	4.5768
258	22.9886	58.8362	1.9412
259	57.6053	96.3468	2.7447
260	81.0628	8.5903	4.2676
261	40.3843	50.0499	8.8708
262	98.8439	52.1590	6.3979
263	8.9999	9.0166	3.3230
264	32.0941	90.4666	4.2258
265	51.1409	88.4389	8.9879
266	6.0606	43.8990	9.1048
267	72.5688	78.1723	5.0316
268	55.6556	14.8465	3.4197
269	52.9360	61.9816	5.9843
270	82.9982	26.0624	2.6096
271	85.8759	44.5656	8.7373
272	78.9029	84.4000	3.0878
273	31.7833	19.6205	2.5129

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
274	45.2207	30.3852	1.2405
275	75.2228	48.3295	3.9019
276	10.9862	33.7812	5.9965
277	10.9742	79.8486	8.4208
278	26.9884	98.7488	8.2382
279	52.4637	15.9048	1.2197
280	97.2651	23.6880	4.3435
281	71.0409	70.2237	5.4268
282	31.1860	37.5472	5.1945
283	29.1457	97.3705	1.3754
284	85.0357	97.2306	6.5530
285	91.1647	64.3698	6.2023
286	63.9276	86.0099	3.6893
287	25.5370	40.1883	4.9210
288	8.8666	63.1931	2.2297
289	83.8256	98.5237	3.6975
290	58.4719	55.9477	7.8524
291	94.8109	93.3592	1.3177
292	6.1029	72.0343	3.4255
293	58.4641	48.4039	9.9664
294	28.5108	63.9031	5.0225
295	82.7732	88.7637	2.3751
296	19.0986	19.8737	8.9761
297	44.2530	39.5366	1.2824
298	39.3412	99.2175	2.0443
299	82.6574	40.2352	3.2577
300	67.6871	65.8856	7.8371
301	20.7603	90.1348	9.0848
302	31.8105	99.5382	3.0108
303	13.3811	65.3163	7.0597
304	67.1463	10.8436	8.3691
305	57.0991	3.6114	9.5404
306	16.9767	61.8091	8.8688
307	14.7656	56.7144	4.5436
308	47.6080	96.1965	9.4327
309	90.8102	74.6105	4.9321
310	55.2175	66.2516	2.4627
311	3.2940	52.3313	3.7884
312	5.3863	25.9894	7.1300
313	80.5063	96.1994	9.4065
314	45.1375	54.0204	9.5265

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
315	38.2646	3.0270	6.3917
316	78.9644	69.6314	9.5399
317	36.4287	51.9716	4.6362
318	53.2350	5.9031	1.3693
319	71.1657	89.0036	3.6444
320	87.1477	33.0202	1.2875
321	32.8690	22.9701	8.7806
322	65.0118	11.3949	4.8929
323	97.4836	31.0923	1.8353
324	7.5967	22.8432	2.2401
325	58.7019	65.1997	3.1777
326	41.3886	6.6160	3.0071
327	30.9136	27.5431	8.8097
328	26.3834	28.1820	7.8776
329	75.8766	88.0066	4.1024
330	99.5216	44.4330	4.4630
331	18.6571	75.5914	6.3538
332	78.1145	60.3296	5.8161
333	19.5798	78.3266	4.0020
334	99.2359	11.3931	8.6921
335	80.2262	97.8564	3.3908
336	42.4227	84.8597	9.4055
337	72.8864	5.0646	4.5085
338	49.8354	46.6202	7.1476
339	80.8990	32.5653	3.4751
340	35.6509	63.0205	1.2516
341	7.3243	23.0299	9.4655
342	59.0991	57.9885	5.8057
343	91.0188	60.3156	7.0406
344	19.3766	59.9879	6.4678
345	43.2368	44.8428	7.7579
346	74.9160	3.5423	9.8319
347	3.9184	51.3815	7.5490
348	94.6325	40.7730	8.7159
349	76.3673	10.8046	9.9266
350	55.8821	45.9876	7.8351
351	18.3843	45.0883	2.3144
352	49.7949	55.1140	3.9367
353	51.7846	80.5404	1.2591
354	99.4243	70.0850	7.2510
355	85.4852	87.2236	9.6288

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
356	96.2404	5.2192	7.5614
357	67.8941	21.9681	7.6308
358	40.3501	45.9642	2.5715
359	93.4979	95.8534	4.1987
360	47.9485	79.0045	6.1718
361	23.1792	45.1875	5.1395
362	39.6290	33.3428	8.5035
363	70.5077	5.9095	8.3390
364	55.8559	74.0905	3.9156
365	75.6631	50.6795	5.1552
366	99.5481	19.9925	7.0656
367	96.2431	42.7194	6.3570
368	53.5067	16.8690	2.2095
369	96.3870	75.1695	1.1754
370	11.5626	36.8351	2.1260
371	5.1448	94.1818	3.0095
372	30.4349	1.7173	5.0422
373	58.0192	82.9056	5.8108
374	53.0964	62.6591	9.9135
375	90.1208	53.8747	7.4561
376	54.0550	65.0508	9.8205
377	43.1981	72.6630	1.4836
378	54.2667	9.4489	6.7319
379	71.2415	87.7574	9.6434
380	1.6675	1.4362	3.4293
381	80.0921	29.4303	9.5447
382	14.2509	17.9915	9.1201
383	47.8474	92.6294	2.7518
384	25.6835	6.8180	7.6056
385	36.9092	58.1093	2.5738
386	66.1765	63.7151	1.9463
387	16.9609	65.1269	3.8270
388	27.8784	86.4622	4.1389
389	19.8222	5.5953	4.5907
390	19.5072	81.6855	3.5553
391	32.6840	52.8922	3.8252
392	88.0338	69.4351	7.4645
393	47.1102	21.2405	9.5018
394	40.3969	54.3280	1.7901
395	17.9231	70.2520	3.5158
396	96.8925	95.6435	6.3654

Continued on next page

Table B.48 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
397	40.7456	44.4542	8.4559
398	84.4487	8.5398	8.0394
399	61.5325	5.7340	6.0151
400	37.6611	62.9450	1.3265

Table B.49: Depot locations and number of vehicles for MS25

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	62.0425	61.0092	1
2	28.2840	20.3592	1
3	20.5181	51.9917	1
4	43.9134	5.3824	1
5	2.7250	86.2187	1
6	87.6184	44.2935	1

Table B.50: Customer locations and service time for MS25

Customer index	x-coordinate	y-coordinate	Service time (short)
1	22.7811	70.6108	7.0243
2	32.1023	83.1360	8.6409
3	82.9562	3.4834	1.5892
4	82.2182	75.7839	4.2469
5	57.0683	95.7112	3.3225
6	57.1830	34.2871	4.8934
7	28.6018	63.8244	3.7546
8	69.9134	34.3006	9.6993
9	79.6258	21.6471	2.1694
10	44.1589	78.6201	2.9569
11	44.6216	72.3090	9.0405
12	46.5662	27.8839	6.5954
13	27.9039	58.2431	4.5835
14	67.5375	42.1006	4.2048
15	90.3665	9.2069	6.8192
16	90.8526	2.4027	7.5978
17	74.7197	49.1146	7.5853
18	26.0512	27.8267	9.6236
19	68.9638	33.9757	1.4136
20	13.1831	28.7350	4.8193
21	12.3501	17.0903	1.0812
22	19.0903	39.9263	7.3342
23	14.5732	69.7650	8.0280
24	58.5044	20.3676	6.0836
25	7.3362	66.6326	1.2097
26	82.2326	44.3066	1.0681
27	72.2903	43.3295	9.9007
28	92.5858	17.5239	2.8148
29	49.2639	19.3202	8.4100

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
30	65.4883	61.6421	4.2486
31	89.0123	26.9011	5.1513
32	53.8526	55.9678	1.9904
33	28.2205	94.4784	8.0314
34	97.5958	71.4472	5.0810
35	3.6426	67.9220	3.6739
36	32.6245	95.9381	4.2256
37	97.3014	77.5334	5.3419
38	36.5033	60.7727	4.8810
39	30.9150	94.8002	7.2894
40	12.0912	5.9642	7.0756
41	91.5766	26.8712	1.0618
42	13.5478	98.6680	1.7109
43	33.2118	77.2207	5.1456
44	89.7480	47.5354	7.9978
45	49.9649	68.0900	8.3509
46	61.5288	41.6935	6.6825
47	58.3133	38.0149	4.2839
48	69.8254	21.3270	8.9875
49	2.9332	38.2938	3.2583
50	52.7883	2.9668	1.5951
51	3.2073	47.2321	7.5444
52	82.7142	33.3373	7.9012
53	33.9986	97.5845	9.0849
54	84.6711	55.5444	7.9014
55	24.6070	84.6304	9.5220
56	58.1491	40.8063	5.8216
57	93.7677	46.2018	9.6380
58	4.7787	82.6307	9.8037
59	5.3978	99.1203	5.6989
60	2.0618	52.3948	8.6082
61	68.1479	92.5437	9.0822
62	59.8629	73.9022	9.3811
63	11.4030	56.7430	5.1188
64	79.6245	96.8778	7.8325
65	61.7851	82.4499	9.4492
66	7.0214	95.9609	8.2963
67	6.9279	64.6346	9.3735
68	13.6007	37.9573	5.0226
69	78.8891	47.6575	8.5050
70	9.2398	91.1890	9.8900

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
71	23.7869	1.4854	4.3268
72	24.3648	15.6694	2.5369
73	10.4822	47.1568	8.4085
74	85.8353	54.2992	6.2835
75	69.8200	5.9691	9.6545
76	73.3742	65.8030	5.4022
77	65.0531	88.9635	3.2817
78	51.6271	10.9633	7.1040
79	32.6388	43.7773	9.2304
80	66.1776	28.0230	6.5537
81	11.7565	98.5246	3.9025
82	14.7817	60.8759	5.4146
83	1.9765	25.3749	4.6671
84	96.4292	13.2615	1.7555
85	97.0373	54.5005	6.3276
86	12.3861	82.7804	8.9111
87	46.7410	83.7006	5.9798
88	65.6694	83.3349	3.6952
89	29.0186	20.3715	9.0731
90	75.4537	54.4418	8.1488
91	55.8118	87.4943	7.9823
92	42.7793	12.1000	6.3907
93	26.7194	85.6351	6.0150
94	75.3736	89.9776	3.6974
95	89.8376	21.7865	5.9289
96	72.8444	7.6979	9.9265
97	40.6830	47.4215	5.3507
98	93.8316	83.5027	7.1630
99	25.5427	46.9394	5.3202
100	53.3163	41.3770	7.7187
101	95.4755	50.2746	2.9028
102	26.7748	12.5440	3.2364
103	25.0085	13.2285	1.8806
104	92.7673	87.0475	7.3780
105	6.8582	60.2950	8.7017
106	29.9400	26.5302	8.1013
107	59.1584	86.4803	7.6856
108	20.3299	5.8109	1.9407
109	63.5883	45.7754	5.6879
110	79.8370	72.2210	8.6197
111	50.1701	33.8999	8.5925

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
112	65.0812	40.1220	4.3997
113	79.5955	52.6980	3.4489
114	23.3374	89.4236	2.1277
115	60.0839	77.8361	7.2222
116	11.2462	6.9368	5.9962
117	51.5766	27.8785	1.0763
118	83.7841	37.9370	4.7443
119	92.0790	86.4673	4.9521
120	49.8228	41.9960	8.0592
121	27.7611	23.9877	8.4700
122	65.2520	59.7655	6.3065
123	91.7299	47.9404	2.2787
124	50.9839	89.8548	6.3398
125	97.4191	93.4709	7.5357
126	19.7279	81.7887	4.8554
127	11.1185	70.8909	2.8971
128	29.7354	74.3221	3.3885
129	39.6419	89.9710	9.9387
130	42.0756	6.5240	5.3268
131	31.1475	33.5911	8.4498
132	69.3843	0.4335	6.4291
133	9.1872	82.8096	8.3606
134	40.2089	50.7435	9.5999
135	29.5181	36.6162	6.8534
136	30.6497	22.6640	6.6488
137	10.5561	53.4832	6.8191
138	59.3828	28.9485	1.5592
139	28.2728	6.8371	9.4438
140	15.5222	8.4971	9.0884
141	0.0659	6.8339	7.2537
142	28.3595	40.9816	3.7937
143	55.0811	12.3381	4.0919
144	87.0902	44.3017	1.6861
145	4.2253	89.8940	5.6785
146	90.4722	35.3639	6.4790
147	13.0974	12.0178	7.5444
148	83.3729	56.9111	1.0007
149	80.0468	87.5033	2.5279
150	91.7880	34.8575	5.1696
151	13.7304	4.1921	4.2567
152	50.4732	14.2340	9.5686

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
153	40.4958	7.6593	9.3897
154	17.3572	74.0527	9.6226
155	57.5184	45.6525	2.8588
156	60.6218	66.8249	2.4373
157	21.4446	69.9246	6.1458
158	51.9932	57.1357	6.3363
159	98.9186	62.8693	7.2875
160	48.9915	87.7764	3.7523
161	69.4873	66.2352	4.5447
162	41.1422	87.5414	4.0320
163	3.4777	46.7517	2.1609
164	29.2832	14.1336	1.7824
165	80.1442	6.8134	5.9405
166	34.6502	71.4242	3.8596
167	8.3316	30.7986	9.9347
168	51.1106	67.1164	7.5121
169	36.6833	65.2421	6.1489
170	73.9480	53.1049	7.4550
171	52.4740	71.5107	9.7890
172	80.4521	50.4811	4.8429
173	81.6911	48.7999	9.2171
174	18.9471	49.7838	9.0758
175	12.3693	93.5976	8.5171
176	82.0996	38.9282	1.4316
177	63.7898	11.7145	4.2335
178	1.6120	24.0424	3.6618
179	89.5955	68.4908	6.6621
180	51.5375	83.9254	2.2257
181	54.4522	97.0145	4.3664
182	60.6442	21.5170	8.7830
183	76.0436	76.0343	3.2525
184	85.5347	58.4103	1.2656
185	38.2868	40.2952	9.9950
186	8.4649	51.0040	6.4463
187	73.3873	49.5644	3.1978
188	33.1989	65.1368	4.9438
189	83.9750	74.3706	7.6158
190	37.1723	30.1953	6.0219
191	82.8215	8.9612	4.9451
192	17.6519	82.5965	6.4319
193	12.9520	38.9587	2.6290

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
194	87.9884	77.5305	8.2791
195	4.4079	17.9369	8.3715
196	68.6720	10.9361	5.3851
197	73.3773	90.5158	7.7955
198	43.7172	87.6351	4.6394
199	37.9839	99.9793	7.5311
200	97.9657	86.4255	2.3861
201	39.8993	3.6878	5.5817
202	44.0187	54.4682	7.0123
203	15.6808	99.7616	2.3732
204	32.6034	51.1008	1.5643
205	31.4062	87.3512	4.0340
206	89.4501	7.0221	5.0135
207	24.7024	98.7539	7.8188
208	31.0679	92.2713	2.1748
209	40.8869	56.4261	9.1136
210	70.8011	43.1462	2.9830
211	14.3638	33.7845	4.4070
212	87.1322	72.0723	4.8048
213	8.3156	1.3656	9.7542
214	46.1738	37.4060	2.5931
215	3.0389	92.2685	8.9405
216	75.3201	54.6480	5.9613
217	70.0043	47.3887	3.8934
218	21.4512	49.6537	9.0986
219	67.9905	30.8971	5.8790
220	55.7293	95.0838	5.1660
221	85.0679	98.1993	8.2718
222	55.8565	51.3563	4.2474
223	90.1774	99.2590	9.7390
224	41.9518	45.5844	5.9997
225	35.8128	42.6041	7.9284
226	48.8988	21.3215	7.1211
227	25.5962	19.3249	2.8468
228	92.9169	83.2754	8.5116
229	46.6757	72.6637	8.7892
230	25.4008	52.9746	1.3737
231	43.1218	82.9081	6.5277
232	70.2530	51.1874	3.4595
233	40.2330	55.1962	7.7204
234	18.1840	21.3285	5.3908

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
235	85.6251	58.7821	8.1314
236	58.4201	14.2763	5.7202
237	37.3579	5.2224	6.3776
238	22.1695	68.3308	2.9803
239	21.8994	60.8559	4.2762
240	52.2232	21.9656	3.6752
241	43.3423	40.6280	8.6646
242	74.1304	62.9908	9.7632
243	7.0450	55.5308	6.6126
244	84.7333	12.7579	9.0305
245	67.9880	16.9198	9.8281
246	13.6652	0.0999	6.8228
247	85.8402	41.8162	8.1894
248	19.9834	48.8486	4.6439
249	60.7340	15.9869	5.3413
250	54.3045	66.6839	1.5750
251	16.2325	1.7920	8.2264
252	0.5653	11.9675	4.1596
253	77.1485	95.2125	8.6435
254	76.4788	97.5854	9.9263
255	42.1069	3.0915	5.3589
256	5.6813	49.3882	4.2073
257	58.5747	86.2722	1.4893
258	17.4155	24.2876	9.2267
259	72.8611	83.4270	7.3447
260	53.4291	81.3591	4.9428
261	25.3064	62.8973	9.7130
262	91.7057	0.2238	7.5144
263	75.8195	37.9724	6.9112
264	88.7031	90.4406	5.6329
265	6.8798	68.0352	8.8935
266	18.3528	37.8823	1.5416
267	73.7073	63.1955	5.2433
268	69.6715	24.3270	3.7991
269	77.6993	57.1413	2.7522
270	50.1903	98.1729	2.3594
271	42.5497	84.9682	9.1128
272	61.1237	28.3444	1.6359
273	85.5772	68.2458	9.6255
274	67.0797	35.8125	7.2990
275	52.3592	98.6927	1.1081

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
276	29.8815	8.3986	1.0439
277	70.3969	25.0306	8.6796
278	38.1611	81.1347	5.2056
279	56.7685	8.4423	8.5305
280	88.7861	53.1254	2.9856
281	84.2949	80.0623	8.2536
282	89.8799	73.8823	3.2372
283	93.9003	14.1663	9.9845
284	81.5435	43.7894	9.4411
285	0.1358	35.0380	5.9856
286	0.3091	47.8497	9.2143
287	8.7469	58.7403	6.7194
288	26.0727	14.5806	8.0209
289	2.2799	90.5331	6.1050
290	42.4085	64.0194	2.7259
291	34.1065	16.2940	9.1562
292	54.1354	56.5911	5.6337
293	92.6169	93.1616	9.9908
294	29.8499	78.3102	4.3960
295	33.8085	68.5687	2.8550
296	85.9480	46.6219	7.5695
297	34.0478	26.0318	3.8209
298	13.8120	56.9268	2.0582
299	50.7799	24.8771	8.9975
300	85.6656	31.9302	7.2381
301	38.4314	91.0802	9.4591
302	69.5691	88.5220	4.7545
303	62.7904	79.4589	8.3419
304	45.0388	92.5810	8.2436
305	47.3618	17.8840	4.2436
306	94.9706	51.7541	9.2243
307	8.3498	62.7005	3.5948
308	27.9829	91.3182	2.4850
309	44.7007	66.3968	5.1028
310	58.7571	38.9193	3.1854
311	87.7634	74.0008	1.0173
312	46.9101	81.7635	6.5381
313	43.7418	60.0345	6.9511
314	74.6185	8.4997	6.9430
315	46.7910	92.2358	7.1243
316	86.0827	5.3598	8.6558

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
317	46.6512	52.7025	1.3358
318	49.8104	11.8853	7.1270
319	48.7431	38.0143	6.1402
320	22.9469	81.2833	7.2119
321	8.5552	24.4096	9.0601
322	6.7383	88.4423	3.4018
323	88.8391	71.2647	1.6170
324	23.3168	37.8148	3.8224
325	86.1596	24.8920	8.1026
326	71.1735	25.2854	5.4851
327	87.2813	76.7244	4.9333
328	93.8002	4.9862	2.5157
329	13.9689	68.5289	3.3811
330	39.3900	62.0278	7.1549
331	98.0563	74.6685	8.3497
332	64.4794	97.7256	7.3497
333	89.6410	38.3914	6.1889
334	48.2230	26.0206	9.9466
335	1.4093	87.7470	5.1507
336	62.2880	80.6096	5.4402
337	23.1095	46.1121	3.4656
338	52.7434	9.0962	6.8959
339	72.4992	56.4269	4.6635
340	60.7416	18.7383	3.6997
341	58.8366	53.1690	6.4489
342	43.3435	35.5033	8.1206
343	24.4173	31.4784	9.7380
344	42.8960	72.6741	7.9605
345	1.0177	51.5773	6.3998
346	60.8821	79.0645	5.0416
347	95.7975	20.4493	2.3813
348	9.5447	67.8106	2.9011
349	3.5591	5.2486	7.3031
350	88.6235	80.1172	9.6056
351	24.6941	67.8569	6.7192
352	0.8915	94.6009	9.0214
353	81.4920	9.1558	2.9466
354	14.0499	90.8438	7.1519
355	87.9866	50.9953	3.8355
356	9.5377	61.4904	1.2285
357	35.2560	31.6071	8.3822

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
358	59.3421	7.7487	4.8940
359	58.5182	85.0614	1.7984
360	66.7682	14.4527	9.4158
361	64.8027	37.0486	4.5170
362	43.3369	62.2391	6.2914
363	13.9759	99.7552	3.1585
364	75.1930	51.7344	6.8821
365	24.1787	99.0511	4.2988
366	65.0459	22.6534	5.3312
367	85.7374	39.8005	4.6152
368	8.4370	69.6569	4.0042
369	97.2089	6.4641	3.4083
370	3.1460	74.7662	7.9106
371	83.5405	42.0400	3.1634
372	83.5713	81.1317	9.6515
373	4.9858	37.9605	9.3120
374	54.5886	31.9068	3.4682
375	94.3170	98.6051	3.0095
376	32.1473	71.8181	3.2691
377	80.6467	41.3183	3.2229
378	60.1399	9.8630	3.1562
379	78.9620	73.4559	4.8543
380	79.9185	63.7306	8.4333
381	4.9565	7.3842	6.5547
382	28.3199	12.0508	2.7449
383	65.3457	98.1596	8.2727
384	48.9655	49.6799	9.8707
385	97.2852	2.2414	2.3374
386	74.8490	5.3832	8.6773
387	56.7841	14.0874	3.1474
388	29.8964	89.3474	4.7525
389	25.6110	46.5820	3.9016
390	88.6564	56.0857	4.9063
391	44.6801	49.4456	3.9468
392	81.5987	6.7785	1.8907
393	9.8337	89.7647	7.0406
394	85.9593	28.8565	1.4442
395	2.7629	26.9047	2.8090
396	89.9156	59.4194	5.4922
397	89.9936	47.5879	3.4788
398	52.4106	36.8311	4.7764

Continued on next page

Table B.50 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
399	12.0200	65.5611	6.3729
400	17.7794	93.8200	1.4423

Table B.51: Depot locations and number of vehicles for MS26

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	87.5721	9.7281	2
2	63.5186	90.8439	2

Table B.52: Customer locations and service time for MS26

Customer index	x-coordinate	y-coordinate	Service time (short)
1	54.8009	38.0848	8.9801
2	56.6861	63.4579	8.7247
3	68.0395	36.3229	1.7656
4	37.1379	40.7619	2.5968
5	7.8229	36.8700	1.1206
6	45.6351	46.8399	6.3099
7	4.7844	50.3414	7.3708
8	73.8257	91.0536	7.8303
9	3.8002	20.6431	2.9257
10	95.4244	33.8604	9.6955
11	74.2372	57.4126	5.3595
12	93.7450	48.6932	1.5622
13	51.3364	26.2219	2.6061
14	24.0905	57.9593	4.0444
15	25.9965	87.8328	8.9243
16	75.8974	6.0950	1.3845
17	99.3343	44.0876	4.1987
18	35.6706	8.4258	6.7667
19	75.2858	56.3238	8.4510
20	11.0048	53.9311	1.4016
21	59.7045	76.8058	8.1174
22	43.0595	23.3090	1.4604
23	73.0718	58.7362	3.6678
24	26.1176	45.8974	3.4493
25	9.4808	86.0982	9.2211
26	45.0963	66.0836	6.4492
27	64.0075	35.3879	5.5200
28	13.2039	34.7186	7.6294
29	45.2822	25.3718	2.0091
30	65.2200	95.2528	8.9604
31	82.6998	29.8201	5.7660
32	30.8077	15.8406	1.0494
33	40.2364	36.1297	2.4658

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	88.4231	74.1629	3.3609
35	70.0580	70.5900	1.3498
36	24.1872	70.0892	7.1386
37	75.9832	0.6226	1.2538
38	29.0926	37.4346	5.4995
39	27.7439	90.1496	5.3263
40	0.6108	31.8345	3.5068
41	37.4711	59.7083	6.3144
42	43.6933	29.7795	3.5867
43	30.4298	12.5014	9.2795
44	29.0860	38.8356	1.0546
45	24.2516	81.7688	6.0808
46	93.6684	98.1176	4.3182
47	86.0190	86.1990	4.3422
48	39.7228	8.3821	1.1907
49	47.9419	33.7712	7.1853
50	56.4996	23.6129	5.9911
51	48.9619	31.7805	7.8889
52	26.9812	98.4448	8.1221
53	98.9740	54.8251	3.2190
54	18.3676	74.9251	2.7983
55	86.1657	84.1852	4.3025
56	3.2633	16.6890	7.4761
57	33.1958	90.3098	2.1283
58	74.8747	10.5124	4.8690
59	64.4366	74.5093	1.1472
60	16.9238	72.9372	1.6392
61	95.2205	71.7470	7.3928
62	54.3270	13.3432	8.2265
63	25.1413	44.5789	9.1918
64	57.8572	50.8787	9.2091
65	91.5477	53.0490	6.6658
66	89.5597	85.9717	2.1834
67	48.2507	67.7725	1.5592
68	44.2740	80.5838	7.9979
69	31.1755	53.1243	7.6793
70	5.5314	95.5896	6.6334
71	75.3792	6.6677	7.5619
72	13.1947	54.1518	2.8271
73	35.5922	28.1660	8.1550
74	39.5871	48.0900	9.7711

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	88.5521	68.4864	4.7813
76	2.1240	20.8258	3.2115
77	84.4081	60.8161	5.3211
78	28.8071	32.6176	7.0208
79	25.0343	88.0847	8.6714
80	48.8380	13.3395	9.5079
81	72.9036	10.2408	2.1586
82	20.2616	95.9117	7.2698
83	21.6276	15.2902	1.7208
84	97.6335	15.2538	1.9321
85	59.3236	15.5553	2.1808
86	30.4404	8.9569	5.6355
87	96.7703	45.4425	5.3360
88	89.5970	66.8896	5.0130
89	19.0025	83.1302	8.1836
90	0.1799	79.0235	5.7604
91	71.1764	71.2711	7.0196
92	86.7727	47.2598	5.3500
93	11.8308	70.8588	3.9942
94	3.9023	95.8059	3.3292
95	59.8195	50.5776	9.7633
96	60.4314	30.5053	3.3792
97	51.6432	78.9811	8.1095
98	0.7507	23.6387	5.4736
99	68.8933	23.4303	3.8871
100	94.6020	46.4699	6.5465
101	87.3536	61.9387	1.0620
102	11.3276	61.5329	1.5664
103	35.4569	12.2624	9.2802
104	24.1937	12.3794	9.1555
105	56.0333	28.4459	8.4838
106	61.2727	73.5733	9.2231
107	30.0809	41.1308	7.1124
108	79.8142	82.8982	7.9935
109	79.5642	93.5114	7.2430
110	78.1092	39.9067	2.7897
111	35.1098	5.2211	5.0715
112	5.4297	57.1186	8.1000
113	70.8705	74.7670	1.0173
114	99.2928	32.0244	6.0002
115	16.2476	49.2934	4.8992

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	11.3566	22.1653	1.5257
117	91.2875	93.9274	4.9776
118	48.1657	48.2305	8.5563
119	85.1806	53.9996	6.5643
120	80.9914	22.1057	7.6743
121	18.6760	9.5945	9.4207
122	24.7200	6.0165	3.9278
123	5.4189	81.9509	7.7139
124	60.8961	77.1478	8.8561
125	77.7232	19.5696	4.8996
126	51.1064	89.5118	5.6940
127	2.7750	68.4300	6.8739
128	99.0385	65.6846	5.2211
129	50.0940	99.0381	2.6497
130	33.1997	3.3692	3.0340
131	17.3883	42.4253	4.7076
132	62.5636	48.9984	1.1376
133	57.5135	58.3504	7.7560
134	75.0985	8.3270	1.5591
135	15.3519	66.0155	4.8852
136	35.6787	5.2305	5.8850
137	14.3951	55.6831	6.4913
138	85.0608	71.2025	4.9261
139	33.7870	48.7911	1.7296
140	27.5196	61.7601	3.5556
141	0.6011	21.3778	1.6590
142	80.1912	64.5659	7.5698
143	49.7408	38.0642	4.1174
144	53.7843	10.3713	6.8698
145	87.0913	37.7512	5.3358
146	72.2844	26.2861	4.4433
147	66.8086	24.1286	3.9420
148	17.8828	62.2924	1.9274
149	55.0495	52.2928	4.3337
150	95.9875	41.3238	4.3970
151	59.6022	21.7792	5.3362
152	80.8571	85.8554	8.1606
153	98.4532	86.1008	7.2225
154	88.5924	28.3939	8.6481
155	21.3837	61.5393	5.6105
156	3.4630	77.9490	8.6953

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	45.1124	95.4847	5.1890
158	1.3795	91.9603	3.3836
159	47.3711	38.4816	6.6654
160	95.1197	16.2643	6.0646
161	24.8952	79.6751	5.8704
162	38.6423	11.3817	4.5398
163	43.1433	15.8824	4.7842
164	83.0886	35.5828	2.2341
165	82.4647	84.7759	3.6296
166	45.2999	58.2781	1.0659
167	38.0560	58.6178	9.3943
168	92.5869	92.5838	6.4833
169	74.0844	57.5078	9.0266
170	73.7633	0.9977	4.7874
171	94.6916	80.9377	4.6016
172	51.0100	60.8808	5.9854
173	79.1879	47.9914	6.3663
174	45.2174	26.8440	5.5565
175	84.9199	25.8096	6.2849
176	39.0431	48.1010	2.1954
177	73.8377	22.7341	7.8544
178	97.6439	4.8602	6.8603
179	52.3299	16.9242	4.1598
180	42.9915	25.8446	3.8134
181	20.7158	19.7910	3.4683
182	32.3401	60.5693	2.3458
183	11.0870	82.3704	4.0091
184	37.5210	81.0615	8.4973
185	32.9904	80.2237	3.1022
186	34.2105	70.8113	1.6232
187	81.7119	85.9378	5.4525
188	53.1685	78.1085	2.0994
189	52.1122	20.3797	4.6236
190	77.4310	99.3343	1.8209
191	12.0263	9.3625	7.4849
192	62.5450	65.0619	4.0811
193	34.6649	21.5177	6.0967
194	33.4619	24.3873	6.8906
195	57.4617	33.9688	6.8725
196	86.3938	19.7862	7.3077
197	19.8563	50.6833	3.7099

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	67.2451	95.0758	1.7692
199	90.1831	39.4607	6.7009
200	19.9157	58.4465	3.3979
201	29.8284	60.6537	9.0483
202	49.6520	71.4643	3.7024
203	88.9904	40.1536	7.4355
204	50.1415	85.8691	3.9732
205	27.6995	92.0485	4.2839
206	53.3958	75.0839	6.3311
207	57.4250	28.5592	9.1467
208	41.2804	79.6816	3.3808
209	1.4764	14.2766	9.5484
210	70.2765	50.4550	7.6486
211	50.6747	61.0688	1.0402
212	38.1266	70.3797	8.6566
213	6.4932	38.3340	7.2601
214	35.8580	72.8683	6.0619
215	23.4251	88.7285	4.0394
216	20.3504	5.5848	3.9952
217	81.3780	13.8216	1.6959
218	39.3435	86.3065	5.1247
219	5.3575	42.1746	6.9147
220	37.5052	41.1314	6.1476
221	77.4994	95.9141	4.6190
222	16.5298	75.0245	9.4123
223	91.2219	98.0997	4.2448
224	31.9206	23.3516	9.5294
225	32.9780	9.6227	1.2711
226	20.4236	38.4582	4.9699
227	76.7215	50.0273	7.3064
228	6.9973	57.0256	7.3269
229	95.0034	97.6632	5.5915
230	15.8210	49.2855	6.5102
231	28.6446	40.0883	7.7173
232	68.7129	99.4990	8.2129
233	14.1150	26.0998	4.0305
234	51.2087	66.5325	6.0768
235	72.1327	96.4257	8.6974
236	92.8845	67.1151	6.3024
237	73.2104	29.9175	5.5742
238	74.9848	53.1127	8.6809

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	40.7320	0.1463	7.1542
240	23.9492	88.3789	1.9570
241	52.0850	40.4384	5.5176
242	21.9077	30.1206	1.1725
243	84.2388	95.0582	4.9835
244	66.2933	46.0648	9.1646
245	81.6235	28.7648	1.4020
246	79.3878	8.4627	9.5067
247	46.9105	58.2181	2.6234
248	30.9525	15.3069	4.3292
249	68.7579	7.3094	2.8472
250	98.6852	58.0565	1.8603
251	76.9934	28.7015	4.8947
252	82.9581	36.1920	3.4980
253	70.6085	72.4825	1.9077
254	59.5336	85.8312	5.4903
255	75.2874	34.7916	3.1513
256	49.6722	96.1746	4.1464
257	86.5133	95.3569	6.0244
258	6.8028	20.6037	5.9326
259	96.8546	76.8245	4.7915
260	9.8756	61.5532	4.4695
261	54.6977	91.8922	4.4260
262	40.2970	60.2537	3.5266
263	10.7040	70.2138	2.6192
264	72.4166	74.3675	2.1456
265	61.3682	38.5102	1.1412
266	78.2968	25.1504	7.7778
267	56.6621	3.6760	5.5446
268	81.1319	47.2123	7.4990
269	57.6776	64.5072	7.8499
270	94.4029	27.8970	3.4205
271	87.1452	51.7861	2.7426
272	50.7602	24.5667	1.5773
273	78.8823	29.7508	4.8284
274	47.3031	65.0474	7.3193
275	82.8802	89.1393	9.7959
276	32.2482	86.1106	5.9642
277	97.6147	20.9915	1.3943
278	27.8211	39.9094	6.2393
279	7.2831	88.7883	3.5054

Continued on next page

Table B.52 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	75.1224	25.6528	5.8797
281	83.1189	96.6802	4.9899
282	92.2338	61.9157	2.0548
283	32.7024	16.5346	4.4195
284	80.4069	82.6199	7.8835
285	53.8250	65.5693	9.2653
286	46.3295	54.6453	7.2343
287	82.0750	25.1329	9.7356
288	95.1907	4.0156	2.1355
289	7.6273	23.3375	6.8177
290	70.8671	36.1113	4.4816
291	23.4926	63.3455	6.0611
292	39.8896	98.6098	2.7852
293	26.8124	20.7157	4.5453
294	83.2513	75.7084	4.0622
295	99.5374	88.6328	4.2083
296	64.9751	47.2230	4.3574
297	70.3953	15.8914	2.0383
298	93.2303	81.0921	5.5109
299	68.7653	47.6508	8.3522
300	56.8354	11.6288	4.0916

Table B.53: Depot locations and number of vehicles for MS27

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	14.9057	75.6670	2
2	2.8279	79.6106	3

Table B.54: Customer locations and service time for MS27

Customer index	x-coordinate	y-coordinate	Service time (short)
1	3.5016	1.5908	5.4868
2	3.9750	95.7514	2.0622
3	98.8568	2.5692	6.1797
4	68.6182	97.1111	5.6392
5	37.6689	29.7596	4.1975
6	50.4324	52.5073	8.7701
7	76.3496	86.2339	4.0961
8	4.8875	89.6405	5.1119
9	72.5928	18.9011	3.1428
10	70.1328	66.0720	7.9405
11	45.8891	94.1231	3.4606
12	58.2295	97.5707	5.7250
13	33.9090	10.7935	5.7800
14	17.0625	17.8899	8.8605
15	39.9193	74.6551	9.4385
16	91.9777	4.9469	1.4385
17	22.6045	7.1285	9.8096
18	36.1007	48.9126	6.6909
19	32.4562	84.9894	1.6537
20	8.3582	99.7041	2.9064
21	51.2666	0.4393	4.2390
22	83.2865	54.2607	4.8401
23	90.4613	86.1348	7.8233
24	72.3596	90.9139	9.2418
25	38.2996	84.5351	6.6677
26	29.8017	87.8873	9.6032
27	69.1712	74.6182	7.7961
28	88.0457	11.7489	5.7350
29	92.4548	50.9022	8.6510
30	8.1253	16.8832	8.3443
31	48.2673	83.1112	2.1892
32	12.8265	92.8011	7.8465
33	25.2911	16.9484	6.5551

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	88.3962	88.3737	4.5788
35	19.6277	38.7863	8.5714
36	12.1354	38.2569	1.3449
37	54.3695	27.1453	1.8659
38	31.4621	86.7883	9.5329
39	38.2041	74.1502	4.5641
40	79.1539	44.7873	5.7904
41	83.9179	70.9639	9.1328
42	68.0236	94.4331	4.0603
43	41.6922	17.4118	6.9751
44	64.2890	24.4596	7.5462
45	21.4081	64.0929	3.0071
46	61.7271	80.8613	5.9991
47	67.5191	85.3371	5.0971
48	60.1023	39.8118	6.4924
49	34.6310	11.5494	5.8959
50	36.4401	8.0281	5.6652
51	17.1481	36.0468	3.5744
52	79.5362	82.8906	8.9111
53	49.2667	21.4610	9.4289
54	35.4623	79.1040	8.2559
55	77.5061	65.4688	9.7218
56	23.6805	2.6146	5.7181
57	84.4833	78.5776	2.0158
58	81.6527	92.2563	6.8521
59	84.6228	49.2313	2.7180
60	37.0187	83.4012	8.7124
61	38.3230	13.1354	9.4857
62	86.1335	75.9783	1.9310
63	46.3909	92.5736	3.6680
64	57.0548	83.2708	8.1913
65	69.5307	25.9401	4.9754
66	96.0917	21.3022	5.4327
67	54.6313	52.2315	1.2656
68	63.6577	39.7357	6.1538
69	57.0892	47.9110	6.1522
70	92.7112	99.3904	7.6752
71	86.3766	60.4478	1.6895
72	16.9839	94.4909	8.0845
73	17.8699	49.0442	2.7415
74	24.3504	43.7947	5.7783

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	75.1779	77.2656	9.3172
76	19.9134	74.4067	9.8745
77	98.2941	44.2904	9.7776
78	70.9639	5.3000	3.7429
79	17.5436	8.7822	7.7827
80	85.8297	79.7986	2.8572
81	90.9411	65.5582	8.7524
82	96.1663	3.2336	6.9206
83	57.0600	55.7067	1.9199
84	56.2879	71.9802	6.2242
85	17.6661	11.0408	9.6714
86	51.3679	21.6647	8.6039
87	54.8472	81.1020	7.7780
88	16.5277	13.8662	7.3274
89	49.3893	88.1899	3.2196
90	53.5117	92.3556	1.3595
91	19.8807	1.2756	5.1590
92	62.3169	37.7159	2.0564
93	2.6315	16.7812	2.4546
94	31.8791	54.0223	4.7778
95	53.3000	10.1662	6.9950
96	32.6774	3.9268	9.7584
97	60.2190	93.3229	3.5169
98	36.1933	97.1592	5.7825
99	13.4921	36.0928	9.3762
100	91.3814	64.4205	2.5000
101	64.0559	6.7947	8.1032
102	65.8774	20.7912	1.9267
103	67.5330	3.9604	8.9526
104	74.4558	46.9359	5.7001
105	84.2178	15.0097	9.7671
106	51.6657	99.1307	7.8049
107	15.1869	42.7062	7.5031
108	38.0664	95.5372	1.0234
109	82.1019	72.4247	2.8505
110	17.1364	58.0892	3.3433
111	32.9975	54.0258	1.7196
112	96.6472	70.5441	7.6179
113	80.6293	0.5029	8.4039
114	22.2188	78.2516	4.0905
115	99.9773	92.6860	2.2252

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	6.3739	0.8296	6.9930
117	42.5483	82.4628	8.4740
118	40.4338	76.7336	7.0626
119	40.0293	99.7137	2.2551
120	11.1923	22.7653	4.4094
121	42.4311	91.9542	7.1053
122	61.3546	64.1999	5.6433
123	98.8061	10.5320	9.8025
124	21.9901	26.8161	3.4095
125	35.4081	76.3844	8.8022
126	26.6242	80.5510	4.3638
127	29.1498	10.4253	2.2297
128	18.8390	46.9759	1.7442
129	2.2860	21.9062	7.6494
130	44.9404	92.2708	4.3486
131	24.3640	32.0323	4.4246
132	86.8727	85.7544	3.7196
133	52.8611	25.9847	3.6507
134	91.4135	87.8063	3.3383
135	97.3930	18.8268	5.1713
136	58.5426	75.9194	9.8907
137	11.8975	3.1689	4.4657
138	92.6533	64.2339	9.4891
139	59.3561	56.6871	2.5030
140	88.3615	37.6410	9.3250
141	42.4476	21.2548	7.7890
142	60.7257	79.2157	8.7094
143	7.0764	14.5443	6.4215
144	92.4772	48.9142	1.9663
145	64.2079	1.2846	5.0993
146	10.4500	18.6612	6.8913
147	70.0225	48.5230	1.5178
148	39.5804	83.8226	1.1914
149	8.4905	14.1057	3.6082
150	21.4479	73.2217	9.3833
151	24.8799	69.1067	5.6262
152	22.6653	3.4493	8.8777
153	70.3004	48.8857	4.4029
154	75.4153	97.1390	8.9606
155	54.7287	11.2451	5.8130
156	55.3483	74.3214	9.0334

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	63.0573	63.8541	1.9249
158	98.5457	59.4183	2.9084
159	63.4278	49.8623	7.3145
160	60.0456	56.7853	4.2522
161	90.9187	42.6504	1.0126
162	57.0837	7.6239	4.4588
163	33.5420	29.0587	3.8813
164	95.7139	56.1335	4.5401
165	43.9923	63.3333	2.6313
166	60.1543	93.0776	2.8844
167	72.0262	97.7769	6.3435
168	67.8778	9.3597	6.3502
169	21.2759	66.1735	2.5522
170	8.1623	60.2773	9.3970
171	27.4479	47.3818	1.5060
172	86.7518	35.6256	2.8155
173	55.9357	47.5578	5.5743
174	46.4628	67.1022	7.8329
175	43.0301	95.9645	2.3145
176	77.3986	8.9084	9.3797
177	65.3920	79.7742	4.7975
178	65.7729	59.0776	1.5085
179	16.1021	91.2197	7.0678
180	43.2377	10.1129	3.5183
181	50.5086	29.3295	8.0208
182	37.5332	5.1588	9.6656
183	48.0372	50.4128	7.1942
184	34.2421	76.8376	5.4858
185	77.7146	28.2985	1.8913
186	38.3944	22.5360	3.5898
187	71.1556	33.1290	5.8430
188	48.0933	45.3251	1.1020
189	72.9180	73.7385	3.5456
190	93.7559	50.9886	6.3061
191	51.7254	38.2514	2.5484
192	90.3069	90.5483	2.5309
193	21.8193	96.5258	7.0871
194	87.3219	62.8267	6.1263
195	8.2693	13.2031	5.9650
196	46.5403	61.8302	9.7070
197	2.1930	38.3020	6.6558

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	80.8281	99.1194	3.9209
199	17.9210	28.6827	5.6891
200	16.5392	70.6191	8.7844
201	18.1603	53.5206	9.9470
202	69.1437	19.3211	8.5464
203	21.3764	68.9435	4.1266
204	29.8105	5.0455	7.7447
205	76.8335	18.4434	9.4547
206	50.1150	4.5658	7.0127
207	90.9465	88.5042	5.3308
208	5.7853	83.9794	3.5755
209	43.6752	11.8155	6.3564
210	57.2255	41.0415	4.0277
211	56.5067	12.0229	9.6360
212	82.3817	57.2093	4.9787
213	12.6099	94.9390	9.6580
214	30.0117	25.6385	7.0875
215	0.2122	98.9865	7.3547
216	95.1107	34.9808	9.6192
217	76.6299	20.8522	9.4589
218	75.1304	66.5827	8.5038
219	13.8865	97.3345	2.3972
220	34.9320	62.2700	8.4739
221	15.1341	6.3538	5.1773
222	49.6721	37.3510	3.6882
223	80.8652	16.6252	5.7097
224	63.2869	23.1278	8.4847
225	68.8401	5.2209	5.8522
226	63.9570	90.1756	3.3385
227	72.9322	79.3292	4.1863
228	85.9846	37.3014	2.6806
229	62.6955	83.2055	4.1559
230	18.0591	75.3835	2.7075
231	57.3307	62.1863	8.5212
232	16.3566	39.4093	4.4574
233	90.6052	35.9278	1.0855
234	7.7343	8.8852	3.7812
235	33.8535	34.1677	8.5307
236	58.0618	54.8671	3.5320
237	47.5235	46.0547	8.0321
238	80.5320	64.5452	5.7836

Continued on next page

Table B.54 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	53.0778	51.3521	2.3852
240	22.7310	81.4426	5.7273
241	70.9485	9.7183	3.5492
242	14.8633	46.3714	7.4338
243	65.8116	58.9817	7.6095
244	63.3983	18.7172	5.0467
245	22.9306	61.1330	2.6387
246	18.2228	5.1942	2.2199
247	16.6353	57.5727	3.4549
248	14.9607	84.2345	6.7208
249	20.2747	49.9726	8.2557
250	95.4959	43.9025	7.0109

Table B.55: Depot locations and number of vehicles for MS28

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	0.1314	34.6471	1
2	98.1268	55.7503	2
3	57.0194	29.9785	2

Table B.56: Customer locations and service time for MS28

Customer index	x-coordinate	y-coordinate	Service time (short)
1	29.3556	24.7546	3.5793
2	11.5207	44.7369	2.2820
3	37.5092	53.2783	3.2129
4	82.8894	35.4651	7.2271
5	84.1777	77.3115	1.6457
6	66.5238	88.1681	5.4879
7	96.0140	73.4092	9.8740
8	94.3118	40.6432	9.1441
9	11.2699	60.4179	6.1769
10	64.8287	64.1105	7.8987
11	48.0804	12.7467	7.7209
12	6.6521	49.6192	7.2580
13	89.7771	31.0469	7.0959
14	49.7230	57.8574	3.5416
15	77.1303	94.3609	6.2368
16	6.0362	42.6940	6.5699
17	26.2457	3.3128	8.3282
18	65.1069	92.9434	1.1439
19	13.3604	92.4982	2.9292
20	63.8546	35.8307	9.8908
21	38.4943	25.9989	8.3560
22	76.5698	78.6860	6.6887
23	65.2916	51.1582	7.1393
24	38.1489	56.2527	8.2740
25	30.0019	68.4794	3.5170
26	34.0140	9.2397	6.9847
27	91.8927	87.2579	1.2639
28	45.6267	94.2938	5.8994
29	44.2497	9.6594	5.7607
30	45.4186	84.5883	8.8585
31	94.5282	90.9396	2.6885
32	21.9119	1.1341	9.3831

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	88.2403	52.3683	9.7872
34	1.9875	65.0345	3.9808
35	34.1765	38.5145	6.6134
36	76.6027	64.9302	5.7435
37	34.2804	76.2853	5.1317
38	61.8806	57.5686	4.2271
39	45.3021	63.1919	4.0084
40	1.0163	27.8204	1.7488
41	59.9081	83.9836	4.5136
42	60.1568	42.6835	3.1541
43	64.9417	63.1622	5.3764
44	34.2721	83.3467	7.3008
45	49.3299	27.0185	2.2354
46	70.1774	40.0801	8.4382
47	88.7803	55.4255	9.3705
48	5.5058	44.3865	8.4586
49	9.8362	9.0384	5.3646
50	64.9783	74.4381	6.9379
51	76.4071	3.2615	5.1076
52	98.7959	42.9743	4.7662
53	12.5325	3.7262	1.3087
54	36.4477	97.5798	9.3416
55	67.6230	52.2340	1.3904
56	37.5758	90.9630	5.2845
57	86.3458	38.3248	4.4717
58	29.1977	88.4452	5.8065
59	13.3475	25.5018	9.9835
60	67.2651	90.9050	9.1223
61	20.2585	89.4560	1.1328
62	86.8515	39.8517	8.0246
63	75.1157	62.5020	5.3676
64	41.9380	56.7597	4.5120
65	0.0231	89.4512	8.4078
66	14.9464	21.4166	8.8698
67	27.3834	0.3859	9.9852
68	87.2425	88.0581	2.7609
69	60.1251	23.5122	8.8297
70	32.1188	24.4865	3.7674
71	28.4293	64.0917	4.7011
72	43.5316	30.4524	8.3471
73	90.3759	82.5621	4.3143

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	92.5106	88.3689	4.8359
75	50.5292	94.5373	1.8210
76	62.7582	39.0795	7.0075
77	71.9264	80.1320	7.5818
78	2.3913	15.7113	3.7074
79	57.4933	62.5165	4.0420
80	4.6534	69.8985	7.6089
81	42.2531	8.5869	9.8691
82	46.7734	53.1180	7.2889
83	2.2628	88.8567	1.8094
84	6.5074	26.3666	5.2366
85	92.3956	23.4786	6.7183
86	53.4143	83.9657	5.7274
87	36.6796	49.5540	2.2721
88	36.3946	15.2366	3.4796
89	15.1374	23.0768	9.8839
90	14.9609	65.7954	8.1550
91	35.0802	56.2948	9.4000
92	33.5966	29.1829	4.1354
93	78.4028	62.2305	2.8822
94	48.6739	71.5905	7.1233
95	46.4798	28.0731	4.1988
96	13.1253	41.2273	4.9454
97	88.6391	36.2206	9.1790
98	67.4557	78.1392	8.5023
99	83.5160	13.5487	4.5225
100	65.6488	90.2070	7.6058
101	98.3917	28.9636	3.6159
102	97.9790	49.9558	3.6292
103	25.0153	78.3590	3.6712
104	62.4571	67.7062	1.2236
105	72.8242	14.9812	9.2606
106	49.8170	69.6619	7.1743
107	84.9828	12.9013	3.1085
108	19.0918	94.5946	5.4762
109	12.4144	88.6412	8.1152
110	0.2790	51.5005	4.4221
111	15.2953	67.9409	2.9673
112	53.4161	97.6793	7.5040
113	51.0634	12.5460	7.9555
114	38.5216	75.2243	7.2395

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	31.0596	82.7052	6.5771
116	0.3555	78.1430	7.8607
117	81.5242	19.0883	5.6033
118	63.8418	42.8641	3.9646
119	44.8339	1.4457	1.0121
120	24.4086	32.5285	6.2258
121	80.3385	13.4702	2.5465
122	82.3971	45.0517	2.7542
123	85.2191	57.2275	2.3529
124	46.7252	79.2023	5.5488
125	97.0699	41.9737	1.1565
126	84.1244	53.2537	5.2409
127	7.8548	92.5704	1.4147
128	23.7599	89.9082	4.9804
129	81.7571	54.4833	2.4720
130	40.5829	90.1124	6.1489
131	46.6312	5.1827	8.3649
132	95.1536	80.8603	1.7681
133	96.5005	33.4905	3.0955
134	76.5285	22.8683	3.2144
135	57.4534	82.2402	4.1674
136	91.5925	34.8235	4.6818
137	49.5432	16.5471	2.0282
138	16.6012	2.8134	4.6649
139	32.5998	95.5370	7.0834
140	29.6436	68.0291	5.8872
141	55.8298	86.0562	4.2142
142	6.7477	93.9094	6.9543
143	6.8978	68.0194	7.1083
144	16.6785	91.7424	2.1840
145	94.7438	25.6692	4.9566
146	81.1088	88.5618	9.4348
147	71.0456	92.0043	6.1320
148	97.0246	30.0063	6.1988
149	99.8427	7.3391	7.8814
150	98.7455	76.7399	3.2226
151	15.0087	8.4952	7.2447
152	95.8479	72.8764	3.6538
153	53.0459	44.7890	6.1363
154	7.4087	65.1249	6.7132
155	31.1821	16.9502	4.5900

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	89.5171	53.1449	3.2400
157	83.4768	63.3801	9.4180
158	0.2349	1.4096	5.0401
159	64.0210	47.0371	5.7861
160	80.3183	88.6326	6.7135
161	24.5131	11.4028	7.0131
162	6.4122	44.2541	4.9511
163	26.3148	65.9548	2.5569
164	10.2720	29.4773	7.2495
165	48.3719	95.0368	9.3243
166	41.8884	69.4286	4.3355
167	38.1289	20.6807	6.7491
168	88.6765	55.4762	9.0071
169	42.0558	87.9278	5.3465
170	28.3848	55.7858	6.6684
171	4.8181	75.2334	5.1852
172	21.9166	89.4901	1.9826
173	23.9176	84.1844	2.0180
174	2.9258	13.0857	1.9710
175	70.2311	18.9154	5.0116
176	0.7636	15.3640	9.4496
177	61.0921	2.8902	6.7043
178	40.8090	0.9085	9.3670
179	24.8947	59.6452	1.5659
180	65.2460	60.9049	3.7625
181	32.0277	91.8923	9.5479
182	10.3672	73.3574	1.0933
183	53.5565	30.1147	2.5104
184	16.4870	49.5574	7.7975
185	88.3439	25.8163	8.5044
186	66.6457	73.2854	6.4527
187	84.7742	11.6761	5.6613
188	76.2661	74.6042	9.4857
189	80.7014	80.9789	7.6709
190	63.2952	74.5234	7.3097
191	71.0427	33.7143	7.7025
192	68.8664	58.4325	8.8644
193	32.0948	46.8952	9.6771
194	53.1648	8.7265	9.8373
195	87.3194	82.8717	9.2677
196	5.4540	68.5945	3.5513

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	50.0401	26.7325	1.5276
198	43.2763	96.9484	8.3890
199	90.4282	18.3774	2.6157
200	63.0183	29.9941	1.3144
201	98.3036	41.1185	7.9419
202	58.5200	23.6489	5.8647
203	84.0637	19.5055	3.9839
204	46.8814	70.5379	6.2039
205	54.5222	18.0548	8.6906
206	17.9104	52.2333	6.7814
207	63.4462	29.6172	4.7809
208	96.2959	46.2782	5.9132
209	53.4014	92.5232	2.6407
210	47.9614	21.5889	3.1265
211	79.3666	0.1009	2.8487
212	9.2714	90.6606	3.3372
213	88.0800	68.0042	9.4837
214	0.3874	51.4952	6.7741
215	51.1529	52.2069	8.4616
216	67.8464	10.2919	4.4989
217	56.5748	99.6880	2.5157
218	47.8459	35.8969	7.6611
219	32.0513	62.5243	8.8552
220	60.1580	39.3367	4.1997
221	91.3153	0.7662	2.6095
222	68.2518	54.5285	9.9678
223	94.6733	50.9110	9.6321
224	9.9089	24.6779	2.4040
225	51.1029	4.5395	9.3604
226	11.0128	84.1730	4.8212
227	54.5262	4.8250	3.0078
228	68.8786	31.6320	2.2276
229	14.7417	78.3419	3.3416
230	77.7561	97.2400	5.9002
231	39.9051	58.6464	1.7399
232	89.8300	77.8044	6.3831
233	30.7044	72.7697	1.2627
234	6.1051	65.0987	5.0942
235	21.9471	66.4615	3.9925
236	8.2833	93.8780	9.4931
237	95.0395	53.5081	3.7279

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	1.6371	39.8440	4.8540
239	11.4668	67.0458	6.9493
240	1.2410	44.0534	4.4298
241	21.6227	13.2874	2.2255
242	1.1428	43.9204	1.8696
243	64.2449	54.7643	3.7465
244	51.6991	39.5136	8.4150
245	24.5542	39.8272	6.6453
246	19.3747	75.1349	2.8534
247	9.0871	52.2350	9.8217
248	36.8442	49.0433	4.9400
249	0.7793	8.8679	8.5168
250	60.2701	25.0852	5.8526
251	47.8855	44.7559	1.2261
252	30.8118	63.7961	1.0614
253	74.4444	70.9445	8.0748
254	83.9349	99.2620	5.0265
255	26.2432	93.2195	3.5986
256	51.4238	9.2229	8.7686
257	44.6774	95.3540	6.9061
258	34.1211	16.2796	3.5622
259	83.9142	97.0455	6.8011
260	98.2493	59.7007	3.3722
261	62.6465	24.0227	2.5730
262	18.1275	7.0295	4.3176
263	12.3017	30.0041	5.8379
264	57.9969	81.3545	9.3377
265	32.8536	7.6710	7.7421
266	26.8186	35.4473	2.3296
267	55.0239	13.2011	1.0260
268	18.0517	15.8180	2.1431
269	67.8492	6.2147	9.2523
270	5.5688	70.1843	7.0491
271	3.4057	8.6482	2.0241
272	28.6518	61.6787	9.6420
273	7.7390	17.3772	2.0744
274	90.0572	65.1401	5.4317
275	84.6606	49.8696	4.2518
276	39.5698	28.4511	5.2300
277	16.9215	83.0560	1.5290
278	43.0452	81.8360	3.9701

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	41.6218	93.8169	3.3807
280	72.8763	0.0326	3.2133
281	40.6474	64.0389	9.5291
282	95.1807	0.7356	1.2920
283	91.1985	10.6421	9.1554
284	95.1414	10.6794	4.3165
285	34.6001	36.7109	6.9629
286	29.0244	23.9608	9.5826
287	88.6701	34.6140	1.8472
288	21.0031	24.9620	7.1678
289	13.0877	38.7064	4.7120
290	52.0516	42.1038	2.0061
291	90.5463	64.0077	5.4265
292	40.2530	78.7553	5.1540
293	21.5761	26.9994	8.8935
294	7.8739	84.3982	6.9422
295	93.3060	74.0468	3.5017
296	60.2872	82.6102	6.9145
297	37.7492	18.2192	6.8087
298	66.4931	6.5436	9.0750
299	79.2190	61.0350	8.9410
300	33.3492	70.1553	4.0166
301	69.2659	11.1618	4.8430
302	20.3816	9.5824	8.2339
303	95.8714	59.7834	9.3078
304	71.1832	81.2233	8.8005
305	16.6907	81.4578	5.4969
306	44.2777	8.9437	6.2603
307	63.2994	73.1279	9.3228
308	92.9967	90.3857	2.4951
309	52.9331	45.2232	4.3692
310	62.6474	7.0688	3.3347
311	68.0819	24.1278	8.4743
312	92.3198	73.1865	1.6316
313	15.2834	4.0492	3.5293
314	40.5721	42.4523	5.9954
315	31.2476	54.0215	6.5707
316	69.3899	95.3828	4.6881
317	89.0688	20.8906	3.3259
318	49.0671	11.6332	4.7507
319	80.5824	64.6220	4.4385

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	32.6439	10.8411	1.8670
321	54.9879	98.3497	2.1816
322	38.8784	24.8344	6.4891
323	89.6829	60.6356	6.9057
324	67.6120	81.6695	8.5690
325	82.8397	83.0054	5.4984
326	11.0089	48.9039	3.7648
327	27.9227	76.0728	2.5279
328	76.7636	91.5108	1.4389
329	21.6057	90.0975	3.0324
330	3.4062	21.4238	4.3027
331	43.6552	54.7061	6.1106
332	93.6864	78.4709	6.1274
333	26.2089	19.4441	8.0090
334	56.9745	74.6889	6.3122
335	35.9553	47.5558	1.9960
336	2.6839	58.3259	6.7661
337	50.0419	26.0548	1.6482
338	82.7015	8.4822	4.2926
339	25.8982	29.8133	3.5857
340	4.5885	91.7129	7.6729
341	24.6472	47.0518	1.6029
342	66.0732	26.9468	7.8145
343	32.9410	76.2970	3.1664
344	65.9496	77.2172	3.0782
345	1.3004	2.1300	1.1079
346	71.8068	87.9986	2.1923
347	39.1119	79.8170	2.8845
348	3.3505	32.4165	2.9276
349	40.6015	66.9044	9.1521
350	71.6308	29.6294	3.5000
351	92.1336	92.9952	1.8739
352	98.4016	28.1960	8.0454
353	98.3421	16.8880	7.0077
354	89.6306	74.5167	6.5141
355	86.5703	47.7134	4.0941
356	80.0961	65.3445	7.2131
357	55.4979	96.6576	3.1020
358	41.8872	31.3027	3.7723
359	12.7123	7.6439	4.2157
360	65.4621	79.1415	2.9503

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	86.3965	36.5384	7.0955
362	27.4598	58.5099	7.6241
363	84.0164	18.3337	1.0902
364	7.0755	7.6919	4.2032
365	37.8792	15.3663	3.1596
366	26.8169	82.6876	9.3485
367	15.2921	30.0957	7.8669
368	63.1000	38.3884	4.4145
369	31.6375	65.0749	7.1736
370	95.9112	81.7371	7.2899
371	49.8674	76.6266	6.3136
372	73.8609	37.4176	9.6585
373	1.2756	18.9862	8.0321
374	60.5353	64.6502	5.8458
375	57.6451	0.3605	1.8472
376	80.7379	28.2888	8.9741
377	65.4968	63.8601	3.3175
378	87.8228	59.2075	5.1716
379	90.2373	32.5289	3.9772
380	15.2233	98.8951	7.8110
381	19.2580	12.3236	8.2256
382	79.0976	73.5877	8.2281
383	6.0705	15.6617	8.8897
384	38.9827	43.4647	1.7873
385	29.9966	83.2243	7.0112
386	73.4180	35.9910	5.5218
387	10.4209	7.6238	4.0201
388	79.2575	55.6926	6.2971
389	78.2729	27.3930	4.1674
390	53.2398	13.2055	2.8605
391	25.3352	69.9655	3.3594
392	7.0955	48.5905	1.8878
393	62.5803	18.2716	2.3506
394	2.4681	10.1215	3.8892
395	6.2042	20.1584	6.3495
396	12.9612	13.4746	2.3836
397	45.0614	32.3789	1.5636
398	67.2336	95.0545	1.0700
399	85.6111	53.2131	7.9683
400	49.8445	24.7686	7.1384
401	4.8785	43.7276	2.0845

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
402	31.3832	66.9088	7.4733
403	64.1631	54.7696	2.4567
404	78.6387	60.9054	2.0814
405	28.9150	86.3135	7.1304
406	49.7868	38.0696	2.3034
407	81.8435	74.8956	1.5204
408	59.5128	15.6697	2.2145
409	53.6425	5.8124	1.1330
410	33.0873	33.9707	2.7021
411	41.1690	81.7176	1.6378
412	79.4006	37.7548	1.3407
413	34.3208	97.2605	3.7708
414	46.2607	60.5319	5.6416
415	36.7824	33.8236	4.5416
416	67.9571	92.7984	9.9568
417	56.7779	89.8425	4.9564
418	65.1777	85.0706	2.3630
419	49.1114	25.6792	8.0025
420	39.8458	28.5496	7.6706
421	47.7484	77.9947	1.7888
422	6.6588	70.1395	5.2338
423	41.1028	49.2512	3.6355
424	96.9092	96.7668	4.6617
425	78.0721	47.6161	4.8721
426	72.9018	99.4906	8.8414
427	76.5651	49.0579	7.3653
428	75.6581	50.3453	1.1287
429	84.3270	76.8773	1.2213
430	77.0157	38.8084	3.1329
431	97.8661	45.3259	6.3844
432	11.1359	13.2854	9.3358
433	39.6077	75.8506	4.0097
434	49.2061	56.5237	4.9873
435	25.8095	64.8637	1.8922
436	3.6966	79.8058	7.4364
437	97.4381	22.0448	7.4947
438	72.6426	85.7891	8.0422
439	14.7965	90.4729	9.4784
440	14.7895	29.2020	1.4281
441	70.4824	72.5870	8.2032
442	38.0994	33.9446	5.2011

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
443	7.6411	27.2681	3.5123
444	41.0840	17.0275	1.4025
445	14.2991	66.4018	8.0880
446	79.8920	53.5852	9.0921
447	93.0248	82.9109	7.9812
448	0.4719	26.7362	8.5371
449	65.0041	17.6156	4.0998
450	67.8532	43.1186	2.7207
451	25.3623	47.5655	4.4060
452	84.3181	78.5221	3.3070
453	29.3959	13.0652	1.1932
454	2.6860	5.1356	3.6395
455	9.3307	62.7506	3.1638
456	79.7885	2.9088	2.8233
457	71.1403	13.6195	4.1340
458	78.3407	69.4556	5.8343
459	62.3923	51.5679	2.1188
460	82.5415	54.2582	2.7346
461	3.5023	80.8484	5.3976
462	40.5475	79.3686	4.6631
463	24.9669	50.1867	7.6143
464	48.0897	27.6632	3.6991
465	88.0839	11.9665	8.2642
466	28.0685	88.6598	9.2230
467	59.9143	97.0289	7.8860
468	2.6226	94.2526	4.0079
469	15.5199	63.8128	7.4740
470	83.3911	9.0590	1.3023
471	19.4893	7.4708	6.5406
472	82.9788	18.2451	2.0097
473	33.8075	3.1688	1.4554
474	67.1117	72.4936	1.4969
475	5.2366	14.4159	1.2360
476	73.4309	63.5927	9.5989
477	49.9482	78.9848	5.7269
478	94.3300	56.6253	7.8063
479	28.9772	37.7414	6.3084
480	37.6560	82.1586	7.6502
481	11.3755	30.4881	3.8748
482	96.4851	31.9373	8.6332
483	43.2512	78.4980	5.4428

Continued on next page

Table B.56 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
484	8.4563	50.3736	2.0335
485	71.6676	26.0997	8.3105
486	50.6787	73.2476	7.0015
487	32.8088	16.2950	4.4360
488	75.3524	92.1075	7.4693
489	83.6006	22.2223	4.7677
490	25.3716	8.3609	1.5034
491	53.4425	7.3702	6.2650
492	43.5165	76.9552	3.6894
493	15.7704	81.7677	4.6861
494	60.0481	74.0426	6.2748
495	93.7451	75.8249	3.8406
496	10.7759	96.1195	2.3262
497	89.9981	46.6425	9.9238
498	55.0465	78.6996	1.9674
499	42.7357	42.2568	4.0083
500	15.2381	94.3730	1.3416

Table B.57: Depot locations and number of vehicles for MS29

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	64.8590	93.2912	2
2	47.4655	9.6444	2

Table B.58: Customer locations and service time for MS29

Customer index	x-coordinate	y-coordinate	Service time (short)
1	15.9073	43.6377	9.3017
2	66.5256	1.2682	4.3583
3	68.4203	22.9023	9.9024
4	79.2409	26.3680	5.8911
5	34.8624	51.1385	6.0698
6	25.0075	21.5085	2.6911
7	34.5003	34.6110	2.9395
8	32.8633	74.7817	5.3678
9	92.7486	41.3619	2.9755
10	75.6072	5.5753	9.4319
11	28.8239	39.0028	3.4986
12	60.6180	47.4484	9.5779
13	76.6029	82.5321	8.3344
14	84.6152	30.3644	4.1464
15	90.1981	82.1790	1.1945
16	59.5707	56.5680	4.0691
17	6.8536	5.4382	4.4596
18	21.8043	26.0014	1.8396
19	86.9408	58.9104	9.7233
20	41.4218	47.9734	2.7104
21	66.1209	19.8651	2.4816
22	78.3485	23.9013	5.5633
23	24.7886	78.0193	5.5741
24	55.4425	61.7310	1.4633
25	22.9585	14.4129	4.3031
26	0.6913	71.6132	6.2632
27	76.6639	40.1506	9.9528
28	2.1833	46.2385	4.9162
29	39.3103	70.7282	7.2640
30	25.2540	40.1211	1.1483
31	20.4217	1.4385	2.3729
32	66.2279	7.4640	9.0958
33	91.4742	59.1068	1.4174

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	0.6903	44.6002	1.2639
35	74.6423	92.6621	6.1700
36	79.9671	9.4893	4.0636
37	90.7799	37.5419	2.9737
38	97.4574	54.5999	9.1359
39	11.9863	11.1678	7.1478
40	51.8970	90.4463	4.3448
41	82.1975	63.3277	4.6101
42	63.7023	90.5412	2.8447
43	95.3910	63.0553	3.1393
44	94.6926	1.4228	8.9592
45	96.6605	31.6478	9.2912
46	6.7344	11.1871	8.0348
47	43.7535	62.9463	3.1772
48	32.0840	6.0709	6.2524
49	13.4052	67.3995	2.8167
50	13.4585	47.7439	2.1436
51	80.5948	30.5546	7.1890
52	52.4764	51.6333	9.1967
53	94.4257	70.7028	7.7585
54	98.8340	81.3611	8.4062
55	40.9894	31.5808	3.0261
56	37.1188	31.1302	4.4807
57	22.6854	34.4977	4.7682
58	44.6031	66.6305	9.4221
59	26.6221	86.1072	1.9500
60	45.9096	76.1779	5.7816
61	43.2905	87.5838	6.5907
62	25.9623	87.1235	3.5231
63	13.3715	17.2790	2.7799
64	41.9228	85.0224	4.6755
65	50.6861	95.9588	4.2634
66	32.4325	77.0207	2.4571
67	68.4689	87.5015	9.0417
68	44.3094	6.7413	4.9643
69	43.5663	64.6792	7.0328
70	79.3024	32.4097	2.8938
71	81.5556	64.0347	5.2403
72	75.2113	87.9751	1.4492
73	78.9256	37.3638	5.4634
74	50.1267	76.6738	3.4275

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	55.5182	16.8087	7.1576
76	63.0750	51.9725	7.7320
77	9.7989	62.7456	4.5248
78	24.5676	71.3914	6.0294
79	61.5725	30.6396	7.5902
80	30.4960	26.3687	6.5046
81	76.6968	91.6004	6.2311
82	26.7229	61.5034	1.6354
83	3.9506	9.3175	4.3682
84	29.6562	62.7697	1.3023
85	55.6365	19.2028	4.6553
86	96.9074	77.6965	6.9216
87	68.9125	86.4501	6.1772
88	71.7881	33.3582	9.7836
89	55.9029	13.5414	4.9748
90	53.3354	76.5467	8.0005
91	87.5724	31.8614	6.1251
92	39.3099	25.2380	1.1899
93	45.8067	20.0075	5.6105
94	20.8245	6.9010	4.6680
95	75.7273	55.1911	2.9785
96	54.6692	40.3812	3.0741
97	35.7388	75.0116	4.9469
98	70.0998	48.7184	9.2790
99	10.9222	38.4786	3.8713
100	0.6611	6.1409	3.5590
101	59.7302	21.3691	4.2740
102	65.9176	54.3873	5.4939
103	58.0006	41.0645	8.3217
104	90.9952	90.0963	3.1134
105	63.6006	5.6290	1.2004
106	52.5561	44.3509	3.7101
107	25.9623	53.7813	3.6826
108	5.1171	13.4061	8.4334
109	73.1950	54.0947	2.2276
110	16.4291	85.7368	8.3312
111	28.0397	19.8017	8.7498
112	25.9427	15.5609	5.9765
113	54.7096	6.1378	1.1668
114	54.1268	66.1074	5.5704
115	78.8113	1.8603	7.4228

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	86.9606	29.1103	7.2797
117	78.7541	97.3824	9.0411
118	96.9428	76.4640	7.3107
119	18.0468	24.3684	9.4356
120	93.0599	68.2116	1.0980
121	4.5152	13.7855	8.3777
122	24.0646	62.9812	1.3084
123	0.8855	85.7015	5.6454
124	67.1594	89.9798	6.8800
125	90.4813	34.8368	7.7871
126	57.2416	48.6310	3.5200
127	15.5461	67.9517	6.4275
128	50.2367	70.4122	8.9990
129	56.7733	46.0884	6.7891
130	18.8272	36.4272	8.0746
131	32.4196	28.0265	5.4203
132	71.6037	7.6204	4.6311
133	55.2929	44.4625	8.8970
134	14.2282	16.5706	7.3736
135	38.0364	39.8749	8.4384
136	39.6569	92.0585	1.0960
137	57.6742	51.1334	1.8600
138	1.9402	91.4142	5.8896
139	57.7580	9.1934	8.7060
140	93.2196	99.3037	3.3792
141	10.6873	9.6434	7.9799
142	73.2150	31.3147	6.7413
143	97.0523	78.5375	7.5255
144	60.8886	60.2400	9.0518
145	71.9666	46.5908	7.9119
146	30.2752	29.8131	2.8616
147	45.9022	13.3173	1.3897
148	4.8029	29.5009	2.3821
149	38.5352	16.6627	7.4648
150	36.1716	31.7104	2.1578
151	28.7584	10.9840	2.9871
152	81.6713	83.2088	5.0820
153	45.0528	97.1593	5.1873
154	80.6633	21.8271	1.8081
155	79.0173	70.6078	5.5606
156	28.2958	3.9014	1.6886

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	6.8309	61.6295	2.4987
158	5.4931	66.9364	7.7294
159	63.7523	3.7202	4.0111
160	42.4286	0.3335	3.7455
161	90.5531	14.2464	8.3699
162	41.7321	86.2405	9.8384
163	15.4058	27.6037	9.7207
164	53.9999	53.1692	6.1896
165	93.7091	52.2221	3.1013
166	66.0955	56.7618	3.6289
167	39.4657	33.3033	7.0639
168	25.8991	41.3417	6.1636
169	84.7912	41.4348	2.7973
170	94.5056	98.3922	9.6238
171	37.7000	5.7739	4.0254
172	6.7280	39.6543	2.3470
173	18.1582	79.1321	3.9554
174	57.5748	59.4185	2.0179
175	18.5885	30.9563	7.9472
176	29.1448	90.1803	8.1331
177	46.1664	9.3127	6.2836
178	34.6977	31.9027	1.7127
179	31.8166	88.6962	2.7361
180	45.9915	65.7432	7.9786
181	23.5895	68.4517	4.1805
182	2.7752	47.3949	8.5505
183	65.8453	14.1244	2.2050
184	15.8804	95.0925	7.2833
185	80.2663	88.2626	2.7131
186	40.8580	43.7439	4.5713
187	32.7392	83.4957	4.0505
188	74.6015	32.5143	9.3042
189	74.6352	36.7639	8.5456
190	17.3955	79.4839	6.6657
191	11.7545	9.9309	8.7894
192	17.4038	95.1782	2.9466
193	62.7409	0.1474	1.5841
194	84.1890	29.5396	7.1020
195	51.0083	4.8455	5.8161
196	16.5764	44.2740	5.6561
197	71.4305	78.9846	3.3015

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	90.7037	91.3521	8.6754
199	21.8538	53.3254	8.4088
200	87.0961	80.4076	1.1491
201	21.1836	56.2660	5.2724
202	83.6665	75.0876	9.4971
203	85.9302	0.9230	5.1276
204	52.3377	47.6785	8.6498
205	47.7363	25.0330	5.8200
206	88.9883	30.7918	4.9069
207	6.5076	96.6949	1.2199
208	50.9456	20.8804	5.5392
209	62.0798	52.0476	8.8884
210	73.3567	22.5546	9.1742
211	22.9996	56.7198	3.5668
212	2.1872	99.8164	2.1943
213	13.8989	13.1865	1.0012
214	76.9507	95.4677	3.8616
215	96.9765	12.3878	5.7710
216	38.6794	18.6238	8.4626
217	99.3428	64.6503	7.0623
218	32.6393	12.8169	9.2171
219	13.7161	8.1321	7.8053
220	38.4754	65.9227	2.5166
221	56.2636	2.7399	9.6761
222	63.3835	98.5180	4.1344
223	54.1606	53.9331	6.3864
224	31.4993	37.3835	7.5825
225	15.9327	70.6735	8.8373
226	15.2616	94.7411	4.0006
227	13.6951	38.2277	5.1674
228	70.9803	69.2909	2.5020
229	46.4864	60.2071	5.1975
230	11.3271	77.5258	5.1073
231	70.0879	59.1834	2.1504
232	17.9986	37.6180	6.7594
233	80.3668	85.0649	9.0684
234	51.3956	22.5735	4.8469
235	54.8438	79.6958	2.5826
236	20.7845	99.6881	3.6541
237	78.4589	28.1311	1.5286
238	52.6490	71.0381	1.5416

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	57.1023	66.4642	1.2399
240	42.2041	41.4836	5.9542
241	72.1156	49.8270	6.0675
242	7.3138	94.9123	3.7414
243	59.4862	95.3182	7.7906
244	86.1977	73.2923	7.0399
245	44.8801	38.4680	9.4585
246	65.2577	4.0083	5.3664
247	30.3473	58.2934	5.6628
248	60.7440	56.4713	8.1028
249	27.8902	35.5183	6.1405
250	79.9562	88.0201	7.8985
251	79.6169	62.4530	9.2815
252	95.4087	62.4016	2.8928
253	44.4338	29.5741	6.4730
254	45.6883	7.4680	5.1915
255	59.9817	29.3706	6.5503
256	84.2622	23.4740	2.8278
257	3.1200	34.5897	7.0984
258	18.7270	84.8490	1.1558
259	94.3594	16.0364	3.0395
260	94.7922	15.7864	9.2302
261	45.2984	50.8659	7.9159
262	81.0833	60.3301	5.7998
263	92.8879	16.1397	1.6154
264	67.2717	63.5454	2.7963
265	37.2332	84.3941	1.1082
266	40.5696	78.2269	9.6991
267	43.8824	26.4566	8.4898
268	67.8649	31.4699	5.0078
269	46.5070	18.3196	9.9145
270	95.3264	44.7473	8.1486
271	35.4698	32.6679	5.3975
272	33.9021	27.9816	2.1753
273	89.5860	93.1764	2.9102
274	54.5434	39.9692	8.4800
275	74.9284	37.9423	3.9141
276	12.4877	59.2846	7.6489
277	45.3235	6.8507	2.4389
278	7.4749	20.5238	7.5832
279	66.3341	72.3618	1.4832

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	70.3652	57.5148	7.4295
281	91.8951	20.0233	2.0956
282	66.0072	84.3480	9.8564
283	69.0105	42.3730	6.3379
284	85.3724	54.4751	3.4259
285	46.7902	52.7967	4.8880
286	45.8479	18.5108	9.3746
287	80.6104	8.1690	5.5710
288	82.4767	46.4094	1.5769
289	19.0436	3.0555	6.9320
290	2.5673	43.4984	5.0425
291	5.6815	55.7865	2.3245
292	14.2936	63.8782	7.9771
293	17.1419	3.4217	5.7814
294	62.5845	70.9900	1.7910
295	2.9515	16.9324	9.1041
296	47.2332	59.3382	8.8134
297	67.8443	60.8065	1.5067
298	11.4789	77.2360	6.7605
299	23.6064	5.6274	9.0034
300	28.9081	85.4725	4.1295
301	17.2756	38.4284	7.0005
302	32.3706	39.9619	5.0901
303	80.1110	32.5417	5.0219
304	29.9634	55.5390	1.1533
305	77.5626	29.5420	8.7528
306	55.2771	36.6120	9.4404
307	55.4692	34.9048	5.3090
308	73.0647	63.0224	6.1285
309	77.3625	66.4442	9.9352
310	90.0847	99.2096	4.6372
311	13.8167	94.4361	2.9786
312	79.4077	35.0348	8.7985
313	18.9413	19.2998	7.2012
314	2.8974	91.9576	2.5432
315	12.7387	28.8692	1.0812
316	13.3736	55.0859	2.5217
317	12.8311	91.9324	2.8575
318	93.5260	9.0049	9.1146
319	27.3230	25.7696	7.3823
320	94.2679	42.7048	2.1874

Continued on next page

Table B.58 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
321	63.8151	57.7723	4.8268
322	87.2531	89.9521	6.9530
323	36.7073	21.8226	3.9014
324	23.6202	96.7032	6.3769
325	18.7318	43.3981	2.8958
326	54.5649	78.4822	2.7066
327	25.5116	52.5234	2.8748
328	30.5824	33.1277	7.4201
329	1.5549	43.1594	3.2743
330	58.7488	71.7902	3.4301
331	96.2558	91.6212	5.3358
332	84.9848	89.0028	2.9861
333	0.7940	13.4706	4.1920
334	63.4026	11.9913	6.7396
335	35.9291	89.3452	7.7478
336	11.4060	65.3086	5.4318
337	54.0818	4.0278	6.5565
338	41.6421	50.4716	3.8751
339	51.7098	89.4453	3.7225
340	88.6123	38.5728	2.2761
341	14.9396	29.2052	8.5991
342	43.4677	23.4037	3.5934
343	5.9039	20.0948	9.1795
344	38.1030	38.0306	2.0189
345	72.2369	59.4790	6.5247
346	9.5119	26.8386	3.5551
347	66.7190	62.2443	5.5732
348	29.6401	80.4567	5.8499
349	59.8563	10.3971	1.4694
350	15.1852	72.9240	4.9337

Table B.59: Depot locations and number of vehicles for MS30

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	13.7563	63.9193	1
2	52.4102	68.2423	1
3	61.1506	55.3530	1
4	35.8528	50.2519	1
5	49.0485	30.5918	1
6	54.8631	58.2473	1
7	39.7564	29.7359	1
8	49.7726	76.5131	1
9	56.8686	58.7746	1
10	34.3808	54.4136	1

Table B.60: Customer locations and service time for MS30

Customer index	x-coordinate	y-coordinate	Service time (short)
1	59.0190	72.3647	8.8736
2	24.3187	33.5261	5.1413
3	46.6143	80.2990	1.0276
4	41.6672	43.7594	5.1845
5	56.3837	25.8043	8.4166
6	56.8673	39.6886	8.8470
7	56.7582	65.5750	3.7097
8	43.9370	67.5988	3.1240
9	40.0121	52.6705	8.4842
10	40.1735	54.7900	4.9398
11	64.2257	60.5484	5.5638
12	19.1165	25.6826	2.6693
13	46.5449	40.3048	2.3635
14	54.5063	19.4975	9.1613
15	39.1205	42.5149	9.9347
16	57.9538	65.8212	4.5107
17	48.8113	61.9574	8.4413
18	34.3616	88.1305	9.5865
19	52.6894	52.7788	9.0446
20	45.5303	14.0585	8.5691
21	43.1688	78.1567	7.1496
22	38.1446	71.3713	2.5462
23	51.0241	40.2895	3.1380
24	19.2312	53.7102	4.9086
25	43.3611	62.9909	1.2256

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
26	40.9409	56.4118	3.4178
27	34.8017	61.6061	9.8214
28	60.8783	48.1214	3.8142
29	37.7621	49.3529	6.1458
30	59.0106	51.4681	6.5050
31	66.2640	36.8391	9.1138
32	47.3855	73.7160	4.5644
33	54.6300	50.1055	7.2349
34	60.6586	61.4413	2.8404
35	48.6504	35.7511	1.5657
36	59.0145	32.0794	6.6015
37	28.9573	48.4839	7.1922
38	68.5071	45.7871	3.6711
39	33.5073	69.9137	6.1441
40	19.5194	60.1011	3.8460
41	73.0750	59.0086	8.2855
42	48.9546	25.9177	4.2895
43	57.4820	33.8718	7.2891
44	43.9457	53.3675	6.7008
45	32.9903	44.2020	9.6812
46	-1.2165	71.5015	2.8072
47	60.4380	72.3526	6.3836
48	45.2219	40.3200	1.7533
49	46.7110	64.5856	5.8997
50	56.7601	73.2575	8.6153
51	26.3442	55.3498	1.3663
52	37.8426	77.0564	3.9642
53	69.1221	67.7072	7.3841
54	59.9644	53.5684	8.7428
55	28.6453	64.6134	5.5081
56	13.2789	53.2401	9.9528
57	40.4792	43.0851	4.8578
58	53.5666	55.9743	3.4061
59	65.7063	50.6037	5.2566
60	51.5621	43.9228	2.4476
61	31.2948	79.5170	2.4301
62	55.1026	53.6879	3.4151
63	30.4611	95.5063	7.8141
64	33.9839	45.0639	6.4826
65	39.1044	59.4049	9.7024
66	29.5101	76.3770	7.9599

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
67	45.4839	95.4872	6.1558
68	35.0008	55.0594	5.0520
69	45.2386	36.8290	3.5835
70	42.2930	63.3897	7.7715
71	43.1702	28.0016	1.8492
72	41.6077	45.4359	1.9611
73	70.5550	54.5311	7.6140
74	60.1718	74.8259	4.1913
75	50.9845	73.9524	6.2257
76	25.5509	49.5406	3.6897
77	22.9033	65.3989	7.4231
78	17.2541	44.6453	4.2444
79	93.4199	61.0187	7.4661
80	66.2062	81.9216	9.9579
81	54.2830	52.6127	1.7533
82	33.7627	44.9911	5.2139
83	30.8939	41.6661	1.8442
84	59.1273	61.9412	7.5265
85	76.0847	72.2881	9.2084
86	21.7776	85.4280	1.7777
87	42.5100	50.9008	5.6796
88	48.5951	52.7173	5.9737
89	16.8000	39.4549	7.1663
90	64.0208	76.8665	3.6969
91	43.0890	48.7425	6.4169
92	81.8697	42.1127	2.7865
93	43.4850	86.4040	6.9108
94	56.8197	63.4980	7.2852
95	30.9595	61.9390	5.1371
96	39.5856	33.2405	2.4189
97	30.5213	57.2331	4.7961
98	56.5429	58.6691	6.3645
99	71.6973	31.7959	3.9010
100	40.1060	46.2368	8.4766
101	57.2729	43.2513	2.1042
102	41.5940	58.7977	3.2606
103	51.7018	33.2173	9.4385
104	69.9375	68.1504	6.8969
105	52.0047	79.7479	7.7762
106	32.7193	44.9374	8.2977
107	35.7149	49.8551	1.4358

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
108	47.1688	58.4439	4.7324
109	46.8055	70.0542	7.5294
110	35.5697	58.7003	2.2514
111	53.0111	56.6174	6.6930
112	71.1088	41.9532	3.2215
113	45.8138	46.1417	8.5598
114	46.5905	60.2231	8.5300
115	13.3080	78.0475	5.0777
116	37.0914	59.4732	4.5528
117	26.7788	29.8995	9.6544
118	43.5628	57.2177	1.0736
119	58.7598	48.4647	4.5859
120	75.3878	45.9324	5.3900
121	79.9749	46.3469	6.5632
122	48.0519	35.3372	1.6301
123	44.6634	44.6533	2.2842
124	63.6253	36.9264	6.8880
125	58.1693	43.9173	2.9649
126	62.7542	51.9545	2.0722
127	62.9713	52.9057	1.3882
128	25.3282	46.4057	2.4900
129	59.0061	47.4565	5.6000
130	48.4743	50.5615	8.8054
131	37.3291	57.6380	7.8963
132	38.4401	71.3605	2.2146
133	71.3576	60.3348	1.5843
134	36.5044	45.2221	7.0520
135	29.3864	59.9669	5.3399
136	53.5781	45.9078	5.4588
137	83.5129	20.3210	3.8214
138	50.4259	10.8793	3.9115
139	55.1383	21.4401	9.1819
140	34.3625	46.0479	5.0530
141	77.9036	39.6729	7.7377
142	52.0831	37.9973	2.6673
143	58.8350	50.6776	1.7643
144	34.1322	39.0170	2.8633
145	64.2340	39.4914	6.0302
146	56.4858	60.1604	6.9553
147	30.7333	63.0389	9.4529
148	50.6623	90.6097	1.3622

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
149	42.4900	55.0401	2.4729
150	51.8208	50.9720	4.9431
151	45.8241	40.4311	3.9310
152	46.8350	46.7465	1.8094
153	32.7848	49.1578	8.2929
154	44.6118	20.7371	4.5960
155	62.7754	45.7107	6.8978
156	79.0779	62.4924	6.1016
157	30.6580	40.4873	1.0281
158	89.6235	58.2372	6.8622
159	75.4346	66.5240	3.8539
160	52.8085	67.9523	3.3934
161	44.9799	62.9474	5.1440
162	38.3558	12.3360	6.6084
163	63.8795	40.5937	8.2167
164	38.4232	65.0249	6.0505
165	42.3020	56.5779	1.2232
166	64.7270	50.0809	8.1419
167	57.2657	57.2820	3.4578
168	64.9458	68.8345	8.4062
169	58.4122	52.5628	7.1970
170	43.3184	37.3562	6.4351
171	41.4359	46.9973	4.4826
172	63.2728	46.5368	1.5898
173	38.8135	64.9458	9.9873
174	69.7777	56.8718	6.9494
175	63.1784	59.1253	3.0626
176	54.7954	52.4639	1.8303
177	50.0538	43.9622	3.1688
178	56.0936	51.0190	9.1231
179	97.3100	53.6118	2.9561
180	48.1261	26.6980	5.3157
181	24.0568	52.9812	9.1831
182	81.9184	65.4597	2.7440
183	60.1641	48.1637	5.0319
184	39.2015	76.2066	6.5602
185	93.6222	59.3415	6.3479
186	59.1825	42.9943	6.9929
187	54.9034	47.4342	3.4091
188	37.0359	45.4134	4.8148
189	32.2512	54.0187	8.1939

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
190	20.5264	62.5781	9.3908
191	42.9513	45.1348	5.2275
192	32.4483	57.6408	3.7567
193	60.7959	79.2548	4.9543
194	44.7062	65.5248	3.7617
195	79.4832	63.7544	3.4751
196	75.1764	36.4199	2.2487
197	52.7335	41.0966	2.4989
198	45.2873	54.0425	5.4455
199	69.2028	48.3225	1.7793
200	30.8915	22.9159	9.3416
201	61.2283	24.7596	2.3363
202	38.8481	67.1032	2.4443
203	43.3280	37.3645	7.4595
204	38.8033	84.6391	7.0741
205	59.5938	12.9669	4.2267
206	37.0318	57.4794	1.8141
207	32.2740	50.0104	1.0742
208	59.2163	37.3960	4.3550
209	42.9429	56.7387	8.0948
210	56.0265	36.7691	5.0256
211	44.1352	64.3297	1.8966
212	54.4923	51.1145	8.2525
213	7.2592	22.6769	6.9351
214	57.7644	9.5875	5.0713
215	80.8927	45.2695	5.8003
216	67.3215	69.0968	5.7400
217	65.1816	53.0195	6.6671
218	46.0045	50.9042	6.8191
219	53.0166	61.4626	2.7265
220	54.0708	26.7765	8.2156
221	51.6065	73.7561	2.7691
222	36.1589	35.1025	4.7016
223	44.1291	50.6294	3.1212
224	47.0871	43.9405	3.4498
225	41.9891	52.4926	1.0780
226	63.9473	17.5914	9.3545
227	92.3058	75.3982	5.6820
228	27.9444	59.0968	5.1771
229	52.1390	83.4988	5.7118
230	25.9603	73.6112	4.0313

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
231	71.7085	50.1913	3.9914
232	73.4985	34.3492	9.8946
233	22.2910	21.0182	5.2635
234	82.3947	50.2828	7.7217
235	31.9217	53.6527	7.0296
236	53.7803	67.4303	8.1603
237	68.3155	34.1503	3.4529
238	52.4531	63.2466	3.5552
239	88.2611	51.1905	7.4553
240	95.8760	37.1052	2.6617
241	52.3053	62.9027	8.5033
242	18.2156	54.4276	2.5270
243	43.9168	46.0816	9.5794
244	35.8648	81.2882	7.5029
245	37.2541	60.1540	2.2082
246	31.2051	48.1621	8.6778
247	51.3031	54.6243	9.3852
248	85.1105	51.4508	6.0777
249	38.0692	52.8932	4.5894
250	45.3247	57.5599	4.9744
251	69.4413	39.9414	7.3151
252	70.2137	36.7163	3.3404
253	58.0923	56.0108	1.2568
254	67.1003	81.4182	9.5317
255	64.5121	44.8863	9.9655
256	43.6374	33.1213	8.0153
257	57.1482	46.0242	9.9046
258	45.0145	41.9331	5.3880
259	35.0022	44.5443	2.1518
260	60.5791	57.9253	5.1793
261	51.1242	47.8333	7.6833
262	46.8813	40.0941	7.0605
263	54.8621	42.6039	8.8658
264	66.4616	27.9578	7.8243
265	56.5489	35.6746	6.5546
266	53.2425	26.4500	3.4734
267	54.6631	41.4002	4.0274
268	50.8537	31.9150	8.5215
269	37.0922	38.2140	4.4730
270	63.1130	44.9724	1.7231
271	73.4818	29.9927	8.7903

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
272	41.0984	49.6773	4.9184
273	82.1293	55.6728	2.5487
274	47.0625	33.9462	1.0387
275	45.9375	68.5654	6.8725
276	35.0400	23.5649	4.3272
277	36.7944	43.4701	4.3849
278	34.1171	25.2552	4.9721
279	55.8984	44.2562	5.6451
280	76.6171	27.9347	3.7010
281	58.7912	40.4194	5.3049
282	64.2367	37.6549	1.0562
283	72.3641	30.2500	2.5429
284	8.3411	15.5857	3.7320
285	47.2073	59.4177	7.7002
286	55.8836	83.3357	6.2280
287	61.9542	87.0555	7.3109
288	28.2525	41.7970	8.2420
289	33.2355	49.2333	8.6679
290	63.1781	42.2375	2.0595
291	48.0571	51.2658	6.9154
292	59.2182	34.6872	7.7766
293	33.9893	18.0089	7.3192
294	22.7700	49.3926	6.4461
295	62.6867	29.5812	1.3444
296	69.8885	18.2928	2.7564
297	77.2010	89.5708	3.9761
298	24.4635	46.1109	6.7855
299	27.7191	56.7313	2.9566
300	25.4359	69.8745	1.6922
301	49.3056	21.9207	9.8253
302	39.7415	56.8858	2.8608
303	71.9026	58.3624	9.8493
304	25.7489	51.3844	6.4933
305	20.9608	52.6300	3.2318
306	53.4217	41.2010	5.6616
307	69.8822	62.0510	7.4155
308	36.6196	35.8343	3.3388
309	28.9061	36.7269	2.0322
310	47.5111	62.0890	5.9470
311	22.7259	78.1091	2.9701
312	50.2891	43.5601	3.8096

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
313	63.8065	41.5820	9.7582
314	53.6290	56.8012	3.7827
315	18.1793	67.8726	9.5162
316	41.0530	66.1330	4.6951
317	44.9661	54.5024	1.0930
318	80.2264	39.4266	3.7906
319	65.2475	60.4961	2.3969
320	49.0487	48.6794	9.9467
321	71.8227	72.9492	5.0522
322	32.5877	26.5298	5.9070
323	44.1956	52.3539	3.3610
324	73.5427	71.4953	8.9429
325	75.0397	41.7511	1.9275
326	62.1729	39.5863	8.4121
327	58.1792	34.4394	4.8446
328	40.2312	45.3546	9.2831
329	62.4150	46.6579	5.7521
330	36.1974	52.2790	8.8375
331	59.5753	35.2775	4.1753
332	54.6974	51.3756	4.6014
333	68.9884	39.9354	6.3813
334	42.9022	43.8545	9.2037
335	60.6023	36.0305	2.1969
336	63.2196	45.2921	1.3795
337	35.0270	97.3100	4.6094
338	52.6041	97.3100	6.3614
339	76.6209	69.1153	9.2771
340	51.8740	63.1210	3.6440
341	44.8563	28.6977	5.9054
342	57.6110	40.2568	8.0351
343	45.4150	39.6766	3.9466
344	57.3857	58.9217	1.8574
345	47.7539	58.0498	4.9751
346	49.6945	51.8079	1.2617
347	57.6798	44.3286	7.0785
348	72.7053	34.5692	2.0043
349	57.5312	50.0887	2.7968
350	77.4731	68.9858	5.7715
351	16.1940	57.1227	6.6462
352	42.5124	53.0172	4.3624
353	53.9332	60.9580	6.4581

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
354	36.0805	59.7374	8.6175
355	28.7341	23.0591	7.3175
356	60.2839	50.3129	4.5359
357	60.2117	42.9007	6.1468
358	54.8230	16.0995	3.2480
359	56.5886	27.8575	7.5461
360	35.4906	44.6686	4.0900
361	41.7052	63.7572	1.7077
362	48.2221	46.1785	3.7201
363	38.5362	54.3708	3.7036
364	55.5313	35.0337	1.2090
365	89.4204	14.0450	2.5850
366	41.9628	51.5653	8.7483
367	60.7908	34.1470	6.9035
368	32.7596	69.5432	8.7088
369	72.3259	78.9183	3.4385
370	33.8477	43.8051	9.0635
371	53.4786	69.8811	2.8791
372	39.6901	65.8941	9.6775
373	58.5336	26.4159	4.7292
374	50.1892	49.4441	3.0661
375	49.2669	54.3520	8.3653
376	97.3100	58.7166	4.2440
377	39.4992	61.2798	5.5137
378	49.2187	61.2399	7.7291
379	94.7171	61.3066	8.4866
380	30.8885	44.7903	4.5502
381	59.2166	56.3207	1.8697
382	32.0590	12.4517	3.3885
383	67.1773	30.5275	8.1275
384	55.4588	70.0328	9.4317
385	60.8687	38.9877	6.1143
386	45.3523	55.4593	9.4422
387	54.0865	75.1355	6.3752
388	74.5419	35.1849	9.8916
389	12.0816	34.0119	7.8611
390	22.7785	41.7880	2.6705
391	56.9245	57.3509	5.6509
392	39.0872	46.5873	6.7614
393	45.0609	33.7032	8.8206
394	25.0514	23.7842	6.4011

Continued on next page

Table B.60 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
395	34.9194	43.8290	9.9970
396	43.2636	46.3142	2.1626
397	37.9034	41.0798	3.6403
398	35.5586	45.6338	5.2919
399	42.9692	31.7431	2.1662
400	34.2889	59.1539	3.0531

Table B.61: Depot locations and number of vehicles for MS31

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	63.1931	99.2175	1
2	98.5237	40.2352	1
3	55.9477	65.8856	1
4	93.3592	90.1348	1
5	72.0343	99.5382	1
6	48.4039	65.3163	1
7	63.9031	10.8436	1
8	88.7637	3.6114	1
9	19.8737	61.8091	1
10	39.5366	56.7144	1

Table B.62: Customer locations and service time for MS31

Customer index	x-coordinate	y-coordinate	Service time (short)
1	43.4400	54.6002	2.6296
2	13.7282	57.6633	7.0481
3	30.0724	46.3749	3.9321
4	56.0888	63.2687	8.1153
5	90.2074	24.6996	5.9141
6	62.3375	32.0847	3.0750
7	55.1624	-1.2028	7.1809
8	40.9669	58.6901	1.4417
9	52.0381	33.4829	6.1534
10	66.0380	45.7812	9.9439
11	45.7671	66.8211	4.2667
12	81.5293	50.8502	6.0285
13	29.6624	42.6595	9.3455
14	43.7294	35.8588	3.3389
15	50.8738	45.9938	8.4923
16	17.4344	60.0488	2.5761
17	59.4237	24.7291	8.9186
18	51.2966	48.8609	3.5167
19	51.3450	63.0399	8.6453
20	63.2451	26.3212	8.2604
21	67.3948	61.1561	2.7021
22	63.3697	61.3873	9.8070
23	42.1863	35.2977	3.2835
24	49.2235	24.9249	8.0069
25	55.8909	57.2190	8.2971

Continued on next page

Table B.62 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
26	29.0533	63.4709	5.4816
27	32.7328	59.6490	9.2415
28	42.8840	62.7142	1.9089
29	51.2945	30.2979	2.2224
30	79.8488	59.7308	8.7249
31	63.2877	40.3332	1.1678
32	42.6250	40.6439	7.5550
33	39.5151	24.0684	8.3499
34	75.5633	68.3368	2.0460
35	95.5590	52.9176	5.3970
36	52.7907	66.7269	4.1270
37	42.0189	75.1835	7.9650
38	26.4558	31.0460	3.5676
39	66.2498	60.7170	8.4196
40	54.8286	49.7873	2.5575
41	69.4235	65.2377	8.7728
42	34.8549	68.4616	9.3345
43	54.0096	63.6745	2.7199
44	39.0992	36.3731	1.4532
45	71.2492	47.8919	5.9360
46	40.8135	54.4024	1.0857
47	48.5432	99.3100	8.4553
48	44.2030	70.4436	9.1769
49	66.5660	88.6773	7.3477
50	57.1406	56.9083	3.1900
51	33.2636	53.5305	6.3031
52	39.4552	60.2194	9.4501
53	32.5715	41.2037	9.0595
54	58.4285	70.6934	6.4560
55	55.5326	47.3728	8.1314
56	22.7431	27.1066	8.5255
57	18.2193	64.5140	6.0413
58	49.3267	23.8578	1.0063
59	61.6199	19.2625	3.2615
60	52.8134	54.8068	4.8875
61	24.2701	34.1515	4.8759
62	24.1366	34.8211	8.8771
63	64.4513	47.3008	1.6088
64	47.5771	41.8516	4.0592
65	43.5626	46.2870	2.5936
66	71.9367	54.5344	3.2143

Continued on next page

Table B.62 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
67	36.7256	30.5245	7.5504
68	52.2574	29.5961	3.5938
69	56.9634	15.0087	3.1361
70	63.6647	43.4960	2.2569
71	35.7608	61.0714	2.9866
72	55.9553	38.2956	8.3579
73	95.8078	58.3555	4.4041
74	24.7837	59.0052	6.9896
75	57.2330	66.5125	9.4223
76	46.1705	66.4896	4.8383
77	36.2152	38.5193	6.4464
78	36.1336	35.7194	9.7263
79	58.2983	50.8065	4.2819
80	88.5938	38.9191	6.9800
81	36.7696	74.2124	3.8328
82	59.0160	72.9974	8.9714
83	40.6823	51.5856	3.6599
84	82.9428	42.8812	3.6583
85	59.0777	58.5135	9.1637
86	47.7016	39.0621	5.4360
87	60.3313	47.9164	2.8643
88	49.9070	41.1589	1.2324
89	68.4533	51.7598	2.5319
90	46.9068	68.8058	3.7211
91	31.3097	62.3746	9.6530
92	54.1075	69.0601	8.0529
93	76.0173	34.7548	7.0593
94	30.0563	52.9967	8.5665
95	45.9609	33.6109	4.7877
96	66.7471	56.4138	7.3336
97	17.9979	55.4283	5.3316
98	60.4241	71.6052	8.3852
99	62.5493	68.3205	4.9365
100	53.5581	60.8871	8.7398
101	37.1628	41.5821	1.0801
102	49.8811	42.0668	9.9643
103	51.5531	15.8073	3.4768
104	65.5875	42.5283	1.3016
105	61.0586	24.1467	2.3689
106	44.1628	65.4971	5.3164
107	76.9980	65.0323	8.9996

Continued on next page

Table B.62 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
108	49.1528	52.3048	3.5508
109	36.4550	43.6932	8.0571
110	42.6930	52.3844	2.5335
111	64.3102	76.7506	7.5816
112	53.2536	72.4853	3.2196
113	64.8144	42.5260	1.7366
114	51.1537	52.8069	8.6762
115	91.4470	31.3251	7.1790
116	22.2393	56.6788	9.6230
117	43.0679	62.3177	9.8655
118	48.5963	65.0007	5.8125
119	51.4875	24.4797	9.1538
120	74.2691	58.4103	5.2898
121	53.6576	35.5964	9.0070
122	48.0854	43.7241	1.2146
123	51.1434	63.1335	2.1585
124	62.5249	54.9701	7.6658
125	38.5095	47.2710	4.5192
126	57.5136	60.1122	4.5427
127	23.9163	77.2416	6.4166
128	48.6867	39.6084	1.2150
129	34.3035	27.4983	4.4890
130	39.1190	30.6293	1.5107
131	54.7088	34.2620	7.2061
132	31.2487	38.8132	5.6835
133	33.5171	59.6114	1.6848
134	24.7357	15.2372	4.6563
135	12.8582	53.9327	4.8719
136	47.4746	37.0263	6.9338
137	69.3791	68.3260	2.9655
138	46.9677	35.7406	1.7298
139	46.1008	50.1260	5.2090
140	32.5544	34.3736	7.5580
141	76.3886	38.6407	6.5259
142	45.8431	45.6643	9.1054
143	71.5670	46.1867	3.2750
144	56.0330	41.2531	2.9809
145	45.6158	68.8053	3.1222
146	68.0357	59.1690	8.2912
147	66.3739	80.9191	7.3217
148	48.1426	45.3784	8.9065

Continued on next page

Table B.62 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
149	71.5992	67.7772	7.3991
150	79.6883	15.0127	6.9497
151	48.9064	60.6414	4.9562
152	45.7387	56.1911	6.0651
153	56.7440	43.7637	9.9128
154	55.8626	61.5891	9.6158
155	63.4585	64.6271	4.0314
156	45.7402	67.2268	2.3991
157	61.9186	56.9965	4.7537
158	67.4766	60.0178	5.9903
159	52.9591	38.7664	1.2678
160	52.5550	31.7470	8.8004
161	29.0946	45.5397	9.0497
162	30.4533	53.1092	5.4747
163	25.6426	65.8491	2.8836
164	29.2619	36.8247	7.4944
165	47.4150	41.8420	7.2974
166	23.0848	99.3100	5.1467
167	87.4344	39.6236	2.5353
168	62.3214	82.0050	8.1493
169	15.5392	66.0191	8.9965
170	30.7575	40.7033	2.2826
171	48.2135	48.2241	9.4570
172	21.4520	46.4140	1.0023
173	42.3351	57.8915	4.9492
174	68.1833	72.7607	1.1005
175	47.2687	22.7033	3.1106
176	48.8793	83.7288	7.3629
177	33.3068	62.9632	7.2475
178	40.7390	40.8516	3.3861
179	27.4741	47.8998	3.9392
180	56.0702	54.9930	1.8391
181	42.4632	54.9362	1.3744
182	63.0561	70.0130	7.8335
183	70.6206	68.1695	3.9239
184	67.9533	44.0216	5.6964
185	49.4193	47.8345	9.5670
186	41.6002	62.2290	7.0208
187	29.5997	52.0055	5.2581
188	51.9752	68.9389	6.8443
189	65.9912	38.5538	6.9907

Continued on next page

Table B.62 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
190	44.3178	57.8614	3.0713
191	47.1114	54.8057	8.2440
192	60.2717	73.1976	5.5251
193	64.3987	27.5750	4.9063
194	26.3848	50.0125	7.3813
195	53.3325	50.8916	5.9974
196	53.2638	10.9682	3.2950
197	47.4811	70.8016	1.6768
198	64.8797	96.8205	6.3019
199	43.9302	46.1303	7.0682
200	36.2302	54.7839	6.2921

Table B.63: Depot locations and number of vehicles for MS32

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	31.4177	22.8672	1
2	61.4209	76.9550	1
3	67.2946	54.4023	1
4	80.3702	31.2142	1
5	41.1835	40.6804	1

Table B.64: Customer locations and service time for MS32

Customer index	x-coordinate	y-coordinate	Service time (short)
1	82.7075	48.4180	5.8033
2	73.4386	73.0536	5.2535
3	58.2806	71.7280	3.9143
4	51.3805	47.9031	4.8789
5	24.1920	40.0521	7.8841
6	81.0527	24.6559	9.9682
7	52.2338	61.1974	3.3852
8	24.2333	50.3807	8.1286
9	57.2214	30.3702	2.2115
10	51.7159	44.4237	1.3198
11	40.4942	19.5091	5.0855
12	58.2177	57.1665	6.0668
13	38.2081	47.1001	3.0779
14	27.5329	77.1874	2.3029
15	20.7616	27.3429	7.0939
16	43.9365	66.1751	4.1866
17	39.5484	52.3940	5.5943
18	57.3358	51.3767	7.2524
19	24.9560	61.9444	6.3576
20	46.5294	69.8914	5.5550
21	24.9146	32.1490	7.9876
22	80.1623	71.9817	7.1668
23	48.0505	29.8333	3.8754
24	70.4368	32.0981	8.4893
25	58.2491	38.7907	6.9474
26	65.1432	62.2744	6.2836
27	30.7630	32.1673	1.1717
28	70.9593	55.5786	8.5326
29	74.2089	56.8647	2.0260
30	15.3865	52.5687	8.5638

Continued on next page

Table B.64 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	47.0585	59.2428	4.0375
32	39.1320	30.4526	4.8649
33	52.6089	66.7931	8.1440
34	35.8296	51.8920	2.2741
35	54.6508	62.1675	6.4729
36	59.9516	33.6081	9.3757
37	54.0786	50.8672	6.7280
38	48.0276	64.6267	1.4299
39	28.5099	66.9024	7.2851
40	50.9594	48.5942	3.3140
41	41.3178	19.1078	7.2181
42	28.6829	31.7197	4.2686
43	49.0629	53.6438	5.8770
44	46.5053	63.2374	2.9993
45	53.2017	57.7187	9.1494
46	66.5389	39.7895	4.3619
47	59.6041	87.4067	1.7093
48	71.7631	51.2058	1.2784
49	37.8449	64.4252	6.6421
50	35.5904	43.0717	9.4330

Table B.65: Depot locations and number of vehicles for MS33

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	57.8128	41.3045	1
2	39.0451	52.6906	1
3	21.3840	32.3032	1
4	74.5087	57.5082	1
5	61.5690	45.4534	1
6	41.4884	48.3091	1
7	51.8898	26.1816	1
8	46.1699	37.2598	1
9	25.6378	56.8356	1
10	1.9611	36.8345	1
11	49.2089	52.6940	1
12	42.2922	82.9651	1
13	40.3892	63.2544	1
14	35.9005	67.2894	1
15	19.7127	89.3388	1

Table B.66: Customer locations and service time for MS33

Customer index	x-coordinate	y-coordinate	Service time (short)
1	18.2596	27.2642	3.8794
2	34.6750	27.9887	7.7066
3	29.9342	22.0640	3.6004
4	27.0229	26.1030	2.1192
5	27.0040	47.2798	5.6267
6	18.1542	24.9369	4.4876
7	33.2759	30.9192	9.8075
8	27.8866	21.1455	3.6264
9	22.8239	20.6010	6.3311
10	23.4607	22.1184	6.1422
11	24.1522	29.7046	6.5427
12	17.6080	18.3205	6.0482
13	31.1781	9.5588	3.5187
14	36.6017	25.4435	2.3666
15	45.6158	21.3632	7.5971
16	29.1993	27.3334	1.3573
17	18.1460	25.7050	8.2146
18	26.6748	31.0760	4.6578
19	16.6079	32.5063	8.4701
20	19.8902	13.9530	9.7393

Continued on next page

Table B.66 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
21	19.5086	12.2952	4.8023
22	18.0564	29.1869	1.4851
23	28.1515	27.5533	8.0833
24	15.7055	17.1737	6.6707
25	30.5603	35.3117	5.5794
26	31.6278	25.2751	6.1092
27	33.6458	26.0297	3.7827
28	24.8297	27.2828	7.7242
29	30.1579	31.2847	4.0299
30	40.0255	37.7041	8.9502
31	25.4416	22.8169	4.0029
32	23.5176	10.5776	8.1641
33	39.7707	33.4455	8.2431
34	4.0933	17.2689	1.4521
35	21.1951	35.3640	4.6225
36	45.2531	20.0876	9.6867
37	21.0712	37.4290	4.7294
38	20.3306	18.2835	3.9747
39	14.7794	15.7283	6.7274
40	31.6079	32.9745	8.7222
41	7.4172	13.6412	8.0946
42	18.3384	30.6715	5.8457
43	29.7248	28.6485	7.6750
44	24.9880	23.8061	7.6575
45	30.1994	22.1539	5.0032
46	26.0537	42.1484	8.6537
47	30.6739	21.8789	5.4508
48	14.2715	23.4150	9.5334
49	26.8174	17.1772	8.1801
50	11.9453	18.2211	2.1974
51	31.5273	20.1365	3.1399
52	22.4119	39.2460	2.1495
53	30.4610	21.7465	5.8071
54	20.5211	19.2495	1.5103
55	27.7387	21.2648	5.2172
56	33.7839	30.9531	9.8442
57	8.5025	14.0356	7.1400
58	9.4384	30.2260	8.8381
59	9.7304	13.9059	5.4659
60	32.0716	23.9096	3.5890
61	28.3766	9.7759	2.6472

Continued on next page

Table B.66 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
62	19.1462	29.4660	9.6510
63	37.4921	30.7739	7.8064
64	26.1483	19.2704	9.5532
65	11.7765	27.6465	7.0414
66	16.5071	26.3570	2.6745
67	13.4564	34.6593	3.6086
68	32.9574	26.0699	1.5239
69	19.9907	33.6622	1.3966
70	15.2342	24.0269	3.5160
71	20.1907	19.5975	2.5342
72	18.0297	24.6835	7.0939
73	32.1081	23.3390	9.1218
74	28.9778	32.3472	4.1679
75	27.5193	24.5321	1.9014
76	28.4648	17.9897	8.1370
77	25.3581	23.7096	5.2159
78	17.0929	34.9050	7.1861
79	29.5134	21.5424	7.1477
80	18.1573	19.5115	4.7929
81	16.0675	33.1999	6.9341
82	16.0492	25.8436	6.7008
83	32.2463	21.9775	5.7263
84	33.1754	18.8431	2.7215
85	10.3431	12.6680	5.6072
86	23.7659	26.2781	7.7350
87	27.0995	22.3582	4.7784
88	19.9135	27.6577	7.6373
89	31.3415	12.8621	7.1782
90	27.1202	36.0153	9.6015
91	23.7264	29.0600	3.7712
92	20.3549	11.9448	4.0807
93	30.6418	33.8088	4.4833
94	32.0775	20.1035	1.2356
95	28.9109	27.5185	6.7019
96	23.0018	26.8289	6.0873
97	32.6749	17.6817	4.2896
98	17.4427	1.1550	4.7931
99	26.2037	29.4630	5.1598
100	36.6367	22.1497	3.8299
101	23.4192	20.0178	3.0310
102	17.9680	28.4909	2.0434

Continued on next page

Table B.66 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
103	41.1953	19.2527	2.2057
104	22.9423	30.5933	9.5187
105	28.6802	26.2575	5.4319
106	18.3032	16.7390	7.7339
107	27.3967	31.9736	3.7984
108	28.8918	28.9542	1.0693
109	25.0380	35.4347	6.5406
110	27.7174	17.5615	4.2182
111	35.0382	17.5394	6.8395
112	13.2990	27.6110	8.6138
113	26.7130	30.5586	1.9122
114	8.4067	31.9010	6.2947
115	25.2367	25.0542	6.2414
116	41.0876	23.0342	5.6962
117	32.8428	30.4402	5.0914
118	24.9423	41.3711	9.7003
119	22.1813	32.3715	2.6408
120	29.4022	25.7045	6.0345
121	33.8075	20.2124	6.6383
122	25.1228	29.1646	1.2712
123	38.4563	20.9658	6.7805
124	18.2012	26.9870	8.5435
125	8.3520	31.4854	4.5562
126	18.7651	32.7023	4.9361
127	23.3391	29.9011	1.7639
128	21.8937	36.4828	6.2324
129	17.9386	40.4267	8.8451
130	36.1437	9.1861	2.8622
131	11.5307	10.1776	1.8515
132	20.9015	17.3113	2.6916
133	16.9225	8.3506	7.0105
134	21.0491	22.0242	7.5918
135	19.4486	22.1967	6.6791
136	28.9865	27.0869	5.2139
137	16.3245	27.3847	3.8293
138	18.1612	19.2819	6.7732
139	25.8427	18.2224	6.0582
140	34.0332	31.6117	6.9735
141	9.5456	21.8171	2.1239
142	39.9979	13.5733	7.0662
143	17.6802	25.0859	7.1228

Continued on next page

Table B.66 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
144	30.3978	26.7011	9.3711
145	33.7464	21.5748	8.4594
146	36.0258	30.5297	2.6029
147	20.6887	26.8815	9.5432
148	25.2026	23.2263	2.7966
149	23.6469	24.6330	2.9591
150	19.9528	28.8182	1.0767
151	71.3215	69.8804	3.7056
152	66.2088	77.0141	3.4702
153	73.7035	79.5779	6.2780
154	76.0762	78.8970	4.5690
155	79.2452	76.5955	2.6776
156	74.7490	73.0850	4.5353
157	71.1886	70.1732	2.3913
158	79.9695	79.0040	8.4907
159	74.0539	71.7764	2.3478
160	81.7252	78.5135	7.1159
161	74.2516	84.0642	7.7508
162	74.9476	56.2556	1.1340
163	74.2345	90.0373	2.2802
164	67.3230	69.7328	1.2759
165	67.2754	85.9705	8.2783
166	66.9898	87.9299	1.4243
167	89.8736	62.7591	6.9956
168	73.3318	76.4745	5.1043
169	82.8368	100.0000	8.2270
170	77.9096	73.2114	4.2260
171	90.4940	79.0524	1.2280
172	82.7256	77.7574	2.9673
173	64.7753	85.5659	7.3982
174	72.2730	84.0876	5.9403
175	82.4304	67.1129	8.8272
176	77.4015	71.3458	7.6495
177	93.8766	77.8602	1.9291
178	74.6009	74.5133	9.7429
179	62.0678	96.1248	7.6484
180	78.7007	78.6554	1.1247
181	67.4015	78.6460	7.1121
182	75.4120	68.0194	5.3695
183	83.9837	64.1041	1.3125
184	77.5682	81.6179	2.0300

Continued on next page

Table B.66 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
185	77.4970	73.3561	1.6896
186	73.3565	80.4096	6.4704
187	73.7798	68.0710	3.1012
188	74.1411	82.4663	2.2781
189	51.6752	59.8876	5.7716
190	78.2773	88.0557	9.3727
191	83.2521	82.0542	6.5521
192	64.1864	75.9180	7.2090
193	62.3169	65.3242	3.1098
194	80.1751	71.6872	2.8616
195	62.4373	77.1191	1.3363
196	61.0050	85.0649	6.9703
197	81.5748	66.3872	5.5653
198	69.5476	85.7929	5.3722
199	85.3742	98.0677	8.7553
200	64.2311	70.8721	9.6896

Table B.67: Depot locations and number of vehicles for MS34

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	93.1616	60.0345	1
2	78.3102	8.4997	1
3	68.5687	92.2358	1
4	46.6219	5.3598	1
5	26.0318	52.7025	1
6	56.9268	11.8853	1
7	24.8771	38.0143	1
8	31.9302	81.2833	1
9	91.0802	24.4096	1
10	88.5220	88.4423	1
11	79.4589	71.2647	1
12	92.5810	37.8148	1
13	17.8840	24.8920	1
14	51.7541	25.2854	1
15	62.7005	76.7244	1
16	91.3182	4.9862	1
17	66.3968	68.5289	1
18	38.9193	62.0278	1
19	74.0008	74.6685	1
20	81.7635	97.7256	1

Table B.68: Customer locations and service time for MS34

Customer index	x-coordinate	y-coordinate	Service time (short)
1	34.7950	28.5498	7.8372
2	28.3145	24.6422	3.2201
3	41.2604	14.6478	7.0864
4	17.4612	20.7921	7.8337
5	19.3154	27.7154	6.2757
6	41.8191	15.7381	8.4020
7	28.7862	28.9015	9.3415
8	24.6491	27.6884	6.7381
9	28.8181	25.8335	1.1704
10	22.7988	27.5120	2.6591
11	22.5668	25.1985	1.2407
12	21.7767	24.8162	9.4150
13	20.3834	24.9270	5.3602
14	17.1356	32.7455	8.1531
15	24.5013	24.2464	5.1115

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
16	20.2110	2.9905	5.4479
17	37.0155	20.9488	4.8314
18	26.9627	26.6331	9.0259
19	33.5115	32.9977	8.8686
20	23.8347	36.5027	6.6984
21	24.3204	17.1545	3.6305
22	35.4854	31.3406	3.6251
23	37.2378	26.9827	3.2095
24	25.2745	23.2636	7.3391
25	39.1040	25.2062	7.9715
26	28.9644	24.7659	8.4039
27	28.0711	26.1697	8.2557
28	43.2667	26.9799	3.2839
29	37.7974	19.4038	8.2045
30	32.5605	16.2917	6.6674
31	28.3522	33.0481	3.0835
32	20.5135	23.1687	4.4297
33	24.0399	36.7878	5.0788
34	40.1833	17.2984	5.5050
35	8.1541	20.0488	5.8651
36	19.6919	36.8440	4.1063
37	23.4266	36.7301	3.6229
38	26.2356	16.4250	7.3318
39	10.1343	26.7209	9.4067
40	29.4089	36.1759	6.3476
41	31.0811	36.1060	6.3378
42	17.1655	14.2925	7.6486
43	22.8393	38.4865	4.3538
44	14.8871	30.5137	5.0794
45	38.5379	26.8946	5.5844
46	28.1126	23.1202	9.3584
47	22.9092	16.9501	5.0571
48	17.2879	25.7918	6.7369
49	25.8222	22.8606	5.1343
50	39.0357	44.2511	5.9840
51	27.2938	26.5838	1.3711
52	27.9441	23.5550	8.2198
53	14.9969	24.8831	7.0436
54	26.3844	19.8938	2.8029
55	31.4680	42.2650	1.1313
56	13.4880	30.3085	7.8685

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
57	34.4023	25.6241	6.1076
58	45.5453	34.3606	6.8879
59	12.0174	24.7239	6.7127
60	7.7779	24.1854	7.6090
61	24.3950	20.3615	8.9859
62	31.3259	19.8708	6.9932
63	24.3195	38.3713	2.0861
64	23.6794	31.4041	7.4236
65	25.0542	25.7244	5.0250
66	16.1283	39.2030	6.7688
67	11.3007	25.1969	6.8401
68	38.1796	27.4170	7.1054
69	27.4385	13.1675	1.5294
70	15.1033	28.9606	3.0156
71	33.9661	12.9390	2.5118
72	14.1886	16.7643	9.3568
73	23.9852	32.9115	5.6371
74	31.1731	27.9269	7.0603
75	17.9940	17.7310	7.0102
76	22.0877	21.6823	1.7332
77	25.2469	27.1370	3.0257
78	41.2698	26.8335	3.5577
79	28.8252	10.7380	9.2239
80	21.6724	14.9520	3.0619
81	23.1218	10.2257	3.2376
82	22.6643	24.3959	7.0866
83	35.8894	10.6574	6.8364
84	22.6302	30.8490	7.3331
85	18.4024	16.6211	8.5339
86	27.0052	15.7798	7.5457
87	24.2113	39.9213	1.1749
88	31.6103	43.0199	6.2537
89	32.9953	18.1727	9.2879
90	34.0592	24.6913	1.8251
91	30.3931	41.3584	5.9910
92	30.2713	20.4978	9.3772
93	40.8606	39.3125	2.7951
94	15.3331	31.8317	5.7279
95	22.1058	25.4627	2.1407
96	10.8745	22.0573	7.7385
97	32.6616	39.1096	3.8320

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
98	25.1794	30.9254	2.6846
99	22.5055	19.7270	9.8236
100	10.6582	28.2727	7.4154
101	26.5286	17.6837	8.4308
102	22.8356	26.2412	7.1490
103	13.7101	37.7657	7.2046
104	15.3546	29.4321	5.7779
105	18.6501	18.6694	2.6997
106	22.9142	27.8999	5.4371
107	11.2603	19.1850	6.0359
108	23.4834	41.8276	8.4545
109	30.1307	10.0525	2.8258
110	21.8610	19.5041	5.7497
111	19.1830	31.4288	8.2703
112	27.5344	18.1638	4.1959
113	34.1757	25.1491	5.9298
114	21.2783	30.4545	7.4569
115	21.1107	35.4808	2.8226
116	13.0348	17.2743	6.7938
117	16.8524	23.5844	1.0008
118	30.0491	21.0694	5.6186
119	24.0529	24.0481	6.1285
120	31.3713	28.0791	1.0633
121	30.5825	19.8449	9.0323
122	28.1315	31.6676	8.4987
123	31.3888	28.5558	7.9765
124	37.6956	21.0639	8.0932
125	29.8069	27.2996	4.3627
126	84.7950	28.5498	2.3708
127	78.3145	24.6422	4.1703
128	91.2604	14.6478	6.8059
129	67.4612	20.7921	9.3874
130	69.3154	27.7154	1.8399
131	91.8191	15.7381	7.6490
132	78.7862	28.9015	1.4974
133	74.6491	27.6884	7.8144
134	78.8181	25.8335	5.1714
135	72.7988	27.5120	1.4050
136	72.5668	25.1985	8.5783
137	71.7767	24.8162	2.4824
138	70.3834	24.9270	2.0357

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
139	67.1356	32.7455	3.4440
140	74.5013	24.2464	3.8295
141	70.2110	2.9905	6.4548
142	87.0155	20.9488	7.0972
143	76.9627	26.6331	9.8888
144	83.5115	32.9977	9.9393
145	73.8347	36.5027	7.8178
146	74.3204	17.1545	3.4755
147	85.4854	31.3406	9.5861
148	87.2378	26.9827	4.6997
149	75.2745	23.2636	2.9496
150	89.1040	25.2062	6.6622
151	78.9644	24.7659	1.1338
152	78.0711	26.1697	1.3897
153	93.2667	26.9799	2.6224
154	87.7974	19.4038	2.8042
155	82.5605	16.2917	7.4742
156	78.3522	33.0481	4.9858
157	70.5135	23.1687	8.6094
158	74.0399	36.7878	4.5081
159	90.1833	17.2984	8.5380
160	58.1541	20.0488	7.7358
161	69.6919	36.8440	6.2547
162	73.4266	36.7301	2.4452
163	76.2356	16.4250	5.7596
164	60.1343	26.7209	5.1640
165	79.4089	36.1759	4.4159
166	81.0811	36.1060	1.8391
167	67.1655	14.2925	3.3323
168	72.8393	38.4865	4.0225
169	64.8871	30.5137	4.3760
170	88.5379	26.8946	2.3163
171	78.1126	23.1202	3.8509
172	72.9092	16.9501	3.5310
173	67.2879	25.7918	8.3811
174	75.8222	22.8606	4.0788
175	89.0357	44.2511	8.8480
176	77.2938	26.5838	3.4123
177	77.9441	23.5550	7.9789
178	64.9969	24.8831	6.4829
179	76.3844	19.8938	1.1617

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
180	81.4680	42.2650	7.3136
181	63.4880	30.3085	1.1418
182	84.4023	25.6241	7.1550
183	95.5453	34.3606	8.9011
184	62.0174	24.7239	4.8863
185	57.7779	24.1854	6.6821
186	74.3950	20.3615	6.2744
187	81.3259	19.8708	3.0467
188	74.3195	38.3713	8.0619
189	73.6794	31.4041	3.5887
190	75.0542	25.7244	9.3194
191	66.1283	39.2030	3.6863
192	61.3007	25.1969	5.8267
193	88.1796	27.4170	4.0028
194	77.4385	13.1675	3.1356
195	65.1033	28.9606	5.9072
196	83.9661	12.9390	1.9692
197	64.1886	16.7643	2.2344
198	73.9852	32.9115	1.8498
199	81.1731	27.9269	3.7980
200	67.9940	17.7310	8.3137
201	72.0877	21.6823	5.6220
202	75.2469	27.1370	8.7983
203	91.2698	26.8335	9.8244
204	78.8252	10.7380	3.9399
205	71.6724	14.9520	2.9766
206	73.1218	10.2257	5.6640
207	72.6643	24.3959	4.1771
208	85.8894	10.6574	8.7353
209	72.6302	30.8490	3.3402
210	68.4024	16.6211	8.5935
211	77.0052	15.7798	6.2452
212	74.2113	39.9213	7.4746
213	81.6103	43.0199	4.0917
214	82.9953	18.1727	1.0835
215	84.0592	24.6913	2.7320
216	80.3931	41.3584	5.5665
217	80.2713	20.4978	1.2182
218	90.8606	39.3125	5.9504
219	65.3331	31.8317	3.4857
220	72.1058	25.4627	7.2662

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
221	60.8745	22.0573	8.9322
222	82.6616	39.1096	1.2221
223	75.1794	30.9254	4.0709
224	72.5055	19.7270	4.7927
225	60.6582	28.2727	1.7201
226	76.5286	17.6837	1.7142
227	72.8356	26.2412	1.6514
228	63.7101	37.7657	9.1031
229	65.3546	29.4321	9.7238
230	68.6501	18.6694	4.5218
231	72.9142	27.8999	3.8223
232	61.2603	19.1850	5.9798
233	73.4834	41.8276	8.1284
234	80.1307	10.0525	8.1848
235	71.8610	19.5041	8.7693
236	69.1830	31.4288	8.1817
237	77.5344	18.1638	1.0574
238	84.1757	25.1491	9.2791
239	71.2783	30.4545	1.1617
240	71.1107	35.4808	1.2647
241	63.0348	17.2743	7.4031
242	66.8524	23.5844	5.8457
243	80.0491	21.0694	5.7213
244	74.0529	24.0481	5.5202
245	81.3713	28.0791	1.5911
246	80.5825	19.8449	3.0704
247	78.1315	31.6676	2.0534
248	81.3888	28.5558	9.9079
249	87.6956	21.0639	1.6346
250	79.8069	27.2996	1.5402
251	84.7950	78.5498	6.9542
252	78.3145	74.6422	4.0965
253	91.2604	64.6478	2.1566
254	67.4612	70.7921	6.7342
255	69.3154	77.7154	7.7184
256	91.8191	65.7381	8.2474
257	78.7862	78.9015	3.4212
258	74.6491	77.6884	4.9058
259	78.8181	75.8335	4.6163
260	72.7988	77.5120	6.4733
261	72.5668	75.1985	7.9308

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
262	71.7767	74.8162	9.4701
263	70.3834	74.9270	2.1832
264	67.1356	82.7455	3.3015
265	74.5013	74.2464	4.4048
266	70.2110	52.9905	9.9436
267	87.0155	70.9488	4.0686
268	76.9627	76.6331	9.0960
269	83.5115	82.9977	3.1373
270	73.8347	86.5027	2.9800
271	74.3204	67.1545	9.9197
272	85.4854	81.3406	9.5599
273	87.2378	76.9827	6.7440
274	75.2745	73.2636	5.5372
275	89.1040	75.2062	4.2231
276	78.9644	74.7659	7.9161
277	78.0711	76.1697	8.0593
278	93.2667	76.9799	1.2603
279	87.7974	69.4038	1.4720
280	82.5605	66.2917	3.9108
281	78.3522	83.0481	8.1972
282	70.5135	73.1687	6.6721
283	74.0399	86.7878	9.8452
284	90.1833	67.2984	2.4242
285	58.1541	70.0488	6.5501
286	69.6919	86.8440	3.7785
287	73.4266	86.7301	1.7657
288	76.2356	66.4250	8.8915
289	60.1343	76.7209	6.3163
290	79.4089	86.1759	3.7281
291	81.0811	86.1060	2.5126
292	67.1655	64.2925	4.0589
293	72.8393	88.4865	1.6070
294	64.8871	80.5137	6.8814
295	88.5379	76.8946	3.1986
296	78.1126	73.1202	7.8213
297	72.9092	66.9501	3.6911
298	67.2879	75.7918	4.7693
299	75.8222	72.8606	1.5025
300	89.0357	94.2511	1.2777
301	77.2938	76.5838	2.6792
302	77.9441	73.5550	3.4382

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
303	64.9969	74.8831	1.5962
304	76.3844	69.8938	4.0014
305	81.4680	92.2650	1.4492
306	63.4880	80.3085	1.9118
307	84.4023	75.6241	1.6468
308	95.5453	84.3606	9.1406
309	62.0174	74.7239	3.8062
310	57.7779	74.1854	6.3259
311	74.3950	70.3615	4.3986
312	81.3259	69.8708	9.5641
313	74.3195	88.3713	7.6816
314	73.6794	81.4041	8.9838
315	75.0542	75.7244	6.3901
316	66.1283	89.2030	7.2067
317	61.3007	75.1969	4.5200
318	88.1796	77.4170	3.0095
319	77.4385	63.1675	2.1813
320	65.1033	78.9606	2.5523
321	83.9661	62.9390	9.4474
322	64.1886	66.7643	1.3103
323	73.9852	82.9115	8.9160
324	81.1731	77.9269	5.7009
325	67.9940	67.7310	8.2742
326	72.0877	71.6823	5.0282
327	75.2469	77.1370	4.1189
328	91.2698	76.8335	7.8144
329	78.8252	60.7380	4.2419
330	71.6724	64.9520	6.0095
331	73.1218	60.2257	8.9985
332	72.6643	74.3959	8.5615
333	85.8894	60.6574	3.1962
334	72.6302	80.8490	4.9206
335	68.4024	66.6211	8.4570
336	77.0052	65.7798	2.3743
337	74.2113	89.9213	7.8216
338	81.6103	93.0199	8.8886
339	82.9953	68.1727	5.5191
340	84.0592	74.6913	6.1324
341	80.3931	91.3584	8.6633
342	80.2713	70.4978	9.8618
343	90.8606	89.3125	8.1119

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
344	65.3331	81.8317	4.1561
345	72.1058	75.4627	5.5171
346	60.8745	72.0573	3.2969
347	82.6616	89.1096	5.5888
348	75.1794	80.9254	1.7076
349	72.5055	69.7270	1.5031
350	60.6582	78.2727	6.7149
351	76.5286	67.6837	6.5521
352	72.8356	76.2412	1.7333
353	63.7101	87.7657	6.4857
354	65.3546	79.4321	5.9020
355	68.6501	68.6694	8.7033
356	72.9142	77.8999	6.7842
357	61.2603	69.1850	3.4447
358	73.4834	91.8276	1.9608
359	80.1307	60.0525	1.5446
360	71.8610	69.5041	6.5969
361	69.1830	81.4288	7.2916
362	77.5344	68.1638	3.4745
363	84.1757	75.1491	4.7977
364	71.2783	80.4545	4.2924
365	71.1107	85.4808	1.7394
366	63.0348	67.2743	1.6279
367	66.8524	73.5844	2.0880
368	80.0491	71.0694	7.1007
369	74.0529	74.0481	2.9704
370	81.3713	78.0791	3.1355
371	80.5825	69.8449	1.0777
372	78.1315	81.6676	7.5440
373	81.3888	78.5558	6.0493
374	87.6956	71.0639	5.9678
375	79.8069	77.2996	7.6803
376	34.7950	78.5498	8.4217
377	28.3145	74.6422	4.5406
378	41.2604	64.6478	2.2235
379	17.4612	70.7921	2.7617
380	19.3154	77.7154	7.4827
381	41.8191	65.7381	7.0267
382	28.7862	78.9015	1.5386
383	24.6491	77.6884	4.4585
384	28.8181	75.8335	5.4211

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
385	22.7988	77.5120	7.9675
386	22.5668	75.1985	2.3303
387	21.7767	74.8162	5.3698
388	20.3834	74.9270	1.6465
389	17.1356	82.7455	8.0870
390	24.5013	74.2464	4.5436
391	20.2110	52.9905	3.1255
392	37.0155	70.9488	1.7251
393	26.9627	76.6331	1.7110
394	33.5115	82.9977	9.3469
395	23.8347	86.5027	2.8424
396	24.3204	67.1545	9.6092
397	35.4854	81.3406	4.0577
398	37.2378	76.9827	9.6397
399	25.2745	73.2636	4.0883
400	39.1040	75.2062	1.5708
401	28.9644	74.7659	6.5123
402	28.0711	76.1697	6.0005
403	43.2667	76.9799	9.1581
404	37.7974	69.4038	2.8110
405	32.5605	66.2917	8.0892
406	28.3522	83.0481	4.1295
407	20.5135	73.1687	9.7494
408	24.0399	86.7878	8.5245
409	40.1833	67.2984	7.4062
410	8.1541	70.0488	2.9341
411	19.6919	86.8440	1.1390
412	23.4266	86.7301	2.8904
413	26.2356	66.4250	5.8282
414	10.1343	76.7209	1.9761
415	29.4089	86.1759	8.6839
416	31.0811	86.1060	9.1977
417	17.1655	64.2925	4.0035
418	22.8393	88.4865	5.2223
419	14.8871	80.5137	1.0261
420	38.5379	76.8946	3.7982
421	28.1126	73.1202	5.3670
422	22.9092	66.9501	3.3595
423	17.2879	75.7918	7.1480
424	25.8222	72.8606	9.2007
425	39.0357	94.2511	6.1345

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
426	27.2938	76.5838	3.3875
427	27.9441	73.5550	9.3562
428	14.9969	74.8831	1.5782
429	26.3844	69.8938	6.6367
430	31.4680	92.2650	9.5345
431	13.4880	80.3085	5.6475
432	34.4023	75.6241	9.6103
433	45.5453	84.3606	3.4482
434	12.0174	74.7239	5.7429
435	7.7779	74.1854	9.2007
436	24.3950	70.3615	2.9322
437	31.3259	69.8708	8.4411
438	24.3195	88.3713	2.2449
439	23.6794	81.4041	4.9398
440	25.0542	75.7244	8.8775
441	16.1283	89.2030	7.3388
442	11.3007	75.1969	5.4732
443	38.1796	77.4170	6.4864
444	27.4385	63.1675	1.7005
445	15.1033	78.9606	3.1729
446	33.9661	62.9390	1.2321
447	14.1886	66.7643	8.6183
448	23.9852	82.9115	1.1338
449	31.1731	77.9269	5.9537
450	17.9940	67.7310	2.0770
451	22.0877	71.6823	6.2915
452	25.2469	77.1370	6.5999
453	41.2698	76.8335	7.7232
454	28.8252	60.7380	3.7894
455	21.6724	64.9520	9.2485
456	23.1218	60.2257	8.0404
457	22.6643	74.3959	1.9094
458	35.8894	60.6574	3.5299
459	22.6302	80.8490	9.1675
460	18.4024	66.6211	1.9998
461	27.0052	65.7798	8.1084
462	24.2113	89.9213	1.9205
463	31.6103	93.0199	7.9115
464	32.9953	68.1727	6.9585
465	34.0592	74.6913	7.9579
466	30.3931	91.3584	9.3878

Continued on next page

Table B.68 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
467	30.2713	70.4978	2.5920
468	40.8606	89.3125	1.1838
469	15.3331	81.8317	8.5028
470	22.1058	75.4627	5.2587
471	10.8745	72.0573	1.9778
472	32.6616	89.1096	1.8015
473	25.1794	80.9254	2.0362
474	22.5055	69.7270	2.5118
475	10.6582	78.2727	9.7526
476	26.5286	67.6837	3.5740
477	22.8356	76.2412	6.3912
478	13.7101	87.7657	8.6699
479	15.3546	79.4321	3.2031
480	18.6501	68.6694	7.5445
481	22.9142	77.8999	4.6071
482	11.2603	69.1850	3.7954
483	23.4834	91.8276	6.8842
484	30.1307	60.0525	4.5264
485	21.8610	69.5041	2.0740
486	19.1830	81.4288	9.8068
487	27.5344	68.1638	5.6643
488	34.1757	75.1491	5.5699
489	21.2783	80.4545	3.9252
490	21.1107	85.4808	2.7754
491	13.0348	67.2743	8.7660
492	16.8524	73.5844	3.4108
493	30.0491	71.0694	5.8481
494	24.0529	74.0481	5.9632
495	31.3713	78.0791	9.6693
496	30.5825	69.8449	3.4262
497	28.1315	81.6676	3.3915
498	31.3888	78.5558	3.7899
499	37.6956	71.0639	6.0157
500	29.8069	77.2996	4.4037

Table B.69: Depot locations and number of vehicles for MS35

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	52.1650	14.9865	2
2	9.6730	65.9605	2
3	81.8149	51.8595	2
4	81.7547	97.2975	2
5	72.2440	64.8991	2

Table B.70: Customer locations and service time for MS35

Customer index	x-coordinate	y-coordinate	Service time (short)
1	41.0389	41.3323	3.2119
2	19.4352	50.3338	7.0856
3	87.6474	50.5795	3.3516
4	35.6304	63.3027	9.6534
5	44.6872	33.0219	5.4782
6	71.7948	52.2203	4.8500
7	57.2265	61.9088	6.1101
8	44.2896	27.4769	6.5173
9	0.7980	53.7462	8.2629
10	3.8427	59.8172	8.9271
11	72.4981	54.8959	2.4398
12	0.7980	64.1321	1.8026
13	37.9099	68.6688	3.8182
14	51.0509	7.9000	6.4662
15	38.0876	22.4084	4.4086
16	53.4161	44.8744	9.3299
17	52.0691	70.9520	1.5131
18	25.1717	64.4245	9.9461
19	26.5161	52.9422	7.0026
20	26.3801	36.8097	6.5543
21	38.8084	72.2001	2.3310
22	70.1248	88.8311	1.2610
23	38.0460	74.1516	6.1522
24	22.8294	44.4415	1.2698
25	41.8518	43.4774	7.4038
26	32.7551	42.4720	2.9263
27	37.8852	52.1714	3.2967
28	55.0573	46.9385	9.6273
29	45.1021	57.9359	2.6370
30	63.1214	35.6330	8.1861

Continued on next page

Table B.70 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	35.1934	72.6949	1.3604
32	69.1178	42.4162	3.7824
33	67.8145	64.1452	9.7038
34	63.4916	55.5814	3.4029
35	99.0714	40.7869	2.0969
36	26.0270	32.6818	6.4664
37	44.5802	68.6273	6.8082
38	62.5821	28.9890	8.8698
39	27.1617	38.9976	9.0760
40	78.5253	51.1311	1.4786
41	51.7040	53.2537	7.8356
42	54.0241	53.6268	8.7301
43	44.6799	55.0518	5.3355
44	44.7857	49.6159	1.6759
45	64.4147	49.1452	1.8165
46	50.5009	36.2323	2.8019
47	52.7480	24.5504	8.0046
48	39.5382	42.2181	4.6655
49	31.7789	53.4952	8.4434
50	31.5121	39.5802	2.3317
51	64.3942	46.9462	7.5962
52	48.7107	67.1628	2.3490
53	70.2353	34.1796	8.5459
54	68.5583	44.8823	5.9083
55	50.1142	47.7471	9.6505
56	24.4562	41.4126	1.6795
57	62.8278	45.6432	9.4045
58	43.8104	65.6914	4.2348
59	53.7597	52.7056	1.6024
60	31.3774	52.4342	9.6934
61	68.1511	58.8669	6.8451
62	49.4574	21.9649	4.7856
63	40.7912	64.5955	6.3680
64	31.6565	58.0636	4.1238
65	24.2631	61.8667	2.9586
66	48.5678	69.5702	1.3406
67	74.8598	53.2040	2.3808
68	62.3717	54.5678	4.3604
69	67.6930	24.4988	8.8913
70	10.8257	54.1504	4.9703
71	60.2600	67.7369	6.7399

Continued on next page

Table B.70 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
72	37.5321	23.2757	4.4903
73	53.2070	29.4220	8.5348
74	35.1898	53.8271	7.8969
75	62.7475	75.1027	2.1303
76	73.3711	57.4105	1.8340
77	73.7063	52.5990	6.9429
78	41.8634	45.3989	4.3990
79	52.9563	54.3527	1.9701
80	53.2676	42.6096	6.6143
81	26.3448	43.4684	6.5944
82	45.1403	70.8446	9.2046
83	46.7031	65.7993	6.4552
84	23.5383	62.3518	5.3681
85	63.4078	58.4636	6.1907
86	38.3896	55.3429	9.8389
87	36.0819	49.7922	5.6671
88	54.0619	99.9800	4.1383
89	46.4055	57.6169	9.8459
90	69.4307	29.2925	9.9281
91	69.1325	67.7784	9.0654
92	48.2521	34.4379	7.6742
93	37.9624	44.1613	6.9826
94	6.9085	50.4834	7.6003
95	61.1148	46.9591	4.9232
96	46.8778	76.0843	4.5967
97	51.3749	51.4090	2.9610
98	82.2170	23.2676	8.9347
99	57.3161	48.3609	9.4786
100	79.9113	49.3104	9.5406
101	35.9937	62.2362	1.9580
102	64.8005	50.5136	1.5218
103	48.3318	46.1275	2.4735
104	59.0755	42.8935	5.7473
105	44.9413	56.2135	1.6277
106	60.0054	53.9409	1.0913
107	41.8339	16.2718	1.8251
108	37.6773	87.6392	6.4669
109	21.4685	12.8426	1.5048
110	53.2354	44.3739	6.9229
111	85.6393	33.3323	6.1824
112	63.9931	77.7361	1.6645

Continued on next page

Table B.70 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
113	27.4234	59.8339	3.1741
114	67.8693	54.6344	4.1608
115	33.9841	42.9547	2.1406
116	47.9325	77.8367	7.6547
117	26.0551	42.1394	5.0111
118	82.6817	70.2141	1.1585
119	53.2950	48.8968	7.1354
120	70.1308	39.1274	8.9275
121	1.5332	44.5490	2.2584
122	36.2464	31.9561	8.2977
123	27.0171	33.2320	3.2757
124	67.6363	60.8485	1.2195
125	57.8103	45.7157	5.7765
126	54.5412	65.7396	9.4137
127	31.6929	72.0298	7.9240
128	54.6312	34.5862	4.6428
129	38.3076	49.9992	7.4603
130	84.1969	50.9153	5.3319
131	55.8975	34.8145	4.9706
132	63.7264	40.0903	9.4812
133	76.2843	44.1633	6.2090
134	41.5338	29.1625	8.0525
135	45.3003	34.5035	7.4333
136	49.4420	46.0039	2.2795
137	72.2280	61.5060	7.2363
138	31.2085	60.8592	4.5428
139	44.1637	30.1316	2.1499
140	54.9844	76.8638	6.7681
141	49.6185	50.4077	5.4776
142	54.3666	82.4808	1.5758
143	79.1702	32.9917	5.7118
144	54.7608	35.6381	3.8309
145	63.8561	49.9806	8.6940
146	66.3201	51.1806	1.0811
147	69.2734	91.4381	2.8233
148	58.8926	40.3138	8.9254
149	83.3773	86.5406	2.9624
150	33.9295	88.6547	3.8592

Table B.71: Depot locations and number of vehicles for MS36

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	79.7742	29.3295	3
2	59.0776	5.1588	3
3	91.2197	50.4128	3
4	10.1129	76.8376	3

Table B.72: Customer locations and service time for MS36

Customer index	x-coordinate	y-coordinate	Service time (short)
1	9.0190	22.3647	4.0957
2	25.6813	16.4739	8.2007
3	46.6143	30.2990	6.1398
4	8.3328	6.2406	8.3191
5	6.3837	25.8043	1.7756
6	6.8673	39.6886	2.7292
7	6.7582	15.5750	6.6655
8	43.9370	17.5988	1.5748
9	40.0121	2.6705	7.6867
10	40.1735	4.7900	6.4306
11	14.2257	10.5484	8.1860
12	30.8835	24.3174	2.4454
13	3.4551	9.6952	7.6414
14	4.5063	19.4975	7.8134
15	10.8795	7.4851	8.9318
16	7.9538	15.8212	4.8632
17	48.8113	11.9574	2.6873
18	34.3616	38.1305	3.7273
19	2.6894	2.7788	3.8868
20	4.4697	35.9415	4.9781
21	43.1688	28.1567	4.2570
22	38.1446	21.3713	6.6304
23	1.0241	40.2895	9.4494
24	19.2312	3.7102	3.5821
25	43.3611	12.9909	3.2014
26	40.9409	6.4118	9.2877
27	34.8017	11.6061	9.3359
28	10.8783	48.1214	3.7895
29	12.2379	0.6471	1.6883
30	9.0106	1.4681	8.0279
31	16.2640	36.8391	2.1767

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
32	47.3855	23.7160	5.1533
33	4.6300	0.1055	4.9615
34	10.6586	11.4413	6.4450
35	1.3496	14.2489	2.1432
36	9.0145	32.0794	6.3914
37	21.0427	1.5161	2.1891
38	18.5071	45.7871	2.0380
39	33.5073	19.9137	4.9697
40	19.5194	10.1011	3.4399
41	23.0750	9.0086	9.4970
42	1.0454	24.0823	5.6498
43	7.4820	33.8718	5.0076
44	43.9457	3.3675	3.7773
45	17.0097	5.7980	5.2264
46	0.0010	21.5015	8.0150
47	10.4380	22.3526	2.5193
48	4.7781	9.6800	1.2021
49	46.7110	14.5856	7.3786
50	6.7601	23.2575	6.4463
51	26.3442	5.3498	4.7231
52	37.8426	27.0564	9.2329
53	19.1221	17.7072	5.2946
54	9.9644	3.5684	9.2460
55	28.6453	14.6134	5.4722
56	13.2789	3.2401	9.3480
57	9.5208	6.9149	7.3329
58	3.5666	5.9743	7.2518
59	15.7063	0.6037	1.0413
60	1.5621	43.9228	5.8620
61	31.2948	29.5170	4.7167
62	5.1026	3.6879	6.6532
63	30.4611	45.5063	5.8918
64	16.0161	4.9361	2.9440
65	39.1044	9.4049	5.9689
66	29.5101	26.3770	8.7647
67	45.4839	45.4872	1.0445
68	35.0008	5.0594	2.1258
69	4.7614	13.1710	7.9756
70	42.2930	13.3897	1.1835
71	6.8298	21.9984	2.2837
72	8.3923	4.5641	3.8837

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
73	20.5550	4.5311	9.1428
74	10.1718	24.8259	6.5274
75	0.9845	23.9524	1.1431
76	24.4491	0.4594	3.8025
77	22.9033	15.3989	2.7349
78	32.7459	5.3547	3.4792
79	43.4199	11.0187	1.2404
80	16.2062	31.9216	8.4758
81	4.2830	2.6127	7.8785
82	16.2373	5.0089	7.4904
83	19.1061	8.3339	8.4045
84	9.1273	11.9412	7.8809
85	26.0847	22.2881	2.0851
86	21.7776	35.4280	4.4590
87	42.5100	0.9008	1.2513
88	48.5951	2.7173	1.0117
89	33.2000	10.5451	1.0630
90	14.0208	26.8665	2.5101
91	6.9110	1.2575	2.3539
92	31.8697	42.1127	5.6394
93	43.4850	36.4040	4.7699
94	6.8197	13.4980	6.3443
95	30.9595	11.9390	3.4928
96	10.4144	16.7595	6.3354
97	30.5213	7.2331	6.2663
98	6.5429	8.6691	2.0943
99	21.6973	31.7959	1.7073
100	9.8940	3.7632	1.2886
101	7.2729	43.2513	2.5135
102	41.5940	8.7977	5.7175
103	1.7018	33.2173	8.5723
104	19.9375	18.1504	3.7577
105	2.0047	29.7479	2.7204
106	17.2807	5.0626	1.5861
107	14.2851	0.1449	9.5141
108	47.1688	8.4439	3.2029
109	46.8055	20.0542	6.6286
110	35.5697	8.7003	2.8601
111	3.0111	6.6174	3.1757
112	21.1088	41.9532	7.6907
113	4.1862	3.8583	2.4040

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
114	46.5905	10.2231	8.4086
115	13.3080	28.0475	1.8459
116	37.0914	9.4732	9.8182
117	23.2212	20.1005	6.8790
118	43.5628	7.2177	3.5570
119	8.7598	48.4647	8.8051
120	25.3878	45.9324	1.2713
121	29.9749	46.3469	7.8484
122	1.9481	14.6628	9.0656
123	5.3366	5.3467	6.5699
124	13.6253	36.9264	7.4867
125	8.1693	43.9173	5.1747
126	12.7542	1.9545	7.8300
127	12.9713	2.9057	1.0643
128	24.6718	3.5943	2.7414
129	9.0061	47.4565	1.8231
130	48.4743	0.5615	2.5114
131	37.3291	7.6380	9.4802
132	38.4401	21.3605	8.6449
133	21.3576	10.3348	2.2355
134	13.4956	4.7779	6.9465
135	29.3864	9.9669	1.3464
136	3.5781	45.9078	2.3335
137	33.5129	20.3210	2.6629
138	0.4259	10.8793	6.8083
139	5.1383	21.4401	8.7090
140	15.6375	3.9521	8.6804
141	27.9036	39.6729	5.4463
142	2.0831	37.9973	8.0279
143	8.8350	0.6776	3.4719
144	15.8678	10.9830	9.7064
145	14.2340	39.4914	9.9148
146	6.4858	10.1604	1.7600
147	30.7333	13.0389	3.9681
148	0.6623	40.6097	3.4147
149	42.4900	5.0401	2.9433
150	1.8208	0.9720	7.9032
151	4.1759	9.5689	4.2855
152	3.1650	3.2535	2.3862
153	17.2152	0.8422	2.4852
154	5.3882	29.2629	9.0403

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
155	12.7754	45.7107	9.5121
156	29.0779	12.4924	5.6572
157	19.3420	9.5127	1.1654
158	39.6235	8.2372	4.7738
159	25.4346	16.5240	2.0988
160	2.8085	17.9523	9.5666
161	44.9799	12.9474	3.4316
162	11.6442	37.6640	9.0429
163	13.8795	40.5937	9.0567
164	38.4232	15.0249	7.9798
165	42.3020	6.5779	9.1794
166	14.7270	0.0809	1.1501
167	7.2657	7.2820	9.6336
168	14.9458	18.8345	1.6773
169	8.4122	2.5628	3.5662
170	6.6816	12.6438	5.3931
171	8.5641	3.0027	9.7351
172	13.2728	46.5368	6.1130
173	38.8135	14.9458	3.4657
174	19.7777	6.8718	2.1618
175	13.1784	9.1253	2.3967
176	4.7954	2.4639	3.4193
177	0.0538	43.9622	4.9050
178	6.0936	1.0190	4.5631
179	49.7980	3.6118	4.8272
180	1.8739	23.3020	6.5295
181	24.0568	2.9812	5.0212
182	31.9184	15.4597	1.1082
183	10.1641	48.1637	1.3084
184	39.2015	26.2066	4.5889
185	43.6222	9.3415	9.8151
186	9.1825	42.9943	5.8849
187	4.9034	47.4342	9.2115
188	12.9641	4.5866	3.9174
189	32.2512	4.0187	3.6146
190	20.5264	12.5781	8.9108
191	7.0487	4.8652	8.0123
192	32.4483	7.6408	4.5497
193	10.7959	29.2548	8.9409
194	44.7062	15.5248	4.8310
195	29.4832	13.7544	5.1974

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
196	25.1764	36.4199	4.8244
197	2.7335	41.0966	5.0969
198	45.2873	4.0425	7.2588
199	19.2028	48.3225	1.8602
200	19.1085	27.0841	7.6011
201	11.2283	24.7596	2.1702
202	38.8481	17.1032	5.4688
203	6.6720	12.6355	3.3369
204	38.8033	34.6391	6.3250
205	9.5938	12.9669	3.0486
206	37.0318	7.4794	9.5961
207	32.2740	0.0104	1.5671
208	9.2163	37.3960	2.6492
209	42.9429	6.7387	6.6182
210	6.0265	36.7691	3.6227
211	44.1352	14.3297	2.2347
212	4.4923	1.1145	2.7004
213	42.7408	27.3231	9.6096
214	7.7644	9.5875	3.6695
215	30.8927	45.2695	3.1348
216	17.3215	19.0968	6.9414
217	15.1816	3.0195	1.0387
218	46.0045	0.9042	1.7035
219	3.0166	11.4626	3.7863
220	4.0708	26.7765	3.0157
221	1.6065	23.7561	7.2576
222	13.8411	14.8975	7.3021
223	44.1291	0.6294	8.6663
224	2.9129	6.0595	6.0315
225	41.9891	2.4926	6.1330
226	13.9473	17.5914	5.7783
227	42.3058	25.3982	8.7300
228	27.9444	9.0968	5.0171
229	2.1390	33.4988	4.4504
230	25.9603	23.6112	6.3582
231	21.7085	0.1913	3.7454
232	23.4985	34.3492	1.9100
233	27.7090	28.9818	4.3475
234	32.3947	0.2828	2.9994
235	31.9217	3.6527	6.7890
236	3.7803	17.4303	7.9899

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
237	18.3155	34.1503	4.8703
238	2.4531	13.2466	6.5896
239	38.2611	1.1905	3.5117
240	45.8760	37.1052	5.3024
241	2.3053	12.9027	3.8327
242	18.2156	4.4276	8.4445
243	6.0832	3.9184	7.6885
244	35.8648	31.2882	2.2988
245	37.2541	10.1540	1.6144
246	18.7949	1.8379	5.7892
247	1.3031	4.6243	7.6956
248	35.1105	1.4508	8.5216
249	38.0692	2.8932	7.4860
250	45.3247	7.5599	8.9886
251	19.4413	39.9414	2.4657
252	20.2137	36.7163	2.8112
253	8.0923	6.0108	8.9377
254	17.1003	31.4182	5.1576
255	14.5121	44.8863	2.6834
256	6.3626	16.8787	7.5239
257	7.1482	46.0242	8.9520
258	4.9855	8.0669	8.1821
259	14.9978	5.4557	8.5868
260	10.5791	7.9253	5.8424
261	1.1242	47.8333	2.8863
262	3.1187	9.9059	5.7740
263	4.8621	42.6039	8.5897
264	16.4616	27.9578	2.9381
265	6.5489	35.6746	7.4505
266	3.2425	26.4500	8.7640
267	4.6631	41.4002	5.2414
268	0.8537	31.9150	5.1445
269	12.9078	11.7860	9.4828
270	13.1130	44.9724	6.6551
271	23.4818	29.9927	8.2575
272	8.9016	0.3227	4.6139
273	32.1293	5.6728	3.8925
274	2.9375	16.0538	4.4093
275	45.9375	18.5654	7.4707
276	14.9600	26.4351	2.7376
277	13.2056	6.5299	5.4099

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
278	15.8829	24.7448	2.0869
279	5.8984	44.2562	2.2593
280	26.6171	27.9347	9.5248
281	8.7912	40.4194	6.6785
282	14.2367	37.6549	4.9479
283	22.3641	30.2500	7.3699
284	41.6589	34.4143	5.7668
285	47.2073	9.4177	6.8718
286	5.8836	33.3357	8.0037
287	11.9542	37.0555	6.5622
288	21.7475	8.2030	5.5188
289	16.7645	0.7667	5.3684
290	13.1781	42.2375	1.9913
291	48.0571	1.2658	9.2489
292	9.2182	34.6872	4.8936
293	16.0107	31.9911	4.8430
294	27.2300	0.6074	1.2636
295	12.6867	29.5812	5.5938
296	19.8885	18.2928	9.6733
297	27.2010	39.5708	3.4782
298	25.5365	3.8891	7.6907
299	27.7191	6.7313	2.0512
300	25.4359	19.8745	7.9240
301	0.6944	28.0793	7.8915
302	39.7415	6.8858	5.8669
303	21.9026	8.3624	2.5239
304	25.7489	1.3844	9.3711
305	20.9608	2.6300	2.8739
306	3.4217	41.2010	1.1778
307	19.8822	12.0510	6.4145
308	13.3804	14.1657	6.4663
309	21.0939	13.2731	5.2197
310	47.5111	12.0890	6.3668
311	22.7259	28.1091	7.5111
312	0.2891	43.5601	4.6730
313	13.8065	41.5820	6.3785
314	3.6290	6.8012	4.8314
315	18.1793	17.8726	2.0966
316	41.0530	16.1330	4.1496
317	44.9661	4.5024	5.9207
318	30.2264	39.4266	2.1439

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
319	15.2475	10.4961	1.7335
320	0.9513	1.3206	3.6051
321	21.8227	22.9492	7.0913
322	17.4123	23.4702	5.1134
323	44.1956	2.3539	5.4929
324	23.5427	21.4953	1.5263
325	25.0397	41.7511	1.6625
326	12.1729	39.5863	4.0409
327	8.1792	34.4394	4.0246
328	9.7688	4.6454	9.8646
329	12.4150	46.6579	7.7650
330	36.1974	2.2790	6.8188
331	9.5753	35.2775	8.9458
332	4.6974	1.3756	5.6070
333	18.9884	39.9354	4.3858
334	7.0978	6.1455	8.9539
335	10.6023	36.0305	3.2119
336	13.2196	45.2921	2.4760
337	35.0270	49.7980	6.9274
338	2.6041	49.7980	3.3006
339	26.6209	19.1153	2.4184
340	1.8740	13.1210	3.4895
341	5.1437	21.3023	3.6884
342	7.6110	40.2568	1.0531
343	4.5850	10.3234	3.0579
344	7.3857	8.9217	7.0311
345	47.7539	8.0498	9.8350
346	49.6945	1.8079	3.3053
347	7.6798	44.3286	6.5726
348	22.7053	34.5692	9.7465
349	7.5312	0.0887	5.4295
350	27.4731	18.9858	3.7092
351	16.1940	7.1227	6.3739
352	42.5124	3.0172	5.8904
353	3.9332	10.9580	2.1679
354	36.0805	9.7374	5.9700
355	21.2659	26.9409	2.3416
356	10.2839	0.3129	3.3269
357	10.2117	42.9007	5.7584
358	4.8230	16.0995	8.3204
359	6.5886	27.8575	7.4668

Continued on next page

Table B.72 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
360	14.5094	5.3314	5.5074
361	41.7052	13.7572	9.0458
362	1.7779	3.8215	9.5565
363	38.5362	4.3708	5.1612
364	5.5313	35.0337	3.5884
365	39.4204	14.0450	9.3373
366	41.9628	1.5653	5.4670
367	10.7908	34.1470	8.8960
368	32.7596	19.5432	2.9191
369	22.3259	28.9183	2.0296
370	16.1523	6.1949	2.1188
371	3.4786	19.8811	6.1669
372	39.6901	15.8941	5.1974
373	8.5336	26.4159	4.3663
374	0.1892	49.4441	7.7915
375	49.2669	4.3520	5.1004
376	49.1515	8.7166	7.3543
377	39.4992	11.2798	9.3656
378	49.2187	11.2399	8.3842
379	44.7171	11.3066	1.3586
380	19.1115	5.2097	9.6957
381	9.2166	6.3207	8.9917
382	17.9410	37.5483	6.7490
383	17.1773	30.5275	1.0986
384	5.4588	20.0328	9.7953
385	10.8687	38.9877	4.4698
386	45.3523	5.4593	4.5969
387	4.0865	25.1355	5.5926
388	24.5419	35.1849	5.9647
389	37.9184	15.9881	9.6300
390	27.2215	8.2120	8.6986
391	6.9245	7.3509	5.2903
392	10.9128	3.4127	8.9003
393	4.9391	16.2968	4.5089
394	24.9486	26.2158	1.4425
395	15.0806	6.1710	3.7669
396	6.7364	3.6858	3.8819
397	12.0966	8.9202	5.1517
398	14.4414	4.3662	5.3932
399	7.0308	18.2569	7.3607
400	34.2889	9.1539	4.3057

Table B.73: Depot locations and number of vehicles for MS37

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	0.0139	4.2229	3
2	52.8695	0.4531	3
3	3.7563	0.0022	3
4	1.1959	87.1996	3
5	55.6227	31.4835	3

Table B.74: Customer locations and service time for MS37

Customer index	x-coordinate	y-coordinate	Service time (short)
1	2.2662	6.7158	9.4730
2	1.1445	86.2278	3.4137
3	3.6360	75.8513	7.7086
4	9.3115	86.1210	9.1817
5	40.0943	4.1422	6.2610
6	13.2562	2.4451	9.1585
7	5.5968	69.7158	1.5101
8	74.2406	0.9265	6.0106
9	89.9352	0.2242	1.0267
10	24.7990	14.1027	2.3784
11	0.2302	74.2355	4.6674
12	23.6375	6.5222	3.1010
13	5.6191	1.0044	5.8178
14	97.3813	0.0488	3.8045
15	2.3597	81.2323	7.3777
16	35.2182	21.9116	6.2835
17	15.3307	5.3793	3.1527
18	0.7213	29.3989	1.5765
19	32.7703	49.7151	1.0303
20	0.0128	3.7090	2.7017
21	0.6274	33.2321	5.4208
22	0.0095	0.8467	6.5482
23	69.3252	88.1184	2.1050
24	59.2269	36.0689	2.1973
25	0.1650	0.4650	3.8276
26	6.9130	8.6807	1.7907
27	0.1738	25.3628	4.6791
28	18.7240	80.4272	3.5409
29	85.5725	14.8314	6.6753
30	1.6853	24.5873	2.9778

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	96.9903	31.5569	6.8883
32	4.2804	78.6835	2.7412
33	0.9067	0.3570	1.8514
34	29.5178	6.6785	9.2652
35	92.2147	3.0511	6.0242
36	24.1455	33.4109	4.7588
37	0.0257	70.6605	1.9940
38	5.2108	11.8133	5.9747
39	0.4595	52.3263	2.0015
40	1.2371	3.4786	3.1242
41	0.0142	16.6265	2.2479
42	73.3276	5.8766	3.9542
43	49.9228	72.1322	4.1180
44	5.1901	30.9080	9.3588
45	57.6044	56.8480	8.9948
46	42.8379	0.1334	8.1104
47	24.0483	2.1771	1.6702
48	6.1206	45.2341	4.7782
49	4.6376	1.0086	4.5705
50	0.0701	0.0040	4.7164
51	3.9888	8.3197	9.7656
52	16.5171	82.2298	3.1411
53	9.7684	1.8003	1.9772
54	26.8901	18.4945	8.2003
55	13.5417	4.6482	1.4033
56	54.0201	0.0019	9.6396
57	0.0918	12.5315	8.2148
58	9.9712	56.5640	9.6454
59	20.5188	1.7370	7.8917
60	0.6557	0.0097	6.4741
61	22.8469	1.4973	9.9014
62	0.0140	28.8454	6.0630
63	19.0831	3.5744	5.4630
64	59.7681	28.6838	3.2774
65	12.4795	0.0002	2.7637
66	8.4619	37.0251	5.4346
67	0.3312	5.9831	7.3980
68	0.0023	0.0038	9.8886
69	43.3231	6.6931	4.0116
70	50.4560	36.7535	2.9815
71	2.5297	78.2086	4.1075

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
72	0.1529	95.2810	1.8245
73	5.2773	95.1083	6.6844
74	56.9504	72.0061	4.4037
75	59.6473	64.8794	8.9863
76	29.4396	51.3847	4.8387
77	88.5123	17.0934	9.0170
78	83.8876	7.3493	3.0181
79	0.1431	0.2054	8.1724
80	27.2460	28.0524	8.7245
81	11.1149	64.4894	4.8439
82	0.0294	2.0706	6.2997
83	72.3597	59.3051	1.8253
84	12.2934	0.0354	3.2552
85	45.8855	5.4350	6.3439
86	0.0220	1.9285	5.6852
87	1.8079	0.3576	9.2265
88	27.5983	25.1239	6.9696
89	0.2385	3.1667	5.4969
90	26.0361	88.2283	6.7132
91	5.7041	12.4008	1.7772
92	44.8924	40.2942	1.3673
93	27.8337	0.0002	7.7641
94	5.5520	22.1833	3.9138
95	2.7005	19.1553	1.5984
96	3.9352	52.6298	9.3093
97	77.5965	28.0970	1.4892
98	9.4985	67.7364	1.6115
99	8.6642	73.4781	6.1618
100	9.3692	0.3528	4.9528
101	84.4664	0.7142	1.2463
102	1.0521	49.4868	1.4473
103	68.7069	0.0224	3.1470
104	0.0008	5.9240	2.1457
105	3.9919	2.6991	6.6730
106	44.9503	39.5738	5.2877
107	4.0284	0.1132	1.9900
108	23.6954	49.7877	4.9189
109	9.2973	47.9550	9.1169
110	0.0001	15.0907	6.0925
111	21.5009	1.6262	7.5758
112	21.7698	0.0357	9.8286

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
113	27.3887	24.5083	6.2939
114	4.0255	0.0015	5.5285
115	12.0041	0.0239	5.7843
116	34.5614	0.2177	6.4566
117	69.9760	9.1499	7.8789
118	0.0167	30.3920	6.4056
119	0.0952	62.7466	7.5033
120	27.4350	12.3838	4.9169
121	44.6068	0.0116	6.8187
122	96.4310	3.0910	2.5903
123	0.1968	26.4153	8.8883
124	4.8418	48.6305	3.2652
125	30.9231	2.4175	4.2084
126	5.3055	12.3408	3.7301
127	64.3761	54.8216	9.7098
128	2.4891	21.0781	2.7306
129	0.2378	15.4357	1.8808
130	30.4347	3.6223	7.2441
131	0.8314	6.9777	1.8642
132	65.5137	50.0578	2.7945
133	42.3831	4.0427	6.4635
134	7.3760	9.9000	7.3874
135	0.0000	4.9764	9.0147
136	0.3339	31.3837	6.4238
137	2.0534	18.3037	8.7621
138	66.4025	27.6883	7.0836
139	21.7354	11.8453	8.0650
140	3.3134	6.3263	5.8298
141	2.2977	10.8862	1.0400
142	8.2492	0.0295	2.7875
143	73.8173	6.9441	4.9485
144	79.1724	91.0112	6.0246
145	12.9012	47.5869	4.4662
146	24.7179	38.7449	6.8217
147	37.2104	44.8840	6.2711
148	0.0014	43.3078	7.8970
149	19.0042	59.9654	2.5717
150	0.0101	45.6812	5.5280
151	7.5436	93.7339	4.4441
152	10.2329	0.1381	9.7948
153	0.0012	6.2135	9.4248

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
154	0.0276	11.9140	9.0346
155	78.8777	1.7192	4.9918
156	15.2396	0.0051	7.7637
157	4.9349	92.5096	9.1846
158	4.8207	38.3331	4.3599
159	0.3469	0.3239	2.0466
160	0.3349	0.3235	5.7261
161	4.3170	35.0140	4.0701
162	3.7922	5.5304	8.6446
163	48.1942	0.0446	2.6761
164	11.5316	6.9346	2.8787
165	10.0414	0.2924	5.7739
166	0.2261	50.9929	1.7586
167	69.6429	80.5001	3.1669
168	30.6942	0.0000	6.7110
169	58.2517	27.4676	1.9997
170	28.2931	31.2401	6.4661
171	95.2523	1.6314	9.0078
172	94.0587	59.9463	5.4162
173	1.5654	2.5401	3.8216
174	24.3638	0.0019	7.8593
175	38.6214	0.0812	9.5907
176	12.3633	50.7950	6.8130
177	61.3753	36.0036	5.3679
178	0.6959	48.0797	4.9436
179	0.1913	24.2880	2.6774
180	0.0000	56.2364	4.9882
181	0.3578	0.0043	5.3931
182	15.2411	6.6664	8.7502
183	13.3146	1.5563	7.4481
184	5.7163	11.1213	6.5830
185	2.9963	68.3423	1.8080
186	0.0000	2.2113	2.0059
187	54.1827	21.5075	6.1803
188	26.0205	0.0018	5.1549
189	9.0120	0.3738	5.9090
190	1.4542	57.9908	1.3421
191	51.8527	0.7403	6.2136
192	55.9417	57.1349	6.6608
193	61.8885	3.8640	5.3373
194	10.2012	30.2269	2.4447

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
195	91.4647	0.0144	7.7894
196	59.5341	39.5947	8.1415
197	0.0485	12.4612	3.6223
198	1.3413	83.9362	5.5685
199	54.6482	2.4332	3.1419
200	6.6839	5.3395	2.7342
201	10.1398	0.1472	8.2783
202	86.1541	89.8215	1.6001
203	89.8647	8.0908	2.7628
204	44.8197	0.0605	9.7730
205	18.9647	36.8103	6.1758
206	76.8387	13.0160	6.2489
207	12.1606	3.5316	9.5502
208	0.4575	42.7850	1.9004
209	3.4645	58.4289	8.9086
210	2.6049	1.6332	9.0231
211	17.4020	15.2637	2.9263
212	0.0307	8.2407	2.5026
213	0.0328	0.3922	6.8151
214	0.4639	21.6520	2.6231
215	85.0458	82.3845	2.0489
216	53.3586	0.1251	4.2880
217	35.8601	72.8955	4.6214
218	91.3366	16.6797	1.8083
219	99.5288	7.8050	7.1539
220	96.2835	0.3538	5.9220
221	0.3381	1.5169	9.8736
222	88.0537	8.9536	2.9147
223	14.9264	15.1235	9.2709
224	0.0407	4.4607	6.9865
225	3.0319	46.2096	7.6913
226	71.7328	68.5385	4.4061
227	58.1698	39.5596	5.2729
228	0.0000	6.7137	1.9564
229	26.2402	22.0545	8.9541
230	51.8135	26.3504	5.0059
231	1.4730	0.2071	7.0141
232	0.0264	12.2166	7.5539
233	1.8222	2.9927	3.5708
234	0.1084	19.3677	6.3432
235	11.3183	84.0187	4.3348

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
236	7.3499	7.7821	8.1607
237	5.5432	0.0036	1.6618
238	69.7310	80.2889	9.9346
239	7.4383	79.1408	7.9843
240	2.2870	4.6001	1.0663
241	0.0112	1.7574	9.0005
242	1.0527	48.7183	8.7771
243	1.3682	13.3889	7.2783
244	0.0025	17.8004	8.9649
245	34.6408	32.1129	5.1908
246	0.0000	0.0789	4.3440
247	22.8010	66.4376	1.7472
248	6.7962	83.8396	9.9750
249	1.5428	0.0901	8.8285
250	27.7755	60.5243	1.0006
251	3.2853	75.2071	7.1198
252	0.1114	0.0001	6.8939
253	15.3616	14.3617	4.7063
254	0.4482	27.5063	5.2873
255	68.9492	5.7131	4.4944
256	29.6017	27.3741	5.0685
257	60.9245	44.3939	1.2408
258	44.3603	19.0791	4.8276
259	52.5585	25.2339	1.9522
260	25.3579	2.1532	1.3880
261	35.8558	59.2358	6.0051
262	32.6604	7.7764	6.5016
263	3.3060	25.1984	7.6495
264	15.0271	57.8982	3.3123
265	66.5782	1.9724	7.5363
266	0.0162	6.4385	7.4193
267	12.5301	17.0266	5.5339
268	8.1050	8.7449	9.0349
269	73.9456	0.0738	8.0145
270	25.0265	41.2464	5.4537
271	94.9967	0.0035	7.8536
272	20.0407	7.9364	7.0034
273	59.4052	0.0052	9.8030
274	10.3039	92.9136	2.0536
275	16.2077	14.2515	8.8239
276	0.5745	75.2652	6.1107

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
277	25.5397	5.6291	2.0814
278	89.2942	69.1868	9.7330
279	15.2285	1.6585	8.5597
280	11.0326	75.1213	1.5608
281	49.9935	71.5862	3.5027
282	0.0797	6.3291	4.6867
283	68.3331	24.4164	6.6413
284	0.0000	18.2861	9.2719
285	13.3848	71.5745	4.7364
286	31.2306	0.9823	7.4035
287	18.1079	0.0000	9.7379
288	10.9530	68.2824	4.9192
289	3.2926	1.2998	6.7184
290	21.7711	1.4682	9.1140
291	76.1431	26.3272	8.8443
292	31.7938	2.8240	2.2844
293	84.8561	56.2784	2.8054
294	0.0973	69.0078	6.5884
295	13.3455	84.4908	7.9753
296	0.1336	5.9683	3.2213
297	16.2112	51.4539	4.3251
298	32.6778	0.3878	4.0699
299	0.3204	24.4335	5.1075
300	47.0114	34.1511	2.5374
301	6.3546	0.0633	7.7105
302	72.4877	14.9873	1.8818
303	2.8947	70.1568	9.0124
304	0.0228	1.8330	1.7388
305	1.0571	1.2942	8.0337
306	0.0568	59.1979	8.6381
307	85.8446	12.1685	5.0579
308	0.0004	0.3537	6.4479
309	0.1508	1.2289	4.1902
310	0.0002	28.4831	7.8319
311	1.0110	17.8404	6.3050
312	0.0001	2.4853	6.5041
313	26.5165	24.0996	8.5885
314	13.8181	36.6916	5.1129
315	1.4804	2.2124	8.9451
316	0.7273	7.0074	5.4422
317	0.0750	4.7519	6.6057

Continued on next page

Table B.74 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
318	5.0016	47.7097	6.0595
319	0.0000	0.2487	7.4949
320	21.8931	73.4040	5.9209
321	10.9802	2.4297	8.0600
322	2.9252	12.4669	5.0172
323	41.2569	48.1135	9.2072
324	59.1328	31.0374	1.7793
325	1.8074	0.3362	9.9904
326	13.5986	33.8055	7.5482
327	8.9179	0.2147	6.0257
328	3.9726	84.6446	2.2854
329	59.0889	69.6477	8.5387
330	94.8392	13.6595	7.5272
331	24.5861	31.3613	4.7564
332	0.5957	93.1983	3.4585
333	0.1862	0.1975	3.8324
334	19.5080	42.5671	6.2353
335	3.5461	56.5716	7.2042
336	1.9289	47.7167	8.7748
337	16.6592	0.6955	2.8977
338	0.5882	7.8756	5.5608
339	31.2345	0.0003	4.8254
340	0.0173	3.4419	3.1573
341	0.0040	0.2444	7.8177
342	2.3521	9.1440	8.1272
343	0.0464	18.7419	4.4729
344	73.0392	49.6837	3.8625
345	60.6798	7.3949	5.3283
346	6.1957	15.1025	3.5066
347	0.4845	79.3263	2.4223
348	7.9758	72.6771	4.5587
349	7.2105	16.1730	3.5691
350	38.7044	73.1735	3.1875

Table B.75: Depot locations and number of vehicles for MS38

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	94.7922	92.8879	2
2	45.2984	67.2717	2
3	81.0833	37.2332	2

Table B.76: Customer locations and service time for MS38

Customer index	x-coordinate	y-coordinate	Service time (short)
1	21.9105	30.1033	6.7827
2	35.4233	14.9131	9.6123
3	14.4828	9.6406	2.6770
4	21.5956	28.8237	9.1857
5	31.8399	18.5288	6.1187
6	24.3372	20.9102	2.7416
7	29.8033	29.5865	7.3381
8	39.4795	25.1528	6.8642
9	21.4470	26.3744	3.9871
10	15.8681	34.8692	5.6941
11	38.0190	33.8825	1.2229
12	21.3550	25.0299	1.2005
13	27.6524	20.5694	8.1867
14	20.1503	15.0518	1.9703
15	11.9267	27.6314	7.1993
16	17.1055	44.2756	7.9752
17	35.9353	33.7257	8.1234
18	21.5405	26.8746	7.3852
19	23.7485	15.8509	9.5188
20	27.5003	14.7845	3.6822
21	34.8068	20.5831	9.9624
22	26.2700	1.0320	5.9900
23	22.8459	28.4782	6.9048
24	17.8961	35.3625	9.5081
25	29.8568	25.9215	3.0217
26	7.5974	22.2743	9.8337
27	15.2085	36.2741	2.5356
28	31.1360	21.4355	9.4695
29	28.7239	20.1719	9.6126
30	14.3597	32.7164	2.5751
31	29.4751	25.0459	1.4888
32	28.9122	19.7126	3.4139

Continued on next page

Table B.76 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	15.1308	32.1527	5.9141
34	24.4019	20.9935	7.9767
35	38.3507	37.4142	6.4338
36	20.8873	19.7551	3.8449
37	13.7705	20.0504	4.9002
38	26.3230	19.7609	8.5850
39	20.3320	27.9688	6.6352
40	22.0108	35.8757	3.4529
41	28.4180	28.0473	5.6308
42	24.5431	31.4340	8.9956
43	21.8213	35.4611	2.5687
44	16.4023	23.9305	8.3806
45	18.1646	32.9052	2.6307
46	16.4707	23.9625	1.8754
47	19.9570	42.4995	1.2818
48	39.6710	27.1690	1.0916
49	26.2305	20.4543	9.7070
50	20.4220	25.8369	8.9923
51	23.9345	18.8925	1.4472
52	27.0444	12.2987	7.0319
53	27.3006	27.9148	9.7896
54	27.6560	26.9405	2.9824
55	34.0878	30.4500	1.7565
56	22.1343	17.9587	4.2298
57	27.9593	18.2907	7.5986
58	19.8449	20.9104	6.4193
59	9.5087	16.6191	5.0623
60	20.2339	47.4280	9.2152
61	36.8165	28.0961	1.0286
62	22.0450	19.5573	5.5907
63	33.5157	28.5360	2.3001
64	30.0152	35.2461	5.5418
65	20.0229	30.6466	6.1139
66	40.9446	32.6387	6.7795
67	32.2786	29.0062	2.8624
68	32.5215	12.4405	4.0617
69	17.4197	18.6676	3.9473
70	19.6077	33.8320	6.5347
71	30.3870	23.3493	6.3207
72	34.9979	27.1600	7.1913
73	24.7802	29.6244	2.4979

Continued on next page

Table B.76 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	39.2661	16.4882	6.8700
75	23.9350	26.5843	7.9177
76	30.9838	21.3768	4.5619
77	25.0281	12.7153	4.5664
78	34.1163	28.2769	7.2291
79	22.2743	17.9660	3.1391
80	24.7385	20.8097	9.5399
81	12.4307	13.8398	2.2218
82	27.5188	19.9753	5.6036
83	25.7478	28.6628	1.3729
84	29.4008	38.0959	3.8117
85	27.8183	15.5704	3.8959
86	19.4222	27.8777	9.5349
87	30.5337	29.3616	2.8661
88	46.7513	33.6997	5.4041
89	19.6545	35.4989	5.0021
90	32.7690	15.7843	8.3876
91	20.1853	25.5114	1.1573
92	17.4298	35.2558	8.0966
93	15.6432	29.5425	5.8671
94	29.7947	36.6665	1.4093
95	25.2770	35.1374	5.6247
96	32.2808	44.5317	5.0106
97	23.4166	3.1665	5.4223
98	15.2053	22.2346	6.9390
99	23.3471	22.1781	5.5483
100	24.3853	13.1365	7.6767
101	70.6564	80.2495	9.4946
102	86.8519	78.1276	8.1939
103	75.4941	66.5426	4.9395
104	83.0049	59.2512	1.8128
105	88.6242	63.0520	9.4021
106	72.5811	77.2995	4.4054
107	71.5865	72.4899	7.8303
108	64.0240	81.3292	8.2341
109	72.6892	71.8338	8.2381
110	69.0442	63.9808	6.3621
111	73.1726	75.8028	3.9249
112	73.1201	84.1754	7.7351
113	68.9303	77.2118	5.2882
114	65.4610	73.4504	5.6403

Continued on next page

Table B.76 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	71.8526	71.4922	5.3209
116	75.1219	85.5677	4.8162
117	67.5361	82.6192	2.5842
118	77.9353	71.4196	3.5250
119	73.7989	63.7801	8.8990
120	72.8279	67.3871	8.8647
121	82.5978	77.7777	5.4063
122	94.2182	65.8951	6.4565
123	82.0637	71.7754	7.4592
124	80.3558	73.9797	2.2602
125	75.0393	69.5019	6.2475
126	76.0816	69.7960	2.7550
127	79.8452	73.1141	1.5700
128	70.3918	70.4097	1.5751
129	62.5620	63.8145	9.4588
130	78.5759	81.1382	5.6817
131	69.1511	67.3371	2.3510
132	78.2810	83.6253	6.8193
133	68.0788	72.1383	6.2540
134	64.5549	72.4343	3.8110
135	63.3047	85.7964	7.0493
136	77.3425	77.1757	4.5735
137	91.2878	71.6477	2.9756
138	76.6703	68.1087	3.1674
139	79.0875	70.6899	4.4774
140	76.1984	78.3326	1.3015
141	76.9175	82.0595	4.1205
142	94.7123	75.4001	5.9684
143	68.4894	70.8923	6.0260
144	73.6759	77.7953	1.6013
145	69.3858	80.5935	6.2375
146	80.9504	71.4861	5.2827
147	77.1266	87.0261	6.9574
148	72.2728	71.9643	8.0749
149	81.1842	82.4857	2.7103
150	66.6191	83.0695	9.6536
151	75.9952	75.4719	5.8156
152	76.6703	74.2944	9.2307
153	88.1154	82.2668	6.8110
154	79.4886	59.9695	2.3812
155	75.2755	75.2812	1.4696

Continued on next page

Table B.76 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	63.8188	75.5762	1.1355
157	62.7424	78.0466	2.7673
158	79.9219	67.6262	5.7494
159	69.1651	63.2485	2.3290
160	72.9901	53.0135	1.6582
161	67.7549	79.5425	5.9936
162	76.5134	83.9834	9.8315
163	76.8990	71.2972	2.4658
164	89.5393	94.8277	2.4094
165	90.1490	69.6585	2.4730
166	83.8469	64.0727	1.7064
167	84.0332	73.7859	7.4656
168	65.2527	75.8815	5.0164
169	85.6314	80.6863	5.5911
170	67.1536	76.0087	6.4463
171	61.6712	68.6365	8.9476
172	99.9730	62.3081	2.0972
173	77.6556	70.1109	3.6123
174	69.4755	63.6355	1.5611
175	75.0660	81.0300	2.2918
176	75.5751	74.1364	1.6117
177	57.7498	59.5583	2.6658
178	69.0371	78.0466	7.9181
179	79.4110	67.3133	9.0791
180	75.2962	86.2531	5.6644
181	61.1425	75.4350	8.6017
182	70.9042	76.9103	3.0588
183	73.7494	68.4385	4.8554
184	75.6778	79.3585	4.3146
185	61.0102	75.5409	7.2644
186	77.1278	76.8014	9.4994
187	87.7421	72.3311	2.9610
188	61.7273	80.3615	7.7770
189	78.6566	54.6733	5.6785
190	86.1971	76.3807	7.8407
191	78.1696	83.7351	8.9278
192	79.9089	73.4111	3.1373
193	71.0413	79.8178	9.4572
194	73.4568	70.0375	1.2444
195	65.4607	76.4396	6.0536
196	73.9874	70.1335	9.0141

Continued on next page

Table B.76 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	70.3949	84.5419	2.5029
198	69.5164	78.9162	4.8272
199	87.0604	86.4661	3.9421
200	74.0245	74.6520	6.1083

Table B.77: Depot locations and number of vehicles for MS39

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	21.2953	21.7754	1
2	49.7323	68.2740	1
3	69.4499	49.0436	1
4	70.2105	53.1982	1
5	54.4113	71.3545	1

Table B.78: Customer locations and service time for MS39

Customer index	x-coordinate	y-coordinate	Service time (short)
1	42.0468	46.2275	4.9494
2	45.7312	44.8848	7.1078
3	63.3112	72.4928	5.1856
4	47.1559	30.7303	9.5794
5	83.9552	46.5681	4.1923
6	44.3386	67.7734	4.0512
7	38.0691	57.0178	9.0627
8	59.0753	31.8632	5.9089
9	53.9218	63.2192	7.7436
10	57.7088	4.9694	2.1239
11	15.1021	41.7902	5.0791
12	47.5000	76.1291	1.6727
13	19.4412	58.3077	6.9701
14	53.0890	63.1935	7.3329
15	62.7498	48.4508	9.2706
16	69.6597	43.6631	6.9406
17	62.5495	61.5986	7.2109
18	58.0680	88.6177	8.6835
19	62.9240	45.5267	5.2111
20	49.0556	73.9503	5.1263
21	49.3583	41.0116	8.2549
22	67.0075	42.8321	8.4229
23	68.1214	60.8456	2.7139
24	42.1528	34.9658	1.2311
25	20.0453	65.7046	1.5113
26	11.7446	21.9456	2.2864
27	22.9570	9.6542	2.5428
28	33.3321	47.3513	6.6326
29	57.4520	55.4814	1.2656
30	37.0693	71.2567	5.2510

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
31	48.5778	51.9945	7.1060
32	56.1565	65.9072	2.0331
33	26.8965	54.0093	3.1246
34	35.8292	61.3249	3.6017
35	37.5103	33.8538	2.5548
36	36.6368	48.7265	3.9134
37	42.6792	40.0368	8.2100
38	63.1197	46.0502	3.6967
39	41.5421	88.2775	7.9806
40	61.5718	26.5974	5.9749
41	55.6721	50.5696	5.9922
42	53.1976	44.6517	7.5758
43	66.2505	56.3230	7.9626
44	85.6693	79.8780	9.1076
45	74.4555	65.2052	2.2435
46	23.5994	39.0514	8.1467
47	58.8319	26.1039	2.7047
48	29.2193	64.1332	1.2608
49	16.4867	33.4647	2.1465
50	29.8215	38.0790	2.2036
51	13.6348	57.7558	2.1548
52	31.1454	24.6259	9.4173
53	72.5716	75.9375	3.4591
54	42.0585	51.7137	9.4841
55	94.6787	46.0985	6.7434
56	56.5136	63.4637	8.8528
57	66.7333	63.4369	4.3037
58	47.5668	45.8472	3.1258
59	45.3404	68.3722	2.6859
60	36.9439	56.1219	5.9108
61	52.6803	68.3334	3.2960
62	25.2844	54.3912	3.7524
63	35.8322	46.8151	1.1399
64	32.1796	79.1458	6.2874
65	52.8056	36.9466	9.6630
66	75.2650	60.5514	8.6486
67	85.9588	83.7065	1.0715
68	20.7383	43.1109	6.7062
69	55.7791	60.5773	4.2336
70	39.0983	55.3259	2.0265
71	31.9754	44.1959	5.8674

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
72	51.7230	49.9408	4.7478
73	42.1356	60.2964	5.6539
74	50.8520	88.8080	8.9751
75	62.8084	64.7738	2.3446
76	34.4087	45.9319	4.9121
77	47.4548	17.1146	1.5313
78	21.6607	54.1510	4.4293
79	43.6125	54.3496	7.5013
80	66.4809	36.8087	1.8561
81	20.9050	66.8222	7.0047
82	56.5142	56.5145	3.6676
83	27.4667	59.7817	6.3871
84	53.6499	41.8969	2.3667
85	42.4951	38.6024	4.9274
86	45.3579	42.2096	1.1141
87	23.2685	31.4903	3.0612
88	34.8155	41.2910	3.3731
89	46.7830	62.1140	5.6025
90	51.1946	12.4109	2.9358
91	46.8114	20.4671	4.1150
92	39.3128	50.4432	7.7304
93	72.1426	55.4749	4.7226
94	46.7589	34.1862	1.5018
95	37.0684	58.9407	4.5103
96	37.3559	70.9837	5.2704
97	48.7400	61.3957	8.4279
98	65.4834	23.9434	3.7328
99	42.9239	37.8239	8.3961
100	64.5261	35.7698	6.0911
101	53.7754	44.3541	1.4894
102	40.6112	38.8119	3.3401
103	36.3796	35.9731	6.3019
104	52.9557	81.8319	5.3176
105	48.2779	44.4505	2.7879
106	34.9168	47.4596	3.1511
107	36.7610	54.7727	8.0217
108	58.9855	21.1296	6.5558
109	58.6944	30.9728	2.2972
110	44.8100	57.8311	7.4452
111	63.7688	55.8565	4.6136
112	44.1677	30.6497	5.1615

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
113	48.0750	68.7610	7.3655
114	70.5804	48.8877	4.6109
115	41.0013	52.3615	1.1295
116	15.9507	51.8214	1.6718
117	28.5187	40.8338	6.3196
118	54.8475	19.4786	5.0140
119	46.4035	47.8187	9.3396
120	95.8557	23.9171	1.8540
121	26.4154	47.2556	4.3788
122	45.9355	53.4558	5.9140
123	50.6708	53.2994	2.0051
124	27.1028	26.8955	9.1402
125	67.9865	56.1100	6.6995
126	62.3989	29.8256	9.1487
127	75.7143	54.1945	6.6750
128	61.4587	60.0534	1.1281
129	-9.1695	76.6401	3.8483
130	33.8824	15.8199	2.0068
131	55.1965	63.8210	6.6652
132	36.4155	47.2974	1.5464
133	54.7228	48.7448	7.0660
134	48.8960	40.6266	5.2970
135	40.8751	53.9026	3.7499
136	51.1343	45.6897	5.6470
137	58.5496	39.6873	7.3633
138	69.0516	41.0232	8.3225
139	35.1009	60.2714	3.8423
140	40.4705	58.1938	3.8017
141	37.9893	68.3437	4.1048
142	64.1316	56.0491	6.9967
143	76.2104	47.5684	8.7496
144	67.5954	31.0271	7.8560
145	72.3502	55.2464	8.8825
146	54.1546	44.8902	8.8411
147	36.6382	53.6919	2.5551
148	61.3291	64.5763	8.6520
149	78.7730	41.7859	9.6363
150	58.4343	41.9623	7.9319
151	65.4869	45.6801	8.8751
152	24.2750	53.5433	1.6067
153	59.5176	83.9490	6.8211

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
154	47.4346	35.4518	3.9169
155	59.2221	72.3321	6.7631
156	71.2797	46.4095	8.9178
157	39.3431	64.9649	4.3627
158	75.0989	50.9951	7.9006
159	34.2768	41.0965	2.5128
160	50.6805	45.6800	5.6775
161	55.1159	65.9812	6.6471
162	67.7804	71.1131	7.4252
163	44.6142	66.0170	3.7576
164	34.4021	40.6040	3.3732
165	73.6102	28.5196	9.2440
166	56.0440	56.6811	6.5353
167	18.1054	58.7997	1.8386
168	55.3320	8.1242	6.6493
169	21.6569	50.4038	2.7283
170	63.1819	84.9260	7.9927
171	73.1194	46.8594	8.7805
172	46.9537	39.2635	4.0022
173	34.8601	33.2039	2.2187
174	70.4488	19.8173	7.8892
175	41.4883	41.8427	3.8675
176	36.3588	55.0238	3.2714
177	28.9705	33.6015	2.8007
178	25.5392	54.2244	1.6211
179	54.5963	63.1328	5.9672
180	44.4709	40.1117	4.6343
181	63.1414	58.2034	7.7510
182	49.0551	59.4247	5.3847
183	46.5052	49.2866	4.4631
184	21.3089	82.6075	1.5527
185	37.0756	28.7966	2.9232
186	51.7405	54.5844	5.8949
187	42.8642	34.5543	4.6958
188	71.2508	37.9706	9.1087
189	19.4762	57.3496	1.5066
190	46.9800	68.2149	4.9916
191	51.9096	52.8351	5.8403
192	37.9607	71.7475	2.2065
193	51.8667	34.4978	5.8685
194	77.6878	55.6360	8.7163

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
195	32.4935	41.1518	2.7822
196	44.1520	37.3774	2.4005
197	26.3487	6.1407	1.5524
198	62.1323	62.6697	6.9497
199	29.8991	81.2475	1.1674
200	35.6968	58.3273	3.6199
201	73.7159	72.9387	9.7644
202	63.7237	50.9830	7.8818
203	37.4005	29.4930	3.1932
204	66.9424	35.4588	7.1390
205	39.0151	36.6222	2.2407
206	51.7671	68.3729	6.6683
207	80.5728	41.9940	8.7131
208	87.6194	51.5240	9.0982
209	42.6141	27.7809	4.1353
210	49.4998	46.9489	5.3768
211	67.3182	22.9022	7.1157
212	60.1252	38.2929	7.3371
213	46.1163	62.6582	5.1480
214	46.5088	78.4942	4.2785
215	36.9329	58.0907	3.5224
216	12.1337	51.6206	1.6858
217	47.3891	67.8877	5.0016
218	30.0355	62.1337	2.4914
219	46.2010	9.1855	4.5887
220	91.1383	20.1406	9.2853
221	50.5648	36.1107	5.6020
222	75.1588	35.4399	9.2273
223	31.4881	23.3295	1.8274
224	71.2595	38.6958	9.9373
225	22.1064	34.4804	1.8679
226	45.3346	68.3370	3.8183
227	54.8459	39.8337	8.0684
228	60.3350	28.7331	6.4216
229	47.9290	43.0622	5.1932
230	31.9629	38.5839	3.6832
231	29.7054	54.3693	2.1986
232	37.9640	46.1452	3.6551
233	33.0139	25.2414	2.4996
234	40.3486	59.6721	3.8539
235	34.1579	43.9341	1.9886

Continued on next page

Table B.78 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
236	70.7010	39.9995	8.4888
237	54.4986	35.8034	9.7443
238	54.7245	63.2315	2.9644
239	36.0169	48.1845	7.3547
240	54.6135	24.1198	1.3511
241	55.3835	86.1799	6.5467
242	34.3992	44.3051	7.0243
243	30.1804	54.5176	1.3348
244	17.7511	55.9138	1.0300
245	64.5466	28.2246	2.2822
246	33.1309	70.3524	8.7616
247	50.7790	54.1853	3.4843
248	51.3852	52.3942	5.7852
249	51.5203	72.5107	5.7000
250	39.3633	52.6516	6.1086

Table B.79: Depot locations and number of vehicles for MS40

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	38.9519	75.5119	1
2	79.9977	29.5210	1
3	39.9794	64.0006	1

Table B.80: Customer locations and service time for MS40

Customer index	x-coordinate	y-coordinate	Service time (short)
1	28.3563	21.7206	3.9973
2	1.0010	9.8747	4.7207
3	11.1355	17.5158	4.7291
4	18.0999	20.4391	9.8553
5	14.2392	11.0801	1.5197
6	26.2789	29.6993	4.5689
7	26.2663	27.5468	8.1219
8	19.2241	19.7738	6.3477
9	34.7455	13.3972	3.7861
10	18.4326	22.7059	9.1162
11	22.1201	23.6012	1.8381
12	19.4385	6.8921	3.8712
13	17.5295	35.8951	8.9827
14	25.4551	28.6294	6.9169
15	13.3820	10.3871	7.1607
16	22.3984	41.4840	5.2655
17	31.9194	23.7204	2.2712
18	31.7815	12.7217	9.5583
19	8.7827	17.2830	8.9436
20	28.3893	27.1892	4.9369
21	21.1835	13.0017	8.5146
22	28.7545	21.0538	3.9263
23	26.4343	24.1541	4.3088
24	22.3660	21.4586	8.1536
25	24.8890	26.6972	1.8938
26	30.0659	19.0666	9.5660
27	31.0502	22.9124	1.0133
28	18.7526	26.5894	3.6586
29	13.9387	6.4993	1.4361
30	21.5079	9.0149	4.9847
31	33.5000	16.1077	8.1086
32	27.8568	25.6654	9.2217

Continued on next page

Table B.80 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	28.2833	26.6900	5.7993
34	21.3122	18.9073	8.2367
35	18.6195	35.9369	6.0639
36	42.3086	34.4417	7.7579
37	24.1236	23.5241	1.0831
38	24.7229	52.7128	5.2911
39	22.7192	21.9558	3.2530
40	25.5810	33.1949	3.7713
41	22.3374	24.4748	9.7025
42	16.2982	10.6262	2.8792
43	29.1079	40.6653	5.6843
44	36.9982	16.1371	3.0299
45	26.5406	25.6144	6.1048
46	18.7988	41.0068	9.9835
47	25.4702	30.3561	2.1868
48	33.5025	28.0916	9.5921
49	39.8595	23.7882	2.1149
50	13.2896	27.0433	2.6761
51	25.9501	40.7514	6.8185
52	21.3893	21.1587	2.1535
53	29.5383	23.1538	1.7319
54	26.4076	21.2035	6.9330
55	20.0948	21.5663	1.2466
56	9.9401	23.5627	9.8666
57	14.8819	30.1573	5.8540
58	19.9467	25.7351	4.3645
59	22.7191	18.6607	7.3606
60	34.7979	38.7663	9.5267
61	20.0452	17.7536	4.4405
62	28.1003	22.2464	7.2362
63	32.5485	25.6675	6.4186
64	26.9305	10.9816	7.9773
65	25.7066	16.5910	6.3265
66	19.9121	14.2195	4.3856
67	32.0110	2.7975	8.6558
68	38.5718	42.7750	3.0316
69	28.9628	18.9137	8.1726
70	27.5610	32.0005	9.9719
71	26.9614	25.1433	3.5318
72	33.6170	16.7155	7.3934
73	22.2425	24.6634	6.9818

Continued on next page

Table B.80 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	20.7317	28.3729	4.7335
75	29.4322	15.4766	5.4844
76	22.4460	34.9842	9.5421
77	32.4319	34.9737	9.5786
78	12.8011	24.1885	7.5963
79	36.0531	30.1196	4.4621
80	18.9115	14.8450	1.3607
81	26.9879	29.7656	6.2464
82	21.1010	23.9307	6.0824
83	30.9464	38.4043	4.1966
84	13.1875	17.0244	8.9218
85	16.1059	41.7626	6.6208
86	38.6032	25.1674	6.6161
87	16.8718	28.7126	3.6617
88	19.1803	37.0794	1.6721
89	25.5193	34.1913	3.6434
90	18.3441	17.7011	3.1127
91	26.2226	17.3730	4.1131
92	34.7994	17.3765	8.6364
93	25.5724	33.9563	2.4433
94	39.3849	23.8692	2.4208
95	12.9188	21.2941	5.5779
96	22.6280	25.6876	6.4297
97	17.7163	33.6314	2.4526
98	28.0708	23.6759	6.7191
99	14.4861	27.5774	8.5955
100	10.3367	5.7050	8.0404
101	69.4368	69.6910	3.3811
102	66.1118	66.5270	3.8323
103	69.6737	84.4089	2.6488
104	68.6503	70.3624	5.0273
105	71.4825	81.2613	3.9401
106	70.9056	61.2937	3.5183
107	80.4812	59.8121	9.3859
108	86.9674	83.3113	4.5972
109	62.2081	79.9442	4.4148
110	89.6070	77.3340	6.3356
111	85.6921	83.0589	1.6166
112	75.7804	75.5633	2.8471
113	88.1675	76.1659	7.5126
114	77.0399	67.7092	6.1763

Continued on next page

Table B.80 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	66.4979	75.0792	2.8021
116	84.3987	65.8307	8.5913
117	93.6039	67.5775	4.8136
118	68.5479	71.0231	5.9028
119	66.6545	76.1561	5.7517
120	84.4861	88.3570	2.6660
121	74.8004	78.1461	1.7352
122	63.6347	78.3845	5.1768
123	85.3026	79.5273	1.2750
124	73.7160	85.0306	4.9149
125	68.3733	79.8368	6.0208
126	70.1536	75.5306	6.7490
127	70.8528	71.3913	1.3080
128	82.8119	79.9768	7.3891
129	65.3689	60.9707	2.5239
130	78.9102	75.3478	6.3404
131	83.3701	82.8604	6.4726
132	67.8346	73.1004	7.9512
133	77.7866	79.8068	1.5065
134	61.2211	76.4369	8.6925
135	80.8073	79.8752	4.4586
136	65.6483	70.8878	4.5966
137	81.7197	88.9272	3.9288
138	78.6130	78.3051	5.9985
139	71.5717	76.1751	3.6588
140	62.6678	65.0783	4.2951
141	86.0966	73.3904	4.1414
142	76.2725	62.9533	6.6720
143	88.9775	72.5951	6.9800
144	75.0714	64.7572	9.9289
145	60.1801	74.4670	9.4993
146	89.0839	76.2684	4.1531
147	72.5718	70.9621	2.7370
148	82.7033	88.6075	9.2762
149	68.9813	86.4075	3.5982
150	80.0986	86.7825	5.9577
151	81.9582	79.9227	9.2739
152	83.4424	81.5000	1.8104
153	79.1587	69.5230	3.3193
154	74.6599	76.0985	4.8434
155	76.2040	65.6465	6.1995

Continued on next page

Table B.80 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	77.5195	76.9987	9.0957
157	68.8462	84.5180	2.9640
158	79.5869	65.8261	9.7033
159	66.1294	73.2593	4.9058
160	59.1219	62.7827	8.0634
161	76.3880	80.0523	5.7271
162	76.6478	85.2569	3.9815
163	76.8395	84.5288	4.8843
164	89.7737	66.4528	7.4611
165	85.2740	69.0914	9.2459
166	90.5316	74.1487	9.0103
167	76.8363	71.7073	2.2124
168	82.5720	70.6037	2.0792
169	70.0736	53.9622	9.0411
170	73.0752	80.3056	6.8778
171	60.4353	73.0465	1.3625
172	75.5819	80.7780	5.5424
173	82.7248	77.2044	9.0501
174	66.1819	50.1788	4.4716
175	73.1460	72.4891	3.6285
176	68.9660	81.5507	3.1063
177	68.2633	83.7097	2.8085
178	82.5199	72.3565	4.4228
179	75.5606	79.3376	6.3531
180	81.1633	76.9832	3.4155
181	78.3065	82.6823	6.6020
182	82.7983	91.3634	8.2411
183	56.1900	67.4047	1.9357
184	66.4823	92.4995	7.5632
185	73.5676	76.7872	6.8373
186	77.8993	68.3414	5.2719
187	84.5703	68.2472	9.3962
188	69.6698	75.9814	1.8680
189	69.9588	76.1502	6.3920
190	72.6237	78.4243	3.1021
191	80.7935	81.8917	1.2910
192	75.8870	78.0133	6.2187
193	84.3808	66.4624	8.5798
194	68.5672	69.2487	6.0121
195	78.4261	68.6759	8.5589
196	78.2266	70.0796	2.8446

Continued on next page

Table B.80 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	61.2999	77.9596	6.5913
198	77.4699	77.8393	2.5662
199	89.4974	73.1038	3.6059
200	65.0185	66.6764	1.1665

Table B.81: Depot locations and number of vehicles for MS41

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	71.3316	71.0348	2
2	66.6381	78.9128	2
3	55.2396	73.9919	2

Table B.82: Customer locations and service time for MS41

Customer index	x-coordinate	y-coordinate	Service time (short)
1	52.5229	33.6356	7.3135
2	18.9956	5.8347	9.5688
3	32.3984	14.7618	7.7411
4	13.0875	27.1115	7.8105
5	17.8149	30.4936	5.8788
6	9.2119	15.5504	3.5386
7	17.7542	13.6559	3.2039
8	39.4605	43.5486	3.5769
9	29.3308	35.5805	9.6682
10	43.0507	56.2817	3.0763
11	50.4623	42.4290	5.8359
12	39.3759	13.9061	2.8451
13	46.2580	0.1800	4.9064
14	45.9164	35.6539	2.2799
15	72.6220	29.5476	4.3803
16	45.9534	42.5760	8.1420
17	8.4667	48.5662	8.3153
18	38.2628	29.9969	9.1341
19	44.4568	35.8131	5.8634
20	49.0443	21.3107	8.3608
21	46.9523	53.3549	7.3757
22	25.1349	34.1981	1.3889
23	33.7949	24.4568	2.3135
24	39.0866	25.7091	3.1000
25	36.9289	63.6379	3.2203
26	67.1499	41.7993	2.5325
27	6.5914	40.3407	3.1155
28	47.5946	38.9488	3.4791
29	53.1071	40.9055	9.5645
30	23.4900	41.2042	4.1200
31	41.5943	33.4396	3.6759
32	31.8500	61.8598	4.6398

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
33	16.1095	29.3428	3.7201
34	35.0112	19.2760	7.8158
35	61.1356	26.4541	4.2377
36	26.6809	53.0494	2.1241
37	43.7920	46.3587	6.5546
38	14.6443	52.8660	4.1997
39	17.9723	29.7641	4.2664
40	12.6826	35.8489	1.6164
41	9.4219	3.0948	8.8045
42	17.6246	49.0933	5.1211
43	18.3393	31.5419	1.6985
44	25.9656	34.2673	9.1443
45	5.9410	50.2249	3.5353
46	24.8858	28.7771	6.5249
47	20.4180	40.5140	6.9567
48	20.1045	21.3692	2.8002
49	28.0527	24.4693	9.6399
50	52.8628	42.3610	6.9860
51	33.2534	29.8038	5.8717
52	40.3505	7.2392	8.8207
53	59.7583	24.3689	6.0134
54	44.7434	81.8252	1.1926
55	35.4898	41.5471	5.3441
56	51.4336	36.9183	8.2719
57	70.4979	26.5164	7.6241
58	24.7173	3.0092	6.1507
59	47.4729	35.5933	1.0809
60	19.7668	0.1800	7.4645
61	12.5256	17.9436	5.0448
62	22.0432	9.0813	6.9366
63	32.1045	29.7784	7.7789
64	0.6378	51.2270	8.2427
65	6.6901	41.9325	1.2624
66	32.3822	25.9389	8.0184
67	43.3427	6.2244	6.1062
68	46.4242	24.4472	1.6850
69	40.6223	13.5737	3.2646
70	30.3366	40.4914	2.2011
71	42.1669	23.5730	6.0803
72	74.8808	56.9457	5.8688
73	66.2802	31.3771	1.6203

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
74	32.3436	8.0190	9.8959
75	56.9072	34.6539	3.2599
76	22.9903	45.2895	3.8393
77	39.1800	25.0677	3.7059
78	35.7404	43.6290	1.3784
79	46.0550	38.9884	5.7511
80	13.0844	39.7408	3.3042
81	43.7376	27.8908	4.6784
82	36.1438	31.2059	9.5276
83	38.8126	31.0955	9.2735
84	16.1898	31.1920	2.0912
85	26.7737	9.0711	6.3275
86	7.5977	33.0289	4.2369
87	21.1023	13.4927	7.4738
88	17.1683	35.4658	5.7120
89	27.5062	13.8926	3.3476
90	36.1540	56.0461	5.4377
91	47.4660	47.0163	8.7025
92	15.5156	24.3468	7.5197
93	38.2270	67.7435	2.7920
94	51.4414	52.3226	2.4156
95	49.3553	47.5566	4.3343
96	6.7592	0.1800	8.7604
97	45.5336	12.2374	7.1629
98	30.5205	21.6287	6.7078
99	56.3568	27.8718	2.2719
100	48.8217	11.4741	1.7137
101	27.5192	44.2513	8.8853
102	37.8237	24.6215	4.7839
103	41.8475	30.5771	5.3890
104	0.1800	24.1909	5.1429
105	23.1002	31.8623	5.6411
106	26.7426	56.2030	3.4479
107	14.2541	2.8255	3.0842
108	0.1800	17.3089	9.0958
109	47.3340	25.4848	9.1783
110	23.1036	42.5790	6.4328
111	52.8693	16.2819	4.2871
112	17.3627	24.5870	6.3873
113	49.2188	45.0581	7.0164
114	45.0574	12.8678	9.0511

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
115	42.6649	50.7935	1.7860
116	16.0334	39.0363	5.8511
117	30.3614	42.8319	4.8560
118	25.5010	33.0852	6.5544
119	17.3352	16.7091	6.0299
120	25.9162	6.6745	3.0327
121	6.3138	35.8897	1.9407
122	30.7101	45.2593	1.0898
123	30.0424	45.4034	1.5324
124	19.4772	31.8992	3.9039
125	43.9556	60.8023	8.0153
126	15.8567	36.4171	4.0193
127	29.1969	26.6169	6.5761
128	42.0819	35.0870	9.9360
129	36.8871	23.0672	6.8321
130	0.1800	44.7922	5.8580
131	20.4597	59.2792	3.0903
132	26.5649	50.6681	7.6585
133	24.1113	37.4710	9.0009
134	10.7839	10.6533	8.7383
135	32.6147	22.7221	6.3735
136	30.5395	40.0507	6.8928
137	54.6599	32.0567	9.2351
138	35.2037	56.3739	4.8986
139	45.0914	44.3476	3.6078
140	31.1601	9.4384	6.6869
141	2.9089	43.8829	3.6588
142	8.7787	44.4768	6.5983
143	20.8099	62.5117	1.4278
144	26.1045	34.7554	9.9515
145	42.9392	37.7169	2.8609
146	19.4257	7.0765	6.4663
147	22.8534	25.6610	4.1287
148	37.5975	8.4408	7.4596
149	23.9658	30.8672	1.2519
150	12.8597	20.3421	1.6016
151	24.0993	11.8654	9.3436
152	21.9954	33.2586	1.7899
153	44.8527	19.3217	3.9916
154	37.0323	54.4630	5.7356
155	42.4322	70.4564	3.2198

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
156	25.6709	35.8777	5.8861
157	68.6119	38.0377	8.0278
158	35.1517	0.6943	5.6969
159	18.0029	58.2899	9.3875
160	11.2732	22.9362	2.3240
161	34.9775	39.8483	4.7509
162	26.5560	29.9784	3.5226
163	10.8018	39.0594	6.3829
164	25.5031	31.8935	1.3283
165	6.1998	35.5115	1.5732
166	44.7070	15.5991	3.9059
167	65.7285	35.5449	1.8854
168	45.6706	8.5272	2.5304
169	27.9470	31.5239	4.3405
170	55.9941	36.3765	1.3579
171	38.1838	28.6926	7.3832
172	0.1800	38.7620	6.7721
173	30.9229	48.0833	2.5665
174	34.6450	6.7667	1.5594
175	42.7036	9.0773	4.6599
176	30.5954	23.0037	5.1676
177	52.8951	40.4701	2.8241
178	11.1934	39.0951	8.8259
179	74.3202	27.4110	6.3815
180	55.8701	43.0017	1.2071
181	29.2204	67.9795	9.0948
182	38.1336	15.3492	5.0765
183	18.7888	19.2319	1.5222
184	17.8207	2.8334	1.9564
185	34.6026	35.5602	9.9858
186	49.7611	46.5799	8.7969
187	48.7640	27.1417	6.5369
188	68.8583	51.5008	1.2425
189	27.9028	29.4740	3.9027
190	29.6164	37.3951	5.1740
191	0.1800	50.2314	1.8912
192	28.1909	43.1319	6.1389
193	35.7685	38.5948	3.9329
194	33.9622	57.1079	5.0544
195	22.5392	18.0990	6.2006
196	11.8765	25.5875	1.6736

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
197	26.4831	38.2700	1.5161
198	70.0091	27.3826	3.7086
199	17.8492	23.9357	5.6955
200	33.3777	45.3397	6.0569
201	14.0396	24.8727	3.1740
202	52.7422	39.9177	9.2145
203	46.4406	30.2771	8.4316
204	36.0057	26.0700	5.0009
205	32.5410	40.9542	9.8386
206	57.9812	38.1850	6.2044
207	42.9628	0.4382	3.1098
208	33.2745	27.6824	8.2953
209	35.6111	15.3564	5.0615
210	58.9831	35.1983	3.2497
211	41.5806	21.3756	9.5989
212	37.8143	33.0973	2.2839
213	42.8095	54.2263	5.6131
214	31.6902	61.6959	9.7473
215	16.8796	46.6424	6.8349
216	39.4601	6.6980	6.5320
217	6.2950	57.7866	5.2269
218	21.7642	51.2512	6.2000
219	50.9657	37.5573	9.2018
220	21.7570	73.8412	4.3860
221	37.8352	25.6508	3.0589
222	29.7455	63.2281	4.8117
223	37.9576	14.8917	3.4624
224	40.3933	26.7128	5.0011
225	24.9846	13.7908	6.6476
226	0.1800	42.7102	5.8118
227	50.3525	39.3990	4.4690
228	24.0347	22.4797	8.8611
229	38.0801	9.8838	3.7031
230	49.4927	0.1800	4.6003
231	15.2933	17.4396	5.6595
232	54.2695	9.4245	1.5564
233	45.6861	44.3514	3.0823
234	35.3730	51.2905	2.0664
235	27.3535	0.1800	1.8890
236	53.4199	4.2102	9.0125
237	40.7631	25.3509	1.3005

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
238	42.2056	49.1223	8.5513
239	78.2147	54.2200	5.5654
240	42.5773	57.8412	2.0234
241	52.9420	26.7268	5.4140
242	32.4886	22.3731	6.3950
243	63.3711	16.1041	1.8119
244	31.7484	42.5155	9.8040
245	16.7501	46.0800	6.8772
246	33.0559	7.8309	5.1502
247	4.7325	31.0029	8.7738
248	54.2933	24.4782	3.3655
249	13.5974	43.3693	8.4157
250	38.0274	52.3982	3.9608
251	48.5725	53.3252	9.4717
252	41.3791	41.4582	3.1970
253	39.5592	26.3547	9.6140
254	18.9254	25.3724	5.5974
255	32.4158	13.7611	6.0812
256	48.8400	52.7391	9.9434
257	20.6070	18.3607	7.9389
258	12.7384	0.8776	3.8242
259	21.6889	19.5498	1.5209
260	47.5740	57.5176	1.3967
261	28.7572	37.5472	8.3165
262	37.0479	27.2207	4.7087
263	4.2528	36.7383	4.4575
264	20.4561	39.8073	5.7081
265	21.6753	40.6324	9.0293
266	12.2345	30.3286	4.6533
267	52.8995	71.4070	6.4395
268	50.6649	50.9706	1.8532
269	7.2131	0.1800	4.0238
270	37.4978	17.4764	2.3036
271	17.2408	32.7918	3.2039
272	30.5709	41.6196	4.4107
273	34.0946	28.5875	3.4329
274	61.8259	32.5689	2.9404
275	39.5073	27.9181	6.7036
276	22.3924	11.3939	8.1974
277	47.1897	68.8294	2.8766
278	47.9333	30.0646	9.0663

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
279	35.6385	72.0776	7.7114
280	70.7039	18.4963	5.8275
281	30.5539	29.0469	9.7297
282	25.6826	11.5193	6.0839
283	42.4366	19.0733	2.9592
284	11.6283	48.3673	8.7199
285	26.4746	45.9294	8.7580
286	24.3320	18.7421	3.8197
287	56.1078	35.8493	3.9429
288	45.1142	25.9934	8.5601
289	43.4595	47.1274	5.4328
290	48.6636	20.5113	1.4671
291	48.3232	59.2629	8.0022
292	33.8786	7.4941	4.8401
293	9.7357	38.1791	3.5197
294	5.3190	8.1163	4.0016
295	33.9630	21.2391	4.3025
296	61.0577	15.4065	8.1531
297	47.1833	59.1470	1.3482
298	50.7942	30.6247	7.5400
299	63.2303	38.7637	8.8542
300	25.2480	9.3015	3.5723
301	22.7728	17.3321	6.9116
302	51.6983	39.1263	3.0870
303	21.3830	31.6147	6.5976
304	70.0004	44.3439	1.6761
305	48.1769	52.6185	9.7008
306	22.7428	18.0102	6.4897
307	27.1083	17.1579	4.4534
308	42.0313	40.9350	1.2751
309	45.2150	31.3197	8.7181
310	52.8068	33.5483	6.4319
311	38.9995	18.5739	8.6306
312	16.4212	17.5236	5.5415
313	34.8858	40.7799	1.0712
314	7.7299	59.3358	9.2717
315	42.9370	27.5581	4.6963
316	42.8677	51.8028	7.5913
317	35.7780	56.1619	2.3599
318	17.9046	51.2000	8.3371
319	54.5523	58.6069	9.1864

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
320	49.7987	39.3130	8.0015
321	21.4690	6.4293	7.8141
322	11.0949	19.6039	4.6468
323	50.0706	30.7573	7.3171
324	43.4752	9.1342	6.0891
325	33.9321	24.5966	6.2626
326	37.5892	54.5783	4.1042
327	44.9527	20.3255	7.3381
328	26.1470	36.7163	2.4478
329	59.2319	38.0214	1.0136
330	39.1108	64.0874	6.0580
331	20.5586	29.1363	5.9184
332	25.1091	44.0893	5.9574
333	58.4089	12.8109	7.2508
334	22.5024	18.7143	9.3474
335	15.6586	38.7758	9.4979
336	52.5788	42.0725	9.1294
337	38.6543	25.4639	6.4370
338	70.0588	37.9122	9.3359
339	28.8682	22.1211	2.0525
340	43.9676	42.9042	4.0672
341	33.0105	21.6275	1.3306
342	40.5376	37.5217	5.8453
343	6.8376	39.2069	7.6351
344	37.4942	57.2147	2.6310
345	46.0518	14.8424	4.8362
346	33.2378	36.8960	1.8835
347	27.3385	4.5599	3.7290
348	33.7651	35.4472	8.0211
349	0.1800	46.4052	5.8326
350	54.0311	15.5470	7.9216
351	39.0357	29.9143	6.7505
352	42.5099	53.8103	9.0383
353	44.2450	60.9298	1.5462
354	38.1135	33.3675	2.5819
355	56.9726	58.0971	4.7470
356	14.6845	30.6908	7.6581
357	32.0885	18.7677	9.0366
358	51.4020	31.6027	1.2327
359	33.0908	4.2900	2.2381
360	44.0488	19.5624	4.8168

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
361	6.3355	22.9796	7.8811
362	39.1458	56.3071	5.7199
363	51.3902	37.0426	7.7903
364	0.1800	67.4024	2.5282
365	29.4059	40.7522	7.0545
366	12.4471	39.2273	6.5679
367	16.1634	29.6045	1.0616
368	43.2139	18.4743	7.6620
369	51.5042	36.1579	9.9256
370	29.8423	27.0644	2.1536
371	24.6796	7.3791	4.2452
372	63.3708	41.9156	2.7197
373	31.8979	30.5835	7.4296
374	39.6768	37.7000	2.6008
375	27.5346	24.6601	9.8816
376	41.7888	44.7566	1.1530
377	12.9639	23.3577	1.3582
378	33.6927	39.2631	8.2390
379	18.5715	44.4699	8.7381
380	30.1396	31.2442	6.0963
381	44.8252	17.9939	7.7870
382	65.9889	37.3107	5.6756
383	25.7993	51.2866	6.2731
384	42.2209	0.1800	2.7166
385	25.7157	35.2334	5.5310
386	34.8241	35.6856	1.4582
387	79.7098	39.1659	1.5049
388	36.3555	27.0221	4.0168
389	23.3842	38.9697	6.6781
390	50.0371	24.0985	9.0278
391	48.7469	37.5883	7.0606
392	7.9720	52.4690	7.1674
393	22.6652	31.8205	7.2617
394	25.8664	15.3463	8.1985
395	29.1056	31.6105	6.9454
396	35.0818	40.5683	5.6794
397	23.9940	28.8296	3.9856
398	40.5574	61.0213	9.4076
399	41.1793	25.9805	3.2183
400	19.2905	26.2487	5.6009
401	39.5987	60.4944	7.6629

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
402	14.6357	38.3107	3.2875
403	47.0815	42.2552	8.6103
404	29.7692	55.5606	5.8434
405	45.3338	22.4136	9.1912
406	16.7755	30.2383	4.1564
407	46.3644	47.8249	9.4179
408	28.7289	20.0557	9.3495
409	32.1226	37.3144	6.2893
410	28.8046	13.9431	1.9159
411	44.5207	41.8219	4.3019
412	63.3787	70.5943	3.4826
413	48.2683	30.6244	3.3949
414	33.8242	26.6289	3.0388
415	20.8737	61.0181	1.0119
416	34.7341	17.6999	9.0371
417	16.7063	27.0568	5.0815
418	31.8774	32.7868	6.2058
419	49.0345	43.4499	3.8404
420	31.8750	15.1826	9.9462
421	53.2129	17.2037	9.8550
422	25.0305	38.4073	9.6809
423	40.6258	30.1810	6.9964
424	38.8341	5.3999	7.5354
425	9.9976	4.6067	4.0064
426	24.6353	4.4646	5.7050
427	50.0820	33.6635	3.4602
428	14.3702	40.8856	7.4654
429	30.7792	44.4511	8.0022
430	17.0958	15.6335	1.7296
431	17.0083	0.1800	2.9942
432	17.9758	43.2039	2.8356
433	47.0523	31.9299	6.6169
434	33.4428	33.0376	7.5268
435	39.5689	26.5651	8.5093
436	24.0801	28.1406	1.1701
437	31.2560	65.0292	2.8191
438	47.2829	30.7692	5.2218
439	11.8754	41.8465	4.4056
440	20.6915	0.1800	4.0635
441	50.3430	8.5443	1.5747
442	61.5738	20.3049	7.8520

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
443	18.9469	35.7799	4.6240
444	40.6547	39.3610	7.0686
445	12.5520	75.1631	5.9597
446	44.2950	4.0444	1.4631
447	35.5521	4.5309	3.7675
448	16.4368	28.6470	9.6890
449	41.8161	18.8429	9.3833
450	54.4084	16.0236	4.4022
451	30.7066	49.2149	6.5590
452	18.3561	26.2220	6.0628
453	14.7006	41.1420	8.4750
454	12.6353	36.7241	9.6193
455	39.9743	6.6558	1.6796
456	38.9899	46.0977	8.9922
457	20.2737	29.0616	6.0620
458	45.9005	22.2974	2.7492
459	15.5736	30.7802	2.9931
460	58.1227	39.8891	7.3519
461	0.1800	51.7493	6.3709
462	28.7704	35.0348	6.2767
463	45.8885	4.5887	9.7164
464	33.5379	47.2388	6.2357
465	34.1512	24.2254	1.8982
466	24.8580	64.0868	2.4994
467	66.0876	43.5006	1.9188
468	25.6611	44.2358	2.3162
469	44.9666	27.6496	7.0441
470	53.5209	19.2792	6.7587
471	27.6707	21.1683	4.3519
472	57.4774	11.7231	2.4659
473	40.7318	19.6054	4.5057
474	8.5366	53.0321	8.1998
475	25.4787	23.3623	4.5981
476	30.9131	32.3405	7.7961
477	43.9654	59.2898	3.6569
478	45.2118	25.0215	6.7601
479	44.9511	29.9759	8.9661
480	9.2167	44.8556	2.8868
481	7.9041	36.6568	5.3232
482	55.7585	41.0434	2.0169
483	47.0574	27.0273	2.1913

Continued on next page

Table B.82 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
484	40.2031	30.3851	1.5760
485	59.1032	60.3317	1.7137
486	64.1158	67.0249	6.6426
487	20.4617	32.7607	4.7020
488	34.0317	20.4323	6.7473
489	40.5178	31.8195	8.7090
490	35.3394	23.7096	7.8722
491	36.7134	21.3575	9.7854
492	36.5692	0.4270	8.0338
493	51.4429	7.4985	9.4202
494	0.1800	32.8437	7.6524
495	33.2351	22.5485	3.2826
496	29.1595	55.3714	7.4733
497	25.5216	2.4799	7.2416
498	35.7335	17.8552	7.9599
499	42.2368	41.7127	7.7250
500	28.5843	41.1501	3.8655

Table B.83: Depot locations and number of vehicles for MS42

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	19.8222	32.6840	2
2	19.5072	88.0338	3

Table B.84: Customer locations and service time for MS42

Customer index	x-coordinate	y-coordinate	Service time (short)
1	9.0190	22.3647	5.5939
2	25.6813	16.4739	7.9576
3	46.6143	30.2990	6.1553
4	8.3328	6.2406	9.5847
5	6.3837	25.8043	2.5442
6	6.8673	39.6886	9.1651
7	6.7582	15.5750	7.7700
8	43.9370	17.5988	3.5756
9	40.0121	2.6705	6.6467
10	0.0121	49.3136	5.1655
11	32.8627	14.0979	2.1650
12	62.3673	94.8101	5.9445
13	5.5398	94.5378	9.7256
14	20.0722	41.4347	4.9793
15	32.4169	73.9770	6.3187
16	0.3770	16.1510	1.9987
17	24.6303	39.9337	2.7987
18	41.2569	97.0691	2.4667
19	4.8959	31.3015	1.3319
20	70.0663	87.1594	3.4545
21	94.2987	51.8894	3.0712
22	71.6347	23.4293	4.2269
23	25.6035	40.8361	2.2091
24	7.7772	78.7899	9.9874
25	55.7437	3.9496	5.6217
26	5.6136	15.6314	4.4906
27	91.6510	98.4412	3.2487
28	38.4723	16.1887	4.2828
29	36.0315	43.4092	4.5915
30	2.9792	81.2428	9.3367
31	0.8163	99.0785	5.4593
32	6.5159	42.6622	6.4827
33	73.7143	1.1758	1.0433

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	83.0043	0.1304	6.2896
35	48.9487	38.2037	7.9972
36	52.5889	32.1653	6.9146
37	5.2848	92.5376	5.7548
38	33.1838	55.6673	8.4320
39	65.7118	43.8928	9.6619
40	16.3089	27.3857	3.8236
41	97.7012	6.7545	8.1738
42	0.8100	92.5432	3.5666
43	10.3003	29.1820	1.1341
44	26.1539	0.0916	1.8473
45	0.3673	48.4854	3.9585
46	52.6623	27.0105	3.7501
47	30.9754	0.3485	1.1622
48	28.0222	79.2164	2.4599
49	68.8871	10.9034	4.9959
50	73.7467	5.2763	7.9009
51	62.2567	1.2984	7.1313
52	10.1018	9.6673	7.4308
53	20.4492	5.2181	5.1380
54	56.5847	42.5100	9.2734
55	1.2070	0.4377	9.9005
56	1.2043	7.5862	9.3934
57	7.2837	7.9423	5.1537
58	27.5244	77.4517	9.1443
59	94.6050	19.7429	4.4781
60	50.4681	57.1406	6.4271
61	9.7257	36.3967	6.0429
62	8.4947	61.3506	8.6126
63	72.3108	1.2980	3.5632
64	83.1101	95.7587	6.9699
65	40.8674	72.0116	6.4203
66	6.5214	0.2565	6.9082
67	0.7862	21.7344	3.7894
68	70.2672	10.6050	3.9848
69	34.1896	39.7158	2.6938
70	89.8910	5.3038	1.9062
71	0.3725	33.6267	3.5791
72	34.1805	36.3798	4.1934
73	8.1287	35.9855	5.8219
74	68.5141	20.1088	9.9175

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	3.6476	0.1255	1.2536
76	19.5833	26.4006	7.3858
77	15.4773	16.6244	9.1464
78	68.3225	1.1674	8.7925
79	45.8154	21.1486	2.0725
80	4.3099	20.3295	9.5975
81	10.1191	30.3756	4.9681
82	1.7905	64.8676	8.8818
83	45.0862	49.1191	8.7846
84	32.6031	76.0795	4.1964
85	2.8821	0.2724	6.6803
86	2.1802	4.8260	8.7809
87	22.6652	21.1271	1.1889
88	82.4650	91.8787	1.6914
89	30.4897	62.4172	4.3904
90	0.1085	20.4191	2.3427
91	0.2901	11.1174	1.3069
92	64.8127	0.3492	8.0402
93	20.3739	54.8941	3.9452
94	14.6418	25.6841	8.3573
95	62.3537	3.9970	2.5626
96	13.2705	18.2494	7.0851
97	28.3396	2.8456	8.8804
98	50.6455	56.5045	7.8144
99	75.9471	13.5682	3.0666
100	10.8037	88.7021	4.2305
101	42.2653	0.0295	4.2685
102	95.0306	68.7334	3.4070
103	0.5771	39.2616	4.0357
104	34.4592	29.0248	1.7826
105	17.1302	42.3160	5.0640
106	9.5565	52.7990	5.0920
107	6.9608	0.8928	1.2613
108	57.5726	77.0136	6.7339
109	99.0455	0.0206	1.5351
110	3.4809	8.6614	2.5228
111	61.0188	3.2369	7.1621
112	3.8337	85.8021	5.9911
113	98.4776	0.4649	1.0543
114	64.3624	33.7669	3.5928
115	17.9968	40.5962	4.3895

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	53.1243	42.4152	2.3184
117	24.8356	74.7571	1.6708
118	65.4465	0.3131	5.1467
119	12.7099	66.7252	4.3335
120	0.5365	27.9759	8.4210
121	34.9271	48.2123	5.8378
122	82.8442	4.5116	8.3576
123	3.7545	29.5153	5.1434
124	18.6942	49.3535	1.1263
125	56.1240	91.4767	1.0448
126	0.1535	19.7618	2.4960
127	89.5531	0.7293	4.2934
128	58.3197	0.3288	7.4639
129	31.2280	39.6208	2.4348
130	3.3798	63.3901	3.5089
131	24.7953	47.7745	6.8044
132	26.8164	11.9238	3.5848
133	98.8519	89.6462	3.8974
134	73.0771	27.0598	2.3988
135	92.6221	90.9759	4.4890
136	46.0961	0.5416	9.0616
137	16.2813	4.2862	8.9899
138	87.4186	60.0668	4.5425
139	22.9905	83.5739	7.0791
140	5.3727	61.2386	3.2699
141	15.7046	8.7340	9.5499
142	49.7134	2.3057	6.6221
143	31.1988	71.8952	2.8625
144	57.2490	61.5997	1.9869
145	99.0983	7.3350	6.0926
146	92.6274	5.1898	3.4690
147	28.6297	10.3056	1.6405
148	92.9046	68.8173	2.4260
149	1.3369	67.5984	1.4457
150	0.2647	32.5679	7.1280
151	9.2628	32.6989	8.0358
152	33.6623	8.1806	8.2663
153	28.1923	48.8788	3.3855
154	81.2176	63.4027	9.0631
155	29.2195	19.5001	6.4719
156	18.6607	19.9108	1.1296

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	29.4487	21.6841	4.0963
158	50.7535	7.7863	5.8030
159	0.0278	45.6132	6.6499
160	64.1474	81.6610	5.0206
161	2.0309	82.5419	8.3000
162	22.8938	55.8303	2.3035
163	6.5964	6.7866	9.7735
164	13.6229	47.5600	8.5038
165	43.7933	1.7379	4.0609
166	2.8767	1.5252	6.5462
167	7.7721	3.6444	3.7338
168	3.9292	2.1238	1.8030
169	3.8053	34.2276	5.6937
170	10.6824	0.5382	8.4276
171	77.4995	67.6220	7.8753
172	22.1937	52.2589	9.5288
173	16.3191	85.7213	4.0019
174	3.2124	24.2693	4.5076
175	93.8816	42.8872	2.3537
176	16.6020	79.2320	4.0033
177	71.3159	29.0010	5.9831
178	37.8625	7.9640	5.9526
179	14.1836	95.2493	2.4438
180	76.9448	0.1327	2.0538
181	61.5993	10.6436	4.5870
182	21.6182	94.6756	8.4824
183	66.2558	13.3249	2.6650
184	80.7202	9.5573	5.5071
185	18.4246	1.4620	2.1368
186	11.1776	83.8627	8.7817
187	35.5988	1.8354	7.8998
188	81.3587	11.0302	6.0792
189	49.2897	80.5470	4.5061
190	14.2472	24.9649	5.4112
191	54.0160	37.8580	8.9821
192	91.0312	34.0044	9.1454
193	29.4646	48.7559	5.4855
194	29.1714	0.0860	5.7630
195	9.6789	27.8660	9.1873
196	0.5074	0.1029	6.2074
197	3.3117	68.4164	7.9821

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	0.8647	11.5591	6.9526
199	21.4822	71.6919	5.2269
200	0.0087	6.0550	2.9779
201	83.7272	33.8132	6.4233
202	41.3117	87.9238	2.6583
203	0.0002	0.2284	2.7776
204	0.0923	0.2914	8.7579
205	4.3460	0.0425	2.1308
206	20.6994	46.4413	6.8102
207	1.6197	35.8356	4.9359
208	0.0075	1.3003	6.5134
209	52.8645	63.4007	7.6373
210	12.5398	38.1739	3.7295
211	60.9096	0.4930	1.3867
212	19.0669	0.4800	8.5196
213	19.0580	1.8498	4.3238
214	0.2422	62.2350	6.9521
215	0.2463	0.8537	9.0615
216	0.8299	5.6582	3.4669
217	35.2880	5.9364	9.9811
218	5.8122	1.0988	8.5092
219	70.7902	73.6769	8.1221
220	73.4814	48.7483	6.9095
221	92.8548	53.8378	5.8931
222	23.9023	42.3190	4.4801
223	4.8537	26.6535	8.4001
224	5.1170	10.6529	6.3580
225	28.8141	43.7948	8.0348
226	58.0811	1.3822	9.8891
227	12.0803	2.1850	8.0943
228	21.2735	0.0391	8.6763
229	40.8735	92.9859	5.3705
230	84.1505	94.1624	8.8638
231	2.6106	1.5341	4.0046
232	51.2134	21.8472	2.8479
233	33.3782	43.1247	5.4492
234	18.7748	8.4208	1.2809
235	78.1885	56.9326	8.4482
236	15.4490	31.1496	3.3783
237	3.2032	18.3007	7.0975
238	40.1111	7.1393	8.1448

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	38.9377	56.8118	7.1366
240	10.7546	80.7080	6.8568
241	64.4753	53.0631	3.1361
242	99.8956	16.5511	5.2966
243	96.2318	88.0437	9.4278
244	1.6138	6.5243	3.1699
245	5.3935	28.4263	2.8820
246	0.0558	91.1557	3.4522
247	36.8974	7.1689	7.9824
248	1.2279	6.2542	3.9827
249	16.6023	86.0577	6.4277
250	78.1592	0.4704	2.6561
251	30.0450	8.9641	1.7871
252	13.6163	34.9971	3.7802
253	4.3408	4.1331	3.0779
254	19.4431	40.4347	9.1827
255	91.4311	63.7395	9.4320
256	1.5382	25.1704	1.2869
257	22.1618	42.3556	6.3428
258	73.4271	63.3544	1.3944
259	0.1883	5.4463	4.8241
260	47.8345	36.1007	5.6942
261	95.8413	1.2648	8.5631
262	8.0241	26.6014	6.6253
263	1.7897	70.1977	3.2968
264	46.9608	84.7854	9.1422
265	82.7108	24.8231	7.9057
266	37.3161	7.7068	6.0640
267	80.9969	42.5782	9.0744
268	3.7417	84.1437	4.3127
269	56.9156	25.9936	4.0396
270	11.9896	94.9049	6.5697
271	17.5247	3.8919	1.7821
272	2.4249	1.2362	4.3795
273	67.0762	8.8420	2.6864
274	39.0529	15.7148	8.2947
275	54.5471	17.7035	7.5092
276	64.8206	9.7017	7.0721
277	0.4519	48.1418	9.2258
278	90.4002	0.8440	8.3886
279	24.7583	16.1675	5.9385

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	57.0245	8.7132	1.1399
281	55.1165	9.3940	1.8522
282	69.0776	1.1143	5.6328
283	2.4493	35.2631	9.5723
284	20.9131	7.9935	8.5876
285	38.2048	2.4094	9.4151
286	86.8966	0.0000	9.7607
287	69.7372	8.0426	4.3527
288	80.1783	30.3393	3.8881
289	33.9328	75.8471	8.0492
290	33.9594	0.1785	2.9100
291	73.0898	81.8522	9.6324
292	0.1216	1.7154	9.3721
293	78.3969	69.5104	4.2916
294	16.6244	64.0750	4.1042
295	0.1324	84.2504	7.2341
296	55.6737	1.8852	7.4494
297	2.3972	25.4755	8.2031
298	2.0710	16.3991	6.3430
299	36.7186	3.0127	1.8746
300	6.4760	33.0836	6.0356
301	10.5076	36.7500	1.3878
302	16.1436	4.5987	7.8187
303	16.5139	27.0330	6.9368
304	14.9144	97.8489	6.3951
305	37.1858	24.0017	3.0430
306	2.7853	48.2849	7.4234
307	3.5379	16.9268	7.5205
308	0.8955	0.1209	4.0980
309	10.4449	8.5750	1.2948
310	59.2279	64.2309	8.5925
311	5.4811	12.0064	7.9327
312	54.8141	0.6942	5.5868
313	47.9997	26.1230	7.3627
314	67.9105	13.4567	8.1206
315	68.5547	54.6830	3.9760
316	8.6065	27.5352	9.2231
317	9.5709	64.7254	6.1903
318	27.3560	66.7344	3.5912
319	10.5819	3.5899	3.4018
320	69.1962	1.5300	9.0116

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
321	65.6578	67.4035	4.2949
322	31.0247	40.6913	2.3501
323	6.9150	0.0260	9.5169
324	46.3170	80.2735	6.8575
325	5.4594	26.5611	9.8399
326	20.8324	29.6504	2.7445
327	14.7892	36.7772	8.4587
328	29.0092	57.8263	5.4442
329	98.3476	73.1618	6.3170
330	57.0358	14.6588	1.4040
331	96.1292	0.7165	6.0801
332	5.5123	53.8570	6.7019
333	27.9375	11.0217	5.4829
334	0.2646	70.5179	1.5366
335	57.2860	13.8178	5.6365
336	36.2380	68.5941	1.4788
337	73.4738	3.1159	8.5927
338	97.6692	1.6775	6.3521
339	86.3941	77.4195	7.2192
340	16.7702	0.1943	6.8250
341	0.0000	47.1584	6.6110
342	29.2549	53.8423	9.5847
343	4.3152	19.1120	2.5925
344	4.8085	14.4278	5.2741
345	10.6150	95.9729	8.5816
346	0.9206	15.9196	5.4727
347	55.8807	19.3765	7.8616
348	56.0266	2.4589	2.6189
349	29.5174	10.6298	7.2246
350	11.4333	9.8635	9.2298
351	69.2779	80.0131	2.4639
352	30.5336	6.1021	4.8529
353	91.6889	9.6521	1.3767
354	79.7151	16.7174	3.0317
355	12.7095	50.1279	6.9954
356	29.8555	2.0632	8.8421
357	12.0188	75.9202	4.1026
358	38.7883	0.6915	1.2453
359	63.4611	21.3202	9.1475
360	55.6329	0.0923	5.2396
361	1.5759	56.7311	9.1942

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
362	67.6332	49.0060	3.9518
363	0.0633	4.6016	7.2199
364	17.1751	46.2270	1.1570
365	53.4957	31.0575	5.6111
366	61.0545	72.3655	3.9863
367	13.4899	31.1995	4.0250
368	55.4828	81.3196	9.5801
369	79.6141	17.5995	7.7545
370	5.8856	12.8256	4.0053
371	1.6795	23.9109	6.6955
372	5.0656	6.5517	4.7399
373	12.2510	86.3356	6.1885
374	8.2418	21.7862	9.6355
375	86.0234	6.4520	6.5426
376	0.2633	18.5949	2.3552
377	35.1254	49.3548	8.5444
378	2.6536	16.1869	7.5355
379	70.2924	3.3066	1.9796
380	2.8077	73.3166	2.4522
381	25.2205	34.1291	3.6731
382	99.8659	13.9561	4.8122
383	12.6314	4.9148	5.7557
384	0.2216	4.7958	3.4759
385	4.5651	27.2727	8.4516
386	15.8276	18.7855	8.1351
387	11.1334	54.9532	3.4637
388	5.2717	0.4963	6.5412
389	87.6321	71.7974	1.9140
390	46.6747	46.2237	7.0297
391	92.5663	1.8674	4.1266
392	19.1821	73.6854	7.0255
393	88.4233	3.9934	3.6577
394	0.0034	36.8862	7.1239
395	37.2475	29.4898	4.5440
396	64.1722	2.6349	4.5264
397	5.4280	0.0032	2.8627
398	86.9498	59.5189	7.5207
399	58.2570	58.4900	8.3737
400	68.3019	17.7299	9.3382
401	32.8860	0.3228	5.6271
402	62.8186	34.3100	2.7383

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
403	10.8268	3.0330	6.4261
404	4.9935	53.0873	2.7836
405	9.7585	28.5467	4.6935
406	34.1668	6.4042	8.6777
407	68.8757	84.0993	4.8617
408	8.4368	57.4859	9.3309
409	16.2050	78.6824	4.3577
410	74.3143	0.4733	7.2842
411	37.7905	3.3683	6.2976
412	98.2453	54.3276	1.9078
413	4.1493	48.5412	4.7116
414	68.4275	60.3718	9.3224
415	45.6789	25.1907	1.5000
416	6.1976	18.1048	4.4564
417	22.6372	37.3611	3.1658
418	15.9261	73.2346	3.0503
419	35.9326	44.9969	4.2141
420	64.0837	27.4149	9.3169
421	1.1039	8.9291	5.5225
422	67.4767	49.5572	8.2291
423	70.7426	14.5627	4.1524
424	12.5675	32.2266	5.1281
425	18.4960	78.8297	9.5599
426	32.7458	71.0564	2.1969
427	49.1155	80.7839	1.6328
428	55.1261	88.1727	7.3547
429	57.4388	66.4934	9.3853
430	15.1421	0.0002	1.9801
431	18.4301	0.0010	6.8653
432	91.4595	0.7651	2.3146
433	32.8296	6.7979	7.2457
434	72.2028	0.0520	6.6305
435	7.6367	17.9848	1.3935
436	38.7287	11.6325	8.1813
437	34.6169	29.3064	9.8759
438	92.8271	85.7789	4.9307
439	0.7379	8.9102	4.1027
440	25.0499	11.4301	1.4393
441	27.2056	73.8706	3.0268
442	0.8130	11.5925	6.2291
443	81.8421	1.9077	6.4124

Continued on next page

Table B.84 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
444	78.2144	25.7860	3.2727
445	19.2712	73.3860	6.8891
446	61.1090	14.7697	1.5409
447	2.2042	48.3986	9.4646
448	38.4172	39.4264	1.8328
449	6.7925	20.2849	4.0058
450	19.8609	22.4314	6.8594

Table B.85: Depot locations and number of vehicles for MS43

Depot index	x-coordinate	y-coordinate	Number of vehicles
1	74.0844	94.6916	2
2	73.7633	51.0100	2

Table B.86: Customer locations and service time for MS43

Customer index	x-coordinate	y-coordinate	Service time (short)
1	28.3119	10.2175	5.5352
2	1.9369	38.5861	5.7783
3	28.4609	13.5457	4.4121
4	25.1899	57.2641	7.9202
5	26.2727	18.3687	3.5426
6	59.3718	0.0334	6.8435
7	83.6215	2.2595	9.2997
8	86.9774	51.3452	3.9760
9	1.2457	10.0833	8.3210
10	58.8032	41.2004	8.0887
11	1.9156	0.0171	2.1189
12	8.3097	83.9081	2.4165
13	1.6177	56.2041	4.7350
14	0.3844	3.5590	7.1860
15	74.0135	83.8281	6.9193
16	36.7357	21.9723	7.1198
17	0.0378	3.9751	1.0845
18	12.6171	6.8213	2.1575
19	1.0731	73.6742	7.8752
20	26.8085	31.5963	8.5772
21	97.2012	42.2006	7.7225
22	14.2219	27.1965	9.5007
23	59.1214	17.0236	9.2774
24	22.3319	72.9648	3.0077
25	7.5629	0.8962	5.5879
26	15.4122	12.9460	8.0897
27	16.9442	70.0670	5.7021
28	32.0996	18.8434	6.5565
29	57.1275	0.4676	6.0242
30	32.6086	4.7045	7.5789
31	97.9749	9.8793	1.5706
32	15.3021	28.4922	5.4351
33	0.1766	54.7129	3.0693

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
34	81.8217	18.5530	4.0365
35	93.0086	56.4346	5.9647
36	1.2942	46.3350	7.6932
37	56.7097	0.7956	4.7107
38	98.2249	1.3174	5.5686
39	3.4255	4.2194	2.1608
40	73.8741	0.5504	2.9335
41	1.4432	67.4304	3.6355
42	81.8343	23.2767	5.0497
43	41.9178	13.9125	3.1625
44	16.5307	0.7537	3.3694
45	17.2074	11.2917	9.0242
46	11.0435	37.3085	6.2753
47	12.3885	6.7596	9.4481
48	32.1071	3.3257	6.5627
49	74.0015	15.9724	3.2565
50	6.1539	83.7230	1.9228
51	57.4887	0.6028	5.9173
52	12.2179	89.5677	4.9838
53	2.0342	22.3705	7.2236
54	83.8377	77.6420	7.8350
55	0.0779	38.4223	4.5948
56	93.8070	3.5032	6.1067
57	2.7092	57.1391	2.8503
58	2.6990	1.3358	9.4918
59	90.2771	8.2572	5.6153
60	20.6219	38.6699	3.4862
61	0.3230	56.4122	3.0623
62	46.0399	55.8228	9.5764
63	3.7455	5.4176	7.2048
64	15.8883	90.2762	7.3709
65	4.4260	9.9043	6.9123
66	4.0327	14.4189	8.0107
67	90.3327	6.4169	6.2242
68	51.3804	0.0517	5.5291
69	12.0092	37.9563	8.9086
70	26.0452	54.7296	4.5365
71	0.0737	1.5014	3.1837
72	6.3257	3.7599	3.5346
73	18.6761	29.0390	9.1429
74	49.1451	82.6351	7.3241

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
75	55.3373	18.9862	8.6775
76	1.2868	66.0347	4.4082
77	30.6029	21.9315	6.6972
78	3.3861	41.5982	1.2840
79	81.2996	46.9522	9.2803
80	1.9714	7.4670	5.2277
81	94.5505	23.4476	5.6791
82	1.0169	4.3830	7.8968
83	1.0013	63.2832	4.0259
84	22.6475	10.3616	6.6339
85	77.4049	89.7784	3.9421
86	67.6023	3.9532	3.8000
87	8.6373	10.3318	6.8147
88	2.8440	0.2915	4.9032
89	93.1546	82.5267	1.9260
90	5.8642	0.8384	3.1254
91	0.1839	24.0146	9.7460
92	43.1819	14.8299	7.2901
93	13.0868	46.7759	6.9351
94	43.1641	85.1029	3.9349
95	61.3917	2.2316	1.1784
96	4.5710	73.1834	6.1343
97	7.6679	39.6288	1.3270
98	52.0073	14.2588	3.3827
99	17.4364	0.0006	2.7159
100	33.5234	23.2957	5.0437
101	82.4339	0.0090	7.9179
102	95.2523	59.8249	6.6514
103	25.8933	36.2398	3.8323
104	52.0898	9.2071	3.6284
105	43.5921	87.4897	1.7041
106	50.7871	6.3675	2.5475
107	68.7401	33.5936	7.4915
108	36.0885	3.5601	1.8050
109	9.1416	38.4890	9.2603
110	63.4131	46.3669	4.8671
111	11.1338	0.0195	1.7175
112	31.0175	7.9422	6.1493
113	32.1154	34.4354	8.4860
114	68.0230	81.2467	4.1263
115	65.0923	7.0459	8.0190

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
116	14.7133	13.1547	7.3751
117	53.4345	85.7769	6.3185
118	19.3884	77.3506	4.3929
119	0.3049	0.0339	4.5444
120	8.1526	25.3211	4.8548
121	10.2900	95.5675	4.8072
122	0.1650	89.5235	2.9703
123	5.0475	73.8098	5.4709
124	15.3878	1.1348	1.3588
125	0.2704	28.5348	6.0833
126	88.4274	19.2847	1.4423
127	53.4782	25.5574	8.8505
128	0.0177	86.9024	8.7402
129	5.1890	1.0476	4.0443
130	27.5253	50.6139	9.7663
131	10.1825	53.4293	9.5930
132	33.9965	16.4678	9.8976
133	38.4215	27.4703	2.4195
134	61.8943	39.9031	1.0263
135	38.0766	11.8604	3.2336
136	94.1545	0.3819	4.1166
137	27.8445	14.4077	3.1000
138	44.4392	51.4318	7.8030
139	0.0583	63.1737	3.0333
140	19.7630	31.4571	5.0360
141	2.3623	94.6242	3.3350
142	35.0389	1.5330	4.1122
143	28.9424	15.2028	9.1266
144	3.0169	63.4265	1.1143
145	0.0077	23.0480	2.1900
146	22.6626	89.5248	4.4926
147	0.5560	1.8992	8.5656
148	6.8110	31.0322	2.9194
149	18.7117	20.4296	9.4171
150	0.0975	18.7610	9.7282
151	3.0800	10.2147	4.3773
152	0.1631	39.5165	9.8638
153	12.5071	84.9662	2.0988
154	38.4929	29.5555	7.8486
155	27.3974	90.6601	6.2143
156	0.7763	6.8509	6.5904

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
157	97.0513	92.5441	5.4091
158	71.1165	0.2094	2.9841
159	27.9241	6.6372	2.2972
160	20.8857	0.3913	6.7166
161	88.4181	23.6815	8.2217
162	11.6943	57.6226	7.0268
163	1.2180	54.7651	5.2444
164	79.2754	5.8093	9.5003
165	31.6099	0.0044	6.3233
166	51.8069	41.3827	3.0407
167	0.0218	6.1079	7.1546
168	15.3070	79.2014	3.8858
169	55.6890	16.2373	7.7403
170	75.2357	32.4222	9.9833
171	20.7021	7.2513	3.4276
172	2.9651	54.5861	9.3868
173	2.6567	81.9373	7.2675
174	2.7773	30.1441	1.8573
175	63.4069	12.9546	3.2128
176	20.7555	75.3357	9.4119
177	1.5639	29.9403	5.3181
178	77.2641	12.0965	8.9427
179	2.0635	2.9930	8.0137
180	1.0045	47.8758	1.1646
181	61.1735	35.7169	7.9369
182	85.1968	1.3402	7.1722
183	27.6450	8.9653	8.8090
184	2.7216	57.4758	6.2246
185	28.1543	5.7681	6.6349
186	34.3666	50.2786	2.0003
187	24.7261	52.2095	2.9232
188	76.4855	98.7822	1.3273
189	75.2929	39.0986	5.0009
190	1.6777	31.7045	3.9392
191	15.7649	48.4001	3.5856
192	53.9782	50.2879	5.4681
193	1.8278	57.3782	2.6353
194	88.7158	0.4009	9.4041
195	29.4031	1.9547	9.4616
196	7.7167	36.3334	6.3232
197	43.6922	27.1004	1.0073

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
198	35.8538	18.9228	9.1271
199	22.3748	26.0488	7.1460
200	1.1186	53.3175	1.6647
201	4.9124	0.0105	9.9675
202	86.6077	66.6385	3.8301
203	52.0152	1.9139	8.2830
204	38.5182	93.5800	5.1531
205	1.8314	44.6280	6.2843
206	33.6446	6.3128	5.2984
207	57.7786	12.6475	5.9721
208	16.1882	69.0166	2.5778
209	27.1020	0.2284	6.2852
210	1.0293	20.8602	2.3932
211	0.4263	56.0382	5.0091
212	3.3165	17.7601	5.8386
213	8.4734	0.7144	5.1571
214	6.5936	1.0900	8.5070
215	1.0058	26.7799	9.9656
216	87.3777	31.0539	9.7502
217	44.1014	47.3681	7.7134
218	99.1349	89.2432	2.7996
219	2.9551	6.0618	1.3270
220	24.2620	75.3515	2.6974
221	40.1750	41.4836	6.1979
222	59.8086	36.4972	6.6545
223	21.6382	1.3105	4.2830
224	50.4832	95.7972	6.7290
225	86.7933	2.4311	9.0216
226	83.7279	50.6843	3.2817
227	86.7991	56.1986	3.5772
228	34.8317	26.1755	2.1288
229	76.8460	7.3421	5.7572
230	31.0231	63.5821	8.3869
231	1.0213	61.4223	3.6980
232	41.7783	0.0560	8.0891
233	77.4087	16.5457	4.9331
234	18.5665	48.3854	5.9549
235	1.5617	0.1043	9.8750
236	42.4355	1.0822	7.2080
237	91.7915	65.6059	9.7312
238	73.5581	99.6405	1.8637

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
239	85.2681	8.3080	9.0828
240	6.7326	1.7496	1.5260
241	29.5365	77.7381	2.1099
242	11.0059	92.3477	6.6765
243	9.0453	16.1448	4.3309
244	18.3735	15.6568	3.8762
245	13.7869	23.3838	8.1612
246	1.4942	98.5042	3.7153
247	11.4006	9.6762	6.4672
248	1.5522	0.2914	5.1578
249	28.3538	1.5993	3.6333
250	73.7304	78.6279	8.4918
251	86.8373	41.6581	6.1347
252	8.1657	57.4660	1.6346
253	47.8883	19.3307	3.3968
254	10.8133	14.9980	2.5379
255	12.0811	48.8868	6.0428
256	21.9915	4.0747	2.8188
257	8.1164	4.1762	5.4313
258	24.5213	4.7921	7.5643
259	26.2145	42.1073	9.5950
260	25.2166	89.4353	7.8613
261	0.4099	8.4853	1.7206
262	37.2977	0.0050	9.4442
263	77.9433	70.1446	9.7703
264	57.6956	78.5765	6.4640
265	9.9283	0.7591	9.6175
266	2.5839	26.8679	3.9759
267	0.0891	2.1961	9.1109
268	61.5959	3.6133	1.0033
269	5.7435	66.1360	5.3495
270	17.2970	56.6708	2.3273
271	35.6467	89.4559	3.8349
272	24.0060	15.2911	2.5424
273	25.4375	4.9625	6.3362
274	12.1544	23.9058	6.9185
275	6.5687	94.5270	4.1407
276	48.7269	0.0092	1.4832
277	82.8806	24.9061	1.4245
278	3.0288	44.6227	1.5027
279	37.2604	68.2469	1.6436

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
280	5.0488	14.0148	1.1411
281	67.3435	18.0510	9.7631
282	79.3237	6.2008	7.6132
283	0.8995	71.6530	7.7715
284	1.5289	41.3723	1.2998
285	0.0000	73.2820	2.0585
286	1.8427	2.2318	3.3517
287	92.7605	43.8416	9.0402
288	20.7314	52.5340	9.7486
289	0.0006	98.8014	9.9467
290	23.9113	3.9239	4.1211
291	1.5999	25.2598	3.6307
292	86.4488	21.3589	2.6852
293	0.0155	1.6664	7.6883
294	0.5973	7.6816	7.4622
295	18.9869	11.0167	2.7001
296	32.3235	67.4324	4.9054
297	43.8450	20.2054	1.4103
298	7.7995	0.1610	6.8993
299	97.2875	16.3198	8.0294
300	39.1801	3.6645	8.7661
301	0.5978	0.0239	8.0682
302	20.5681	1.3013	4.9014
303	27.6795	61.8052	4.1304
304	25.3475	93.1939	1.4985
305	47.7521	30.1265	8.3750
306	0.2417	97.2601	1.9544
307	0.0324	27.6980	1.0547
308	23.6621	0.2382	3.4754
309	0.0055	56.4073	9.4849
310	29.6106	37.6477	7.0683
311	32.9429	32.3268	4.4709
312	61.9031	2.8599	8.7125
313	65.0846	3.0749	7.0734
314	2.7971	29.9211	6.4729
315	7.4727	38.3706	4.9548
316	22.1139	0.5495	9.6516
317	2.9213	6.7162	8.4062
318	23.8267	6.8836	1.0945
319	20.0738	0.2818	2.2746
320	61.8921	24.0002	5.3453

Continued on next page

Table B.86 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time (short)
321	16.9892	4.3314	6.2256
322	73.4855	30.0114	3.6369
323	89.8280	2.2741	4.9498
324	10.0294	37.1575	4.5844
325	15.3226	6.8447	2.2357
326	60.8937	0.0555	9.5749
327	35.2504	22.7244	4.2404
328	13.6968	32.4997	8.5328
329	19.7751	62.8598	1.3720
330	76.1118	45.7786	4.8145
331	69.0231	79.0552	1.6807
332	99.8002	39.0362	3.8243
333	33.8535	44.9029	9.5138
334	26.1647	43.2826	8.6905
335	70.5820	3.3446	2.5618
336	11.0997	21.9319	5.8230
337	96.4480	22.9324	3.6540
338	77.4971	5.0936	9.1258
339	0.2292	77.3938	1.7325
340	0.0583	14.0288	8.0873
341	93.9127	42.6868	2.5697
342	25.6156	44.2731	7.4799
343	1.8845	18.0951	3.0881
344	57.3236	1.8513	2.8642
345	2.7466	64.2301	2.9452
346	3.4748	10.7288	9.7900
347	13.7661	0.9637	4.4366
348	99.5529	64.1349	6.7176
349	38.4742	49.2405	1.4191
350	0.9138	25.3492	3.0886

Appendix C: Min-Max Single-Depot Vehicle Routing Problem test instances

In this appendix, we present the problem data for the Min-Max Single-Depot Vehicle Routing Problem used in Chapter 4. These data are modified from [25]. There are 21 instances. Each instance has customers located on concentric circles. The instances differ in the number of customers per circle (A) and the number of circles (B). Table C.1 gives the specification of each instance. The number n gives the number of customers, i.e., $n = A \times B$. The number m gives the number of vehicles. All customers require service time equal to 100.

Table C.2: Min-Max Single-Depot Split-Delivery VRP instance SD1

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	0.0000	100.0000	100
3	-100.0000	0.0000	100
4	0.0000	-100.0000	100
5	200.0000	0.0000	100
6	0.0000	200.0000	100
7	-200.0000	0.0000	100
8	0.0000	-200.0000	100
Depot	0	0	N.A.

Table C.1: SD instance specifications

Problem	A	B	n	m	Problem	A	B	n	m
SD1	4	2	8	6	SD12	8	10	80	12
SD2	4	4	16	6	SD13	8	12	96	12
SD3	8	2	16	12	SD14	12	10	120	18
SD4	12	2	24	18	SD15	12	12	144	18
SD5	8	4	32	12	SD16	72	2	144	108
SD6	16	2	32	24	SD17	8	20	160	12
SD7	4	10	40	6	SD18	16	10	160	24
SD8	4	12	48	6	SD19	16	12	192	24
SD9	12	4	48	18	SD20	12	20	240	18
SD10	16	4	64	24	SD21	72	4	288	108
SD11	4	20	80	6					

A : number of customers per circle

B : number of concentric circles

n : total number of customers

m : number of routes

l : number of longest routes

Table C.3: Min-Max Single-Depot Split-Delivery VRP instance SD2

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	0.0000	100.0000	100
3	-100.0000	0.0000	100
4	0.0000	-100.0000	100
5	200.0000	0.0000	100
6	0.0000	200.0000	100
7	-200.0000	0.0000	100
8	0.0000	-200.0000	100
9	300.0000	0.0000	100
10	0.0000	300.0000	100
11	-300.0000	0.0000	100
12	0.0000	-300.0000	100
13	400.0000	0.0000	100
14	0.0000	400.0000	100
15	-400.0000	0.0000	100
16	0.0000	-400.0000	100
Depot	0	0	N.A.

Table C.4: Min-Max Single-Depot Split-Delivery VRP instance SD3

Customer index	x-coordinate	y-coordinate	Service time
----------------	--------------	--------------	--------------

Table C.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
16	141.4210	-141.4210	100
Depot	0	0	N.A.

Table C.5: Min-Max Single-Depot Split-Delivery VRP instance SD4

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	86.6025	50.0000	100
3	50.0000	86.6025	100
4	0.0000	100.0000	100
5	-50.0000	86.6025	100
6	-86.6025	50.0000	100
7	-100.0000	0.0000	100
8	-86.6025	-50.0000	100
9	-50.0000	-86.6025	100
10	0.0000	-100.0000	100
11	50.0000	-86.6025	100
12	86.6025	-50.0000	100
13	200.0000	0.0000	100
14	173.2050	100.0000	100
15	100.0000	173.2050	100
16	0.0000	200.0000	100
17	-100.0000	173.2050	100
18	-173.2050	100.0000	100
19	-200.0000	0.0000	100
20	-173.2050	-100.0000	100
21	-100.0000	-173.2050	100
22	0.0000	-200.0000	100
23	100.0000	-173.2050	100
24	173.2050	-100.0000	100
Depot	0	0	N.A.

Table C.6: Min-Max Single-Depot Split-Delivery VRP instance SD5

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	70.7107	70.7107	100
3	0.0000	100.0000	100
4	-70.7107	70.7107	100
5	-100.0000	0.0000	100
6	-70.7107	-70.7107	100
7	0.0000	-100.0000	100
8	70.7107	-70.7107	100
9	200.0000	0.0000	100
10	141.4210	141.4210	100
11	0.0000	200.0000	100
12	-141.4210	141.4210	100
13	-200.0000	0.0000	100
14	-141.4210	-141.4210	100
15	0.0000	-200.0000	100
16	141.4210	-141.4210	100
17	300.0000	0.0000	100
18	212.1320	212.1320	100
19	0.0000	300.0000	100
20	-212.1320	212.1320	100
21	-300.0000	0.0000	100
22	-212.1320	-212.1320	100
23	0.0000	-300.0000	100
24	212.1320	-212.1320	100
25	400.0000	0.0000	100
26	282.8430	282.8430	100
27	0.0000	400.0000	100
28	-282.8430	282.8430	100
29	-400.0000	0.0000	100
30	-282.8430	-282.8430	100
31	0.0000	-400.0000	100
32	282.8430	-282.8430	100
Depot	0	0	N.A.

Table C.7: Min-Max Single-Depot Split-Delivery VRP instance SD6

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	92.3880	38.2683	100
3	70.7107	70.7107	100
4	38.2683	92.3880	100
5	0.0000	100.0000	100
6	-38.2683	92.3880	100
7	-70.7107	70.7107	100
8	-92.3880	38.2683	100
9	-100.0000	0.0000	100
10	-92.3880	-38.2683	100
11	-70.7107	-70.7107	100
12	-38.2683	-92.3880	100
13	0.0000	-100.0000	100
14	38.2683	-92.3880	100
15	70.7107	-70.7107	100
16	92.3880	-38.2683	100
17	200.0000	0.0000	100
18	184.7760	76.5367	100
19	141.4210	141.4210	100
20	76.5367	184.7760	100
21	0.0000	200.0000	100
22	-76.5367	184.7760	100
23	-141.4210	141.4210	100
24	-184.7760	76.5367	100
25	-200.0000	0.0000	100
26	-184.7760	-76.5367	100
27	-141.4210	-141.4210	100
28	-76.5367	-184.7760	100
29	0.0000	-200.0000	100
30	76.5367	-184.7760	100
31	141.4210	-141.4210	100
32	184.7760	-76.5367	100
Depot	0	0	N.A.

Table C.8: Min-Max Single-Depot Split-Delivery VRP instance SD7

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	0.0000	100.0000	100
3	-100.0000	0.0000	100
4	0.0000	-100.0000	100
5	200.0000	0.0000	100
6	0.0000	200.0000	100
7	-200.0000	0.0000	100
8	0.0000	-200.0000	100
9	300.0000	0.0000	100
10	0.0000	300.0000	100
11	-300.0000	0.0000	100
12	0.0000	-300.0000	100
13	400.0000	0.0000	100
14	0.0000	400.0000	100
15	-400.0000	0.0000	100
16	0.0000	-400.0000	100
17	500.0000	0.0000	100
18	0.0000	500.0000	100
19	-500.0000	0.0000	100
20	0.0000	-500.0000	100
21	600.0000	0.0000	100
22	0.0000	600.0000	100
23	-600.0000	0.0000	100
24	0.0000	-600.0000	100
25	700.0000	0.0000	100
26	0.0000	700.0000	100
27	-700.0000	0.0000	100
28	0.0000	-700.0000	100
29	800.0000	0.0000	100
30	0.0000	800.0000	100
31	-800.0000	0.0000	100
32	0.0000	-800.0000	100
33	900.0000	0.0000	100
34	0.0000	900.0000	100
35	-900.0000	0.0000	100
36	0.0000	-900.0000	100
37	1000.0000	0.0000	100
38	0.0000	1000.0000	100
39	-1000.0000	0.0000	100
40	0.0000	-1000.0000	100

Continued on next page

Table C.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
Depot	0	0	N.A.

Table C.9: Min-Max Single-Depot Split-Delivery VRP instance SD8

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	0.0000	100.0000	100
3	-100.0000	0.0000	100
4	0.0000	-100.0000	100
5	200.0000	0.0000	100
6	0.0000	200.0000	100
7	-200.0000	0.0000	100
8	0.0000	-200.0000	100
9	300.0000	0.0000	100
10	0.0000	300.0000	100
11	-300.0000	0.0000	100
12	0.0000	-300.0000	100
13	400.0000	0.0000	100
14	0.0000	400.0000	100
15	-400.0000	0.0000	100
16	0.0000	-400.0000	100
17	500.0000	0.0000	100
18	0.0000	500.0000	100
19	-500.0000	0.0000	100
20	0.0000	-500.0000	100
21	600.0000	0.0000	100
22	0.0000	600.0000	100
23	-600.0000	0.0000	100
24	0.0000	-600.0000	100
25	700.0000	0.0000	100
26	0.0000	700.0000	100
27	-700.0000	0.0000	100
28	0.0000	-700.0000	100
29	800.0000	0.0000	100
30	0.0000	800.0000	100
31	-800.0000	0.0000	100
32	0.0000	-800.0000	100

Continued on next page

Table C.9 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
33	900.0000	0.0000	100
34	0.0000	900.0000	100
35	-900.0000	0.0000	100
36	0.0000	-900.0000	100
37	1000.0000	0.0000	100
38	0.0000	1000.0000	100
39	-1000.0000	0.0000	100
40	0.0000	-1000.0000	100
41	1100.0000	0.0000	100
42	0.0000	1100.0000	100
43	-1100.0000	0.0000	100
44	0.0000	-1100.0000	100
45	1200.0000	0.0000	100
46	0.0000	1200.0000	100
47	-1200.0000	0.0000	100
48	0.0000	-1200.0000	100
Depot	0	0	N.A.

Table C.10: Min-Max Single-Depot Split-Delivery VRP instance SD9

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	86.6025	50.0000	100
3	50.0000	86.6025	100
4	0.0000	100.0000	100
5	-50.0000	86.6025	100
6	-86.6025	50.0000	100
7	-100.0000	0.0000	100
8	-86.6025	-50.0000	100
9	-50.0000	-86.6025	100
10	0.0000	-100.0000	100
11	50.0000	-86.6025	100
12	86.6025	-50.0000	100
13	200.0000	0.0000	100
14	173.2050	100.0000	100
15	100.0000	173.2050	100
16	0.0000	200.0000	100

Continued on next page

Table C.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
17	-100.0000	173.2050	100
18	-173.2050	100.0000	100
19	-200.0000	0.0000	100
20	-173.2050	-100.0000	100
21	-100.0000	-173.2050	100
22	0.0000	-200.0000	100
23	100.0000	-173.2050	100
24	173.2050	-100.0000	100
25	300.0000	0.0000	100
26	259.8080	150.0000	100
27	150.0000	259.8080	100
28	0.0000	300.0000	100
29	-150.0000	259.8080	100
30	-259.8080	150.0000	100
31	-300.0000	0.0000	100
32	-259.8080	-150.0000	100
33	-150.0000	-259.8080	100
34	0.0000	-300.0000	100
35	150.0000	-259.8080	100
36	259.8080	-150.0000	100
37	400.0000	0.0000	100
38	346.4100	200.0000	100
39	200.0000	346.4100	100
40	0.0000	400.0000	100
41	-200.0000	346.4100	100
42	-346.4100	200.0000	100
43	-400.0000	0.0000	100
44	-346.4100	-200.0000	100
45	-200.0000	-346.4100	100
46	0.0000	-400.0000	100
47	200.0000	-346.4100	100
48	346.4100	-200.0000	100
Depot	0	0	N.A.

Table C.11: Min-Max Single-Depot Split-Delivery VRP instance SD10

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	92.3880	38.2683	100
3	70.7107	70.7107	100
4	38.2683	92.3880	100
5	0.0000	100.0000	100
6	-38.2683	92.3880	100
7	-70.7107	70.7107	100
8	-92.3880	38.2683	100
9	-100.0000	0.0000	100
10	-92.3880	-38.2683	100
11	-70.7107	-70.7107	100
12	-38.2683	-92.3880	100
13	0.0000	-100.0000	100
14	38.2683	-92.3880	100
15	70.7107	-70.7107	100
16	92.3880	-38.2683	100
17	200.0000	0.0000	100
18	184.7760	76.5367	100
19	141.4210	141.4210	100
20	76.5367	184.7760	100
21	0.0000	200.0000	100
22	-76.5367	184.7760	100
23	-141.4210	141.4210	100
24	-184.7760	76.5367	100
25	-200.0000	0.0000	100
26	-184.7760	-76.5367	100
27	-141.4210	-141.4210	100
28	-76.5367	-184.7760	100
29	0.0000	-200.0000	100
30	76.5367	-184.7760	100
31	141.4210	-141.4210	100
32	184.7760	-76.5367	100
33	300.0000	0.0000	100
34	277.1640	114.8050	100
35	212.1320	212.1320	100
36	114.8050	277.1640	100
37	0.0000	300.0000	100
38	-114.8050	277.1640	100
39	-212.1320	212.1320	100
40	-277.1640	114.8050	100

Continued on next page

Table C.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
41	-300.0000	0.0000	100
42	-277.1640	-114.8050	100
43	-212.1320	-212.1320	100
44	-114.8050	-277.1640	100
45	0.0000	-300.0000	100
46	114.8050	-277.1640	100
47	212.1320	-212.1320	100
48	277.1640	-114.8050	100
49	400.0000	0.0000	100
50	369.5520	153.0730	100
51	282.8430	282.8430	100
52	153.0730	369.5520	100
53	0.0000	400.0000	100
54	-153.0730	369.5520	100
55	-282.8430	282.8430	100
56	-369.5520	153.0730	100
57	-400.0000	0.0000	100
58	-369.5520	-153.0730	100
59	-282.8430	-282.8430	100
60	-153.0730	-369.5520	100
61	0.0000	-400.0000	100
62	153.0730	-369.5520	100
63	282.8430	-282.8430	100
64	369.5520	-153.0730	100
Depot	0	0	N.A.

Table C.12: Min-Max Single-Depot Split-Delivery VRP instance SD11

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	0.0000	100.0000	100
3	-100.0000	0.0000	100
4	0.0000	-100.0000	100
5	200.0000	0.0000	100
6	0.0000	200.0000	100
7	-200.0000	0.0000	100
8	0.0000	-200.0000	100

Continued on next page

Table C.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
9	300.0000	0.0000	100
10	0.0000	300.0000	100
11	-300.0000	0.0000	100
12	0.0000	-300.0000	100
13	400.0000	0.0000	100
14	0.0000	400.0000	100
15	-400.0000	0.0000	100
16	0.0000	-400.0000	100
17	500.0000	0.0000	100
18	0.0000	500.0000	100
19	-500.0000	0.0000	100
20	0.0000	-500.0000	100
21	600.0000	0.0000	100
22	0.0000	600.0000	100
23	-600.0000	0.0000	100
24	0.0000	-600.0000	100
25	700.0000	0.0000	100
26	0.0000	700.0000	100
27	-700.0000	0.0000	100
28	0.0000	-700.0000	100
29	800.0000	0.0000	100
30	0.0000	800.0000	100
31	-800.0000	0.0000	100
32	0.0000	-800.0000	100
33	900.0000	0.0000	100
34	0.0000	900.0000	100
35	-900.0000	0.0000	100
36	0.0000	-900.0000	100
37	1000.0000	0.0000	100
38	0.0000	1000.0000	100
39	-1000.0000	0.0000	100
40	0.0000	-1000.0000	100
41	1100.0000	0.0000	100
42	0.0000	1100.0000	100
43	-1100.0000	0.0000	100
44	0.0000	-1100.0000	100
45	1200.0000	0.0000	100
46	0.0000	1200.0000	100
47	-1200.0000	0.0000	100
48	0.0000	-1200.0000	100
49	1300.0000	0.0000	100

Continued on next page

Table C.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
50	0.0000	1300.0000	100
51	-1300.0000	0.0000	100
52	0.0000	-1300.0000	100
53	1400.0000	0.0000	100
54	0.0000	1400.0000	100
55	-1400.0000	0.0000	100
56	0.0000	-1400.0000	100
57	1500.0000	0.0000	100
58	0.0000	1500.0000	100
59	-1500.0000	0.0000	100
60	0.0000	-1500.0000	100
61	1600.0000	0.0000	100
62	0.0000	1600.0000	100
63	-1600.0000	0.0000	100
64	0.0000	-1600.0000	100
65	1700.0000	0.0000	100
66	0.0000	1700.0000	100
67	-1700.0000	0.0000	100
68	0.0000	-1700.0000	100
69	1800.0000	0.0000	100
70	0.0000	1800.0000	100
71	-1800.0000	0.0000	100
72	0.0000	-1800.0000	100
73	1900.0000	0.0000	100
74	0.0000	1900.0000	100
75	-1900.0000	0.0000	100
76	0.0000	-1900.0000	100
77	2000.0000	0.0000	100
78	0.0000	2000.0000	100
79	-2000.0000	0.0000	100
80	0.0000	-2000.0000	100
Depot	0	0	N.A.

Table C.13: Min-Max Single-Depot Split-Delivery VRP instance SD12

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100

Continued on next page

Table C.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
2	70.7107	70.7107	100
3	0.0000	100.0000	100
4	-70.7107	70.7107	100
5	-100.0000	0.0000	100
6	-70.7107	-70.7107	100
7	0.0000	-100.0000	100
8	70.7107	-70.7107	100
9	200.0000	0.0000	100
10	141.4210	141.4210	100
11	0.0000	200.0000	100
12	-141.4210	141.4210	100
13	-200.0000	0.0000	100
14	-141.4210	-141.4210	100
15	0.0000	-200.0000	100
16	141.4210	-141.4210	100
17	300.0000	0.0000	100
18	212.1320	212.1320	100
19	0.0000	300.0000	100
20	-212.1320	212.1320	100
21	-300.0000	0.0000	100
22	-212.1320	-212.1320	100
23	0.0000	-300.0000	100
24	212.1320	-212.1320	100
25	400.0000	0.0000	100
26	282.8430	282.8430	100
27	0.0000	400.0000	100
28	-282.8430	282.8430	100
29	-400.0000	0.0000	100
30	-282.8430	-282.8430	100
31	0.0000	-400.0000	100
32	282.8430	-282.8430	100
33	500.0000	0.0000	100
34	353.5530	353.5530	100
35	0.0000	500.0000	100
36	-353.5530	353.5530	100
37	-500.0000	0.0000	100
38	-353.5530	-353.5530	100
39	0.0000	-500.0000	100
40	353.5530	-353.5530	100
41	600.0000	0.0000	100
42	424.2640	424.2640	100

Continued on next page

Table C.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
43	0.0000	600.0000	100
44	-424.2640	424.2640	100
45	-600.0000	0.0000	100
46	-424.2640	-424.2640	100
47	0.0000	-600.0000	100
48	424.2640	-424.2640	100
49	700.0000	0.0000	100
50	494.9750	494.9750	100
51	0.0000	700.0000	100
52	-494.9750	494.9750	100
53	-700.0000	0.0000	100
54	-494.9750	-494.9750	100
55	0.0000	-700.0000	100
56	494.9750	-494.9750	100
57	800.0000	0.0000	100
58	565.6850	565.6850	100
59	0.0000	800.0000	100
60	-565.6850	565.6850	100
61	-800.0000	0.0000	100
62	-565.6850	-565.6850	100
63	0.0000	-800.0000	100
64	565.6850	-565.6850	100
65	900.0000	0.0000	100
66	636.3960	636.3960	100
67	0.0000	900.0000	100
68	-636.3960	636.3960	100
69	-900.0000	0.0000	100
70	-636.3960	-636.3960	100
71	0.0000	-900.0000	100
72	636.3960	-636.3960	100
73	1000.0000	0.0000	100
74	707.1070	707.1070	100
75	0.0000	1000.0000	100
76	-707.1070	707.1070	100
77	-1000.0000	0.0000	100
78	-707.1070	-707.1070	100
79	0.0000	-1000.0000	100
80	707.1070	-707.1070	100
Depot	0	0	N.A.

Table C.14: Min-Max Single-Depot Split-Delivery VRP instance SD13

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	70.7107	70.7107	100
3	0.0000	100.0000	100
4	-70.7107	70.7107	100
5	-100.0000	0.0000	100
6	-70.7107	-70.7107	100
7	0.0000	-100.0000	100
8	70.7107	-70.7107	100
9	200.0000	0.0000	100
10	141.4210	141.4210	100
11	0.0000	200.0000	100
12	-141.4210	141.4210	100
13	-200.0000	0.0000	100
14	-141.4210	-141.4210	100
15	0.0000	-200.0000	100
16	141.4210	-141.4210	100
17	300.0000	0.0000	100
18	212.1320	212.1320	100
19	0.0000	300.0000	100
20	-212.1320	212.1320	100
21	-300.0000	0.0000	100
22	-212.1320	-212.1320	100
23	0.0000	-300.0000	100
24	212.1320	-212.1320	100
25	400.0000	0.0000	100
26	282.8430	282.8430	100
27	0.0000	400.0000	100
28	-282.8430	282.8430	100
29	-400.0000	0.0000	100
30	-282.8430	-282.8430	100
31	0.0000	-400.0000	100
32	282.8430	-282.8430	100
33	500.0000	0.0000	100
34	353.5530	353.5530	100
35	0.0000	500.0000	100
36	-353.5530	353.5530	100
37	-500.0000	0.0000	100
38	-353.5530	-353.5530	100
39	0.0000	-500.0000	100
40	353.5530	-353.5530	100

Continued on next page

Table C.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
41	600.0000	0.0000	100
42	424.2640	424.2640	100
43	0.0000	600.0000	100
44	-424.2640	424.2640	100
45	-600.0000	0.0000	100
46	-424.2640	-424.2640	100
47	0.0000	-600.0000	100
48	424.2640	-424.2640	100
49	700.0000	0.0000	100
50	494.9750	494.9750	100
51	0.0000	700.0000	100
52	-494.9750	494.9750	100
53	-700.0000	0.0000	100
54	-494.9750	-494.9750	100
55	0.0000	-700.0000	100
56	494.9750	-494.9750	100
57	800.0000	0.0000	100
58	565.6850	565.6850	100
59	0.0000	800.0000	100
60	-565.6850	565.6850	100
61	-800.0000	0.0000	100
62	-565.6850	-565.6850	100
63	0.0000	-800.0000	100
64	565.6850	-565.6850	100
65	900.0000	0.0000	100
66	636.3960	636.3960	100
67	0.0000	900.0000	100
68	-636.3960	636.3960	100
69	-900.0000	0.0000	100
70	-636.3960	-636.3960	100
71	0.0000	-900.0000	100
72	636.3960	-636.3960	100
73	1000.0000	0.0000	100
74	707.1070	707.1070	100
75	0.0000	1000.0000	100
76	-707.1070	707.1070	100
77	-1000.0000	0.0000	100
78	-707.1070	-707.1070	100
79	0.0000	-1000.0000	100
80	707.1070	-707.1070	100
81	1100.0000	0.0000	100

Continued on next page

Table C.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
82	777.8170	777.8170	100
83	0.0000	1100.0000	100
84	-777.8170	777.8170	100
85	-1100.0000	0.0000	100
86	-777.8170	-777.8170	100
87	0.0000	-1100.0000	100
88	777.8170	-777.8170	100
89	1200.0000	0.0000	100
90	848.5280	848.5280	100
91	0.0000	1200.0000	100
92	-848.5280	848.5280	100
93	-1200.0000	0.0000	100
94	-848.5280	-848.5280	100
95	0.0000	-1200.0000	100
96	848.5280	-848.5280	100
Depot	0	0	N.A.

Table C.15: Min-Max Single-Depot Split-Delivery VRP instance SD14

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	86.6025	50.0000	100
3	50.0000	86.6025	100
4	0.0000	100.0000	100
5	-50.0000	86.6025	100
6	-86.6025	50.0000	100
7	-100.0000	0.0000	100
8	-86.6025	-50.0000	100
9	-50.0000	-86.6025	100
10	0.0000	-100.0000	100
11	50.0000	-86.6025	100
12	86.6025	-50.0000	100
13	200.0000	0.0000	100
14	173.2050	100.0000	100
15	100.0000	173.2050	100
16	0.0000	200.0000	100
17	-100.0000	173.2050	100

Continued on next page

Table C.15 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
18	-173.2050	100.0000	100
19	-200.0000	0.0000	100
20	-173.2050	-100.0000	100
21	-100.0000	-173.2050	100
22	0.0000	-200.0000	100
23	100.0000	-173.2050	100
24	173.2050	-100.0000	100
25	300.0000	0.0000	100
26	259.8080	150.0000	100
27	150.0000	259.8080	100
28	0.0000	300.0000	100
29	-150.0000	259.8080	100
30	-259.8080	150.0000	100
31	-300.0000	0.0000	100
32	-259.8080	-150.0000	100
33	-150.0000	-259.8080	100
34	0.0000	-300.0000	100
35	150.0000	-259.8080	100
36	259.8080	-150.0000	100
37	400.0000	0.0000	100
38	346.4100	200.0000	100
39	200.0000	346.4100	100
40	0.0000	400.0000	100
41	-200.0000	346.4100	100
42	-346.4100	200.0000	100
43	-400.0000	0.0000	100
44	-346.4100	-200.0000	100
45	-200.0000	-346.4100	100
46	0.0000	-400.0000	100
47	200.0000	-346.4100	100
48	346.4100	-200.0000	100
49	500.0000	0.0000	100
50	433.0130	250.0000	100
51	250.0000	433.0130	100
52	0.0000	500.0000	100
53	-250.0000	433.0130	100
54	-433.0130	250.0000	100
55	-500.0000	0.0000	100
56	-433.0130	-250.0000	100
57	-250.0000	-433.0130	100
58	0.0000	-500.0000	100

Continued on next page

Table C.15 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
59	250.0000	-433.0130	100
60	433.0130	-250.0000	100
61	600.0000	0.0000	100
62	519.6150	300.0000	100
63	300.0000	519.6150	100
64	0.0000	600.0000	100
65	-300.0000	519.6150	100
66	-519.6150	300.0000	100
67	-600.0000	0.0000	100
68	-519.6150	-300.0000	100
69	-300.0000	-519.6150	100
70	0.0000	-600.0000	100
71	300.0000	-519.6150	100
72	519.6150	-300.0000	100
73	700.0000	0.0000	100
74	606.2180	350.0000	100
75	350.0000	606.2180	100
76	0.0000	700.0000	100
77	-350.0000	606.2180	100
78	-606.2180	350.0000	100
79	-700.0000	0.0000	100
80	-606.2180	-350.0000	100
81	-350.0000	-606.2180	100
82	0.0000	-700.0000	100
83	350.0000	-606.2180	100
84	606.2180	-350.0000	100
85	800.0000	0.0000	100
86	692.8200	400.0000	100
87	400.0000	692.8200	100
88	0.0000	800.0000	100
89	-400.0000	692.8200	100
90	-692.8200	400.0000	100
91	-800.0000	0.0000	100
92	-692.8200	-400.0000	100
93	-400.0000	-692.8200	100
94	0.0000	-800.0000	100
95	400.0000	-692.8200	100
96	692.8200	-400.0000	100
97	900.0000	0.0000	100
98	779.4230	450.0000	100
99	450.0000	779.4230	100

Continued on next page

Table C.15 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
100	0.0000	900.0000	100
101	-450.0000	779.4230	100
102	-779.4230	450.0000	100
103	-900.0000	0.0000	100
104	-779.4230	-450.0000	100
105	-450.0000	-779.4230	100
106	0.0000	-900.0000	100
107	450.0000	-779.4230	100
108	779.4230	-450.0000	100
109	1000.0000	0.0000	100
110	866.0250	500.0000	100
111	500.0000	866.0250	100
112	0.0000	1000.0000	100
113	-500.0000	866.0250	100
114	-866.0250	500.0000	100
115	-1000.0000	0.0000	100
116	-866.0250	-500.0000	100
117	-500.0000	-866.0250	100
118	0.0000	-1000.0000	100
119	500.0000	-866.0250	100
120	866.0250	-500.0000	100
Depot	0	0	N.A.

Table C.16: Min-Max Single-Depot Split-Delivery VRP instance SD15

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	86.6025	50.0000	100
3	50.0000	86.6025	100
4	0.0000	100.0000	100
5	-50.0000	86.6025	100
6	-86.6025	50.0000	100
7	-100.0000	0.0000	100
8	-86.6025	-50.0000	100
9	-50.0000	-86.6025	100
10	0.0000	-100.0000	100
11	50.0000	-86.6025	100

Continued on next page

Table C.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
12	86.6025	-50.0000	100
13	200.0000	0.0000	100
14	173.2050	100.0000	100
15	100.0000	173.2050	100
16	0.0000	200.0000	100
17	-100.0000	173.2050	100
18	-173.2050	100.0000	100
19	-200.0000	0.0000	100
20	-173.2050	-100.0000	100
21	-100.0000	-173.2050	100
22	0.0000	-200.0000	100
23	100.0000	-173.2050	100
24	173.2050	-100.0000	100
25	300.0000	0.0000	100
26	259.8080	150.0000	100
27	150.0000	259.8080	100
28	0.0000	300.0000	100
29	-150.0000	259.8080	100
30	-259.8080	150.0000	100
31	-300.0000	0.0000	100
32	-259.8080	-150.0000	100
33	-150.0000	-259.8080	100
34	0.0000	-300.0000	100
35	150.0000	-259.8080	100
36	259.8080	-150.0000	100
37	400.0000	0.0000	100
38	346.4100	200.0000	100
39	200.0000	346.4100	100
40	0.0000	400.0000	100
41	-200.0000	346.4100	100
42	-346.4100	200.0000	100
43	-400.0000	0.0000	100
44	-346.4100	-200.0000	100
45	-200.0000	-346.4100	100
46	0.0000	-400.0000	100
47	200.0000	-346.4100	100
48	346.4100	-200.0000	100
49	500.0000	0.0000	100
50	433.0130	250.0000	100
51	250.0000	433.0130	100
52	0.0000	500.0000	100

Continued on next page

Table C.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
53	-250.0000	433.0130	100
54	-433.0130	250.0000	100
55	-500.0000	0.0000	100
56	-433.0130	-250.0000	100
57	-250.0000	-433.0130	100
58	0.0000	-500.0000	100
59	250.0000	-433.0130	100
60	433.0130	-250.0000	100
61	600.0000	0.0000	100
62	519.6150	300.0000	100
63	300.0000	519.6150	100
64	0.0000	600.0000	100
65	-300.0000	519.6150	100
66	-519.6150	300.0000	100
67	-600.0000	0.0000	100
68	-519.6150	-300.0000	100
69	-300.0000	-519.6150	100
70	0.0000	-600.0000	100
71	300.0000	-519.6150	100
72	519.6150	-300.0000	100
73	700.0000	0.0000	100
74	606.2180	350.0000	100
75	350.0000	606.2180	100
76	0.0000	700.0000	100
77	-350.0000	606.2180	100
78	-606.2180	350.0000	100
79	-700.0000	0.0000	100
80	-606.2180	-350.0000	100
81	-350.0000	-606.2180	100
82	0.0000	-700.0000	100
83	350.0000	-606.2180	100
84	606.2180	-350.0000	100
85	800.0000	0.0000	100
86	692.8200	400.0000	100
87	400.0000	692.8200	100
88	0.0000	800.0000	100
89	-400.0000	692.8200	100
90	-692.8200	400.0000	100
91	-800.0000	0.0000	100
92	-692.8200	-400.0000	100
93	-400.0000	-692.8200	100

Continued on next page

Table C.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
94	0.0000	-800.0000	100
95	400.0000	-692.8200	100
96	692.8200	-400.0000	100
97	900.0000	0.0000	100
98	779.4230	450.0000	100
99	450.0000	779.4230	100
100	0.0000	900.0000	100
101	-450.0000	779.4230	100
102	-779.4230	450.0000	100
103	-900.0000	0.0000	100
104	-779.4230	-450.0000	100
105	-450.0000	-779.4230	100
106	0.0000	-900.0000	100
107	450.0000	-779.4230	100
108	779.4230	-450.0000	100
109	1000.0000	0.0000	100
110	866.0250	500.0000	100
111	500.0000	866.0250	100
112	0.0000	1000.0000	100
113	-500.0000	866.0250	100
114	-866.0250	500.0000	100
115	-1000.0000	0.0000	100
116	-866.0250	-500.0000	100
117	-500.0000	-866.0250	100
118	0.0000	-1000.0000	100
119	500.0000	-866.0250	100
120	866.0250	-500.0000	100
121	1100.0000	0.0000	100
122	952.6280	550.0000	100
123	550.0000	952.6280	100
124	0.0000	1100.0000	100
125	-550.0000	952.6280	100
126	-952.6280	550.0000	100
127	-1100.0000	0.0000	100
128	-952.6280	-550.0000	100
129	-550.0000	-952.6280	100
130	0.0000	-1100.0000	100
131	550.0000	-952.6280	100
132	952.6280	-550.0000	100
133	1200.0000	0.0000	100
134	1039.2300	600.0000	100

Continued on next page

Table C.16 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
135	600.0000	1039.2300	100
136	0.0000	1200.0000	100
137	-600.0000	1039.2300	100
138	-1039.2300	600.0000	100
139	-1200.0000	0.0000	100
140	-1039.2300	-600.0000	100
141	-600.0000	-1039.2300	100
142	0.0000	-1200.0000	100
143	600.0000	-1039.2300	100
144	1039.2300	-600.0000	100
Depot	0	0	N.A.

Table C.17: Min-Max Single-Depot Split-Delivery VRP instance SD16

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	99.6195	8.7156	100
3	98.4808	17.3648	100
4	96.5926	25.8819	100
5	93.9693	34.2020	100
6	90.6308	42.2618	100
7	86.6025	50.0000	100
8	81.9152	57.3576	100
9	76.6044	64.2788	100
10	70.7107	70.7107	100
11	64.2788	76.6044	100
12	57.3576	81.9152	100
13	50.0000	86.6025	100
14	42.2618	90.6308	100
15	34.2020	93.9693	100
16	25.8819	96.5926	100
17	17.3648	98.4808	100
18	8.7156	99.6195	100
19	0.0000	100.0000	100
20	-8.7156	99.6195	100
21	-17.3648	98.4808	100
22	-25.8819	96.5926	100

Continued on next page

Table C.17 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
23	-34.2020	93.9693	100
24	-42.2618	90.6308	100
25	-50.0000	86.6025	100
26	-57.3576	81.9152	100
27	-64.2788	76.6044	100
28	-70.7107	70.7107	100
29	-76.6044	64.2788	100
30	-81.9152	57.3576	100
31	-86.6025	50.0000	100
32	-90.6308	42.2618	100
33	-93.9693	34.2020	100
34	-96.5926	25.8819	100
35	-98.4808	17.3648	100
36	-99.6195	8.7156	100
37	-100.0000	0.0000	100
38	-99.6195	-8.7156	100
39	-98.4808	-17.3648	100
40	-96.5926	-25.8819	100
41	-93.9693	-34.2020	100
42	-90.6308	-42.2618	100
43	-86.6025	-50.0000	100
44	-81.9152	-57.3576	100
45	-76.6044	-64.2788	100
46	-70.7107	-70.7107	100
47	-64.2788	-76.6044	100
48	-57.3576	-81.9152	100
49	-50.0000	-86.6025	100
50	-42.2618	-90.6308	100
51	-34.2020	-93.9693	100
52	-25.8819	-96.5926	100
53	-17.3648	-98.4808	100
54	-8.7156	-99.6195	100
55	0.0000	-100.0000	100
56	8.7156	-99.6195	100
57	17.3648	-98.4808	100
58	25.8819	-96.5926	100
59	34.2020	-93.9693	100
60	42.2618	-90.6308	100
61	50.0000	-86.6025	100
62	57.3576	-81.9152	100
63	64.2788	-76.6044	100

Continued on next page

Table C.17 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
64	70.7107	-70.7107	100
65	76.6044	-64.2788	100
66	81.9152	-57.3576	100
67	86.6025	-50.0000	100
68	90.6308	-42.2618	100
69	93.9693	-34.2020	100
70	96.5926	-25.8819	100
71	98.4808	-17.3648	100
72	99.6195	-8.7156	100
73	200.0000	0.0000	100
74	199.2390	17.4311	100
75	196.9620	34.7296	100
76	193.1850	51.7638	100
77	187.9390	68.4040	100
78	181.2620	84.5237	100
79	173.2050	100.0000	100
80	163.8300	114.7150	100
81	153.2090	128.5580	100
82	141.4210	141.4210	100
83	128.5580	153.2090	100
84	114.7150	163.8300	100
85	100.0000	173.2050	100
86	84.5237	181.2620	100
87	68.4040	187.9390	100
88	51.7638	193.1850	100
89	34.7296	196.9620	100
90	17.4311	199.2390	100
91	0.0000	200.0000	100
92	-17.4311	199.2390	100
93	-34.7296	196.9620	100
94	-51.7638	193.1850	100
95	-68.4040	187.9390	100
96	-84.5237	181.2620	100
97	-100.0000	173.2050	100
98	-114.7150	163.8300	100
99	-128.5580	153.2090	100
100	-141.4210	141.4210	100
101	-153.2090	128.5580	100
102	-163.8300	114.7150	100
103	-173.2050	100.0000	100
104	-181.2620	84.5237	100

Continued on next page

Table C.17 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
105	-187.9390	68.4040	100
106	-193.1850	51.7638	100
107	-196.9620	34.7296	100
108	-199.2390	17.4311	100
109	-200.0000	0.0000	100
110	-199.2390	-17.4311	100
111	-196.9620	-34.7296	100
112	-193.1850	-51.7638	100
113	-187.9390	-68.4040	100
114	-181.2620	-84.5237	100
115	-173.2050	-100.0000	100
116	-163.8300	-114.7150	100
117	-153.2090	-128.5580	100
118	-141.4210	-141.4210	100
119	-128.5580	-153.2090	100
120	-114.7150	-163.8300	100
121	-100.0000	-173.2050	100
122	-84.5237	-181.2620	100
123	-68.4040	-187.9390	100
124	-51.7638	-193.1850	100
125	-34.7296	-196.9620	100
126	-17.4311	-199.2390	100
127	0.0000	-200.0000	100
128	17.4311	-199.2390	100
129	34.7296	-196.9620	100
130	51.7638	-193.1850	100
131	68.4040	-187.9390	100
132	84.5237	-181.2620	100
133	100.0000	-173.2050	100
134	114.7150	-163.8300	100
135	128.5580	-153.2090	100
136	141.4210	-141.4210	100
137	153.2090	-128.5580	100
138	163.8300	-114.7150	100
139	173.2050	-100.0000	100
140	181.2620	-84.5237	100
141	187.9390	-68.4040	100
142	193.1850	-51.7638	100
143	196.9620	-34.7296	100
144	199.2390	-17.4311	100
Depot	0	0	N.A.

Table C.18: Min-Max Single-Depot Split-Delivery VRP instance SD17

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	70.7107	70.7107	100
3	0.0000	100.0000	100
4	-70.7107	70.7107	100
5	-100.0000	0.0000	100
6	-70.7107	-70.7107	100
7	0.0000	-100.0000	100
8	70.7107	-70.7107	100
9	200.0000	0.0000	100
10	141.4210	141.4210	100
11	0.0000	200.0000	100
12	-141.4210	141.4210	100
13	-200.0000	0.0000	100
14	-141.4210	-141.4210	100
15	0.0000	-200.0000	100
16	141.4210	-141.4210	100
17	300.0000	0.0000	100
18	212.1320	212.1320	100
19	0.0000	300.0000	100
20	-212.1320	212.1320	100
21	-300.0000	0.0000	100
22	-212.1320	-212.1320	100
23	0.0000	-300.0000	100
24	212.1320	-212.1320	100
25	400.0000	0.0000	100
26	282.8430	282.8430	100
27	0.0000	400.0000	100
28	-282.8430	282.8430	100
29	-400.0000	0.0000	100
30	-282.8430	-282.8430	100
31	0.0000	-400.0000	100
32	282.8430	-282.8430	100
33	500.0000	0.0000	100
34	353.5530	353.5530	100
35	0.0000	500.0000	100
36	-353.5530	353.5530	100
37	-500.0000	0.0000	100
38	-353.5530	-353.5530	100

Continued on next page

Table C.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
39	0.0000	-500.0000	100
40	353.5530	-353.5530	100
41	600.0000	0.0000	100
42	424.2640	424.2640	100
43	0.0000	600.0000	100
44	-424.2640	424.2640	100
45	-600.0000	0.0000	100
46	-424.2640	-424.2640	100
47	0.0000	-600.0000	100
48	424.2640	-424.2640	100
49	700.0000	0.0000	100
50	494.9750	494.9750	100
51	0.0000	700.0000	100
52	-494.9750	494.9750	100
53	-700.0000	0.0000	100
54	-494.9750	-494.9750	100
55	0.0000	-700.0000	100
56	494.9750	-494.9750	100
57	800.0000	0.0000	100
58	565.6850	565.6850	100
59	0.0000	800.0000	100
60	-565.6850	565.6850	100
61	-800.0000	0.0000	100
62	-565.6850	-565.6850	100
63	0.0000	-800.0000	100
64	565.6850	-565.6850	100
65	900.0000	0.0000	100
66	636.3960	636.3960	100
67	0.0000	900.0000	100
68	-636.3960	636.3960	100
69	-900.0000	0.0000	100
70	-636.3960	-636.3960	100
71	0.0000	-900.0000	100
72	636.3960	-636.3960	100
73	1000.0000	0.0000	100
74	707.1070	707.1070	100
75	0.0000	1000.0000	100
76	-707.1070	707.1070	100
77	-1000.0000	0.0000	100
78	-707.1070	-707.1070	100
79	0.0000	-1000.0000	100

Continued on next page

Table C.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
80	707.1070	-707.1070	100
81	1100.0000	0.0000	100
82	777.8170	777.8170	100
83	0.0000	1100.0000	100
84	-777.8170	777.8170	100
85	-1100.0000	0.0000	100
86	-777.8170	-777.8170	100
87	0.0000	-1100.0000	100
88	777.8170	-777.8170	100
89	1200.0000	0.0000	100
90	848.5280	848.5280	100
91	0.0000	1200.0000	100
92	-848.5280	848.5280	100
93	-1200.0000	0.0000	100
94	-848.5280	-848.5280	100
95	0.0000	-1200.0000	100
96	848.5280	-848.5280	100
97	1300.0000	0.0000	100
98	919.2390	919.2390	100
99	0.0000	1300.0000	100
100	-919.2390	919.2390	100
101	-1300.0000	0.0000	100
102	-919.2390	-919.2390	100
103	0.0000	-1300.0000	100
104	919.2390	-919.2390	100
105	1400.0000	0.0000	100
106	989.9490	989.9490	100
107	0.0000	1400.0000	100
108	-989.9490	989.9490	100
109	-1400.0000	0.0000	100
110	-989.9490	-989.9490	100
111	0.0000	-1400.0000	100
112	989.9490	-989.9490	100
113	1500.0000	0.0000	100
114	1060.6600	1060.6600	100
115	0.0000	1500.0000	100
116	-1060.6600	1060.6600	100
117	-1500.0000	0.0000	100
118	-1060.6600	-1060.6600	100
119	0.0000	-1500.0000	100
120	1060.6600	-1060.6600	100

Continued on next page

Table C.18 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
121	1600.0000	0.0000	100
122	1131.3700	1131.3700	100
123	0.0000	1600.0000	100
124	-1131.3700	1131.3700	100
125	-1600.0000	0.0000	100
126	-1131.3700	-1131.3700	100
127	0.0000	-1600.0000	100
128	1131.3700	-1131.3700	100
129	1700.0000	0.0000	100
130	1202.0800	1202.0800	100
131	0.0000	1700.0000	100
132	-1202.0800	1202.0800	100
133	-1700.0000	0.0000	100
134	-1202.0800	-1202.0800	100
135	0.0000	-1700.0000	100
136	1202.0800	-1202.0800	100
137	1800.0000	0.0000	100
138	1272.7900	1272.7900	100
139	0.0000	1800.0000	100
140	-1272.7900	1272.7900	100
141	-1800.0000	0.0000	100
142	-1272.7900	-1272.7900	100
143	0.0000	-1800.0000	100
144	1272.7900	-1272.7900	100
145	1900.0000	0.0000	100
146	1343.5000	1343.5000	100
147	0.0000	1900.0000	100
148	-1343.5000	1343.5000	100
149	-1900.0000	0.0000	100
150	-1343.5000	-1343.5000	100
151	0.0000	-1900.0000	100
152	1343.5000	-1343.5000	100
153	2000.0000	0.0000	100
154	1414.2100	1414.2100	100
155	0.0000	2000.0000	100
156	-1414.2100	1414.2100	100
157	-2000.0000	0.0000	100
158	-1414.2100	-1414.2100	100
159	0.0000	-2000.0000	100
160	1414.2100	-1414.2100	100
Depot	0	0	N.A.

Table C.19: Min-Max Single-Depot Split-Delivery VRP instance SD18

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	92.3880	38.2683	100
3	70.7107	70.7107	100
4	38.2683	92.3880	100
5	0.0000	100.0000	100
6	-38.2683	92.3880	100
7	-70.7107	70.7107	100
8	-92.3880	38.2683	100
9	-100.0000	0.0000	100
10	-92.3880	-38.2683	100
11	-70.7107	-70.7107	100
12	-38.2683	-92.3880	100
13	0.0000	-100.0000	100
14	38.2683	-92.3880	100
15	70.7107	-70.7107	100
16	92.3880	-38.2683	100
17	200.0000	0.0000	100
18	184.7760	76.5367	100
19	141.4210	141.4210	100
20	76.5367	184.7760	100
21	0.0000	200.0000	100
22	-76.5367	184.7760	100
23	-141.4210	141.4210	100
24	-184.7760	76.5367	100
25	-200.0000	0.0000	100
26	-184.7760	-76.5367	100
27	-141.4210	-141.4210	100
28	-76.5367	-184.7760	100
29	0.0000	-200.0000	100
30	76.5367	-184.7760	100
31	141.4210	-141.4210	100
32	184.7760	-76.5367	100
33	300.0000	0.0000	100
34	277.1640	114.8050	100
35	212.1320	212.1320	100
36	114.8050	277.1640	100
37	0.0000	300.0000	100
38	-114.8050	277.1640	100

Continued on next page

Table C.19 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
39	-212.1320	212.1320	100
40	-277.1640	114.8050	100
41	-300.0000	0.0000	100
42	-277.1640	-114.8050	100
43	-212.1320	-212.1320	100
44	-114.8050	-277.1640	100
45	0.0000	-300.0000	100
46	114.8050	-277.1640	100
47	212.1320	-212.1320	100
48	277.1640	-114.8050	100
49	400.0000	0.0000	100
50	369.5520	153.0730	100
51	282.8430	282.8430	100
52	153.0730	369.5520	100
53	0.0000	400.0000	100
54	-153.0730	369.5520	100
55	-282.8430	282.8430	100
56	-369.5520	153.0730	100
57	-400.0000	0.0000	100
58	-369.5520	-153.0730	100
59	-282.8430	-282.8430	100
60	-153.0730	-369.5520	100
61	0.0000	-400.0000	100
62	153.0730	-369.5520	100
63	282.8430	-282.8430	100
64	369.5520	-153.0730	100
65	500.0000	0.0000	100
66	461.9400	191.3420	100
67	353.5530	353.5530	100
68	191.3420	461.9400	100
69	0.0000	500.0000	100
70	-191.3420	461.9400	100
71	-353.5530	353.5530	100
72	-461.9400	191.3420	100
73	-500.0000	0.0000	100
74	-461.9400	-191.3420	100
75	-353.5530	-353.5530	100
76	-191.3420	-461.9400	100
77	0.0000	-500.0000	100
78	191.3420	-461.9400	100
79	353.5530	-353.5530	100

Continued on next page

Table C.19 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
80	461.9400	-191.3420	100
81	600.0000	0.0000	100
82	554.3280	229.6100	100
83	424.2640	424.2640	100
84	229.6100	554.3280	100
85	0.0000	600.0000	100
86	-229.6100	554.3280	100
87	-424.2640	424.2640	100
88	-554.3280	229.6100	100
89	-600.0000	0.0000	100
90	-554.3280	-229.6100	100
91	-424.2640	-424.2640	100
92	-229.6100	-554.3280	100
93	0.0000	-600.0000	100
94	229.6100	-554.3280	100
95	424.2640	-424.2640	100
96	554.3280	-229.6100	100
97	700.0000	0.0000	100
98	646.7160	267.8780	100
99	494.9750	494.9750	100
100	267.8780	646.7160	100
101	0.0000	700.0000	100
102	-267.8780	646.7160	100
103	-494.9750	494.9750	100
104	-646.7160	267.8780	100
105	-700.0000	0.0000	100
106	-646.7160	-267.8780	100
107	-494.9750	-494.9750	100
108	-267.8780	-646.7160	100
109	0.0000	-700.0000	100
110	267.8780	-646.7160	100
111	494.9750	-494.9750	100
112	646.7160	-267.8780	100
113	800.0000	0.0000	100
114	739.1040	306.1470	100
115	565.6850	565.6850	100
116	306.1470	739.1040	100
117	0.0000	800.0000	100
118	-306.1470	739.1040	100
119	-565.6850	565.6850	100
120	-739.1040	306.1470	100

Continued on next page

Table C.19 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
121	-800.0000	0.0000	100
122	-739.1040	-306.1470	100
123	-565.6850	-565.6850	100
124	-306.1470	-739.1040	100
125	0.0000	-800.0000	100
126	306.1470	-739.1040	100
127	565.6850	-565.6850	100
128	739.1040	-306.1470	100
129	900.0000	0.0000	100
130	831.4920	344.4150	100
131	636.3960	636.3960	100
132	344.4150	831.4920	100
133	0.0000	900.0000	100
134	-344.4150	831.4920	100
135	-636.3960	636.3960	100
136	-831.4920	344.4150	100
137	-900.0000	0.0000	100
138	-831.4920	-344.4150	100
139	-636.3960	-636.3960	100
140	-344.4150	-831.4920	100
141	0.0000	-900.0000	100
142	344.4150	-831.4920	100
143	636.3960	-636.3960	100
144	831.4920	-344.4150	100
145	1000.0000	0.0000	100
146	923.8800	382.6830	100
147	707.1070	707.1070	100
148	382.6830	923.8800	100
149	0.0000	1000.0000	100
150	-382.6830	923.8800	100
151	-707.1070	707.1070	100
152	-923.8800	382.6830	100
153	-1000.0000	0.0000	100
154	-923.8800	-382.6830	100
155	-707.1070	-707.1070	100
156	-382.6830	-923.8800	100
157	0.0000	-1000.0000	100
158	382.6830	-923.8800	100
159	707.1070	-707.1070	100
160	923.8800	-382.6830	100
Depot	0	0	N.A.

Table C.20: Min-Max Single-Depot Split-Delivery VRP instance SD19

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	92.3880	38.2683	100
3	70.7107	70.7107	100
4	38.2683	92.3880	100
5	0.0000	100.0000	100
6	-38.2683	92.3880	100
7	-70.7107	70.7107	100
8	-92.3880	38.2683	100
9	-100.0000	0.0000	100
10	-92.3880	-38.2683	100
11	-70.7107	-70.7107	100
12	-38.2683	-92.3880	100
13	0.0000	-100.0000	100
14	38.2683	-92.3880	100
15	70.7107	-70.7107	100
16	92.3880	-38.2683	100
17	200.0000	0.0000	100
18	184.7760	76.5367	100
19	141.4210	141.4210	100
20	76.5367	184.7760	100
21	0.0000	200.0000	100
22	-76.5367	184.7760	100
23	-141.4210	141.4210	100
24	-184.7760	76.5367	100
25	-200.0000	0.0000	100
26	-184.7760	-76.5367	100
27	-141.4210	-141.4210	100
28	-76.5367	-184.7760	100
29	0.0000	-200.0000	100
30	76.5367	-184.7760	100
31	141.4210	-141.4210	100
32	184.7760	-76.5367	100
33	300.0000	0.0000	100
34	277.1640	114.8050	100
35	212.1320	212.1320	100
36	114.8050	277.1640	100
37	0.0000	300.0000	100
38	-114.8050	277.1640	100

Continued on next page

Table C.20 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
39	-212.1320	212.1320	100
40	-277.1640	114.8050	100
41	-300.0000	0.0000	100
42	-277.1640	-114.8050	100
43	-212.1320	-212.1320	100
44	-114.8050	-277.1640	100
45	0.0000	-300.0000	100
46	114.8050	-277.1640	100
47	212.1320	-212.1320	100
48	277.1640	-114.8050	100
49	400.0000	0.0000	100
50	369.5520	153.0730	100
51	282.8430	282.8430	100
52	153.0730	369.5520	100
53	0.0000	400.0000	100
54	-153.0730	369.5520	100
55	-282.8430	282.8430	100
56	-369.5520	153.0730	100
57	-400.0000	0.0000	100
58	-369.5520	-153.0730	100
59	-282.8430	-282.8430	100
60	-153.0730	-369.5520	100
61	0.0000	-400.0000	100
62	153.0730	-369.5520	100
63	282.8430	-282.8430	100
64	369.5520	-153.0730	100
65	500.0000	0.0000	100
66	461.9400	191.3420	100
67	353.5530	353.5530	100
68	191.3420	461.9400	100
69	0.0000	500.0000	100
70	-191.3420	461.9400	100
71	-353.5530	353.5530	100
72	-461.9400	191.3420	100
73	-500.0000	0.0000	100
74	-461.9400	-191.3420	100
75	-353.5530	-353.5530	100
76	-191.3420	-461.9400	100
77	0.0000	-500.0000	100
78	191.3420	-461.9400	100
79	353.5530	-353.5530	100

Continued on next page

Table C.20 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
80	461.9400	-191.3420	100
81	600.0000	0.0000	100
82	554.3280	229.6100	100
83	424.2640	424.2640	100
84	229.6100	554.3280	100
85	0.0000	600.0000	100
86	-229.6100	554.3280	100
87	-424.2640	424.2640	100
88	-554.3280	229.6100	100
89	-600.0000	0.0000	100
90	-554.3280	-229.6100	100
91	-424.2640	-424.2640	100
92	-229.6100	-554.3280	100
93	0.0000	-600.0000	100
94	229.6100	-554.3280	100
95	424.2640	-424.2640	100
96	554.3280	-229.6100	100
97	700.0000	0.0000	100
98	646.7160	267.8780	100
99	494.9750	494.9750	100
100	267.8780	646.7160	100
101	0.0000	700.0000	100
102	-267.8780	646.7160	100
103	-494.9750	494.9750	100
104	-646.7160	267.8780	100
105	-700.0000	0.0000	100
106	-646.7160	-267.8780	100
107	-494.9750	-494.9750	100
108	-267.8780	-646.7160	100
109	0.0000	-700.0000	100
110	267.8780	-646.7160	100
111	494.9750	-494.9750	100
112	646.7160	-267.8780	100
113	800.0000	0.0000	100
114	739.1040	306.1470	100
115	565.6850	565.6850	100
116	306.1470	739.1040	100
117	0.0000	800.0000	100
118	-306.1470	739.1040	100
119	-565.6850	565.6850	100
120	-739.1040	306.1470	100

Continued on next page

Table C.20 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
121	-800.0000	0.0000	100
122	-739.1040	-306.1470	100
123	-565.6850	-565.6850	100
124	-306.1470	-739.1040	100
125	0.0000	-800.0000	100
126	306.1470	-739.1040	100
127	565.6850	-565.6850	100
128	739.1040	-306.1470	100
129	900.0000	0.0000	100
130	831.4920	344.4150	100
131	636.3960	636.3960	100
132	344.4150	831.4920	100
133	0.0000	900.0000	100
134	-344.4150	831.4920	100
135	-636.3960	636.3960	100
136	-831.4920	344.4150	100
137	-900.0000	0.0000	100
138	-831.4920	-344.4150	100
139	-636.3960	-636.3960	100
140	-344.4150	-831.4920	100
141	0.0000	-900.0000	100
142	344.4150	-831.4920	100
143	636.3960	-636.3960	100
144	831.4920	-344.4150	100
145	1000.0000	0.0000	100
146	923.8800	382.6830	100
147	707.1070	707.1070	100
148	382.6830	923.8800	100
149	0.0000	1000.0000	100
150	-382.6830	923.8800	100
151	-707.1070	707.1070	100
152	-923.8800	382.6830	100
153	-1000.0000	0.0000	100
154	-923.8800	-382.6830	100
155	-707.1070	-707.1070	100
156	-382.6830	-923.8800	100
157	0.0000	-1000.0000	100
158	382.6830	-923.8800	100
159	707.1070	-707.1070	100
160	923.8800	-382.6830	100
161	1100.0000	0.0000	100

Continued on next page

Table C.20 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
162	1016.2700	420.9520	100
163	777.8170	777.8170	100
164	420.9520	1016.2700	100
165	0.0000	1100.0000	100
166	-420.9520	1016.2700	100
167	-777.8170	777.8170	100
168	-1016.2700	420.9520	100
169	-1100.0000	0.0000	100
170	-1016.2700	-420.9520	100
171	-777.8170	-777.8170	100
172	-420.9520	-1016.2700	100
173	0.0000	-1100.0000	100
174	420.9520	-1016.2700	100
175	777.8170	-777.8170	100
176	1016.2700	-420.9520	100
177	1200.0000	0.0000	100
178	1108.6600	459.2200	100
179	848.5280	848.5280	100
180	459.2200	1108.6600	100
181	0.0000	1200.0000	100
182	-459.2200	1108.6600	100
183	-848.5280	848.5280	100
184	-1108.6600	459.2200	100
185	-1200.0000	0.0000	100
186	-1108.6600	-459.2200	100
187	-848.5280	-848.5280	100
188	-459.2200	-1108.6600	100
189	0.0000	-1200.0000	100
190	459.2200	-1108.6600	100
191	848.5280	-848.5280	100
192	1108.6600	-459.2200	100
Depot	0	0	N.A.

Table C.21: Min-Max Single-Depot Split-Delivery VRP instance SD20

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
2	86.6025	50.0000	100
3	50.0000	86.6025	100
4	0.0000	100.0000	100
5	-50.0000	86.6025	100
6	-86.6025	50.0000	100
7	-100.0000	0.0000	100
8	-86.6025	-50.0000	100
9	-50.0000	-86.6025	100
10	0.0000	-100.0000	100
11	50.0000	-86.6025	100
12	86.6025	-50.0000	100
13	200.0000	0.0000	100
14	173.2050	100.0000	100
15	100.0000	173.2050	100
16	0.0000	200.0000	100
17	-100.0000	173.2050	100
18	-173.2050	100.0000	100
19	-200.0000	0.0000	100
20	-173.2050	-100.0000	100
21	-100.0000	-173.2050	100
22	0.0000	-200.0000	100
23	100.0000	-173.2050	100
24	173.2050	-100.0000	100
25	300.0000	0.0000	100
26	259.8080	150.0000	100
27	150.0000	259.8080	100
28	0.0000	300.0000	100
29	-150.0000	259.8080	100
30	-259.8080	150.0000	100
31	-300.0000	0.0000	100
32	-259.8080	-150.0000	100
33	-150.0000	-259.8080	100
34	0.0000	-300.0000	100
35	150.0000	-259.8080	100
36	259.8080	-150.0000	100
37	400.0000	0.0000	100
38	346.4100	200.0000	100
39	200.0000	346.4100	100
40	0.0000	400.0000	100
41	-200.0000	346.4100	100
42	-346.4100	200.0000	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
43	-400.0000	0.0000	100
44	-346.4100	-200.0000	100
45	-200.0000	-346.4100	100
46	0.0000	-400.0000	100
47	200.0000	-346.4100	100
48	346.4100	-200.0000	100
49	500.0000	0.0000	100
50	433.0130	250.0000	100
51	250.0000	433.0130	100
52	0.0000	500.0000	100
53	-250.0000	433.0130	100
54	-433.0130	250.0000	100
55	-500.0000	0.0000	100
56	-433.0130	-250.0000	100
57	-250.0000	-433.0130	100
58	0.0000	-500.0000	100
59	250.0000	-433.0130	100
60	433.0130	-250.0000	100
61	600.0000	0.0000	100
62	519.6150	300.0000	100
63	300.0000	519.6150	100
64	0.0000	600.0000	100
65	-300.0000	519.6150	100
66	-519.6150	300.0000	100
67	-600.0000	0.0000	100
68	-519.6150	-300.0000	100
69	-300.0000	-519.6150	100
70	0.0000	-600.0000	100
71	300.0000	-519.6150	100
72	519.6150	-300.0000	100
73	700.0000	0.0000	100
74	606.2180	350.0000	100
75	350.0000	606.2180	100
76	0.0000	700.0000	100
77	-350.0000	606.2180	100
78	-606.2180	350.0000	100
79	-700.0000	0.0000	100
80	-606.2180	-350.0000	100
81	-350.0000	-606.2180	100
82	0.0000	-700.0000	100
83	350.0000	-606.2180	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
84	606.2180	-350.0000	100
85	800.0000	0.0000	100
86	692.8200	400.0000	100
87	400.0000	692.8200	100
88	0.0000	800.0000	100
89	-400.0000	692.8200	100
90	-692.8200	400.0000	100
91	-800.0000	0.0000	100
92	-692.8200	-400.0000	100
93	-400.0000	-692.8200	100
94	0.0000	-800.0000	100
95	400.0000	-692.8200	100
96	692.8200	-400.0000	100
97	900.0000	0.0000	100
98	779.4230	450.0000	100
99	450.0000	779.4230	100
100	0.0000	900.0000	100
101	-450.0000	779.4230	100
102	-779.4230	450.0000	100
103	-900.0000	0.0000	100
104	-779.4230	-450.0000	100
105	-450.0000	-779.4230	100
106	0.0000	-900.0000	100
107	450.0000	-779.4230	100
108	779.4230	-450.0000	100
109	1000.0000	0.0000	100
110	866.0250	500.0000	100
111	500.0000	866.0250	100
112	0.0000	1000.0000	100
113	-500.0000	866.0250	100
114	-866.0250	500.0000	100
115	-1000.0000	0.0000	100
116	-866.0250	-500.0000	100
117	-500.0000	-866.0250	100
118	0.0000	-1000.0000	100
119	500.0000	-866.0250	100
120	866.0250	-500.0000	100
121	1100.0000	0.0000	100
122	952.6280	550.0000	100
123	550.0000	952.6280	100
124	0.0000	1100.0000	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
125	-550.0000	952.6280	100
126	-952.6280	550.0000	100
127	-1100.0000	0.0000	100
128	-952.6280	-550.0000	100
129	-550.0000	-952.6280	100
130	0.0000	-1100.0000	100
131	550.0000	-952.6280	100
132	952.6280	-550.0000	100
133	1200.0000	0.0000	100
134	1039.2300	600.0000	100
135	600.0000	1039.2300	100
136	0.0000	1200.0000	100
137	-600.0000	1039.2300	100
138	-1039.2300	600.0000	100
139	-1200.0000	0.0000	100
140	-1039.2300	-600.0000	100
141	-600.0000	-1039.2300	100
142	0.0000	-1200.0000	100
143	600.0000	-1039.2300	100
144	1039.2300	-600.0000	100
145	1300.0000	0.0000	100
146	1125.8300	650.0000	100
147	650.0000	1125.8300	100
148	0.0000	1300.0000	100
149	-650.0000	1125.8300	100
150	-1125.8300	650.0000	100
151	-1300.0000	0.0000	100
152	-1125.8300	-650.0000	100
153	-650.0000	-1125.8300	100
154	0.0000	-1300.0000	100
155	650.0000	-1125.8300	100
156	1125.8300	-650.0000	100
157	1400.0000	0.0000	100
158	1212.4400	700.0000	100
159	700.0000	1212.4400	100
160	0.0000	1400.0000	100
161	-700.0000	1212.4400	100
162	-1212.4400	700.0000	100
163	-1400.0000	0.0000	100
164	-1212.4400	-700.0000	100
165	-700.0000	-1212.4400	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
166	0.0000	-1400.0000	100
167	700.0000	-1212.4400	100
168	1212.4400	-700.0000	100
169	1500.0000	0.0000	100
170	1299.0400	750.0000	100
171	750.0000	1299.0400	100
172	0.0000	1500.0000	100
173	-750.0000	1299.0400	100
174	-1299.0400	750.0000	100
175	-1500.0000	0.0000	100
176	-1299.0400	-750.0000	100
177	-750.0000	-1299.0400	100
178	0.0000	-1500.0000	100
179	750.0000	-1299.0400	100
180	1299.0400	-750.0000	100
181	1600.0000	0.0000	100
182	1385.6400	800.0000	100
183	800.0000	1385.6400	100
184	0.0000	1600.0000	100
185	-800.0000	1385.6400	100
186	-1385.6400	800.0000	100
187	-1600.0000	0.0000	100
188	-1385.6400	-800.0000	100
189	-800.0000	-1385.6400	100
190	0.0000	-1600.0000	100
191	800.0000	-1385.6400	100
192	1385.6400	-800.0000	100
193	1700.0000	0.0000	100
194	1472.2400	850.0000	100
195	850.0000	1472.2400	100
196	0.0000	1700.0000	100
197	-850.0000	1472.2400	100
198	-1472.2400	850.0000	100
199	-1700.0000	0.0000	100
200	-1472.2400	-850.0000	100
201	-850.0000	-1472.2400	100
202	0.0000	-1700.0000	100
203	850.0000	-1472.2400	100
204	1472.2400	-850.0000	100
205	1800.0000	0.0000	100
206	1558.8500	900.0000	100

Continued on next page

Table C.21 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
207	900.0000	1558.8500	100
208	0.0000	1800.0000	100
209	-900.0000	1558.8500	100
210	-1558.8500	900.0000	100
211	-1800.0000	0.0000	100
212	-1558.8500	-900.0000	100
213	-900.0000	-1558.8500	100
214	0.0000	-1800.0000	100
215	900.0000	-1558.8500	100
216	1558.8500	-900.0000	100
217	1900.0000	0.0000	100
218	1645.4500	950.0000	100
219	950.0000	1645.4500	100
220	0.0000	1900.0000	100
221	-950.0000	1645.4500	100
222	-1645.4500	950.0000	100
223	-1900.0000	0.0000	100
224	-1645.4500	-950.0000	100
225	-950.0000	-1645.4500	100
226	0.0000	-1900.0000	100
227	950.0000	-1645.4500	100
228	1645.4500	-950.0000	100
229	2000.0000	0.0000	100
230	1732.0500	1000.0000	100
231	1000.0000	1732.0500	100
232	0.0000	2000.0000	100
233	-1000.0000	1732.0500	100
234	-1732.0500	1000.0000	100
235	-2000.0000	0.0000	100
236	-1732.0500	-1000.0000	100
237	-1000.0000	-1732.0500	100
238	0.0000	-2000.0000	100
239	1000.0000	-1732.0500	100
240	1732.0500	-1000.0000	100
Depot	0	0	N.A.

Table C.22: Min-Max Single-Depot Split-Delivery VRP instance SD21

Customer index	x-coordinate	y-coordinate	Service time
1	100.0000	0.0000	100
2	99.6195	8.7156	100
3	98.4808	17.3648	100
4	96.5926	25.8819	100
5	93.9693	34.2020	100
6	90.6308	42.2618	100
7	86.6025	50.0000	100
8	81.9152	57.3576	100
9	76.6044	64.2788	100
10	70.7107	70.7107	100
11	64.2788	76.6044	100
12	57.3576	81.9152	100
13	50.0000	86.6025	100
14	42.2618	90.6308	100
15	34.2020	93.9693	100
16	25.8819	96.5926	100
17	17.3648	98.4808	100
18	8.7156	99.6195	100
19	0.0000	100.0000	100
20	-8.7156	99.6195	100
21	-17.3648	98.4808	100
22	-25.8819	96.5926	100
23	-34.2020	93.9693	100
24	-42.2618	90.6308	100
25	-50.0000	86.6025	100
26	-57.3576	81.9152	100
27	-64.2788	76.6044	100
28	-70.7107	70.7107	100
29	-76.6044	64.2788	100
30	-81.9152	57.3576	100
31	-86.6025	50.0000	100
32	-90.6308	42.2618	100
33	-93.9693	34.2020	100
34	-96.5926	25.8819	100
35	-98.4808	17.3648	100
36	-99.6195	8.7156	100
37	-100.0000	0.0000	100
38	-99.6195	-8.7156	100
39	-98.4808	-17.3648	100
40	-96.5926	-25.8819	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
41	-93.9693	-34.2020	100
42	-90.6308	-42.2618	100
43	-86.6025	-50.0000	100
44	-81.9152	-57.3576	100
45	-76.6044	-64.2788	100
46	-70.7107	-70.7107	100
47	-64.2788	-76.6044	100
48	-57.3576	-81.9152	100
49	-50.0000	-86.6025	100
50	-42.2618	-90.6308	100
51	-34.2020	-93.9693	100
52	-25.8819	-96.5926	100
53	-17.3648	-98.4808	100
54	-8.7156	-99.6195	100
55	0.0000	-100.0000	100
56	8.7156	-99.6195	100
57	17.3648	-98.4808	100
58	25.8819	-96.5926	100
59	34.2020	-93.9693	100
60	42.2618	-90.6308	100
61	50.0000	-86.6025	100
62	57.3576	-81.9152	100
63	64.2788	-76.6044	100
64	70.7107	-70.7107	100
65	76.6044	-64.2788	100
66	81.9152	-57.3576	100
67	86.6025	-50.0000	100
68	90.6308	-42.2618	100
69	93.9693	-34.2020	100
70	96.5926	-25.8819	100
71	98.4808	-17.3648	100
72	99.6195	-8.7156	100
73	200.0000	0.0000	100
74	199.2390	17.4311	100
75	196.9620	34.7296	100
76	193.1850	51.7638	100
77	187.9390	68.4040	100
78	181.2620	84.5237	100
79	173.2050	100.0000	100
80	163.8300	114.7150	100
81	153.2090	128.5580	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
82	141.4210	141.4210	100
83	128.5580	153.2090	100
84	114.7150	163.8300	100
85	100.0000	173.2050	100
86	84.5237	181.2620	100
87	68.4040	187.9390	100
88	51.7638	193.1850	100
89	34.7296	196.9620	100
90	17.4311	199.2390	100
91	0.0000	200.0000	100
92	-17.4311	199.2390	100
93	-34.7296	196.9620	100
94	-51.7638	193.1850	100
95	-68.4040	187.9390	100
96	-84.5237	181.2620	100
97	-100.0000	173.2050	100
98	-114.7150	163.8300	100
99	-128.5580	153.2090	100
100	-141.4210	141.4210	100
101	-153.2090	128.5580	100
102	-163.8300	114.7150	100
103	-173.2050	100.0000	100
104	-181.2620	84.5237	100
105	-187.9390	68.4040	100
106	-193.1850	51.7638	100
107	-196.9620	34.7296	100
108	-199.2390	17.4311	100
109	-200.0000	0.0000	100
110	-199.2390	-17.4311	100
111	-196.9620	-34.7296	100
112	-193.1850	-51.7638	100
113	-187.9390	-68.4040	100
114	-181.2620	-84.5237	100
115	-173.2050	-100.0000	100
116	-163.8300	-114.7150	100
117	-153.2090	-128.5580	100
118	-141.4210	-141.4210	100
119	-128.5580	-153.2090	100
120	-114.7150	-163.8300	100
121	-100.0000	-173.2050	100
122	-84.5237	-181.2620	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
123	-68.4040	-187.9390	100
124	-51.7638	-193.1850	100
125	-34.7296	-196.9620	100
126	-17.4311	-199.2390	100
127	0.0000	-200.0000	100
128	17.4311	-199.2390	100
129	34.7296	-196.9620	100
130	51.7638	-193.1850	100
131	68.4040	-187.9390	100
132	84.5237	-181.2620	100
133	100.0000	-173.2050	100
134	114.7150	-163.8300	100
135	128.5580	-153.2090	100
136	141.4210	-141.4210	100
137	153.2090	-128.5580	100
138	163.8300	-114.7150	100
139	173.2050	-100.0000	100
140	181.2620	-84.5237	100
141	187.9390	-68.4040	100
142	193.1850	-51.7638	100
143	196.9620	-34.7296	100
144	199.2390	-17.4311	100
145	300.0000	0.0000	100
146	298.8580	26.1467	100
147	295.4420	52.0945	100
148	289.7780	77.6457	100
149	281.9080	102.6060	100
150	271.8920	126.7850	100
151	259.8080	150.0000	100
152	245.7460	172.0730	100
153	229.8130	192.8360	100
154	212.1320	212.1320	100
155	192.8360	229.8130	100
156	172.0730	245.7460	100
157	150.0000	259.8080	100
158	126.7850	271.8920	100
159	102.6060	281.9080	100
160	77.6457	289.7780	100
161	52.0945	295.4420	100
162	26.1467	298.8580	100
163	0.0000	300.0000	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
164	-26.1467	298.8580	100
165	-52.0945	295.4420	100
166	-77.6457	289.7780	100
167	-102.6060	281.9080	100
168	-126.7850	271.8920	100
169	-150.0000	259.8080	100
170	-172.0730	245.7460	100
171	-192.8360	229.8130	100
172	-212.1320	212.1320	100
173	-229.8130	192.8360	100
174	-245.7460	172.0730	100
175	-259.8080	150.0000	100
176	-271.8920	126.7850	100
177	-281.9080	102.6060	100
178	-289.7780	77.6457	100
179	-295.4420	52.0945	100
180	-298.8580	26.1467	100
181	-300.0000	0.0000	100
182	-298.8580	-26.1467	100
183	-295.4420	-52.0945	100
184	-289.7780	-77.6457	100
185	-281.9080	-102.6060	100
186	-271.8920	-126.7850	100
187	-259.8080	-150.0000	100
188	-245.7460	-172.0730	100
189	-229.8130	-192.8360	100
190	-212.1320	-212.1320	100
191	-192.8360	-229.8130	100
192	-172.0730	-245.7460	100
193	-150.0000	-259.8080	100
194	-126.7850	-271.8920	100
195	-102.6060	-281.9080	100
196	-77.6457	-289.7780	100
197	-52.0945	-295.4420	100
198	-26.1467	-298.8580	100
199	0.0000	-300.0000	100
200	26.1467	-298.8580	100
201	52.0945	-295.4420	100
202	77.6457	-289.7780	100
203	102.6060	-281.9080	100
204	126.7850	-271.8920	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
205	150.0000	-259.8080	100
206	172.0730	-245.7460	100
207	192.8360	-229.8130	100
208	212.1320	-212.1320	100
209	229.8130	-192.8360	100
210	245.7460	-172.0730	100
211	259.8080	-150.0000	100
212	271.8920	-126.7850	100
213	281.9080	-102.6060	100
214	289.7780	-77.6457	100
215	295.4420	-52.0945	100
216	298.8580	-26.1467	100
217	400.0000	0.0000	100
218	398.4780	34.8623	100
219	393.9230	69.4593	100
220	386.3700	103.5280	100
221	375.8770	136.8080	100
222	362.5230	169.0470	100
223	346.4100	200.0000	100
224	327.6610	229.4310	100
225	306.4180	257.1150	100
226	282.8430	282.8430	100
227	257.1150	306.4180	100
228	229.4310	327.6610	100
229	200.0000	346.4100	100
230	169.0470	362.5230	100
231	136.8080	375.8770	100
232	103.5280	386.3700	100
233	69.4593	393.9230	100
234	34.8623	398.4780	100
235	0.0000	400.0000	100
236	-34.8623	398.4780	100
237	-69.4593	393.9230	100
238	-103.5280	386.3700	100
239	-136.8080	375.8770	100
240	-169.0470	362.5230	100
241	-200.0000	346.4100	100
242	-229.4310	327.6610	100
243	-257.1150	306.4180	100
244	-282.8430	282.8430	100
245	-306.4180	257.1150	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
246	-327.6610	229.4310	100
247	-346.4100	200.0000	100
248	-362.5230	169.0470	100
249	-375.8770	136.8080	100
250	-386.3700	103.5280	100
251	-393.9230	69.4593	100
252	-398.4780	34.8623	100
253	-400.0000	0.0000	100
254	-398.4780	-34.8623	100
255	-393.9230	-69.4593	100
256	-386.3700	-103.5280	100
257	-375.8770	-136.8080	100
258	-362.5230	-169.0470	100
259	-346.4100	-200.0000	100
260	-327.6610	-229.4310	100
261	-306.4180	-257.1150	100
262	-282.8430	-282.8430	100
263	-257.1150	-306.4180	100
264	-229.4310	-327.6610	100
265	-200.0000	-346.4100	100
266	-169.0470	-362.5230	100
267	-136.8080	-375.8770	100
268	-103.5280	-386.3700	100
269	-69.4593	-393.9230	100
270	-34.8623	-398.4780	100
271	0.0000	-400.0000	100
272	34.8623	-398.4780	100
273	69.4593	-393.9230	100
274	103.5280	-386.3700	100
275	136.8080	-375.8770	100
276	169.0470	-362.5230	100
277	200.0000	-346.4100	100
278	229.4310	-327.6610	100
279	257.1150	-306.4180	100
280	282.8430	-282.8430	100
281	306.4180	-257.1150	100
282	327.6610	-229.4310	100
283	346.4100	-200.0000	100
284	362.5230	-169.0470	100
285	375.8770	-136.8080	100
286	386.3700	-103.5280	100

Continued on next page

Table C.22 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service time
287	393.9230	-69.4593	100
288	398.4780	-34.8623	100
Depot	0	0	N.A.

Appendix D: Close-Enough Traveling Salesman Problem test instances

In this appendix, we present the test instances for the Close-Enough Traveling Salesman Problem in Chapter 6. (The min-max Close-Enough Vehicle Routing Problem has exactly the same customer locations.) There are 14 instances. Each instance is presented in one table. For example, instance kroD100rdmRad is presented in Table D.1. The first column gives the customer index. The second and third columns give the x and y coordinates of the location. The fourth column gives the customer's service range. The last row of each table gives the location of the depot.

We also present the solutions produced by MMSZ in Figures D.1 to D.14. The depot is represented by a red '*'. The customers are drawn using blue circles to show both their locations and service ranges. The route is shown by a thick black line.

Table D.1: CETSP instance kroD100rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	29.9500	2.6400	1.4400
2	2.0200	2.3300	1.4400
3	9.8100	8.4800	1.4400
4	13.4600	4.0800	1.4400
5	7.8100	6.7000	1.4400
6	10.0900	10.0100	1.4400
7	29.2700	17.7700	1.4400
8	29.8200	9.4900	1.4400
9	5.5500	11.2100	1.4400
10	4.6400	13.0200	1.4400
11	34.5200	6.3700	1.4400
12	5.7100	19.8200	1.4400
13	26.5600	1.2800	1.4400
14	16.2300	17.2300	1.4400
15	20.6700	6.9400	1.4400
16	17.2500	9.2700	1.4400
17	36.0000	4.5900	1.4400
18	11.0900	11.9600	1.4400
19	3.6600	3.3900	1.4400
20	7.7800	12.8200	1.4400
21	3.8600	16.1600	1.4400
22	39.1800	12.1700	1.4400
23	33.3200	10.4900	1.4400
24	25.9700	3.4900	1.4400
25	8.1100	12.9500	1.4400
26	2.4100	10.6900	1.4400
27	26.5800	3.6000	1.4400
28	3.9400	19.4400	1.4400
29	37.8600	18.6200	1.4400
30	2.6400	0.3600	1.4400
31	20.5000	18.3300	1.4400
32	35.3800	1.2500	1.4400
33	16.4600	18.1700	1.4400
34	29.9300	6.2400	1.4400
35	5.4700	0.2500	1.4400
36	33.7300	19.0200	1.4400
37	4.6000	2.6700	1.4400
38	30.6000	7.8100	1.4400
39	18.2800	4.5600	1.4400
40	10.2100	9.6200	1.4400
41	23.4700	3.8800	1.4400

Continued on next page

Table D.1 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	35.3500	11.1200	1.4400
43	15.2900	5.8100	1.4400
44	12.0300	3.8500	1.4400
45	17.8700	19.0200	1.4400
46	27.4000	11.0100	1.4400
47	5.5500	17.5300	1.4400
48	0.4700	3.6300	1.4400
49	39.3500	5.4000	1.4400
50	30.6200	3.2900	1.4400
51	3.8700	1.9900	1.4400
52	29.0100	9.2000	1.4400
53	9.3100	5.1200	1.4400
54	17.6600	6.9200	1.4400
55	4.0100	9.8000	1.4400
56	1.4900	16.2900	1.4400
57	22.1400	19.7700	1.4400
58	38.0500	16.1900	1.4400
59	11.7900	9.6900	1.4400
60	10.1700	3.3300	1.4400
61	28.3400	15.1200	1.4400
62	6.3400	2.9400	1.4400
63	18.1900	8.1400	1.4400
64	13.9300	8.5900	1.4400
65	17.6800	15.7800	1.4400
66	30.2300	8.7100	1.4400
67	32.4800	19.0600	1.4400
68	16.3200	17.4200	1.4400
69	22.2300	9.9000	1.4400
70	38.6800	6.9700	1.4400
71	15.4100	3.5400	1.4400
72	23.7400	19.4400	1.4400
73	19.6200	3.8900	1.4400
74	30.0700	15.2400	1.4400
75	32.2000	19.4500	1.4400
76	23.5600	15.6800	1.4400
77	16.0400	7.0600	1.4400
78	20.2800	17.3600	1.4400
79	25.8100	1.2100	1.4400
80	22.2100	15.7800	1.4400
81	29.4400	6.3200	1.4400
82	10.8200	15.6100	1.4400

Continued on next page

Table D.1 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	9.9700	9.4200	1.4400
84	23.3400	5.2300	1.4400
85	12.6400	10.9000	1.4400
86	16.9900	12.9400	1.4400
87	2.3500	10.5900	1.4400
88	25.9200	2.4800	1.4400
89	36.4200	6.9900	1.4400
90	35.9900	5.1400	1.4400
91	17.6600	6.7800	1.4400
92	2.4000	6.1900	1.4400
93	12.7200	2.4600	1.4400
94	35.0300	3.0100	1.4400
95	0.8000	15.3300	1.4400
96	16.7700	12.3800	1.4400
97	37.6600	1.5400	1.4400
98	39.4600	4.5900	1.4400
99	19.9400	18.5200	1.4400
Depot	2.7800	1.6500	N.A.

Table D.2: CETSP instance rat195rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	0.3000	1.2000	18.1000
2	1.7000	1.2000	18.1000
3	2.3000	0.9000	18.1000
4	3.4000	1.1000	18.1000
5	4.7000	1.1000	18.1000
6	5.4000	1.2000	18.1000
7	6.6000	1.6000	18.1000
8	7.5000	0.7000	18.1000
9	8.6000	0.6000	18.1000
10	9.4000	0.8000	18.1000
11	10.7000	0.9000	18.1000
12	11.5000	1.4000	18.1000
13	12.3000	1.5000	18.1000
14	0.3000	3.2000	18.1000
15	1.5000	3.2000	18.1000
16	2.6000	3.4000	18.1000
17	3.3000	3.4000	18.1000
18	4.2000	3.4000	18.1000
19	5.3000	2.5000	18.1000
20	6.4000	3.2000	18.1000
21	7.4000	3.2000	18.1000
22	8.5000	3.4000	18.1000
23	9.5000	2.8000	18.1000
24	10.4000	2.5000	18.1000
25	11.3000	3.1000	18.1000
26	12.5000	3.4000	18.1000
27	0.3000	4.8000	18.1000
28	1.5000	4.6000	18.1000
29	2.6000	5.0000	18.1000
30	3.6000	5.4000	18.1000
31	4.8000	5.0000	18.1000
32	5.4000	4.6000	18.1000
33	6.4000	5.4000	18.1000
34	7.5000	4.4000	18.1000
35	8.8000	4.9000	18.1000
36	9.8000	5.0000	18.1000
37	10.3000	5.4000	18.1000
38	11.5000	4.7000	18.1000
39	12.7000	4.9000	18.1000
40	0.6000	7.5000	18.1000
41	1.5000	7.5000	18.1000

Continued on next page

Table D.2 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	2.7000	7.3000	18.1000
43	3.6000	7.3000	18.1000
44	4.7000	6.8000	18.1000
45	5.4000	7.2000	18.1000
46	6.6000	6.8000	18.1000
47	7.4000	6.7000	18.1000
48	8.5000	6.5000	18.1000
49	9.4000	7.4000	18.1000
50	10.7000	6.5000	18.1000
51	11.7000	6.5000	18.1000
52	12.5000	6.8000	18.1000
53	0.6000	8.4000	18.1000
54	1.3000	9.5000	18.1000
55	2.5000	9.4000	18.1000
56	3.7000	8.4000	18.1000
57	4.7000	8.7000	18.1000
58	5.3000	9.5000	18.1000
59	6.3000	8.6000	18.1000
60	7.7000	9.3000	18.1000
61	8.3000	8.9000	18.1000
62	9.4000	9.5000	18.1000
63	10.3000	9.2000	18.1000
64	11.5000	9.5000	18.1000
65	12.3000	9.3000	18.1000
66	0.7000	11.4000	18.1000
67	1.5000	11.1000	18.1000
68	2.4000	11.2000	18.1000
69	3.6000	10.8000	18.1000
70	4.3000	11.2000	18.1000
71	5.6000	10.5000	18.1000
72	6.4000	11.2000	18.1000
73	7.3000	11.2000	18.1000
74	8.6000	10.7000	18.1000
75	9.8000	10.8000	18.1000
76	10.4000	11.3000	18.1000
77	11.7000	11.5000	18.1000
78	12.6000	10.9000	18.1000
79	0.6000	12.7000	18.1000
80	1.7000	12.5000	18.1000
81	2.7000	13.4000	18.1000
82	3.5000	12.6000	18.1000

Continued on next page

Table D.2 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	4.4000	13.1000	18.1000
84	5.4000	13.2000	18.1000
85	6.3000	12.4000	18.1000
86	7.7000	12.7000	18.1000
87	8.2000	13.4000	18.1000
88	9.6000	12.8000	18.1000
89	10.3000	12.6000	18.1000
90	11.6000	13.0000	18.1000
91	12.6000	13.4000	18.1000
92	0.7000	15.2000	18.1000
93	1.6000	14.7000	18.1000
94	2.4000	15.3000	18.1000
95	3.5000	15.1000	18.1000
96	4.5000	15.4000	18.1000
97	5.5000	14.6000	18.1000
98	6.3000	15.5000	18.1000
99	7.5000	15.1000	18.1000
100	8.7000	15.4000	18.1000
101	9.3000	15.6000	18.1000
102	10.4000	15.1000	18.1000
103	11.7000	15.3000	18.1000
104	12.7000	14.8000	18.1000
105	0.3000	16.4000	18.1000
106	1.6000	17.2000	18.1000
107	2.5000	16.5000	18.1000
108	3.5000	17.5000	18.1000
109	4.4000	16.9000	18.1000
110	5.3000	17.4000	18.1000
111	6.4000	16.8000	18.1000
112	7.6000	17.1000	18.1000
113	8.7000	17.3000	18.1000
114	9.5000	17.4000	18.1000
115	10.6000	16.8000	18.1000
116	11.4000	16.9000	18.1000
117	12.5000	16.9000	18.1000
118	0.3000	19.0000	18.1000
119	1.6000	18.8000	18.1000
120	2.5000	19.5000	18.1000
121	3.7000	18.6000	18.1000
122	4.4000	18.9000	18.1000
123	5.4000	19.4000	18.1000

Continued on next page

Table D.2 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	6.6000	19.2000	18.1000
125	7.7000	19.2000	18.1000
126	8.5000	18.8000	18.1000
127	9.3000	18.5000	18.1000
128	10.6000	19.2000	18.1000
129	11.3000	19.3000	18.1000
130	12.5000	19.5000	18.1000
131	0.5000	20.7000	18.1000
132	1.5000	21.3000	18.1000
133	2.4000	20.9000	18.1000
134	3.3000	21.4000	18.1000
135	4.3000	20.6000	18.1000
136	5.3000	21.1000	18.1000
137	6.4000	21.3000	18.1000
138	7.4000	21.2000	18.1000
139	8.4000	21.2000	18.1000
140	9.4000	20.9000	18.1000
141	10.4000	21.5000	18.1000
142	11.5000	20.6000	18.1000
143	12.7000	20.9000	18.1000
144	0.6000	22.9000	18.1000
145	1.3000	22.7000	18.1000
146	2.6000	23.5000	18.1000
147	3.4000	22.5000	18.1000
148	4.3000	22.7000	18.1000
149	5.5000	22.5000	18.1000
150	6.7000	22.9000	18.1000
151	7.5000	23.4000	18.1000
152	8.7000	23.0000	18.1000
153	9.5000	23.5000	18.1000
154	10.5000	22.8000	18.1000
155	11.7000	22.5000	18.1000
156	12.7000	23.0000	18.1000
157	0.6000	24.9000	18.1000
158	1.5000	24.6000	18.1000
159	2.6000	25.5000	18.1000
160	3.3000	24.6000	18.1000
161	4.7000	24.8000	18.1000
162	5.8000	25.2000	18.1000
163	6.5000	24.8000	18.1000
164	7.3000	24.7000	18.1000

Continued on next page

Table D.2 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	8.7000	24.9000	18.1000
166	9.4000	24.5000	18.1000
167	10.4000	25.6000	18.1000
168	11.3000	24.6000	18.1000
169	12.5000	25.3000	18.1000
170	0.5000	26.6000	18.1000
171	1.6000	27.4000	18.1000
172	2.4000	26.7000	18.1000
173	3.7000	26.6000	18.1000
174	4.5000	26.7000	18.1000
175	5.4000	26.6000	18.1000
176	6.7000	26.7000	18.1000
177	7.4000	26.5000	18.1000
178	8.7000	26.4000	18.1000
179	9.5000	27.1000	18.1000
180	10.6000	26.4000	18.1000
181	11.6000	27.1000	18.1000
182	12.7000	27.3000	18.1000
183	0.7000	28.7000	18.1000
184	1.7000	29.4000	18.1000
185	2.3000	28.7000	18.1000
186	3.3000	28.4000	18.1000
187	4.3000	28.8000	18.1000
188	5.3000	29.5000	18.1000
189	6.7000	28.8000	18.1000
190	7.3000	28.6000	18.1000
191	8.7000	29.3000	18.1000
192	9.4000	28.4000	18.1000
193	10.4000	29.1000	18.1000
194	11.4000	29.4000	18.1000
Depot	12.7000	29.0000	N.A.

Table D.3: CETSP instance lin318rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	6.3000	7.1000	39.2000
2	9.4000	7.1000	39.2000
3	14.2000	37.0000	39.2000
4	17.3000	127.6000	39.2000
5	20.5000	121.3000	39.2000
6	21.3000	6.9000	39.2000
7	24.4000	6.9000	39.2000
8	27.6000	63.0000	39.2000
9	28.3000	73.2000	39.2000
10	36.2000	6.9000	39.2000
11	39.4000	6.9000	39.2000
12	44.9000	37.0000	39.2000
13	48.0000	127.6000	39.2000
14	51.2000	121.3000	39.2000
15	52.8000	15.7000	39.2000
16	58.3000	63.0000	39.2000
17	59.1000	73.2000	39.2000
18	63.8000	65.4000	39.2000
19	63.8000	49.6000	39.2000
20	63.8000	31.4000	39.2000
21	63.8000	14.2000	39.2000
22	66.9000	14.2000	39.2000
23	67.7000	31.5000	39.2000
24	67.7000	49.6000	39.2000
25	67.7000	65.4000	39.2000
26	70.9000	65.4000	39.2000
27	70.9000	49.6000	39.2000
28	70.9000	31.5000	39.2000
29	70.1000	14.2000	39.2000
30	76.4000	22.0000	39.2000
31	81.1000	18.9000	39.2000
32	84.3000	17.3000	39.2000
33	85.8000	37.0000	39.2000
34	89.0000	127.6000	39.2000
35	92.1000	121.3000	39.2000
36	99.2000	63.0000	39.2000
37	100.0000	73.2000	39.2000
38	119.7000	127.6000	39.2000
39	122.8000	121.3000	39.2000
40	127.6000	20.5000	39.2000
41	129.9000	63.0000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	130.7000	73.2000	39.2000
43	136.2000	65.4000	39.2000
44	136.2000	49.6000	39.2000
45	136.2000	29.1000	39.2000
46	142.5000	65.4000	39.2000
47	142.5000	49.6000	39.2000
48	142.5000	29.1000	39.2000
49	141.7000	17.3000	39.2000
50	148.8000	29.1000	39.2000
51	148.8000	49.6000	39.2000
52	148.8000	65.4000	39.2000
53	155.1000	65.4000	39.2000
54	155.1000	49.6000	39.2000
55	155.1000	29.1000	39.2000
56	161.4000	29.1000	39.2000
57	161.4000	49.6000	39.2000
58	161.4000	65.4000	39.2000
59	173.2000	18.9000	39.2000
60	181.1000	127.6000	39.2000
61	184.3000	121.3000	39.2000
62	191.3000	63.0000	39.2000
63	192.1000	73.2000	39.2000
64	208.7000	37.0000	39.2000
65	211.8000	127.6000	39.2000
66	215.0000	121.3000	39.2000
67	218.9000	20.5000	39.2000
68	222.0000	18.9000	39.2000
69	222.0000	63.0000	39.2000
70	222.8000	73.2000	39.2000
71	224.4000	14.2000	39.2000
72	227.6000	31.5000	39.2000
73	227.6000	49.6000	39.2000
74	227.6000	65.4000	39.2000
75	231.5000	65.4000	39.2000
76	231.5000	49.6000	39.2000
77	231.5000	31.5000	39.2000
78	233.1000	14.2000	39.2000
79	234.6000	31.5000	39.2000
80	234.6000	49.6000	39.2000
81	234.6000	65.4000	39.2000
82	236.2000	14.2000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	240.2000	15.7000	39.2000
84	240.2000	22.0000	39.2000
85	248.0000	14.2000	39.2000
86	249.6000	37.0000	39.2000
87	252.8000	127.6000	39.2000
88	255.9000	121.3000	39.2000
89	263.0000	63.0000	39.2000
90	263.8000	73.2000	39.2000
91	275.6000	6.9000	39.2000
92	278.7000	6.9000	39.2000
93	280.3000	37.0000	39.2000
94	283.5000	127.6000	39.2000
95	286.6000	121.3000	39.2000
96	290.6000	6.9000	39.2000
97	293.7000	6.9000	39.2000
98	293.7000	63.0000	39.2000
99	294.5000	73.2000	39.2000
100	301.6000	127.6000	39.2000
101	305.5000	6.9000	39.2000
102	308.7000	6.9000	39.2000
103	60.6000	22.0000	39.2000
104	116.5000	37.0000	39.2000
105	178.0000	37.0000	39.2000
106	6.3000	140.2000	39.2000
107	9.4000	140.2000	39.2000
108	14.2000	170.1000	39.2000
109	17.3000	260.7000	39.2000
110	20.5000	254.4000	39.2000
111	21.3000	140.0000	39.2000
112	24.4000	140.0000	39.2000
113	27.6000	196.1000	39.2000
114	28.3000	206.3000	39.2000
115	36.2000	140.0000	39.2000
116	39.4000	140.0000	39.2000
117	44.9000	170.1000	39.2000
118	48.0000	260.7000	39.2000
119	51.2000	254.4000	39.2000
120	52.8000	148.8000	39.2000
121	58.3000	196.1000	39.2000
122	59.1000	206.3000	39.2000
123	63.8000	198.5000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	63.8000	182.7000	39.2000
125	63.8000	164.5000	39.2000
126	63.8000	147.3000	39.2000
127	66.9000	147.3000	39.2000
128	67.7000	164.6000	39.2000
129	67.7000	182.7000	39.2000
130	67.7000	198.5000	39.2000
131	70.9000	198.5000	39.2000
132	70.9000	182.7000	39.2000
133	70.9000	164.6000	39.2000
134	70.1000	147.3000	39.2000
135	76.4000	155.1000	39.2000
136	81.1000	152.0000	39.2000
137	84.3000	150.4000	39.2000
138	85.8000	170.1000	39.2000
139	89.0000	260.7000	39.2000
140	92.1000	254.4000	39.2000
141	99.2000	196.1000	39.2000
142	100.0000	206.3000	39.2000
143	119.7000	260.7000	39.2000
144	122.8000	254.4000	39.2000
145	127.6000	153.6000	39.2000
146	129.9000	196.1000	39.2000
147	130.7000	206.3000	39.2000
148	136.2000	198.5000	39.2000
149	136.2000	182.7000	39.2000
150	136.2000	162.2000	39.2000
151	142.5000	198.5000	39.2000
152	142.5000	182.7000	39.2000
153	142.5000	162.2000	39.2000
154	141.7000	150.4000	39.2000
155	148.8000	162.2000	39.2000
156	148.8000	182.7000	39.2000
157	148.8000	198.5000	39.2000
158	155.1000	198.5000	39.2000
159	155.1000	182.7000	39.2000
160	155.1000	162.2000	39.2000
161	161.4000	162.2000	39.2000
162	161.4000	182.7000	39.2000
163	161.4000	198.5000	39.2000
164	173.2000	152.0000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	181.1000	260.7000	39.2000
166	184.3000	254.4000	39.2000
167	191.3000	196.1000	39.2000
168	192.1000	206.3000	39.2000
169	208.7000	170.1000	39.2000
170	211.8000	260.7000	39.2000
171	215.0000	254.4000	39.2000
172	218.9000	153.6000	39.2000
173	222.0000	152.0000	39.2000
174	222.0000	196.1000	39.2000
175	222.8000	206.3000	39.2000
176	224.4000	147.3000	39.2000
177	227.6000	164.6000	39.2000
178	227.6000	182.7000	39.2000
179	227.6000	198.5000	39.2000
180	231.5000	198.5000	39.2000
181	231.5000	182.7000	39.2000
182	231.5000	164.6000	39.2000
183	233.1000	147.3000	39.2000
184	234.6000	164.6000	39.2000
185	234.6000	182.7000	39.2000
186	234.6000	198.5000	39.2000
187	236.2000	147.3000	39.2000
188	240.2000	148.8000	39.2000
189	240.2000	155.1000	39.2000
190	248.0000	147.3000	39.2000
191	249.6000	170.1000	39.2000
192	252.8000	260.7000	39.2000
193	255.9000	254.4000	39.2000
194	263.0000	196.1000	39.2000
195	263.8000	206.3000	39.2000
196	275.6000	140.0000	39.2000
197	278.7000	140.0000	39.2000
198	280.3000	170.1000	39.2000
199	283.5000	260.7000	39.2000
200	286.6000	254.4000	39.2000
201	290.6000	140.0000	39.2000
202	293.7000	140.0000	39.2000
203	293.7000	196.1000	39.2000
204	294.5000	206.3000	39.2000
205	301.6000	260.7000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	305.5000	140.0000	39.2000
207	308.7000	140.0000	39.2000
208	60.6000	155.1000	39.2000
209	116.5000	170.1000	39.2000
210	178.0000	170.1000	39.2000
211	6.3000	273.3000	39.2000
212	9.4000	273.3000	39.2000
213	14.2000	303.2000	39.2000
214	17.3000	393.8000	39.2000
215	20.5000	387.5000	39.2000
216	21.3000	273.1000	39.2000
217	24.4000	273.1000	39.2000
218	27.6000	329.2000	39.2000
219	28.3000	339.4000	39.2000
220	36.2000	273.1000	39.2000
221	39.4000	273.1000	39.2000
222	44.9000	303.2000	39.2000
223	48.0000	393.8000	39.2000
224	51.2000	387.5000	39.2000
225	52.8000	281.9000	39.2000
226	58.3000	329.2000	39.2000
227	59.1000	339.4000	39.2000
228	63.8000	331.6000	39.2000
229	63.8000	315.8000	39.2000
230	63.8000	297.6000	39.2000
231	63.8000	280.4000	39.2000
232	66.9000	280.4000	39.2000
233	67.7000	297.7000	39.2000
234	67.7000	315.8000	39.2000
235	67.7000	331.6000	39.2000
236	70.9000	331.6000	39.2000
237	70.9000	315.8000	39.2000
238	70.9000	297.7000	39.2000
239	70.1000	280.4000	39.2000
240	76.4000	288.2000	39.2000
241	81.1000	285.1000	39.2000
242	84.3000	283.5000	39.2000
243	85.8000	303.2000	39.2000
244	89.0000	393.8000	39.2000
245	92.1000	387.5000	39.2000
246	99.2000	329.2000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	100.0000	339.4000	39.2000
248	119.7000	393.8000	39.2000
249	122.8000	387.5000	39.2000
250	127.6000	286.7000	39.2000
251	129.9000	329.2000	39.2000
252	130.7000	339.4000	39.2000
253	136.2000	331.6000	39.2000
254	136.2000	315.8000	39.2000
255	136.2000	295.3000	39.2000
256	142.5000	331.6000	39.2000
257	142.5000	315.8000	39.2000
258	142.5000	295.3000	39.2000
259	141.7000	283.5000	39.2000
260	148.8000	295.3000	39.2000
261	148.8000	315.8000	39.2000
262	148.8000	331.6000	39.2000
263	155.1000	331.6000	39.2000
264	155.1000	315.8000	39.2000
265	155.1000	295.3000	39.2000
266	161.4000	295.3000	39.2000
267	161.4000	315.8000	39.2000
268	161.4000	331.6000	39.2000
269	173.2000	285.1000	39.2000
270	181.1000	393.8000	39.2000
271	184.3000	387.5000	39.2000
272	191.3000	329.2000	39.2000
273	192.1000	339.4000	39.2000
274	208.7000	303.2000	39.2000
275	211.8000	393.8000	39.2000
276	215.0000	387.5000	39.2000
277	218.9000	286.7000	39.2000
278	222.0000	285.1000	39.2000
279	222.0000	329.2000	39.2000
280	222.8000	339.4000	39.2000
281	224.4000	280.4000	39.2000
282	227.6000	297.7000	39.2000
283	227.6000	315.8000	39.2000
284	227.6000	331.6000	39.2000
285	231.5000	331.6000	39.2000
286	231.5000	315.8000	39.2000
287	231.5000	297.7000	39.2000

Continued on next page

Table D.3 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	233.1000	280.4000	39.2000
289	234.6000	297.7000	39.2000
290	234.6000	315.8000	39.2000
291	234.6000	331.6000	39.2000
292	236.2000	280.4000	39.2000
293	240.2000	281.9000	39.2000
294	240.2000	288.2000	39.2000
295	248.0000	280.4000	39.2000
296	249.6000	303.2000	39.2000
297	252.8000	393.8000	39.2000
298	255.9000	387.5000	39.2000
299	263.0000	329.2000	39.2000
300	263.8000	339.4000	39.2000
301	275.6000	273.1000	39.2000
302	278.7000	273.1000	39.2000
303	280.3000	303.2000	39.2000
304	283.5000	393.8000	39.2000
305	286.6000	387.5000	39.2000
306	290.6000	273.1000	39.2000
307	293.7000	273.1000	39.2000
308	293.7000	329.2000	39.2000
309	294.5000	339.4000	39.2000
310	301.6000	393.8000	39.2000
311	305.5000	273.1000	39.2000
312	308.7000	273.1000	39.2000
313	60.6000	288.2000	39.2000
314	116.5000	303.2000	39.2000
315	178.0000	303.2000	39.2000
316	141.7000	-7.9000	39.2000
317	149.6000	-7.9000	39.2000
Depot	169.3000	405.5000	N.A.

Table D.4: CETSP instance rd400rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	43.5841	58.7522	0.0954
2	60.2539	80.1704	0.0954
3	86.1563	95.4019	0.0954
4	44.4217	55.3301	0.0954
5	79.6042	79.6519	0.0954
6	8.8906	83.8954	0.0954
7	23.3569	85.0798	0.0954
8	47.6864	20.3976	0.0954
9	40.6271	60.1839	0.0954
10	95.4573	78.5053	0.0954
11	59.3326	96.8644	0.0954
12	94.6100	43.2995	0.0954
13	8.3074	60.1487	0.0954
14	86.1254	75.4120	0.0954
15	24.7619	69.8637	0.0954
16	96.3227	96.5824	0.0954
17	12.5872	53.6987	0.0954
18	56.3237	2.0737	0.0954
19	5.5259	61.9092	0.0954
20	69.1414	57.6653	0.0954
21	23.7167	70.7298	0.0954
22	58.3448	60.9201	0.0954
23	40.4171	94.2218	0.0954
24	1.5771	61.4642	0.0954
25	2.0081	6.2897	0.0954
26	19.6656	61.3862	0.0954
27	91.3249	42.8902	0.0954
28	82.8340	58.4111	0.0954
29	4.9605	4.0606	0.0954
30	27.1361	73.6904	0.0954
31	97.9153	71.6970	0.0954
32	48.9418	95.7946	0.0954
33	81.7106	28.1120	0.0954
34	33.2771	46.6520	0.0954
35	27.8353	94.5623	0.0954
36	16.8540	97.4806	0.0954
37	80.6139	53.7748	0.0954
38	44.5404	30.6860	0.0954
39	30.6696	55.2626	0.0954
40	55.5492	35.9315	0.0954
41	15.6444	17.8995	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	14.0141	70.4084	0.0954
43	96.3235	44.2629	0.0954
44	46.0829	25.5503	0.0954
45	38.5534	48.7846	0.0954
46	93.1464	19.8146	0.0954
47	27.9893	89.6021	0.0954
48	33.1283	92.3481	0.0954
49	3.3536	88.9860	0.0954
50	51.1528	6.0410	0.0954
51	23.2874	32.7742	0.0954
52	87.0562	74.7862	0.0954
53	12.6307	2.7083	0.0954
54	2.5716	38.4711	0.0954
55	55.0990	31.7710	0.0954
56	42.1545	66.9856	0.0954
57	69.9395	64.1832	0.0954
58	3.0606	88.1315	0.0954
59	48.6626	98.7924	0.0954
60	54.7886	87.0165	0.0954
61	76.4190	22.7841	0.0954
62	48.9340	88.5471	0.0954
63	90.8764	48.3318	0.0954
64	19.5225	82.1483	0.0954
65	17.1854	11.1942	0.0954
66	59.9164	58.7500	0.0954
67	13.2524	50.7626	0.0954
68	32.7208	86.8800	0.0954
69	26.7929	78.8352	0.0954
70	79.2919	13.6517	0.0954
71	15.6993	18.7479	0.0954
72	18.6101	90.3489	0.0954
73	74.5996	81.8744	0.0954
74	67.2670	14.1516	0.0954
75	79.5061	49.6701	0.0954
76	29.8827	79.6840	0.0954
77	9.1600	37.8018	0.0954
78	91.7898	10.5225	0.0954
79	37.0272	27.4581	0.0954
80	78.9206	73.8168	0.0954
81	80.0350	15.8589	0.0954
82	74.8357	53.7031	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	48.6979	8.8591	0.0954
84	14.8737	9.5107	0.0954
85	23.1984	1.0131	0.0954
86	97.2905	22.0419	0.0954
87	4.0560	25.9589	0.0954
88	19.2470	29.2712	0.0954
89	2.4039	50.9808	0.0954
90	31.6686	31.1822	0.0954
91	49.4944	16.3270	0.0954
92	52.5118	68.1256	0.0954
93	83.5669	88.2708	0.0954
94	77.5205	18.1054	0.0954
95	10.9477	2.7353	0.0954
96	65.3011	67.1869	0.0954
97	62.8285	19.7058	0.0954
98	0.1949	71.2335	0.0954
99	73.0640	44.6995	0.0954
100	58.0371	93.3465	0.0954
101	37.7453	86.3505	0.0954
102	25.8125	25.1372	0.0954
103	65.9297	69.3415	0.0954
104	70.0979	43.9308	0.0954
105	80.1207	32.7664	0.0954
106	75.5117	58.1702	0.0954
107	16.8354	77.4785	0.0954
108	60.7710	67.3196	0.0954
109	56.9788	35.9946	0.0954
110	50.5772	79.5094	0.0954
111	69.2786	47.5055	0.0954
112	61.5258	41.6034	0.0954
113	43.3068	85.4106	0.0954
114	22.6997	14.9199	0.0954
115	32.6410	61.5676	0.0954
116	75.6359	99.7073	0.0954
117	17.5187	55.1629	0.0954
118	20.7262	75.3080	0.0954
119	12.7313	98.6134	0.0954
120	24.5176	59.5849	0.0954
121	36.8488	32.2474	0.0954
122	61.8453	80.8454	0.0954
123	28.4623	90.5817	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	34.7487	93.2543	0.0954
125	94.2046	73.3577	0.0954
126	92.3029	41.0170	0.0954
127	15.3759	23.0999	0.0954
128	47.6331	25.3181	0.0954
129	23.2085	58.8069	0.0954
130	43.9629	81.9344	0.0954
131	95.9404	38.2332	0.0954
132	65.9332	98.9174	0.0954
133	47.5220	42.2920	0.0954
134	73.4709	7.6166	0.0954
135	84.4594	85.6238	0.0954
136	1.0251	82.9527	0.0954
137	35.9094	68.8825	0.0954
138	90.1100	20.7153	0.0954
139	60.7208	77.8844	0.0954
140	68.2389	8.4710	0.0954
141	84.0931	75.7357	0.0954
142	44.9959	88.3516	0.0954
143	72.5650	40.2263	0.0954
144	88.2698	14.9994	0.0954
145	42.9870	22.9253	0.0954
146	98.0879	82.1977	0.0954
147	57.8122	54.5104	0.0954
148	54.1690	81.8375	0.0954
149	50.9211	16.4053	0.0954
150	87.5589	25.1226	0.0954
151	10.1219	82.0450	0.0954
152	48.5894	0.5480	0.0954
153	13.4000	22.8874	0.0954
154	16.7243	94.3593	0.0954
155	15.6372	44.5891	0.0954
156	26.7979	6.9020	0.0954
157	47.6475	71.1843	0.0954
158	45.6946	80.9262	0.0954
159	21.7245	2.0113	0.0954
160	16.5471	81.1813	0.0954
161	38.1612	45.7549	0.0954
162	31.0765	22.0815	0.0954
163	0.2198	2.5849	0.0954
164	13.5318	57.9262	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	25.7714	33.2927	0.0954
166	67.8108	54.6502	0.0954
167	17.6011	61.1721	0.0954
168	56.0389	33.1015	0.0954
169	41.6783	52.1535	0.0954
170	85.2354	42.0312	0.0954
171	85.0689	32.1301	0.0954
172	74.5771	5.7082	0.0954
173	10.4725	58.8780	0.0954
174	6.4345	8.7023	0.0954
175	41.7205	19.4188	0.0954
176	88.4474	55.9131	0.0954
177	86.8707	18.0065	0.0954
178	26.2003	42.5604	0.0954
179	66.9764	66.2314	0.0954
180	42.0178	3.4429	0.0954
181	42.4972	23.9973	0.0954
182	61.5069	0.4821	0.0954
183	96.7473	23.5618	0.0954
184	18.0640	96.3276	0.0954
185	15.3897	25.3897	0.0954
186	13.8308	54.4775	0.0954
187	2.3883	24.0295	0.0954
188	70.1018	4.3454	0.0954
189	95.1537	79.2325	0.0954
190	19.0116	0.9770	0.0954
191	34.7579	99.7518	0.0954
192	33.1085	0.8828	0.0954
193	54.7387	20.4852	0.0954
194	77.6794	29.1288	0.0954
195	75.6586	91.7899	0.0954
196	17.2306	77.2747	0.0954
197	8.5705	3.3673	0.0954
198	90.4883	12.6216	0.0954
199	8.7542	38.9280	0.0954
200	2.1973	10.2510	0.0954
201	41.7302	58.1199	0.0954
202	20.5641	47.7219	0.0954
203	48.6743	62.5481	0.0954
204	37.2177	7.7925	0.0954
205	11.7937	48.0467	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	29.5533	92.3189	0.0954
207	87.9339	96.7331	0.0954
208	88.9914	10.7701	0.0954
209	63.6977	85.2552	0.0954
210	38.2491	9.6174	0.0954
211	13.4598	41.6191	0.0954
212	75.9957	81.4020	0.0954
213	4.4507	94.0863	0.0954
214	24.4594	47.3987	0.0954
215	64.2573	58.9530	0.0954
216	22.8193	53.7552	0.0954
217	64.5769	3.6618	0.0954
218	88.1955	43.6361	0.0954
219	68.0574	15.6194	0.0954
220	81.1997	46.6210	0.0954
221	96.3481	58.4969	0.0954
222	31.2678	61.1344	0.0954
223	85.3959	62.1638	0.0954
224	51.8363	98.9629	0.0954
225	27.2482	20.2425	0.0954
226	76.2214	75.1456	0.0954
227	64.8783	60.3790	0.0954
228	78.3667	74.2083	0.0954
229	39.9475	19.2268	0.0954
230	3.2499	93.8751	0.0954
231	81.4209	43.6493	0.0954
232	29.1053	29.2049	0.0954
233	60.7013	1.3612	0.0954
234	9.2745	43.3967	0.0954
235	76.9072	18.2917	0.0954
236	17.5856	40.8861	0.0954
237	34.4656	38.8185	0.0954
238	22.7183	34.3604	0.0954
239	49.1148	32.8614	0.0954
240	2.5522	66.9796	0.0954
241	78.9060	18.0381	0.0954
242	98.0725	73.5090	0.0954
243	5.8182	20.7452	0.0954
244	19.5262	30.4483	0.0954
245	54.3707	99.6057	0.0954
246	55.7170	37.8511	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	25.6513	60.6643	0.0954
248	80.5435	37.2793	0.0954
249	46.2037	41.7062	0.0954
250	81.8209	62.9891	0.0954
251	41.5460	82.3742	0.0954
252	20.3288	28.0220	0.0954
253	32.5896	90.7590	0.0954
254	51.2472	90.6526	0.0954
255	82.6909	80.2719	0.0954
256	37.4105	49.4356	0.0954
257	59.9164	61.9972	0.0954
258	32.7353	38.4372	0.0954
259	36.0033	17.5038	0.0954
260	80.9911	75.8316	0.0954
261	26.0672	21.3383	0.0954
262	93.4248	68.5015	0.0954
263	17.6023	36.5196	0.0954
264	60.6972	35.5066	0.0954
265	66.7645	81.0279	0.0954
266	85.2864	82.4650	0.0954
267	74.6320	5.6044	0.0954
268	9.3555	53.1101	0.0954
269	81.8774	60.6902	0.0954
270	74.6616	49.1772	0.0954
271	23.1083	96.0553	0.0954
272	68.3546	93.0491	0.0954
273	43.1006	68.5786	0.0954
274	70.9830	56.1077	0.0954
275	45.2184	66.3382	0.0954
276	38.4806	81.2568	0.0954
277	88.6343	0.4944	0.0954
278	5.2584	27.1001	0.0954
279	15.2733	95.1553	0.0954
280	80.8889	76.3527	0.0954
281	77.5352	78.0347	0.0954
282	17.8085	51.9553	0.0954
283	98.8743	25.6460	0.0954
284	11.4258	37.7412	0.0954
285	23.6126	49.4214	0.0954
286	31.4339	43.8079	0.0954
287	27.3595	17.3028	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	4.9997	74.2733	0.0954
289	0.6429	35.3950	0.0954
290	54.0007	52.8659	0.0954
291	78.6058	43.2582	0.0954
292	99.5164	7.7748	0.0954
293	50.9984	83.4341	0.0954
294	89.0360	30.7257	0.0954
295	30.4468	53.5688	0.0954
296	47.3917	2.2305	0.0954
297	86.8559	48.4797	0.0954
298	9.1727	66.1356	0.0954
299	61.6789	74.8507	0.0954
300	41.4131	74.8199	0.0954
301	23.6206	68.3440	0.0954
302	97.4766	17.1802	0.0954
303	73.2088	32.0501	0.0954
304	33.4192	59.4830	0.0954
305	56.1254	1.4053	0.0954
306	3.3012	54.5758	0.0954
307	45.1636	79.7971	0.0954
308	19.7287	0.1987	0.0954
309	23.6339	40.0124	0.0954
310	74.7866	36.0265	0.0954
311	43.0779	81.6476	0.0954
312	2.1823	25.6845	0.0954
313	34.4638	23.0393	0.0954
314	75.4786	92.9344	0.0954
315	25.7178	17.8950	0.0954
316	23.3293	78.9181	0.0954
317	10.9638	55.5178	0.0954
318	81.8496	38.8539	0.0954
319	43.8962	13.6901	0.0954
320	34.4937	83.7515	0.0954
321	92.0634	46.0336	0.0954
322	95.0473	3.3982	0.0954
323	12.3803	91.1149	0.0954
324	82.6839	23.4883	0.0954
325	96.7716	16.6523	0.0954
326	76.3859	55.8636	0.0954
327	47.7087	83.4773	0.0954
328	18.9042	62.1271	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	50.0418	88.5256	0.0954
330	80.7777	87.9354	0.0954
331	0.6136	12.2624	0.0954
332	68.0526	97.9535	0.0954
333	75.2455	17.3084	0.0954
334	74.0572	35.9870	0.0954
335	49.4045	19.9610	0.0954
336	22.5447	55.6169	0.0954
337	78.2186	68.7569	0.0954
338	55.9929	17.1432	0.0954
339	46.3399	71.1700	0.0954
340	9.9608	19.2347	0.0954
341	25.7615	81.4539	0.0954
342	4.2889	92.6489	0.0954
343	17.2907	17.3232	0.0954
344	48.3206	81.4332	0.0954
345	53.7144	89.3849	0.0954
346	0.2990	97.3272	0.0954
347	28.6889	43.6077	0.0954
348	3.4457	28.2052	0.0954
349	38.2173	22.8740	0.0954
350	40.7053	85.7824	0.0954
351	95.7659	2.5535	0.0954
352	53.4254	44.9898	0.0954
353	89.1084	77.1611	0.0954
354	60.9907	71.4945	0.0954
355	80.0506	36.8529	0.0954
356	0.6594	19.6999	0.0954
357	12.2621	43.6923	0.0954
358	51.7930	64.9464	0.0954
359	23.5387	4.1313	0.0954
360	60.3560	72.3736	0.0954
361	91.0373	94.8618	0.0954
362	49.8328	92.6571	0.0954
363	54.8665	95.2849	0.0954
364	77.9110	9.9019	0.0954
365	58.2097	7.5607	0.0954
366	21.4744	8.2189	0.0954
367	56.0439	62.2937	0.0954
368	69.3672	55.5594	0.0954
369	9.0496	1.6796	0.0954

Continued on next page

Table D.4 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	76.0500	41.1841	0.0954
371	62.6521	52.6724	0.0954
372	99.5853	23.4577	0.0954
373	91.8947	87.6684	0.0954
374	98.9579	4.7321	0.0954
375	37.7688	31.4408	0.0954
376	96.1419	41.3034	0.0954
377	82.5413	70.9361	0.0954
378	82.7455	58.0479	0.0954
379	3.5780	99.0366	0.0954
380	62.0154	28.1819	0.0954
381	10.9524	12.0779	0.0954
382	73.8931	82.0767	0.0954
383	27.4222	25.8428	0.0954
384	8.2541	64.3565	0.0954
385	59.2712	76.4167	0.0954
386	72.4782	47.1166	0.0954
387	77.8131	90.2453	0.0954
388	88.5712	66.6382	0.0954
389	2.6887	16.3883	0.0954
390	74.1314	97.2935	0.0954
391	16.5760	71.2313	0.0954
392	25.6231	12.6549	0.0954
393	92.7385	89.9534	0.0954
394	52.4925	5.3725	0.0954
395	7.2192	42.3799	0.0954
396	36.7230	86.3354	0.0954
397	34.9224	79.9328	0.0954
398	12.7116	4.2915	0.0954
399	58.7637	13.9566	0.0954
Depot	2.2832	35.5085	N.A.

Table D.5: CETSP instance pcb442rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	2.0000	4.0000	6.0000
2	2.0000	5.0000	6.0000
3	2.0000	6.0000	6.0000
4	2.0000	7.0000	6.0000
5	2.0000	8.0000	6.0000
6	2.0000	9.0000	6.0000
7	2.0000	10.0000	6.0000
8	2.0000	11.0000	6.0000
9	2.0000	12.0000	6.0000
10	2.0000	13.0000	6.0000
11	2.0000	14.0000	6.0000
12	2.0000	15.0000	6.0000
13	2.0000	16.0000	6.0000
14	2.0000	17.0000	6.0000
15	2.0000	18.0000	6.0000
16	2.0000	19.0000	6.0000
17	2.0000	20.0000	6.0000
18	2.0000	21.0000	6.0000
19	2.0000	22.0000	6.0000
20	2.0000	23.0000	6.0000
21	2.0000	24.0000	6.0000
22	2.0000	25.0000	6.0000
23	2.0000	26.0000	6.0000
24	2.0000	27.0000	6.0000
25	2.0000	28.0000	6.0000
26	2.0000	29.0000	6.0000
27	2.0000	30.0000	6.0000
28	2.0000	31.0000	6.0000
29	2.0000	32.0000	6.0000
30	2.0000	33.0000	6.0000
31	2.0000	34.0000	6.0000
32	2.0000	35.0000	6.0000
33	2.0000	36.0000	6.0000
34	3.0000	4.0000	6.0000
35	3.0000	5.0000	6.0000
36	3.0000	6.0000	6.0000
37	3.0000	7.0000	6.0000
38	3.0000	8.0000	6.0000
39	3.0000	9.0000	6.0000
40	3.0000	10.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
41	3.0000	11.0000	6.0000
42	3.0000	12.0000	6.0000
43	3.0000	13.0000	6.0000
44	3.0000	14.0000	6.0000
45	3.0000	15.0000	6.0000
46	3.0000	16.0000	6.0000
47	3.0000	17.0000	6.0000
48	3.0000	18.0000	6.0000
49	3.0000	19.0000	6.0000
50	3.0000	20.0000	6.0000
51	3.0000	21.0000	6.0000
52	3.0000	22.0000	6.0000
53	3.0000	23.0000	6.0000
54	3.0000	24.0000	6.0000
55	3.0000	25.0000	6.0000
56	3.0000	26.0000	6.0000
57	3.0000	27.0000	6.0000
58	3.0000	28.0000	6.0000
59	3.0000	29.0000	6.0000
60	3.0000	30.0000	6.0000
61	3.0000	31.0000	6.0000
62	3.0000	32.0000	6.0000
63	3.0000	33.0000	6.0000
64	3.0000	34.0000	6.0000
65	3.0000	35.0000	6.0000
66	4.0000	4.0000	6.0000
67	4.0000	5.0000	6.0000
68	4.0000	6.0000	6.0000
69	4.0000	7.0000	6.0000
70	4.0000	8.0000	6.0000
71	4.0000	9.0000	6.0000
72	4.0000	10.0000	6.0000
73	4.0000	11.0000	6.0000
74	4.0000	12.0000	6.0000
75	4.0000	13.0000	6.0000
76	4.0000	14.0000	6.0000
77	4.0000	15.0000	6.0000
78	4.0000	16.0000	6.0000
79	4.0000	17.0000	6.0000
80	4.0000	18.0000	6.0000
81	4.0000	19.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
82	4.0000	20.0000	6.0000
83	4.0000	21.0000	6.0000
84	4.0000	22.0000	6.0000
85	4.0000	23.0000	6.0000
86	4.0000	24.0000	6.0000
87	4.0000	25.0000	6.0000
88	4.0000	26.0000	6.0000
89	4.0000	27.0000	6.0000
90	4.0000	28.0000	6.0000
91	4.0000	29.0000	6.0000
92	4.0000	30.0000	6.0000
93	4.0000	31.0000	6.0000
94	4.0000	32.0000	6.0000
95	4.0000	33.0000	6.0000
96	4.0000	34.0000	6.0000
97	4.0000	35.0000	6.0000
98	4.0000	36.0000	6.0000
99	5.0000	15.0000	6.0000
100	5.0000	18.3000	6.0000
101	5.0000	31.0000	6.0000
102	6.0000	4.0000	6.0000
103	7.0000	3.0000	6.0000
104	7.0000	6.0000	6.0000
105	7.0000	15.0000	6.0000
106	7.0000	16.0000	6.0000
107	7.0000	18.0000	6.0000
108	7.0000	21.0000	6.0000
109	7.0000	24.0000	6.0000
110	7.0000	27.0000	6.0000
111	7.0000	30.0000	6.0000
112	7.0000	33.0000	6.0000
113	7.0000	36.0000	6.0000
114	8.0000	3.0000	6.0000
115	8.0000	6.0000	6.0000
116	8.0000	10.3000	6.0000
117	8.0000	15.0000	6.0000
118	8.0000	18.0000	6.0000
119	8.0000	21.0000	6.0000
120	8.0000	24.0000	6.0000
121	8.0000	26.0000	6.0000
122	8.0000	27.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
123	8.0000	30.0000	6.0000
124	8.0000	33.0000	6.0000
125	8.0000	36.0000	6.0000
126	9.0000	3.0000	6.0000
127	9.0000	6.0000	6.0000
128	9.0000	15.0000	6.0000
129	9.0000	18.0000	6.0000
130	9.0000	21.0000	6.0000
131	9.0000	24.0000	6.0000
132	9.0000	27.0000	6.0000
133	9.0000	30.0000	6.0000
134	9.0000	33.0000	6.0000
135	9.0000	36.0000	6.0000
136	10.0000	3.0000	6.0000
137	10.0000	6.0000	6.0000
138	10.0000	11.0000	6.0000
139	10.0000	15.0000	6.0000
140	10.0000	16.3000	6.0000
141	10.0000	18.0000	6.0000
142	10.0000	21.0000	6.0000
143	10.0000	24.0000	6.0000
144	10.0000	26.0000	6.0000
145	10.0000	27.0000	6.0000
146	10.0000	30.0000	6.0000
147	10.0000	33.0000	6.0000
148	10.0000	36.0000	6.0000
149	11.0000	3.0000	6.0000
150	11.0000	6.0000	6.0000
151	11.0000	7.0000	6.0000
152	11.0000	9.0000	6.0000
153	11.0000	15.0000	6.0000
154	11.0000	18.0000	6.0000
155	11.0000	21.0000	6.0000
156	11.0000	24.0000	6.0000
157	11.0000	27.0000	6.0000
158	11.0000	30.0000	6.0000
159	11.0000	33.0000	6.0000
160	11.0000	36.0000	6.0000
161	12.0000	3.0000	6.0000
162	12.0000	6.0000	6.0000
163	12.0000	15.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
164	12.0000	17.0000	6.0000
165	12.0000	18.0000	6.0000
166	12.0000	21.0000	6.0000
167	12.0000	24.0000	6.0000
168	12.0000	27.0000	6.0000
169	12.0000	30.0000	6.0000
170	12.0000	33.0000	6.0000
171	12.0000	36.0000	6.0000
172	13.0000	3.0000	6.0000
173	13.0000	6.0000	6.0000
174	13.0000	7.0000	6.0000
175	13.0000	11.3000	6.0000
176	13.0000	15.0000	6.0000
177	13.0000	18.0000	6.0000
178	13.0000	21.0000	6.0000
179	13.0000	22.0000	6.0000
180	13.0000	24.0000	6.0000
181	13.0000	27.0000	6.0000
182	13.0000	30.0000	6.0000
183	13.0000	33.0000	6.0000
184	13.0000	36.0000	6.0000
185	14.0000	3.0000	6.0000
186	14.0000	6.0000	6.0000
187	14.0000	9.3000	6.0000
188	14.0000	15.0000	6.0000
189	14.0000	18.0000	6.0000
190	14.0000	20.0000	6.0000
191	14.0000	21.0000	6.0000
192	14.0000	24.0000	6.0000
193	14.0000	25.0000	6.0000
194	14.0000	27.0000	6.0000
195	14.0000	28.2000	6.0000
196	14.0000	29.0000	6.0000
197	14.0000	30.0000	6.0000
198	14.0000	33.0000	6.0000
199	14.0000	36.0000	6.0000
200	15.0000	15.0000	6.0000
201	15.0000	18.0000	6.0000
202	15.0000	19.0000	6.0000
203	15.0000	21.0000	6.0000
204	15.0000	24.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
205	15.0000	27.0000	6.0000
206	15.0000	28.0000	6.0000
207	15.0000	28.6000	6.0000
208	15.0000	30.0000	6.0000
209	15.0000	33.0000	6.0000
210	15.0000	36.0000	6.0000
211	16.0000	11.0000	6.0000
212	16.0000	13.0000	6.0000
213	16.0000	15.0000	6.0000
214	16.0000	18.0000	6.0000
215	16.0000	21.0000	6.0000
216	16.0000	24.0000	6.0000
217	16.0000	27.0000	6.0000
218	16.0000	30.0000	6.0000
219	16.0000	33.0000	6.0000
220	16.0000	36.0000	6.0000
221	17.0000	12.0000	6.0000
222	17.0000	15.0000	6.0000
223	17.0000	18.0000	6.0000
224	17.0000	21.0000	6.0000
225	17.0000	24.0000	6.0000
226	17.0000	36.0000	6.0000
227	18.0000	3.0000	6.0000
228	18.0000	6.0000	6.0000
229	18.0000	12.3000	6.0000
230	18.0000	15.0000	6.0000
231	18.0000	18.0000	6.0000
232	18.0000	21.0000	6.0000
233	18.0000	24.0000	6.0000
234	19.0000	3.0000	6.0000
235	19.0000	6.0000	6.0000
236	19.0000	30.0000	6.0000
237	19.0000	35.2000	6.0000
238	20.0000	3.0000	6.0000
239	20.0000	3.7000	6.0000
240	20.0000	6.0000	6.0000
241	20.0000	8.0000	6.0000
242	20.0000	9.0000	6.0000
243	20.0000	10.0000	6.0000
244	20.0000	11.0000	6.0000
245	20.0000	12.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
246	20.0000	13.0000	6.0000
247	20.0000	14.0000	6.0000
248	20.0000	15.0000	6.0000
249	20.0000	16.0000	6.0000
250	20.0000	17.0000	6.0000
251	20.0000	18.0000	6.0000
252	20.0000	19.0000	6.0000
253	20.0000	20.0000	6.0000
254	20.0000	21.0000	6.0000
255	20.0000	22.0000	6.0000
256	20.0000	23.0000	6.0000
257	20.0000	24.0000	6.0000
258	20.0000	25.0000	6.0000
259	20.0000	26.0000	6.0000
260	20.0000	27.0000	6.0000
261	20.0000	28.0000	6.0000
262	20.0000	29.0000	6.0000
263	20.0000	30.0000	6.0000
264	20.0000	31.0000	6.0000
265	20.0000	35.0000	6.0000
266	21.0000	3.0000	6.0000
267	21.0000	6.0000	6.0000
268	21.0000	32.0000	6.0000
269	22.0000	3.0000	6.0000
270	22.0000	4.7000	6.0000
271	22.0000	6.0000	6.0000
272	22.0000	32.0000	6.0000
273	23.0000	3.0000	6.0000
274	23.0000	6.0000	6.0000
275	23.0000	34.0000	6.0000
276	24.0000	3.0000	6.0000
277	24.0000	6.0000	6.0000
278	24.0000	21.0000	6.0000
279	25.0000	3.0000	6.0000
280	25.0000	8.0000	6.0000
281	26.0000	4.0000	6.0000
282	26.0000	5.0000	6.0000
283	26.0000	8.0000	6.0000
284	26.0000	9.0000	6.0000
285	26.0000	10.0000	6.0000
286	26.0000	11.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
287	26.0000	12.0000	6.0000
288	26.0000	13.0000	6.0000
289	26.0000	14.0000	6.0000
290	26.0000	15.0000	6.0000
291	26.0000	16.0000	6.0000
292	26.0000	17.0000	6.0000
293	26.0000	18.0000	6.0000
294	26.0000	19.0000	6.0000
295	26.0000	20.0000	6.0000
296	26.0000	21.0000	6.0000
297	26.0000	22.0000	6.0000
298	26.0000	23.0000	6.0000
299	26.0000	24.0000	6.0000
300	26.0000	25.0000	6.0000
301	26.0000	26.0000	6.0000
302	26.0000	27.0000	6.0000
303	26.0000	28.0000	6.0000
304	26.0000	29.0000	6.0000
305	26.0000	30.0000	6.0000
306	26.0000	31.0000	6.0000
307	26.0000	34.0000	6.0000
308	27.0000	7.0000	6.0000
309	27.0000	8.0000	6.0000
310	27.0000	9.0000	6.0000
311	27.0000	10.0000	6.0000
312	27.0000	11.0000	6.0000
313	27.0000	12.0000	6.0000
314	27.0000	13.0000	6.0000
315	27.0000	14.0000	6.0000
316	27.0000	15.0000	6.0000
317	27.0000	16.0000	6.0000
318	27.0000	17.0000	6.0000
319	27.0000	18.0000	6.0000
320	27.0000	19.0000	6.0000
321	27.0000	20.0000	6.0000
322	27.0000	21.0000	6.0000
323	27.0000	22.0000	6.0000
324	27.0000	23.0000	6.0000
325	27.0000	25.0000	6.0000
326	27.0000	26.0000	6.0000
327	27.0000	27.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
328	27.0000	28.0000	6.0000
329	27.0000	29.0000	6.0000
330	27.0000	30.0000	6.0000
331	27.0000	31.0000	6.0000
332	27.0000	32.0000	6.0000
333	27.0000	33.0000	6.0000
334	27.0000	34.0000	6.0000
335	27.0000	35.0000	6.0000
336	27.0000	36.0000	6.0000
337	27.0000	37.0000	6.0000
338	27.0000	38.0000	6.0000
339	28.0000	9.0000	6.0000
340	28.0000	11.3000	6.0000
341	29.0000	4.0000	6.0000
342	29.0000	5.0000	6.0000
343	29.0000	14.0000	6.0000
344	29.0000	24.0000	6.0000
345	29.0000	30.0000	6.0000
346	30.0000	7.0000	6.0000
347	30.0000	8.0000	6.0000
348	30.0000	9.0000	6.0000
349	30.0000	10.0000	6.0000
350	30.0000	11.0000	6.0000
351	30.0000	12.0000	6.0000
352	30.0000	13.0000	6.0000
353	30.0000	15.0000	6.0000
354	30.0000	16.0000	6.0000
355	30.0000	17.0000	6.0000
356	30.0000	18.0000	6.0000
357	30.0000	19.0000	6.0000
358	30.0000	20.0000	6.0000
359	30.0000	21.0000	6.0000
360	30.0000	22.0000	6.0000
361	30.0000	23.0000	6.0000
362	30.0000	25.0000	6.0000
363	30.0000	26.0000	6.0000
364	30.0000	27.0000	6.0000
365	30.0000	28.0000	6.0000
366	30.0000	29.0000	6.0000
367	30.0000	30.0000	6.0000
368	30.0000	31.0000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
369	30.0000	32.0000	6.0000
370	30.0000	33.0000	6.0000
371	30.0000	34.0000	6.0000
372	30.0000	35.0000	6.0000
373	30.0000	36.0000	6.0000
374	30.0000	37.0000	6.0000
375	30.0000	38.0000	6.0000
376	1.5000	35.0000	6.0000
377	1.5000	35.5000	6.0000
378	4.7000	25.5000	6.0000
379	4.7000	33.5000	6.0000
380	4.7000	34.5000	6.0000
381	5.4000	23.3000	6.0000
382	5.4000	24.3000	6.0000
383	6.2000	36.5000	6.0000
384	6.2000	37.1000	6.0000
385	7.5000	25.5000	6.0000
386	8.5000	5.2000	6.0000
387	8.5000	7.0000	6.0000
388	8.5000	22.8000	6.0000
389	9.4000	7.4000	6.0000
390	9.5000	22.2000	6.0000
391	9.1000	26.0000	6.0000
392	10.5000	10.5000	6.0000
393	11.5000	13.5000	6.0000
394	11.7000	22.8000	6.0000
395	12.2000	22.1000	6.0000
396	13.5000	7.5000	6.0000
397	13.5000	17.0000	6.0000
398	13.5000	21.4000	6.0000
399	14.5000	7.7000	6.0000
400	15.5000	3.0000	6.0000
401	15.5000	5.0000	6.0000
402	15.5000	18.5000	6.0000
403	16.5000	10.5000	6.0000
404	16.9000	26.8000	6.0000
405	17.1000	3.1000	6.0000
406	17.1000	5.1000	6.0000
407	17.5000	7.5000	6.0000
408	17.9000	25.8000	6.0000
409	17.2000	26.1000	6.0000

Continued on next page

Table D.5 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
410	17.9000	33.3000	6.0000
411	17.2000	34.1000	6.0000
412	18.3000	27.0000	6.0000
413	18.3000	28.0000	6.0000
414	18.3000	34.5000	6.0000
415	20.6000	16.5000	6.0000
416	20.5000	31.5000	6.0000
417	21.7000	19.0000	6.0000
418	21.1000	20.0000	6.0000
419	21.2000	27.5000	6.0000
420	21.5000	32.5000	6.0000
421	22.9000	14.0000	6.0000
422	22.2000	28.2000	6.0000
423	22.8000	32.5000	6.0000
424	23.9000	13.0000	6.0000
425	23.2000	15.0000	6.0000
426	24.5000	7.1000	6.0000
427	26.2000	36.5000	6.0000
428	27.5000	5.2000	6.0000
429	27.6000	23.6000	6.0000
430	28.5000	22.0000	6.0000
431	28.5000	27.0000	6.0000
432	28.5000	33.5000	6.0000
433	29.3000	9.5000	6.0000
434	29.5000	17.5000	6.0000
435	29.5000	20.5000	6.0000
436	5.2000	32.0000	6.0000
437	23.0000	35.0000	6.0000
438	23.2000	31.5000	6.0000
439	5.3000	21.0000	6.0000
440	25.5000	7.1000	6.0000
441	7.5000	4.9000	6.0000
Depot	0.0000	0.0000	N.A.

Table D.6: CETSP instance d493rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	11.1630	15.5520	0.6510
2	13.5760	14.7900	0.6510
3	11.4810	17.7110	0.6510
4	11.8620	17.9650	0.6510
5	12.0520	18.8540	0.6510
6	12.3700	19.9340	0.6510
7	13.0050	20.0610	0.6510
8	11.6080	20.2510	0.6510
9	11.7350	20.3780	0.6510
10	12.2430	20.5050	0.6510
11	13.5130	22.4100	0.6510
12	17.3230	21.3310	0.6510
13	17.4500	21.9020	0.6510
14	17.6400	22.9180	0.6510
15	17.6400	23.4260	0.6510
16	17.3230	23.9340	0.6510
17	17.4500	24.1880	0.6510
18	16.4970	24.3150	0.6510
19	17.5770	25.2040	0.6510
20	22.9740	17.7110	0.6510
21	22.1490	14.2820	0.6510
22	22.2760	13.3930	0.6510
23	21.8310	13.2030	0.6510
24	26.1490	11.1070	0.6510
25	25.0700	11.6150	0.6510
26	23.4820	9.5200	0.6510
27	22.2120	10.0910	0.6510
28	22.0850	10.8530	0.6510
29	22.0220	11.3610	0.6510
30	22.1490	11.7420	0.6510
31	20.2440	11.2340	0.6510
32	20.4340	13.0120	0.6510
33	19.4820	13.0760	0.6510
34	19.4180	13.9010	0.6510
35	18.4660	14.1550	0.6510
36	17.5770	13.6470	0.6510
37	18.0210	13.5200	0.6510
38	18.3390	12.6310	0.6510
39	17.3230	12.5040	0.6510
40	20.4340	15.8060	0.6510
41	20.4980	17.4570	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	19.9900	18.0290	0.6510
43	19.6090	18.1560	0.6510
44	20.5610	18.2190	0.6510
45	20.1170	18.2830	0.6510
46	20.4340	18.5370	0.6510
47	18.4660	17.8380	0.6510
48	18.2120	18.2830	0.6510
49	18.4660	18.6640	0.6510
50	18.1480	16.5050	0.6510
51	16.6880	18.0920	0.6510
52	18.5930	21.6480	0.6510
53	19.8630	21.3310	0.6510
54	20.1170	21.7750	0.6510
55	19.4820	21.9660	0.6510
56	18.9100	22.4740	0.6510
57	20.1170	22.7280	0.6510
58	20.3710	23.0450	0.6510
59	20.5610	23.5530	0.6510
60	18.9740	24.1250	0.6510
61	18.9740	24.5690	0.6510
62	19.1640	24.6960	0.6510
63	20.5610	24.6960	0.6510
64	21.5770	21.3940	0.6510
65	16.3700	26.9820	0.6510
66	17.0690	27.0460	0.6510
67	17.6400	27.4900	0.6510
68	17.0690	27.7440	0.6510
69	17.6400	27.9980	0.6510
70	18.7200	30.6650	0.6510
71	18.5290	30.0300	0.6510
72	18.7200	29.9670	0.6510
73	18.9740	29.9670	0.6510
74	22.1490	29.7130	0.6510
75	21.9580	29.3950	0.6510
76	22.4660	28.8870	0.6510
77	18.9100	28.6970	0.6510
78	22.0220	28.4430	0.6510
79	19.0370	28.1890	0.6510
80	18.7200	28.1890	0.6510
81	20.1170	27.6170	0.6510
82	19.0370	26.9820	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	19.5450	25.8390	0.6510
84	20.5610	25.7760	0.6510
85	20.9420	25.6490	0.6510
86	21.9580	24.7600	0.6510
87	25.8950	29.9030	0.6510
88	26.0860	29.9030	0.6510
89	25.0700	30.0300	0.6510
90	28.9430	30.4750	0.6510
91	28.9430	30.0300	0.6510
92	29.0700	29.7130	0.6510
93	30.2770	30.4750	0.6510
94	27.9270	28.1250	0.6510
95	22.2760	28.1250	0.6510
96	25.8320	27.9980	0.6510
97	25.9590	27.7440	0.6510
98	25.0700	27.7440	0.6510
99	27.2290	27.5540	0.6510
100	26.1490	27.4900	0.6510
101	28.8800	27.3000	0.6510
102	32.1180	27.3000	0.6510
103	31.4200	27.1730	0.6510
104	27.5460	26.9820	0.6510
105	24.5620	26.9820	0.6510
106	25.7050	26.2200	0.6510
107	27.2290	26.2200	0.6510
108	33.6420	26.2200	0.6510
109	29.0070	26.1570	0.6510
110	31.3560	26.0300	0.6510
111	27.1020	25.9660	0.6510
112	27.1650	25.4580	0.6510
113	28.8800	25.3310	0.6510
114	28.4990	25.1410	0.6510
115	22.9740	25.1410	0.6510
116	26.0860	24.9500	0.6510
117	32.2450	24.8870	0.6510
118	26.9110	24.7600	0.6510
119	28.7530	24.3790	0.6510
120	25.0060	24.1880	0.6510
121	24.3080	23.9980	0.6510
122	28.7530	23.9980	0.6510
123	31.2930	23.6800	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	25.8320	23.6800	0.6510
125	24.9430	23.6800	0.6510
126	27.8000	23.6170	0.6510
127	23.3550	23.5530	0.6510
128	26.1490	23.1720	0.6510
129	29.2610	23.0450	0.6510
130	28.0540	22.9180	0.6510
131	25.8320	22.9180	0.6510
132	28.2450	22.8550	0.6510
133	28.6260	22.7910	0.6510
134	27.9910	22.6010	0.6510
135	26.9110	22.6010	0.6510
136	27.5460	22.5370	0.6510
137	29.1340	22.5370	0.6510
138	23.4820	22.4100	0.6510
139	29.0700	22.3470	0.6510
140	31.3560	22.3470	0.6510
141	29.2610	22.2830	0.6510
142	34.3410	22.0290	0.6510
143	28.8160	21.9020	0.6510
144	26.0220	21.9020	0.6510
145	27.1020	21.6480	0.6510
146	27.9270	21.4580	0.6510
147	28.2450	21.3310	0.6510
148	24.2440	21.0770	0.6510
149	28.6890	21.0130	0.6510
150	34.3410	21.0130	0.6510
151	26.1490	20.8860	0.6510
152	30.7850	20.8230	0.6510
153	25.8950	20.7590	0.6510
154	24.8790	20.6320	0.6510
155	27.3560	20.6320	0.6510
156	34.4680	20.4420	0.6510
157	33.5150	20.3150	0.6510
158	26.2760	20.1880	0.6510
159	26.9750	20.0610	0.6510
160	24.8790	19.9340	0.6510
161	26.8480	19.7430	0.6510
162	24.6250	19.6800	0.6510
163	31.3560	19.6800	0.6510
164	33.9600	19.6800	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	27.4830	19.6160	0.6510
166	27.2290	19.6160	0.6510
167	32.3090	19.5530	0.6510
168	29.7050	19.4260	0.6510
169	24.7520	19.3620	0.6510
170	25.1330	19.2350	0.6510
171	29.2610	19.1720	0.6510
172	24.9430	19.1080	0.6510
173	26.1490	19.0450	0.6510
174	25.1970	18.9180	0.6510
175	25.8950	18.9180	0.6510
176	34.0870	18.9180	0.6510
177	36.4360	18.9180	0.6510
178	27.8640	18.8540	0.6510
179	26.5940	18.8540	0.6510
180	24.9430	18.7910	0.6510
181	29.5780	18.7910	0.6510
182	34.5950	18.7910	0.6510
183	30.5310	18.6640	0.6510
184	27.7370	18.6640	0.6510
185	27.1020	18.6640	0.6510
186	32.3720	18.5370	0.6510
187	33.2610	18.5370	0.6510
188	27.3560	18.4730	0.6510
189	24.9430	18.3460	0.6510
190	32.6900	18.3460	0.6510
191	33.0710	18.3460	0.6510
192	33.6420	18.3460	0.6510
193	26.7210	18.2830	0.6510
194	33.5150	18.2190	0.6510
195	34.7220	18.2190	0.6510
196	28.6890	18.1560	0.6510
197	28.1180	18.0920	0.6510
198	33.5150	18.0290	0.6510
199	32.9440	17.9650	0.6510
200	25.4510	17.9650	0.6510
201	31.1020	17.7750	0.6510
202	31.6100	17.7750	0.6510
203	32.8170	17.7750	0.6510
204	33.3880	17.5840	0.6510
205	29.9590	17.5840	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	31.9910	17.2030	0.6510
207	30.0230	17.2030	0.6510
208	26.3400	17.2030	0.6510
209	25.0700	17.0760	0.6510
210	29.6420	17.0760	0.6510
211	30.5940	17.0760	0.6510
212	30.9750	17.0760	0.6510
213	36.4360	17.0760	0.6510
214	28.0540	17.0130	0.6510
215	25.8320	16.9490	0.6510
216	30.7850	16.9490	0.6510
217	28.9430	16.8860	0.6510
218	31.4830	16.8220	0.6510
219	32.1820	16.6320	0.6510
220	31.9910	16.6320	0.6510
221	27.2920	16.6320	0.6510
222	29.5150	16.5050	0.6510
223	24.3080	16.4410	0.6510
224	25.0700	16.3140	0.6510
225	35.9920	16.3140	0.6510
226	31.3560	16.2510	0.6510
227	30.7850	16.2510	0.6510
228	30.5940	16.2510	0.6510
229	27.7370	16.2510	0.6510
230	29.1340	16.1870	0.6510
231	33.0710	16.1870	0.6510
232	31.3560	16.0600	0.6510
233	30.1500	16.0600	0.6510
234	24.2440	15.9970	0.6510
235	28.3080	15.9330	0.6510
236	32.9440	15.9330	0.6510
237	31.2930	15.8060	0.6510
238	33.7690	15.6790	0.6510
239	26.1490	15.6790	0.6510
240	29.3240	15.4890	0.6510
241	30.4620	15.4730	0.6510
242	30.7220	15.4730	0.6510
243	30.9820	15.4730	0.6510
244	31.2420	15.4730	0.6510
245	31.5020	15.4730	0.6510
246	31.7620	15.4730	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	32.0220	15.4730	0.6510
248	32.2820	15.4730	0.6510
249	32.5420	15.4730	0.6510
250	32.8020	15.4730	0.6510
251	33.0620	15.4730	0.6510
252	33.3220	15.4730	0.6510
253	33.5820	15.4730	0.6510
254	27.2290	15.3620	0.6510
255	30.6570	15.2460	0.6510
256	31.1120	15.2460	0.6510
257	31.3720	15.2460	0.6510
258	31.6320	15.2460	0.6510
259	31.8920	15.2460	0.6510
260	32.1520	15.2460	0.6510
261	32.4120	15.2460	0.6510
262	32.6720	15.2460	0.6510
263	32.9320	15.2460	0.6510
264	33.4520	15.2460	0.6510
265	24.3710	15.2350	0.6510
266	29.6420	15.1080	0.6510
267	27.4190	15.0440	0.6510
268	24.3080	15.0440	0.6510
269	34.1350	14.9860	0.6510
270	29.9750	14.9210	0.6510
271	28.2450	14.8540	0.6510
272	30.2020	14.7910	0.6510
273	33.9070	14.7910	0.6510
274	34.1350	14.7260	0.6510
275	28.3720	14.6630	0.6510
276	26.0860	14.6630	0.6510
277	29.9750	14.6610	0.6510
278	31.0470	14.6610	0.6510
279	31.3070	14.6610	0.6510
280	31.5670	14.6610	0.6510
281	31.8270	14.6610	0.6510
282	32.0870	14.6610	0.6510
283	32.3470	14.6610	0.6510
284	32.6070	14.6610	0.6510
285	32.8670	14.6610	0.6510
286	33.1270	14.6610	0.6510
287	34.1350	14.4660	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	30.7870	14.4660	0.6510
289	31.1770	14.4330	0.6510
290	31.4370	14.4330	0.6510
291	31.6970	14.4330	0.6510
292	31.9570	14.4330	0.6510
293	32.2170	14.4330	0.6510
294	32.4770	14.4330	0.6510
295	32.7370	14.4330	0.6510
296	29.0070	14.4090	0.6510
297	26.9110	14.4090	0.6510
298	29.9750	14.4010	0.6510
299	33.3220	14.4010	0.6510
300	24.3710	14.3460	0.6510
301	33.9070	14.3360	0.6510
302	33.0950	14.2710	0.6510
303	30.2020	14.2710	0.6510
304	25.8320	14.2190	0.6510
305	30.7870	14.2060	0.6510
306	34.1350	14.2060	0.6510
307	32.8350	14.1730	0.6510
308	31.2750	14.1730	0.6510
309	29.9750	14.1410	0.6510
310	33.3220	14.1410	0.6510
311	32.3720	14.0920	0.6510
312	31.9910	14.0920	0.6510
313	31.0150	14.0760	0.6510
314	33.9070	14.0760	0.6510
315	34.4040	14.0280	0.6510
316	29.5150	14.0280	0.6510
317	30.2020	14.0110	0.6510
318	33.0950	14.0110	0.6510
319	34.1350	13.9460	0.6510
320	30.7870	13.9460	0.6510
321	31.6100	13.9010	0.6510
322	29.9750	13.8810	0.6510
323	33.3220	13.8810	0.6510
324	29.3880	13.8380	0.6510
325	28.7530	13.8380	0.6510
326	31.0150	13.8160	0.6510
327	33.9070	13.8160	0.6510
328	31.3990	13.7540	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	30.2020	13.7510	0.6510
330	33.0950	13.7510	0.6510
331	34.1350	13.6860	0.6510
332	30.7870	13.6860	0.6510
333	27.9910	13.6470	0.6510
334	35.9920	13.6470	0.6510
335	33.3220	13.6210	0.6510
336	29.9750	13.6210	0.6510
337	31.0150	13.5560	0.6510
338	33.9070	13.5560	0.6510
339	32.6900	13.5200	0.6510
340	29.1970	13.5200	0.6510
341	28.3720	13.5200	0.6510
342	30.2020	13.4910	0.6510
343	33.0950	13.4910	0.6510
344	28.7530	13.4570	0.6510
345	30.7870	13.4260	0.6510
346	34.1350	13.4260	0.6510
347	34.8490	13.3930	0.6510
348	29.7050	13.3930	0.6510
349	29.9750	13.3610	0.6510
350	33.3220	13.3610	0.6510
351	29.1340	13.3300	0.6510
352	31.0150	13.2960	0.6510
353	33.9070	13.2960	0.6510
354	33.0950	13.2310	0.6510
355	32.4360	13.2310	0.6510
356	30.2020	13.2310	0.6510
357	29.5780	13.2030	0.6510
358	31.5470	13.2030	0.6510
359	30.7870	13.1660	0.6510
360	34.1350	13.1660	0.6510
361	36.1190	13.1390	0.6510
362	33.3220	13.1010	0.6510
363	29.9750	13.1010	0.6510
364	31.0150	13.0360	0.6510
365	33.9070	13.0360	0.6510
366	33.0950	12.9710	0.6510
367	30.2020	12.9710	0.6510
368	28.4990	12.9490	0.6510
369	28.7530	12.9490	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	29.0070	12.9490	0.6510
371	35.4200	12.9490	0.6510
372	34.1350	12.9060	0.6510
373	30.7870	12.9060	0.6510
374	31.7370	12.8850	0.6510
375	33.3220	12.8410	0.6510
376	29.9750	12.8410	0.6510
377	31.0150	12.7760	0.6510
378	33.9070	12.7760	0.6510
379	33.0950	12.7110	0.6510
380	30.2020	12.7110	0.6510
381	27.6730	12.6950	0.6510
382	30.7870	12.6460	0.6510
383	34.1350	12.6460	0.6510
384	26.0220	12.6310	0.6510
385	31.2750	12.6130	0.6510
386	32.8350	12.6130	0.6510
387	33.3220	12.5810	0.6510
388	29.9750	12.5810	0.6510
389	28.8160	12.5680	0.6510
390	27.9270	12.5680	0.6510
391	25.5780	12.5680	0.6510
392	31.0150	12.5160	0.6510
393	33.9070	12.5160	0.6510
394	34.7850	12.5040	0.6510
395	30.2020	12.4510	0.6510
396	29.1970	12.4410	0.6510
397	28.1810	12.4410	0.6510
398	25.1970	12.4410	0.6510
399	30.7870	12.3860	0.6510
400	34.1350	12.3860	0.6510
401	32.9320	12.3530	0.6510
402	32.6720	12.3530	0.6510
403	32.4120	12.3530	0.6510
404	32.1520	12.3530	0.6510
405	31.8920	12.3530	0.6510
406	31.6320	12.3530	0.6510
407	31.3720	12.3530	0.6510
408	29.9750	12.3210	0.6510
409	33.3220	12.3210	0.6510
410	28.8160	12.2500	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
411	30.9820	12.1260	0.6510
412	31.2420	12.1260	0.6510
413	31.5020	12.1260	0.6510
414	31.7620	12.1260	0.6510
415	32.0220	12.1260	0.6510
416	32.2820	12.1260	0.6510
417	32.5420	12.1260	0.6510
418	32.8020	12.1260	0.6510
419	33.0620	12.1260	0.6510
420	34.1350	12.1260	0.6510
421	25.8950	12.1230	0.6510
422	25.7050	12.1230	0.6510
423	29.9750	12.0610	0.6510
424	30.2020	11.9960	0.6510
425	33.9070	11.9960	0.6510
426	34.5950	11.9960	0.6510
427	34.8490	11.9960	0.6510
428	26.5940	11.9330	0.6510
429	34.1350	11.8660	0.6510
430	29.3880	11.8040	0.6510
431	29.9750	11.8010	0.6510
432	30.6570	11.5410	0.6510
433	31.1770	11.5410	0.6510
434	31.4370	11.5410	0.6510
435	31.6970	11.5410	0.6510
436	31.9570	11.5410	0.6510
437	32.2170	11.5410	0.6510
438	32.4770	11.5410	0.6510
439	32.7370	11.5410	0.6510
440	32.9970	11.5410	0.6510
441	33.4520	11.5410	0.6510
442	29.2610	11.4250	0.6510
443	30.5270	11.3130	0.6510
444	30.7870	11.3130	0.6510
445	31.0470	11.3130	0.6510
446	31.3070	11.3130	0.6510
447	31.5670	11.3130	0.6510
448	31.8270	11.3130	0.6510
449	32.0870	11.3130	0.6510
450	32.3470	11.3130	0.6510
451	32.6070	11.3130	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
452	32.8670	11.3130	0.6510
453	33.1270	11.3130	0.6510
454	33.3870	11.3130	0.6510
455	33.6470	11.3130	0.6510
456	27.4190	11.2980	0.6510
457	28.6260	11.2340	0.6510
458	30.6580	10.9800	0.6510
459	30.3400	10.9170	0.6510
460	28.7530	10.7900	0.6510
461	27.9270	10.4090	0.6510
462	29.0070	10.2820	0.6510
463	28.3720	10.2180	0.6510
464	29.4510	10.1550	0.6510
465	28.6260	10.0910	0.6510
466	29.3880	8.3130	0.6510
467	30.7210	9.3290	0.6510
468	30.5940	9.5200	0.6510
469	30.3400	9.6470	0.6510
470	30.6580	9.7100	0.6510
471	30.9120	9.9010	0.6510
472	32.0550	9.8370	0.6510
473	34.0870	8.7580	0.6510
474	34.5950	9.2020	0.6510
475	35.1030	10.1550	0.6510
476	33.6420	10.1550	0.6510
477	33.8330	10.2820	0.6510
478	34.9760	10.2820	0.6510
479	33.9600	10.5360	0.6510
480	32.9440	10.5360	0.6510
481	35.1660	10.7260	0.6510
482	32.1820	10.9800	0.6510
483	35.6740	11.0440	0.6510
484	35.5470	11.2340	0.6510
485	33.9600	11.2340	0.6510
486	35.4840	11.4250	0.6510
487	35.2930	11.5520	0.6510
488	34.0870	11.6150	0.6510
489	34.7220	11.7420	0.6510
490	36.9440	13.0120	0.6510
491	37.4520	12.7580	0.6510
492	37.4520	10.2180	0.6510

Continued on next page

Table D.6 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
Depot	0.0000	0.0000	N.A.

Table D.7: CETSP instance dsj1000rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	98.1036	50.8139	1.1045
2	53.4120	-4.2453	1.1045
3	57.7878	-4.3732	1.1045
4	53.2890	-9.6645	1.1045
5	20.5322	21.5891	1.1045
6	22.5923	19.7950	1.1045
7	6.9842	66.7632	1.1045
8	39.1965	105.4524	1.1045
9	31.0065	-1.0714	1.1045
10	24.7401	75.4523	1.1045
11	21.7951	21.8350	1.1045
12	44.3097	5.4051	1.1045
13	4.7342	63.0935	1.1045
14	31.7515	71.3679	1.1045
15	30.1816	102.1772	1.1045
16	95.0864	33.2234	1.1045
17	27.6433	72.5657	1.1045
18	92.1801	41.0349	1.1045
19	55.5508	6.7090	1.1045
20	40.9959	37.9409	1.1045
21	96.8097	54.0588	1.1045
22	4.0089	72.1860	1.1045
23	70.2011	52.7050	1.1045
24	72.6191	32.6684	1.1045
25	99.0428	19.6959	1.1045
26	38.1890	100.3805	1.1045
27	40.9527	105.6227	1.1045
28	67.5609	49.6310	1.1045
29	97.1071	18.8552	1.1045
30	93.2494	81.8793	1.1045
31	93.6083	38.4774	1.1045
32	83.5076	51.7826	1.1045
33	12.0444	66.3239	1.1045
34	64.8516	39.5774	1.1045
35	40.2323	12.6508	1.1045
36	30.7839	5.7178	1.1045
37	39.7333	98.7582	1.1045
38	31.4281	94.9219	1.1045
39	10.5042	66.7806	1.1045
40	100.6036	46.8020	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
41	47.3356	31.1656	1.1045
42	97.0499	25.7334	1.1045
43	91.9732	45.8332	1.1045
44	103.3956	43.6231	1.1045
45	93.4265	31.4744	1.1045
46	23.9142	5.5856	1.1045
47	72.0304	52.5053	1.1045
48	48.0764	105.8084	1.1045
49	97.0063	39.6578	1.1045
50	54.3132	33.4794	1.1045
51	75.5587	49.1352	1.1045
52	97.5653	74.5618	1.1045
53	27.2842	5.8331	1.1045
54	53.7123	16.5900	1.1045
55	51.9742	12.9315	1.1045
56	3.5924	94.7451	1.1045
57	106.4442	49.0895	1.1045
58	48.9393	11.7496	1.1045
59	63.1320	27.7543	1.1045
60	26.1674	96.1159	1.1045
61	53.4617	5.8056	1.1045
62	69.1689	51.2673	1.1045
63	18.2654	71.5277	1.1045
64	94.5838	45.9916	1.1045
65	62.7821	-0.0838	1.1045
66	102.2110	28.3893	1.1045
67	45.8725	14.3747	1.1045
68	27.3755	-1.0984	1.1045
69	29.3760	80.5861	1.1045
70	46.6598	16.0110	1.1045
71	90.6179	26.4649	1.1045
72	71.2619	53.5794	1.1045
73	24.0847	21.2619	1.1045
74	99.3782	93.0601	1.1045
75	32.2034	92.5655	1.1045
76	95.4600	44.3790	1.1045
77	99.5817	52.1789	1.1045
78	26.7943	-2.6353	1.1045
79	67.4673	33.2544	1.1045
80	97.8160	74.8015	1.1045
81	35.3466	107.7036	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
82	37.1788	95.0118	1.1045
83	77.9223	44.6051	1.1045
84	52.5136	31.1620	1.1045
85	102.6402	60.9181	1.1045
86	61.9524	-0.3330	1.1045
87	64.4232	44.0581	1.1045
88	19.8821	27.2321	1.1045
89	28.0990	29.8348	1.1045
90	47.5893	27.8934	1.1045
91	29.1897	96.4145	1.1045
92	47.6091	10.2274	1.1045
93	3.4538	93.5151	1.1045
94	98.5493	33.1624	1.1045
95	2.5533	99.1767	1.1045
96	102.9016	24.8202	1.1045
97	104.1034	98.3317	1.1045
98	92.2880	83.6157	1.1045
99	75.4748	37.8532	1.1045
100	19.3676	20.9011	1.1045
101	26.9511	99.1097	1.1045
102	60.8351	33.4935	1.1045
103	22.1344	71.2137	1.1045
104	94.0795	80.8773	1.1045
105	3.5503	90.3653	1.1045
106	19.4163	-0.8394	1.1045
107	45.9581	33.5048	1.1045
108	33.1638	109.6815	1.1045
109	53.8796	31.7093	1.1045
110	50.5069	12.3029	1.1045
111	70.6191	48.1820	1.1045
112	97.4314	81.9460	1.1045
113	33.5170	80.8699	1.1045
114	77.4079	49.1470	1.1045
115	72.7757	56.7077	1.1045
116	46.9054	30.8841	1.1045
117	98.2345	80.8600	1.1045
118	63.5739	32.9982	1.1045
119	55.9782	19.9329	1.1045
120	86.5983	36.2039	1.1045
121	56.6229	3.2945	1.1045
122	94.5355	44.3621	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
123	34.3074	104.3145	1.1045
124	45.6407	35.6580	1.1045
125	93.0994	86.3608	1.1045
126	46.5030	16.5426	1.1045
127	58.5931	27.1316	1.1045
128	7.8142	89.6258	1.1045
129	22.8762	75.7017	1.1045
130	64.1748	30.2745	1.1045
131	26.5500	96.7350	1.1045
132	-1.8619	98.5581	1.1045
133	43.7681	7.8375	1.1045
134	65.7303	47.3671	1.1045
135	20.7311	19.0512	1.1045
136	103.9916	60.6173	1.1045
137	50.1654	34.2980	1.1045
138	80.8872	43.1227	1.1045
139	97.9141	29.0493	1.1045
140	96.2582	32.5713	1.1045
141	85.8477	60.7859	1.1045
142	68.2062	28.5319	1.1045
143	101.8123	94.8910	1.1045
144	55.5686	2.3786	1.1045
145	89.5287	45.4109	1.1045
146	37.3296	94.7968	1.1045
147	-0.3116	97.6012	1.1045
148	61.7542	11.5270	1.1045
149	73.5268	49.2611	1.1045
150	95.4724	61.7777	1.1045
151	56.5140	2.6652	1.1045
152	89.2688	56.3248	1.1045
153	91.1677	84.1211	1.1045
154	107.9810	80.0957	1.1045
155	77.8264	55.5164	1.1045
156	41.9974	13.5778	1.1045
157	51.1106	98.2963	1.1045
158	68.2826	55.0673	1.1045
159	53.4554	15.0784	1.1045
160	25.4767	75.4810	1.1045
161	34.0163	93.2553	1.1045
162	50.8592	31.2824	1.1045
163	57.9508	29.6187	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
164	96.1560	30.1327	1.1045
165	49.3862	17.5735	1.1045
166	50.1386	26.6573	1.1045
167	46.3909	8.8190	1.1045
168	33.8390	67.1668	1.1045
169	96.5235	92.1962	1.1045
170	71.0505	50.7680	1.1045
171	36.7928	9.6586	1.1045
172	106.1692	29.0085	1.1045
173	57.7618	2.6586	1.1045
174	56.8778	27.6180	1.1045
175	12.0097	66.7734	1.1045
176	43.9840	9.2005	1.1045
177	40.0650	98.6098	1.1045
178	94.4072	76.9857	1.1045
179	60.4630	30.4795	1.1045
180	93.3823	48.5086	1.1045
181	33.6792	4.7017	1.1045
182	98.4258	65.8894	1.1045
183	66.5887	34.1226	1.1045
184	68.3701	31.3080	1.1045
185	28.6989	1.5656	1.1045
186	72.7013	43.6681	1.1045
187	19.6457	23.2311	1.1045
188	48.9533	90.4759	1.1045
189	0.4838	63.8626	1.1045
190	96.4356	62.0951	1.1045
191	1.4019	97.5847	1.1045
192	101.1610	45.7653	1.1045
193	108.6560	34.8419	1.1045
194	33.1881	90.5996	1.1045
195	44.6028	29.9319	1.1045
196	98.9521	56.5952	1.1045
197	63.8645	34.3723	1.1045
198	8.0472	76.1743	1.1045
199	91.8795	37.1845	1.1045
200	96.2133	40.5576	1.1045
201	9.0002	73.0359	1.1045
202	106.6231	51.9460	1.1045
203	31.4455	71.7336	1.1045
204	69.8977	54.8286	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
205	99.0152	86.1550	1.1045
206	42.0156	103.5929	1.1045
207	98.9198	48.0008	1.1045
208	102.4997	24.4075	1.1045
209	67.5765	27.7962	1.1045
210	101.7295	28.4449	1.1045
211	27.9452	7.0873	1.1045
212	6.6701	63.5082	1.1045
213	79.9479	46.2913	1.1045
214	35.9551	95.9225	1.1045
215	-2.1508	94.1499	1.1045
216	17.9606	81.6588	1.1045
217	68.0220	53.7678	1.1045
218	10.9416	69.7746	1.1045
219	102.0461	86.7072	1.1045
220	26.4488	5.1021	1.1045
221	51.3200	11.9016	1.1045
222	32.4952	97.9758	1.1045
223	-2.3037	90.7079	1.1045
224	42.5793	100.4271	1.1045
225	24.5076	73.1150	1.1045
226	73.2401	49.0047	1.1045
227	49.5432	29.0024	1.1045
228	86.3374	85.7586	1.1045
229	100.0845	45.3198	1.1045
230	0.5802	93.7511	1.1045
231	32.2488	71.8762	1.1045
232	29.7064	94.0211	1.1045
233	7.8039	17.6061	1.1045
234	31.0707	1.7474	1.1045
235	43.1057	91.7939	1.1045
236	101.2985	78.2917	1.1045
237	91.0332	34.8187	1.1045
238	103.6911	80.6200	1.1045
239	60.4167	1.4088	1.1045
240	103.4615	37.3033	1.1045
241	59.5552	26.5288	1.1045
242	48.0446	14.6778	1.1045
243	96.8706	83.0827	1.1045
244	52.0827	15.9727	1.1045
245	92.7178	89.1801	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
246	5.8502	91.8647	1.1045
247	67.8857	28.9512	1.1045
248	92.1982	53.9806	1.1045
249	106.6895	31.0233	1.1045
250	98.2152	53.7701	1.1045
251	55.3647	9.0137	1.1045
252	54.6523	25.2022	1.1045
253	97.0347	92.0258	1.1045
254	54.2786	24.4277	1.1045
255	103.8062	50.1176	1.1045
256	93.9444	64.9000	1.1045
257	75.5201	48.6107	1.1045
258	24.5208	1.7631	1.1045
259	85.9154	51.5363	1.1045
260	92.8209	56.9207	1.1045
261	22.8581	29.0039	1.1045
262	89.8350	77.7460	1.1045
263	48.6326	32.1618	1.1045
264	35.4152	92.5489	1.1045
265	30.7482	95.8761	1.1045
266	92.0851	66.8651	1.1045
267	9.6606	65.5604	1.1045
268	92.6699	80.6400	1.1045
269	74.8417	48.5823	1.1045
270	63.3607	23.5913	1.1045
271	52.0306	12.0787	1.1045
272	25.9081	14.4892	1.1045
273	45.9850	27.4123	1.1045
274	14.5018	68.1646	1.1045
275	95.9481	74.2510	1.1045
276	-3.1358	95.2162	1.1045
277	33.1686	108.6172	1.1045
278	10.7344	66.9849	1.1045
279	103.8959	45.4099	1.1045
280	88.0225	60.7529	1.1045
281	66.9490	50.6855	1.1045
282	54.8257	29.6059	1.1045
283	32.6970	74.6737	1.1045
284	42.9285	106.2179	1.1045
285	97.5519	44.8528	1.1045
286	61.1622	34.1592	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
287	98.9119	80.0767	1.1045
288	55.8132	15.4408	1.1045
289	56.0470	-0.6998	1.1045
290	93.4941	85.8189	1.1045
291	85.0650	35.2948	1.1045
292	95.4289	57.3916	1.1045
293	47.4903	33.2139	1.1045
294	47.2412	18.0641	1.1045
295	27.1736	83.2653	1.1045
296	91.8600	79.7087	1.1045
297	54.5895	27.7676	1.1045
298	6.0914	73.9114	1.1045
299	91.1842	48.1207	1.1045
300	99.5987	51.3246	1.1045
301	33.6244	92.4492	1.1045
302	66.9624	36.7077	1.1045
303	21.3113	31.7798	1.1045
304	38.2186	96.6747	1.1045
305	85.1876	33.1130	1.1045
306	37.9917	90.5379	1.1045
307	47.9603	31.0225	1.1045
308	26.4587	69.6793	1.1045
309	50.5738	30.8854	1.1045
310	100.5275	34.9543	1.1045
311	1.1743	92.9818	1.1045
312	96.6284	43.2460	1.1045
313	6.6564	74.2265	1.1045
314	98.5933	78.8152	1.1045
315	17.7323	26.9057	1.1045
316	58.2741	0.1622	1.1045
317	104.1728	96.9352	1.1045
318	44.7075	13.3055	1.1045
319	35.7224	107.3600	1.1045
320	93.9524	73.1450	1.1045
321	98.0763	43.3554	1.1045
322	46.6840	28.1154	1.1045
323	20.8129	26.0745	1.1045
324	99.0651	51.1078	1.1045
325	87.5583	39.2312	1.1045
326	56.6752	3.9284	1.1045
327	64.9829	35.6055	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
328	58.3955	-2.2935	1.1045
329	105.5782	30.6326	1.1045
330	22.0744	6.6433	1.1045
331	106.8535	30.7643	1.1045
332	95.7576	96.9635	1.1045
333	42.4155	0.0668	1.1045
334	58.2864	0.0731	1.1045
335	45.0704	101.2748	1.1045
336	73.6428	45.1426	1.1045
337	70.0624	50.1219	1.1045
338	59.4358	8.0877	1.1045
339	103.8313	82.5056	1.1045
340	103.0838	43.6629	1.1045
341	46.2130	15.3079	1.1045
342	41.5990	92.4813	1.1045
343	23.1689	25.5900	1.1045
344	36.4279	-4.3699	1.1045
345	98.9301	33.2654	1.1045
346	42.0978	97.5030	1.1045
347	22.4229	-2.1641	1.1045
348	99.9754	58.6633	1.1045
349	66.2863	51.2705	1.1045
350	80.8076	41.6004	1.1045
351	49.1677	19.2175	1.1045
352	0.6138	95.4238	1.1045
353	1.6453	95.7178	1.1045
354	24.4797	75.3540	1.1045
355	101.5830	94.8217	1.1045
356	95.8908	32.6754	1.1045
357	58.0726	3.0503	1.1045
358	29.9497	8.0977	1.1045
359	12.0877	66.3858	1.1045
360	102.0152	42.2262	1.1045
361	9.4578	72.6847	1.1045
362	61.1452	36.2851	1.1045
363	9.1700	97.1621	1.1045
364	92.2396	41.0703	1.1045
365	40.7150	18.8306	1.1045
366	98.8373	99.4165	1.1045
367	25.2224	21.1268	1.1045
368	102.9211	31.8790	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
369	22.8228	67.5784	1.1045
370	18.1963	16.0602	1.1045
371	19.4151	20.4264	1.1045
372	99.0429	61.6589	1.1045
373	96.2485	47.1277	1.1045
374	48.7027	4.8736	1.1045
375	42.8212	36.4305	1.1045
376	73.6395	46.5004	1.1045
377	43.7231	10.6871	1.1045
378	95.9325	86.7596	1.1045
379	62.9268	27.0211	1.1045
380	47.0712	4.3382	1.1045
381	40.2693	101.3043	1.1045
382	40.5226	102.8002	1.1045
383	19.4476	21.0876	1.1045
384	100.7126	88.5952	1.1045
385	100.6388	53.8259	1.1045
386	90.2672	64.2791	1.1045
387	99.4285	63.8276	1.1045
388	52.1655	19.1446	1.1045
389	71.5231	31.8286	1.1045
390	72.9198	44.5581	1.1045
391	73.9110	51.0144	1.1045
392	104.3693	90.8389	1.1045
393	44.0393	95.7757	1.1045
394	64.6914	7.7788	1.1045
395	70.1037	27.3839	1.1045
396	97.8831	81.9659	1.1045
397	85.9182	41.8430	1.1045
398	97.1852	78.7831	1.1045
399	26.9783	71.0141	1.1045
400	73.7963	57.8273	1.1045
401	48.4930	25.1860	1.1045
402	50.0191	-2.6033	1.1045
403	36.2059	6.8965	1.1045
404	61.2083	54.3519	1.1045
405	55.4854	26.8201	1.1045
406	87.8413	47.1867	1.1045
407	53.9006	102.5381	1.1045
408	24.5354	72.6275	1.1045
409	94.5490	73.3405	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
410	15.1112	64.3610	1.1045
411	81.9079	40.1742	1.1045
412	23.9369	61.5866	1.1045
413	9.3844	71.5303	1.1045
414	65.4552	32.6167	1.1045
415	55.9275	34.3566	1.1045
416	100.6204	94.7646	1.1045
417	98.8530	91.6792	1.1045
418	46.4115	30.3033	1.1045
419	52.3173	10.0275	1.1045
420	92.1151	81.2598	1.1045
421	67.6588	29.7348	1.1045
422	93.3932	53.1876	1.1045
423	40.8939	84.3555	1.1045
424	42.9721	90.3177	1.1045
425	46.8369	6.4403	1.1045
426	29.8552	101.3038	1.1045
427	70.6940	53.8562	1.1045
428	78.0993	54.3894	1.1045
429	21.1184	76.9048	1.1045
430	-1.9602	93.9224	1.1045
431	101.1976	33.4905	1.1045
432	-2.5612	92.1356	1.1045
433	92.4623	94.7340	1.1045
434	67.2420	26.9141	1.1045
435	102.4507	89.6037	1.1045
436	26.6904	96.1713	1.1045
437	13.2613	67.7948	1.1045
438	87.5129	47.9594	1.1045
439	104.9423	23.5210	1.1045
440	58.8992	5.3006	1.1045
441	107.8221	37.3636	1.1045
442	55.0890	27.0379	1.1045
443	95.6122	103.8055	1.1045
444	23.1228	16.7524	1.1045
445	46.7163	23.0055	1.1045
446	45.4650	105.2608	1.1045
447	99.6903	41.4772	1.1045
448	94.0924	96.5838	1.1045
449	105.6149	29.5786	1.1045
450	-3.2639	94.8889	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
451	31.1050	77.2121	1.1045
452	96.5473	37.5774	1.1045
453	58.2987	1.8222	1.1045
454	29.7849	97.5299	1.1045
455	88.6062	92.2681	1.1045
456	12.5389	66.9051	1.1045
457	13.7649	76.0563	1.1045
458	49.9475	19.2284	1.1045
459	103.2876	94.1817	1.1045
460	28.0443	7.2557	1.1045
461	46.7677	27.4481	1.1045
462	58.4334	33.3219	1.1045
463	21.6596	11.2130	1.1045
464	35.5392	31.6783	1.1045
465	4.7737	93.7785	1.1045
466	96.8865	41.9997	1.1045
467	96.8345	90.0197	1.1045
468	33.7832	8.5886	1.1045
469	48.3020	2.6164	1.1045
470	63.0749	1.8033	1.1045
471	50.8742	24.2729	1.1045
472	73.8072	55.2741	1.1045
473	-4.2807	74.2616	1.1045
474	21.4132	25.3225	1.1045
475	42.7704	10.2739	1.1045
476	19.6468	14.5775	1.1045
477	32.8593	93.0881	1.1045
478	67.6648	48.1141	1.1045
479	98.5859	34.5756	1.1045
480	58.6228	31.6703	1.1045
481	24.1578	73.3792	1.1045
482	14.2239	63.9607	1.1045
483	26.2460	7.8923	1.1045
484	104.5599	87.8351	1.1045
485	31.4906	71.3219	1.1045
486	70.5527	57.3223	1.1045
487	57.3839	0.9502	1.1045
488	102.0076	93.0750	1.1045
489	40.2335	17.1357	1.1045
490	23.4089	84.0628	1.1045
491	60.4719	1.0667	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
492	47.1260	99.3914	1.1045
493	69.9782	57.1009	1.1045
494	80.3964	49.7264	1.1045
495	98.1138	89.5940	1.1045
496	26.4833	65.6457	1.1045
497	20.5046	21.2685	1.1045
498	54.7376	29.7596	1.1045
499	93.9129	43.6355	1.1045
500	27.6562	5.4902	1.1045
501	42.4716	105.6496	1.1045
502	37.4272	33.8061	1.1045
503	60.9493	37.7343	1.1045
504	45.4903	38.3462	1.1045
505	98.0879	44.5657	1.1045
506	58.6741	1.1796	1.1045
507	-6.6860	94.6391	1.1045
508	22.6294	-1.9579	1.1045
509	63.3795	20.1125	1.1045
510	96.2085	41.8253	1.1045
511	93.6941	39.0671	1.1045
512	95.1558	61.2395	1.1045
513	73.7989	28.6287	1.1045
514	93.5538	62.1822	1.1045
515	42.9226	100.4615	1.1045
516	19.0397	19.3917	1.1045
517	52.7074	28.2489	1.1045
518	39.6285	91.4521	1.1045
519	55.1607	27.7715	1.1045
520	35.4006	103.6799	1.1045
521	98.8606	57.9963	1.1045
522	29.2451	9.0499	1.1045
523	29.3468	93.7461	1.1045
524	102.1595	55.9791	1.1045
525	14.0233	68.3418	1.1045
526	47.5448	13.9665	1.1045
527	70.4096	46.4113	1.1045
528	93.9312	28.9768	1.1045
529	56.2795	36.0371	1.1045
530	26.4747	67.9787	1.1045
531	73.2283	44.0709	1.1045
532	90.4865	46.0315	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
533	88.0687	81.4777	1.1045
534	102.8738	56.4102	1.1045
535	70.1344	58.5671	1.1045
536	46.0729	100.6780	1.1045
537	1.7661	66.5446	1.1045
538	92.4120	50.9961	1.1045
539	89.3668	41.3430	1.1045
540	72.4429	44.8985	1.1045
541	101.1477	85.2681	1.1045
542	94.4828	106.1237	1.1045
543	28.1717	107.4546	1.1045
544	94.5987	62.0376	1.1045
545	21.1889	21.2670	1.1045
546	33.8351	99.3235	1.1045
547	96.9541	82.6989	1.1045
548	39.1960	99.7694	1.1045
549	62.0243	36.1020	1.1045
550	98.9319	91.3958	1.1045
551	98.3241	22.4412	1.1045
552	3.1448	100.7200	1.1045
553	47.2642	16.1804	1.1045
554	0.3096	68.1954	1.1045
555	84.6532	51.7406	1.1045
556	72.0385	47.6030	1.1045
557	90.1236	40.7240	1.1045
558	23.1615	20.5337	1.1045
559	32.3564	-1.4633	1.1045
560	100.6297	27.3107	1.1045
561	95.9041	59.3009	1.1045
562	92.7490	64.7326	1.1045
563	66.7168	38.6980	1.1045
564	6.3198	96.0864	1.1045
565	44.7902	101.1589	1.1045
566	70.6462	49.6735	1.1045
567	98.4033	39.6451	1.1045
568	53.5890	37.6567	1.1045
569	53.8048	-5.0553	1.1045
570	72.4926	42.7909	1.1045
571	101.6020	92.3175	1.1045
572	24.8641	0.1355	1.1045
573	15.3124	65.2050	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
574	16.9397	16.1570	1.1045
575	94.1971	38.0204	1.1045
576	98.5670	80.2017	1.1045
577	67.7055	32.9993	1.1045
578	28.2891	98.2700	1.1045
579	73.2561	47.9132	1.1045
580	1.2023	90.7259	1.1045
581	61.5106	34.0654	1.1045
582	70.5497	45.0925	1.1045
583	29.5221	90.7635	1.1045
584	43.7884	36.8808	1.1045
585	88.6759	82.3658	1.1045
586	-0.1009	90.0487	1.1045
587	67.4955	46.0347	1.1045
588	63.4530	34.6286	1.1045
589	14.2076	63.0144	1.1045
590	12.7300	75.2001	1.1045
591	96.1169	76.0362	1.1045
592	73.3859	52.8201	1.1045
593	68.5789	56.8701	1.1045
594	91.1655	36.0648	1.1045
595	66.0257	55.1875	1.1045
596	-0.0468	93.7668	1.1045
597	37.0706	93.0168	1.1045
598	43.0828	99.6317	1.1045
599	46.5714	10.1740	1.1045
600	94.3087	39.6383	1.1045
601	92.9131	56.6287	1.1045
602	62.5649	23.4331	1.1045
603	92.5654	91.5305	1.1045
604	99.1261	78.6323	1.1045
605	68.7356	47.8890	1.1045
606	25.8989	0.7413	1.1045
607	21.5395	100.4343	1.1045
608	98.7715	55.3698	1.1045
609	28.1449	5.3771	1.1045
610	94.6583	60.3511	1.1045
611	31.0449	71.9995	1.1045
612	77.9078	47.2474	1.1045
613	47.7278	5.7114	1.1045
614	105.6501	47.8555	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
615	100.6854	61.8170	1.1045
616	11.6475	70.8021	1.1045
617	53.9650	12.2967	1.1045
618	54.7597	1.1902	1.1045
619	71.8327	48.0379	1.1045
620	94.6877	57.1733	1.1045
621	92.4351	33.0022	1.1045
622	18.9682	67.0820	1.1045
623	96.9343	84.9430	1.1045
624	97.9579	54.2407	1.1045
625	103.5291	67.9060	1.1045
626	49.0558	10.2790	1.1045
627	32.8361	107.2479	1.1045
628	49.5265	1.5006	1.1045
629	97.7943	87.7833	1.1045
630	7.0214	70.8048	1.1045
631	53.5826	-3.7128	1.1045
632	99.7789	45.6905	1.1045
633	99.7259	57.0659	1.1045
634	101.7941	49.0832	1.1045
635	98.3613	42.0392	1.1045
636	92.6340	40.1716	1.1045
637	54.6465	1.3270	1.1045
638	30.8807	93.5109	1.1045
639	27.2709	73.9256	1.1045
640	101.7780	67.1686	1.1045
641	77.9705	58.8491	1.1045
642	93.2846	41.9379	1.1045
643	41.1669	5.3004	1.1045
644	107.2392	85.9448	1.1045
645	42.2565	98.7398	1.1045
646	70.1179	52.2878	1.1045
647	2.5704	90.3092	1.1045
648	101.0606	82.9382	1.1045
649	102.2936	85.0217	1.1045
650	87.5726	32.8781	1.1045
651	87.1149	58.1702	1.1045
652	90.6435	28.0536	1.1045
653	31.7997	5.4917	1.1045
654	44.2621	15.3855	1.1045
655	94.6788	63.8911	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
656	79.5330	47.2684	1.1045
657	98.2007	80.5294	1.1045
658	99.2720	31.5703	1.1045
659	95.0304	53.2116	1.1045
660	50.3723	32.2399	1.1045
661	66.7818	30.0369	1.1045
662	94.5726	47.3613	1.1045
663	31.4187	76.5703	1.1045
664	97.4429	30.1528	1.1045
665	47.4524	12.1509	1.1045
666	95.7654	46.8722	1.1045
667	34.0458	95.0903	1.1045
668	2.7376	84.0979	1.1045
669	48.4975	2.4432	1.1045
670	10.0835	69.7230	1.1045
671	104.0844	32.9988	1.1045
672	93.6487	25.1273	1.1045
673	35.0473	98.5367	1.1045
674	44.7872	36.1398	1.1045
675	3.5998	89.8159	1.1045
676	43.0131	-4.6452	1.1045
677	75.9022	40.5634	1.1045
678	69.1853	30.9522	1.1045
679	94.6798	69.1984	1.1045
680	71.8965	50.0142	1.1045
681	81.1686	57.7423	1.1045
682	96.3928	32.1668	1.1045
683	39.9467	-2.3317	1.1045
684	60.1370	35.2014	1.1045
685	32.1756	91.0244	1.1045
686	96.6051	36.0943	1.1045
687	80.0004	48.0282	1.1045
688	86.2321	62.7290	1.1045
689	45.9074	18.6439	1.1045
690	94.4684	44.7163	1.1045
691	51.5450	-0.7619	1.1045
692	49.9971	19.9155	1.1045
693	48.2378	10.8880	1.1045
694	101.5683	27.6266	1.1045
695	77.6289	48.4559	1.1045
696	64.2784	38.8059	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
697	35.7306	102.2767	1.1045
698	35.5571	102.2950	1.1045
699	70.5469	25.0661	1.1045
700	9.9143	75.8382	1.1045
701	53.9046	16.3668	1.1045
702	91.0116	75.8870	1.1045
703	97.0865	83.6094	1.1045
704	98.7317	39.6579	1.1045
705	18.7531	32.5360	1.1045
706	-5.5457	98.4014	1.1045
707	34.0464	97.1856	1.1045
708	105.6506	92.4297	1.1045
709	49.2438	-0.5725	1.1045
710	49.3090	3.6922	1.1045
711	76.5498	52.2180	1.1045
712	33.2241	90.2072	1.1045
713	40.9431	96.0349	1.1045
714	97.3283	27.0933	1.1045
715	31.1128	-2.8096	1.1045
716	36.4235	4.5159	1.1045
717	58.5415	3.6684	1.1045
718	102.9023	68.4164	1.1045
719	23.5270	73.6169	1.1045
720	70.8564	51.5507	1.1045
721	8.8648	72.0358	1.1045
722	39.7266	17.3977	1.1045
723	61.5650	4.5717	1.1045
724	31.1391	0.2266	1.1045
725	58.8785	37.4935	1.1045
726	48.3250	36.1010	1.1045
727	95.4790	61.1306	1.1045
728	97.7133	51.9341	1.1045
729	104.3617	84.8664	1.1045
730	46.0937	-5.8176	1.1045
731	62.5325	1.7660	1.1045
732	44.1303	30.8739	1.1045
733	25.7737	68.9159	1.1045
734	99.0228	31.9463	1.1045
735	18.4916	22.0310	1.1045
736	52.4859	17.4578	1.1045
737	24.3218	77.9732	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
738	94.9909	83.4209	1.1045
739	-0.3390	97.1979	1.1045
740	74.5598	39.2546	1.1045
741	88.7937	67.4470	1.1045
742	3.8110	100.5395	1.1045
743	77.8794	45.0468	1.1045
744	87.2346	40.5435	1.1045
745	103.8628	98.4843	1.1045
746	58.6318	9.4344	1.1045
747	89.3464	46.1786	1.1045
748	91.9372	36.8319	1.1045
749	100.8882	91.1406	1.1045
750	92.5592	25.4331	1.1045
751	51.2901	7.6487	1.1045
752	14.7433	68.1941	1.1045
753	15.4332	72.9689	1.1045
754	19.5225	24.6717	1.1045
755	93.1133	78.1389	1.1045
756	72.1444	51.2772	1.1045
757	100.5945	52.9653	1.1045
758	57.2331	12.7874	1.1045
759	98.2349	98.4363	1.1045
760	88.2545	36.0660	1.1045
761	5.2812	65.5492	1.1045
762	65.2110	38.9167	1.1045
763	90.0140	39.9150	1.1045
764	41.6896	94.8028	1.1045
765	3.0162	107.1796	1.1045
766	42.6808	88.2098	1.1045
767	108.1531	76.0691	1.1045
768	34.7819	91.1147	1.1045
769	100.8862	48.4618	1.1045
770	68.3676	27.3310	1.1045
771	42.8352	101.6931	1.1045
772	22.0389	18.6688	1.1045
773	95.0373	98.5247	1.1045
774	98.6560	92.6213	1.1045
775	47.4152	28.2569	1.1045
776	89.9500	80.2132	1.1045
777	90.4784	41.2284	1.1045
778	28.2410	67.9653	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
779	36.1694	94.3523	1.1045
780	100.5649	91.4192	1.1045
781	93.1284	88.6615	1.1045
782	18.7218	26.0511	1.1045
783	35.2297	94.8683	1.1045
784	36.8108	99.4487	1.1045
785	7.5677	74.3816	1.1045
786	100.3840	25.6874	1.1045
787	96.2545	87.1498	1.1045
788	74.3979	53.0985	1.1045
789	68.0366	38.8903	1.1045
790	8.4928	63.9998	1.1045
791	44.5228	11.8645	1.1045
792	35.4073	87.2216	1.1045
793	53.2794	21.4994	1.1045
794	33.9629	96.8355	1.1045
795	-0.7351	89.6931	1.1045
796	76.2244	51.9684	1.1045
797	94.4551	58.0456	1.1045
798	82.0477	53.0979	1.1045
799	46.0043	6.8606	1.1045
800	90.0385	42.8005	1.1045
801	8.3117	72.2049	1.1045
802	34.9317	80.2335	1.1045
803	44.2937	4.7268	1.1045
804	17.2669	18.1061	1.1045
805	16.9754	26.2994	1.1045
806	92.8093	39.7693	1.1045
807	31.6341	101.1443	1.1045
808	15.0509	21.8739	1.1045
809	33.4349	0.0139	1.1045
810	35.2228	101.4244	1.1045
811	88.4465	41.4478	1.1045
812	-0.1710	97.1566	1.1045
813	44.0031	6.0986	1.1045
814	58.0725	5.2013	1.1045
815	45.5397	7.2979	1.1045
816	29.4417	11.4808	1.1045
817	97.7455	51.8526	1.1045
818	59.6709	-1.5476	1.1045
819	76.0043	50.5809	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
820	-1.2335	86.0108	1.1045
821	74.4488	50.3129	1.1045
822	94.6945	78.5720	1.1045
823	60.5785	6.8128	1.1045
824	91.1400	83.5499	1.1045
825	89.6611	52.1615	1.1045
826	97.7624	79.6432	1.1045
827	29.6205	6.6839	1.1045
828	69.5886	28.6002	1.1045
829	94.3452	48.7818	1.1045
830	93.0102	50.1223	1.1045
831	45.9242	19.9000	1.1045
832	95.1298	37.6897	1.1045
833	26.6151	77.1467	1.1045
834	37.1983	106.3470	1.1045
835	98.3827	22.3334	1.1045
836	92.9420	26.4511	1.1045
837	12.0587	67.8257	1.1045
838	54.0368	23.8586	1.1045
839	47.9812	30.2306	1.1045
840	70.7664	48.6137	1.1045
841	62.6603	37.1290	1.1045
842	97.9014	66.9835	1.1045
843	-4.1255	85.5960	1.1045
844	67.4683	58.2291	1.1045
845	31.9656	14.6164	1.1045
846	38.0686	7.3443	1.1045
847	61.6430	23.6955	1.1045
848	22.0857	71.4539	1.1045
849	26.2205	72.9044	1.1045
850	51.6732	17.1776	1.1045
851	21.2889	20.2133	1.1045
852	95.2026	90.5293	1.1045
853	35.7481	97.1257	1.1045
854	97.0806	39.3994	1.1045
855	73.6611	50.4924	1.1045
856	35.1535	70.6086	1.1045
857	80.7698	50.7290	1.1045
858	97.3108	57.8200	1.1045
859	63.8119	26.0212	1.1045
860	51.6292	37.4529	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
861	2.1469	96.6722	1.1045
862	103.1106	83.2736	1.1045
863	49.1449	22.3659	1.1045
864	102.9297	48.0592	1.1045
865	92.7124	33.4453	1.1045
866	0.6193	91.0377	1.1045
867	16.7224	69.1113	1.1045
868	78.2967	50.1808	1.1045
869	15.0856	70.6386	1.1045
870	22.9431	70.0987	1.1045
871	96.0562	52.3857	1.1045
872	18.7356	77.2891	1.1045
873	4.4426	63.6871	1.1045
874	88.3633	87.3681	1.1045
875	29.2732	5.6917	1.1045
876	104.1102	44.8822	1.1045
877	63.4243	4.3429	1.1045
878	97.3132	81.5365	1.1045
879	58.9981	26.6128	1.1045
880	51.5390	18.7116	1.1045
881	10.4334	62.8220	1.1045
882	93.0933	68.7697	1.1045
883	45.0418	3.8658	1.1045
884	93.2379	56.4517	1.1045
885	72.0955	52.6394	1.1045
886	100.0565	80.1054	1.1045
887	43.4311	0.4843	1.1045
888	52.2056	3.4977	1.1045
889	44.8479	-0.9391	1.1045
890	62.4332	-0.6840	1.1045
891	3.1184	98.9240	1.1045
892	90.3356	51.1932	1.1045
893	101.3770	48.1816	1.1045
894	64.2717	31.7627	1.1045
895	-12.8049	93.8535	1.1045
896	95.0864	47.4256	1.1045
897	45.4526	36.1210	1.1045
898	46.5537	103.4177	1.1045
899	53.9150	28.4629	1.1045
900	102.5430	45.6081	1.1045
901	27.0312	22.0371	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
902	72.2401	34.2889	1.1045
903	54.4331	-6.2551	1.1045
904	76.4125	46.9810	1.1045
905	69.1565	53.3430	1.1045
906	67.8488	53.6384	1.1045
907	93.9684	87.8762	1.1045
908	73.2116	57.7970	1.1045
909	50.3352	41.2014	1.1045
910	60.2628	6.0605	1.1045
911	9.1569	61.6426	1.1045
912	50.9668	1.7170	1.1045
913	8.0611	104.0930	1.1045
914	98.2004	50.3921	1.1045
915	55.7669	1.6852	1.1045
916	99.3434	90.9979	1.1045
917	96.0238	29.4057	1.1045
918	8.1477	101.1634	1.1045
919	58.1260	35.2400	1.1045
920	52.0607	4.6851	1.1045
921	67.7991	50.1342	1.1045
922	22.4003	2.9895	1.1045
923	51.7623	34.8081	1.1045
924	44.5689	9.7500	1.1045
925	69.2681	55.3133	1.1045
926	22.6268	64.3936	1.1045
927	7.6803	61.1857	1.1045
928	11.4442	66.9869	1.1045
929	52.3291	3.6705	1.1045
930	91.9756	47.4725	1.1045
931	85.5250	32.0217	1.1045
932	9.1707	70.0865	1.1045
933	47.7428	26.4380	1.1045
934	52.8937	1.3390	1.1045
935	72.0723	49.2863	1.1045
936	47.1015	12.1757	1.1045
937	96.2521	73.5638	1.1045
938	60.1802	30.6710	1.1045
939	25.3366	76.5380	1.1045
940	76.3790	48.6237	1.1045
941	17.3215	22.8150	1.1045
942	91.1291	78.4897	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
943	65.3289	43.5846	1.1045
944	75.7300	42.7229	1.1045
945	32.6009	89.9531	1.1045
946	4.9579	99.4405	1.1045
947	51.8363	2.0767	1.1045
948	62.4640	33.4003	1.1045
949	47.7789	92.5461	1.1045
950	43.7175	13.3612	1.1045
951	63.2951	31.2899	1.1045
952	94.8477	58.3247	1.1045
953	89.3520	47.1855	1.1045
954	24.5729	19.8583	1.1045
955	51.0819	30.8837	1.1045
956	51.7765	0.7553	1.1045
957	35.7859	98.3251	1.1045
958	66.7482	27.6121	1.1045
959	98.3726	88.4744	1.1045
960	31.3011	106.2109	1.1045
961	-7.5489	96.9207	1.1045
962	44.3034	16.6265	1.1045
963	31.6916	96.8159	1.1045
964	98.4228	65.0226	1.1045
965	77.5882	39.4219	1.1045
966	53.1154	7.9184	1.1045
967	99.3413	60.5080	1.1045
968	42.4139	3.5597	1.1045
969	21.3934	72.6127	1.1045
970	97.5011	28.0267	1.1045
971	100.3439	52.2486	1.1045
972	31.7064	96.9880	1.1045
973	33.0573	97.9271	1.1045
974	75.2757	50.6388	1.1045
975	11.4886	67.7219	1.1045
976	44.3651	39.5082	1.1045
977	86.5120	33.4131	1.1045
978	51.4730	33.7115	1.1045
979	97.1838	29.5842	1.1045
980	105.0575	26.2706	1.1045
981	39.3246	101.8921	1.1045
982	69.4154	51.8752	1.1045
983	54.5841	1.3000	1.1045

Continued on next page

Table D.7 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
984	23.7960	77.2181	1.1045
985	50.2911	5.2466	1.1045
986	89.5631	83.3752	1.1045
987	89.1249	38.0318	1.1045
988	95.5040	96.3510	1.1045
989	70.9160	53.3608	1.1045
990	72.9378	43.4347	1.1045
991	79.7169	32.9378	1.1045
992	89.0134	41.3658	1.1045
993	23.3217	16.9506	1.1045
994	95.8598	39.2349	1.1045
995	75.9853	41.4015	1.1045
996	90.7200	30.0490	1.1045
997	95.1396	47.3596	1.1045
998	46.0030	37.4534	1.1045
999	54.3108	6.5803	1.1045
Depot	47.1287	11.9659	N.A.

Table D.8: CETSP instance team1_100rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	78.2140	79.2180	2.9020
2	74.4470	77.3820	2.9020
3	76.1540	71.7630	2.9020
4	77.9190	74.0570	2.9020
5	54.0320	12.1970	2.9020
6	53.7540	0.1480	2.9020
7	46.1540	2.0830	2.9020
8	53.4050	3.0410	2.9020
9	40.8680	2.9810	2.9020
10	45.2930	9.0570	2.9020
11	27.2190	44.5100	2.9020
12	19.8810	93.1810	2.9020
13	1.5270	46.5990	2.9020
14	74.6790	41.8650	2.9020
15	36.9240	96.6360	2.9020
16	30.5030	90.0560	2.9020
17	24.0530	94.1890	2.9020
18	33.4430	88.5780	2.9020
19	36.7620	86.0920	2.9020
20	20.3930	83.7930	2.9020
21	33.6260	83.8690	2.9020
22	27.5900	93.6440	2.9020
23	19.5690	24.4490	2.9020
24	25.5420	20.5060	2.9020
25	15.7720	12.5490	2.9020
26	29.4470	11.2430	2.9020
27	21.4590	12.5300	2.9020
28	33.5000	17.3520	2.9020
29	33.3410	22.1780	2.9020
30	26.8390	11.7320	2.9020
31	12.4140	20.9620	2.9020
32	22.4940	14.2020	2.9020
33	20.5410	9.2600	2.9020
34	16.1230	17.5680	2.9020
35	49.5710	48.1400	2.9020
36	47.2320	45.2700	2.9020
37	52.9750	65.5600	2.9020
38	51.2900	49.5800	2.9020
39	55.2810	51.8710	2.9020
40	59.0070	60.2130	2.9020
41	49.0200	51.5410	2.9020

Continued on next page

Table D.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	57.2430	55.7920	2.9020
43	40.9780	46.4900	2.9020
44	59.5340	67.7320	2.9020
45	43.2430	58.4040	2.9020
46	42.8040	54.7400	2.9020
47	57.1420	56.8570	2.9020
48	53.9580	52.6810	2.9020
49	89.3590	10.8390	2.9020
50	85.8410	12.6530	2.9020
51	91.8570	16.5020	2.9020
52	94.9260	4.0060	2.9020
53	91.0070	13.2490	2.9020
54	92.8890	3.8550	2.9020
55	85.5540	10.0610	2.9020
56	88.4570	8.1850	2.9020
57	95.3170	17.8640	2.9020
58	93.5740	3.2550	2.9020
59	20.7350	74.6590	2.9020
60	26.2130	68.9770	2.9020
61	26.7320	55.6120	2.9020
62	21.2990	57.5930	2.9020
63	11.8440	68.3940	2.9020
64	13.4540	69.0070	2.9020
65	5.7770	62.0030	2.9020
66	17.3740	67.5290	2.9020
67	8.6410	64.1880	2.9020
68	25.9230	53.1850	2.9020
69	19.6190	52.7340	2.9020
70	11.1230	60.4420	2.9020
71	20.1030	52.3470	2.9020
72	7.2350	62.3670	2.9020
73	11.8780	70.4440	2.9020
74	25.2010	54.5070	2.9020
75	18.4500	52.9540	2.9020
76	5.7390	68.5350	2.9020
77	93.6940	56.9250	2.9020
78	87.1730	60.9980	2.9020
79	87.1800	60.8600	2.9020
80	89.0910	59.8860	2.9020
81	93.4560	57.6900	2.9020
82	87.6330	63.4320	2.9020

Continued on next page

Table D.8 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	91.0430	63.6910	2.9020
84	93.9460	64.0030	2.9020
85	94.8940	61.2620	2.9020
86	94.6190	62.1030	2.9020
87	63.6310	81.2240	2.9020
88	73.5230	67.7270	2.9020
89	81.4760	87.3160	2.9020
90	86.7850	67.2170	2.9020
91	68.1930	67.1240	2.9020
92	67.6430	91.8290	2.9020
93	85.9680	75.1940	2.9020
94	66.9710	72.2010	2.9020
95	84.1460	71.4270	2.9020
96	87.2520	72.9520	2.9020
97	66.9570	73.7970	2.9020
98	67.1790	79.7460	2.9020
99	61.4930	65.5920	2.9020
100	62.3520	63.1440	2.9020
Depot	50.0000	10.0000	N.A.

Table D.9: CETSP instance team_200rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	70.5547	53.3424	6.3030
2	57.9519	28.9562	6.3030
3	30.1948	77.4740	6.3030
4	1.4018	76.0724	6.3030
5	81.4490	70.9038	6.3030
6	4.5353	41.4033	6.3030
7	86.2619	79.0480	6.3030
8	37.3536	96.1953	6.3030
9	87.1446	5.6237	6.3030
10	94.9557	36.4019	6.3030
11	52.4868	76.7112	6.3030
12	5.3505	59.2458	6.3030
13	46.8700	29.8165	6.3030
14	62.2697	64.7821	6.3030
15	26.3793	27.9342	6.3030
16	82.9802	82.4602	6.3030
17	58.9163	98.6093	6.3030
18	91.0964	22.6866	6.3030
19	69.5115	98.0003	6.3030
20	24.3931	53.3873	6.3030
21	10.6370	99.9415	6.3030
22	67.6176	1.5704	6.3030
23	57.5184	10.0052	6.3030
24	10.3023	79.8884	6.3030
25	28.4480	4.5649	6.3030
26	29.5773	38.2011	6.3030
27	30.0970	94.8571	6.3030
28	97.9829	40.1374	6.3030
29	27.8280	16.0441	6.3030
30	16.2822	64.6587	6.3030
31	41.0073	41.2767	6.3030
32	71.2730	32.6206	6.3030
33	63.3179	20.7561	6.3030
34	18.6014	58.3359	6.3030
35	8.0715	45.7971	6.3030
36	90.5730	26.1368	6.3030
37	78.5212	37.8903	6.3030
38	28.9665	91.9377	6.3030
39	63.1742	62.7642	6.3030
40	42.8456	9.7974	6.3030
41	56.1040	69.4485	6.3030

Continued on next page

Table D.9 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	91.3718	83.4817	6.3030
43	2.2629	54.3361	6.3030
44	91.6164	43.0261	6.3030
45	67.7948	0.2454	6.3030
46	51.3738	46.2980	6.3030
47	35.3473	40.4834	6.3030
48	26.9732	5.5594	6.3030
49	24.3845	97.9078	6.3030
50	6.0916	39.0291	6.3030
51	36.4995	48.9895	6.3030
52	15.5663	47.4459	6.3030
53	25.7268	62.8752	6.3030
54	54.2070	15.6302	6.3030
55	93.8545	65.4499	6.3030
56	50.6087	39.0471	6.3030
57	10.7375	78.3995	6.3030
58	45.9641	75.3688	6.3030
59	59.6095	83.2730	6.3030
60	1.8758	21.0369	6.3030
61	7.3953	10.5453	6.3030
62	33.1694	12.8250	6.3030
63	0.0241	3.6794	6.3030
64	65.7055	54.4014	6.3030
65	82.7412	8.1894	6.3030
66	19.1923	67.8913	6.3030
67	45.4208	35.7023	6.3030
68	14.9981	70.4396	6.3030
69	92.8786	53.0213	6.3030
70	8.9641	75.7729	6.3030
71	40.1842	46.1874	6.3030
72	49.2166	20.7627	6.3030
73	32.9736	9.5429	6.3030
74	58.9793	16.9873	6.3030
75	92.7617	9.7930	6.3030
76	44.3862	27.2947	6.3030
77	87.2547	75.0688	6.3030
78	27.2942	67.3647	6.3030
79	25.6629	8.9897	6.3030
80	3.0951	32.2718	6.3030
81	79.0129	29.7258	6.3030
82	23.5282	48.0475	6.3030

Continued on next page

Table D.9 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	25.4602	34.0607	6.3030
84	4.4934	48.2428	6.3030
85	20.6017	86.4535	6.3030
86	58.8629	75.4908	6.3030
87	92.7883	33.1017	6.3030
88	54.2941	8.0691	6.3030
89	63.4372	41.0037	6.3030
90	96.0423	11.4623	6.3030
91	92.3445	62.0210	6.3030
92	34.7726	14.9246	6.3030
93	47.9978	21.9409	6.3030
94	99.3731	13.0420	6.3030
95	2.8886	34.5392	6.3030
96	54.7669	92.2955	6.3030
97	53.8246	40.6421	6.3030
98	84.7245	82.6226	6.3030
99	67.2428	72.1895	6.3030
100	99.6771	33.9806	6.3030
101	49.5211	41.2968	6.3030
102	69.5282	17.9089	6.3030
103	42.2918	54.3177	6.3030
104	81.4664	54.0914	6.3030
105	42.7533	50.9068	6.3030
106	22.7782	61.9188	6.3030
107	48.9830	68.0819	6.3030
108	88.6600	37.0515	6.3030
109	30.2498	29.2867	6.3030
110	15.0311	2.9821	6.3030
111	22.3262	58.4529	6.3030
112	36.3459	87.5975	6.3030
113	47.8014	19.0633	6.3030
114	68.4062	74.7416	6.3030
115	61.3935	78.2139	6.3030
116	16.1744	80.7780	6.3030
117	20.2618	95.6762	6.3030
118	6.5851	6.1522	6.3030
119	79.3198	37.9605	6.3030
120	46.3584	11.9544	6.3030
121	11.5470	17.3773	6.3030
122	4.8119	71.4816	6.3030
123	53.3022	56.1009	6.3030

Continued on next page

Table D.9 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	21.6734	6.8006	6.3030
125	74.6355	75.2311	6.3030
126	39.8932	90.3099	6.3030
127	74.6007	8.8559	6.3030
128	63.4571	71.3028	6.3030
129	1.5682	43.1144	6.3030
130	40.1983	27.5296	6.3030
131	98.5374	80.2587	6.3030
132	69.6101	41.7599	6.3030
133	73.4488	27.7168	6.3030
134	35.6586	43.3457	6.3030
135	94.4971	12.1550	6.3030
136	64.5951	34.7833	6.3030
137	10.4432	18.5403	6.3030
138	7.7685	43.2760	6.3030
139	95.9271	54.2029	6.3030
140	49.4377	97.2967	6.3030
141	21.7800	37.8991	6.3030
142	39.5844	28.1503	6.3030
143	50.3371	13.8732	6.3030
144	51.7256	96.5364	6.3030
145	55.7501	90.9204	6.3030
146	65.7256	44.1115	6.3030
147	69.2995	6.4491	6.3030
148	75.6093	70.0514	6.3030
149	49.7071	15.5436	6.3030
150	22.3738	32.6144	6.3030
151	78.4489	5.0263	6.3030
152	51.8016	75.7030	6.3030
153	80.0670	32.5205	6.3030
154	97.2729	80.4267	6.3030
155	67.4826	90.5129	6.3030
156	87.5780	41.6648	6.3030
157	12.3083	95.4158	6.3030
158	79.7297	69.6285	6.3030
159	40.1605	1.6298	6.3030
160	16.7763	16.4234	6.3030
161	50.9720	40.6063	6.3030
162	10.6134	27.6123	6.3030
163	64.3047	84.9100	6.3030
164	49.7969	18.7775	6.3030

Continued on next page

Table D.9 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	89.6617	37.2814	6.3030
166	32.3555	77.0833	6.3030
167	21.8000	44.6993	6.3030
168	23.6028	87.8385	6.3030
169	61.0433	37.4432	6.3030
170	38.9502	86.0589	6.3030
171	58.5938	93.1559	6.3030
172	51.7192	33.0301	6.3030
173	86.8454	25.9061	6.3030
174	25.9541	17.8694	6.3030
175	34.6957	0.2506	6.3030
176	74.2342	84.0887	6.3030
177	27.8589	70.2970	6.3030
178	40.4865	81.1571	6.3030
179	74.1781	43.7664	6.3030
180	7.7981	41.0632	6.3030
181	33.9375	71.0554	6.3030
182	31.2288	79.8774	6.3030
183	15.1756	59.2991	6.3030
184	95.6237	24.3148	6.3030
185	93.9971	11.4333	6.3030
186	98.4253	63.2976	6.3030
187	59.8856	90.2570	6.3030
188	57.4865	24.5174	6.3030
189	86.0162	7.4950	6.3030
190	43.8826	75.9979	6.3030
191	24.5679	37.8606	6.3030
192	39.7244	52.6573	6.3030
193	27.0359	58.1176	6.3030
194	20.9699	7.8709	6.3030
195	89.5446	11.1433	6.3030
196	65.2377	90.0334	6.3030
197	23.1597	94.9905	6.3030
198	84.6187	44.1216	6.3030
199	49.2006	76.9507	6.3030
200	83.4893	38.2569	6.3030
Depot	19.5535	32.6157	N.A.

Table D.10: CETSP instance team3_300rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	44.7500	90.0800	11.2700
2	82.4200	49.9900	11.2700
3	2.0100	79.0100	11.2700
4	25.8400	61.0900	11.2700
5	88.2100	3.6100	11.2700
6	24.4700	65.2400	11.2700
7	5.0700	73.1500	11.2700
8	85.7600	19.2700	11.2700
9	64.8700	11.3600	11.2700
10	43.2100	42.6100	11.2700
11	49.7800	61.4800	11.2700
12	51.3800	10.5100	11.2700
13	23.5500	20.8300	11.2700
14	27.7400	25.6300	11.2700
15	40.1400	85.4700	11.2700
16	39.2800	92.9900	11.2700
17	46.8000	93.4300	11.2700
18	48.9800	92.0300	11.2700
19	37.9300	93.9200	11.2700
20	39.3100	87.1400	11.2700
21	42.3700	92.4500	11.2700
22	40.1400	88.2500	11.2700
23	47.6700	92.5900	11.2700
24	47.5600	92.0300	11.2700
25	37.8800	93.1600	11.2700
26	49.1100	94.3100	11.2700
27	49.9100	91.9000	11.2700
28	48.8900	93.1000	11.2700
29	39.7000	88.7300	11.2700
30	41.1100	92.5500	11.2700
31	47.0800	88.2600	11.2700
32	45.5700	93.7100	11.2700
33	46.8900	94.8500	11.2700
34	47.4800	94.9000	11.2700
35	46.9200	92.9400	11.2700
36	42.9300	88.7800	11.2700
37	39.1800	94.8600	11.2700
38	38.9900	86.4200	11.2700
39	41.1100	86.3300	11.2700
40	38.3600	90.4300	11.2700
41	48.4200	91.5300	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	48.2500	85.2600	11.2700
43	48.6800	92.5500	11.2700
44	42.7800	91.8700	11.2700
45	38.0800	89.4800	11.2700
46	40.1300	86.4800	11.2700
47	50.9100	90.3000	11.2700
48	44.3300	87.3000	11.2700
49	51.7500	85.8100	11.2700
50	85.7800	45.3700	11.2700
51	86.8800	55.3400	11.2700
52	92.8200	43.5000	11.2700
53	90.9300	51.7800	11.2700
54	89.3300	46.2300	11.2700
55	84.4700	44.9100	11.2700
56	85.4300	53.0000	11.2700
57	91.0800	56.3200	11.2700
58	89.5900	51.8800	11.2700
59	85.2100	44.3500	11.2700
60	92.9200	45.3000	11.2700
61	92.5900	46.1600	11.2700
62	87.2600	54.5300	11.2700
63	92.0000	48.8000	11.2700
64	93.8600	49.1100	11.2700
65	92.0900	44.0800	11.2700
66	85.0200	48.7500	11.2700
67	89.3600	56.0300	11.2700
68	84.4700	48.1600	11.2700
69	89.1100	45.9400	11.2700
70	88.9200	43.6200	11.2700
71	87.5600	46.9900	11.2700
72	87.9200	47.4600	11.2700
73	85.8500	46.4900	11.2700
74	8.9500	75.4300	11.2700
75	3.4400	75.5800	11.2700
76	0.7600	80.9700	11.2700
77	2.9900	72.0900	11.2700
78	6.6200	72.9600	11.2700
79	6.3600	80.4400	11.2700
80	1.2100	81.9700	11.2700
81	4.1500	75.9200	11.2700
82	1.3600	82.4100	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	0.9700	75.7800	11.2700
84	10.6600	76.4400	11.2700
85	8.2900	81.4500	11.2700
86	2.1900	82.1300	11.2700
87	4.7500	76.3700	11.2700
88	8.0600	78.3600	11.2700
89	8.6000	80.5600	11.2700
90	0.9100	72.4300	11.2700
91	11.2300	82.6000	11.2700
92	21.7500	55.1900	11.2700
93	30.8500	54.3900	11.2700
94	23.7800	67.3700	11.2700
95	23.5000	55.8400	11.2700
96	23.1900	66.2200	11.2700
97	30.3600	58.1400	11.2700
98	19.6500	58.2000	11.2700
99	86.4600	7.1500	11.2700
100	90.7100	5.3500	11.2700
101	90.1400	0.7400	11.2700
102	86.7100	7.9000	11.2700
103	84.2100	1.1500	11.2700
104	84.5700	2.1900	11.2700
105	90.4500	0.1800	11.2700
106	84.2200	4.2500	11.2700
107	84.8500	7.4900	11.2700
108	85.1800	6.8100	11.2700
109	91.8600	5.0900	11.2700
110	83.5000	4.8300	11.2700
111	89.8100	1.3300	11.2700
112	83.9800	4.2400	11.2700
113	86.4900	3.9700	11.2700
114	87.0600	2.8900	11.2700
115	90.7900	7.2700	11.2700
116	83.0800	5.9000	11.2700
117	83.6300	6.6100	11.2700
118	85.3400	3.1300	11.2700
119	83.0800	6.8500	11.2700
120	24.0300	65.5600	11.2700
121	20.6400	65.0000	11.2700
122	28.7700	62.0500	11.2700
123	23.5200	71.0500	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	26.5000	63.4400	11.2700
125	20.8800	59.5100	11.2700
126	25.8600	63.8500	11.2700
127	25.2400	60.7700	11.2700
128	27.6400	62.7800	11.2700
129	27.4000	59.8400	11.2700
130	25.0100	63.1200	11.2700
131	27.6200	60.6100	11.2700
132	22.1700	64.9400	11.2700
133	22.5100	60.1500	11.2700
134	27.2800	65.4700	11.2700
135	28.8600	67.8400	11.2700
136	27.3600	59.9400	11.2700
137	24.4900	66.2700	11.2700
138	26.1500	61.9600	11.2700
139	21.3900	62.7100	11.2700
140	20.5600	61.4400	11.2700
141	25.6200	68.9800	11.2700
142	24.8600	66.0500	11.2700
143	22.6500	62.2000	11.2700
144	20.3500	68.7500	11.2700
145	8.6700	72.7700	11.2700
146	21.4900	69.2000	11.2700
147	19.8600	66.1100	11.2700
148	4.8000	88.5100	11.2700
149	28.9500	69.7200	11.2700
150	1.0100	87.8300	11.2700
151	21.9900	57.1500	11.2700
152	24.2500	76.6600	11.2700
153	4.2100	66.5300	11.2700
154	28.8200	81.7800	11.2700
155	35.5800	76.0600	11.2700
156	30.8300	54.4200	11.2700
157	37.8500	53.7600	11.2700
158	12.8200	66.4900	11.2700
159	27.1800	54.0400	11.2700
160	39.4200	71.5400	11.2700
161	36.6000	82.9400	11.2700
162	23.4700	70.4900	11.2700
163	16.7900	62.6700	11.2700
164	35.4600	90.5000	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	21.1000	78.1200	11.2700
166	13.3600	65.0000	11.2700
167	24.2000	92.4200	11.2700
168	35.3700	65.9900	11.2700
169	11.7400	69.1700	11.2700
170	16.9900	78.3600	11.2700
171	12.1400	56.7600	11.2700
172	12.0700	80.1400	11.2700
173	34.7900	81.5700	11.2700
174	31.9900	67.7400	11.2700
175	27.3500	82.2400	11.2700
176	11.1800	57.9200	11.2700
177	58.7500	56.6300	11.2700
178	92.9200	88.4600	11.2700
179	2.5700	49.6700	11.2700
180	70.7000	73.7000	11.2700
181	72.9300	73.7000	11.2700
182	24.6700	93.3400	11.2700
183	33.0100	55.5500	11.2700
184	31.2200	0.1800	11.2700
185	90.6500	58.2600	11.2700
186	60.9400	57.5600	11.2700
187	68.1700	79.2100	11.2700
188	51.1200	47.5400	11.2700
189	19.4800	4.7500	11.2700
190	53.7300	28.3700	11.2700
191	16.0700	82.1400	11.2700
192	5.5400	99.2900	11.2700
193	48.2600	14.5800	11.2700
194	9.4100	84.3800	11.2700
195	74.4900	84.4600	11.2700
196	47.3000	55.2500	11.2700
197	98.4100	37.6400	11.2700
198	54.0500	68.3900	11.2700
199	63.2600	50.7700	11.2700
200	57.5700	78.4400	11.2700
201	65.1600	40.7800	11.2700
202	3.2100	36.3500	11.2700
203	32.4200	78.2700	11.2700
204	1.2400	99.0100	11.2700
205	60.1200	71.0500	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	53.3500	83.1400	11.2700
207	3.3600	12.5400	11.2700
208	78.9800	97.8300	11.2700
209	22.6000	70.1000	11.2700
210	54.8300	99.8800	11.2700
211	5.5800	22.9000	11.2700
212	24.6600	9.1300	11.2700
213	15.5400	52.8300	11.2700
214	4.0100	20.5000	11.2700
215	96.4300	49.7300	11.2700
216	60.8900	11.9900	11.2700
217	61.2700	24.4100	11.2700
218	78.0100	26.1900	11.2700
219	44.5300	2.7200	11.2700
220	54.2200	8.1800	11.2700
221	71.3300	32.2300	11.2700
222	50.2100	0.8200	11.2700
223	63.3500	21.4900	11.2700
224	55.5000	8.8600	11.2700
225	73.6300	17.0700	11.2700
226	47.3400	38.2500	11.2700
227	45.5700	28.2600	11.2700
228	58.0200	32.4600	11.2700
229	79.7900	30.3200	11.2700
230	56.3100	21.3100	11.2700
231	62.1600	16.8800	11.2700
232	43.2300	11.5400	11.2700
233	75.9800	28.2600	11.2700
234	45.6300	23.7600	11.2700
235	74.9300	38.6300	11.2700
236	50.3000	13.2800	11.2700
237	77.9400	16.7300	11.2700
238	40.0000	38.7700	11.2700
239	66.8700	17.1000	11.2700
240	41.4700	31.6900	11.2700
241	67.0000	3.9400	11.2700
242	63.8800	23.8100	11.2700
243	76.8100	16.4000	11.2700
244	41.4900	2.2900	11.2700
245	78.4100	15.8800	11.2700
246	49.8500	30.5600	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	44.1500	32.6400	11.2700
248	42.7200	42.8400	11.2700
249	42.9500	44.7400	11.2700
250	42.6900	39.7800	11.2700
251	45.6000	43.9300	11.2700
252	43.2100	42.3500	11.2700
253	42.6200	44.8100	11.2700
254	42.5900	39.1600	11.2700
255	41.0700	43.9800	11.2700
256	41.9700	43.2200	11.2700
257	40.1100	39.6000	11.2700
258	45.4200	39.9100	11.2700
259	40.4000	40.1900	11.2700
260	45.6000	41.8100	11.2700
261	42.5600	42.2800	11.2700
262	43.9600	42.1000	11.2700
263	45.7100	40.8000	11.2700
264	64.3000	1.0300	11.2700
265	30.6900	95.9800	11.2700
266	11.4600	53.0700	11.2700
267	0.6200	84.9500	11.2700
268	34.2400	70.4600	11.2700
269	85.6000	88.6500	11.2700
270	66.2600	99.0700	11.2700
271	25.6500	24.5300	11.2700
272	70.2300	90.7300	11.2700
273	9.0700	51.9200	11.2700
274	53.8700	15.5100	11.2700
275	57.6600	15.5100	11.2700
276	52.1200	16.8400	11.2700
277	47.4500	7.4900	11.2700
278	48.0000	4.0000	11.2700
279	50.9700	4.5900	11.2700
280	55.4000	11.1700	11.2700
281	54.5000	15.9100	11.2700
282	52.6700	8.8800	11.2700
283	52.9600	3.7500	11.2700
284	44.7200	11.8700	11.2700
285	55.3800	10.1300	11.2700
286	45.5700	12.7600	11.2700
287	56.9400	12.1800	11.2700

Continued on next page

Table D.10 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	53.8500	15.0800	11.2700
289	56.3800	14.3200	11.2700
290	54.1500	15.5400	11.2700
291	56.2600	10.3400	11.2700
292	46.3800	12.3100	11.2700
293	50.5200	8.6800	11.2700
294	56.8500	15.4900	11.2700
295	55.2400	13.3700	11.2700
296	51.9800	10.9900	11.2700
297	45.0900	11.7000	11.2700
298	52.6700	4.6500	11.2700
299	51.8600	7.7000	11.2700
300	52.0300	16.0400	11.2700
Depot	23.5500	20.8300	N.A.

Table D.11: CETSP instance team4_400rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	68.7924	27.9017	3.9464
2	17.2729	64.9732	3.9464
3	77.7502	18.7938	3.9464
4	0.0015	79.2564	3.9464
5	54.8709	48.0989	3.9464
6	91.0810	71.6915	3.9464
7	36.1103	75.9600	3.9464
8	22.2764	97.9200	3.9464
9	76.1173	11.8321	3.9464
10	92.4806	84.1266	3.9464
11	33.3240	88.8623	3.9464
12	92.0500	40.0562	3.9464
13	2.1250	13.8908	3.9464
14	2.4043	62.3745	3.9464
15	91.0375	80.9252	3.9464
16	16.4015	79.8607	3.9464
17	83.1155	24.6903	3.9464
18	80.0039	44.2789	3.9464
19	14.3588	25.8838	3.9464
20	55.5813	65.9389	3.9464
21	74.4430	98.0205	3.9464
22	34.0987	26.4840	3.9464
23	72.8895	91.5533	3.9464
24	33.2403	8.1602	3.9464
25	40.4237	12.9471	3.9464
26	39.6583	53.3929	3.9464
27	94.4040	75.1851	3.9464
28	40.2902	96.6895	3.9464
29	28.2020	68.6988	3.9464
30	87.3023	11.9374	3.9464
31	14.2410	46.1101	3.9464
32	18.4766	32.5001	3.9464
33	2.3493	1.7072	3.9464
34	90.7256	70.4444	3.9464
35	64.4698	94.9116	3.9464
36	56.4281	90.2054	3.9464
37	27.6568	28.0813	3.9464
38	98.6909	7.7236	3.9464
39	76.2706	23.4637	3.9464
40	31.8731	36.0461	3.9464
41	27.4824	83.1530	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	12.5519	14.7340	3.9464
43	75.8385	89.3970	3.9464
44	76.5389	22.0861	3.9464
45	43.0542	52.0799	3.9464
46	75.5897	88.7076	3.9464
47	74.9194	66.3328	3.9464
48	56.7601	13.3255	3.9464
49	10.7326	2.4910	3.9464
50	20.9401	75.2051	3.9464
51	71.8295	5.8557	3.9464
52	99.8277	8.4995	3.9464
53	67.6795	96.8283	3.9464
54	95.4862	52.7465	3.9464
55	77.3352	0.0095	3.9464
56	23.8316	88.2043	3.9464
57	82.1504	71.4598	3.9464
58	96.9141	16.7463	3.9464
59	84.9479	97.5133	3.9464
60	62.9449	12.9098	3.9464
61	20.6862	21.9667	3.9464
62	72.1063	71.5136	3.9464
63	54.0981	10.2091	3.9464
64	39.2436	59.3441	3.9464
65	59.3606	77.3659	3.9464
66	70.1631	48.5955	3.9464
67	40.9139	82.7298	3.9464
68	86.1930	99.2032	3.9464
69	44.8986	41.3810	3.9464
70	61.4918	51.7088	3.9464
71	57.2413	42.4061	3.9464
72	37.3237	47.1648	3.9464
73	28.8727	55.2137	3.9464
74	84.2511	92.6645	3.9464
75	12.1212	83.5253	3.9464
76	32.7339	86.4767	3.9464
77	61.3321	47.8180	3.9464
78	76.5757	39.1932	3.9464
79	42.3184	87.3475	3.9464
80	60.2356	81.9564	3.9464
81	69.3496	77.5166	3.9464
82	8.3478	79.0334	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	98.9377	68.3223	3.9464
84	91.8252	77.1235	3.9464
85	80.1284	42.2928	3.9464
86	44.6523	7.1683	3.9464
87	49.1001	97.0702	3.9464
88	13.3837	46.0323	3.9464
89	30.7328	57.7810	3.9464
90	59.8276	37.2156	3.9464
91	9.3526	52.2461	3.9464
92	2.3079	97.4497	3.9464
93	43.3124	33.0226	3.9464
94	51.0767	59.9316	3.9464
95	95.9689	41.8080	3.9464
96	47.9977	20.6394	3.9464
97	61.7325	60.2897	3.9464
98	45.1100	59.2193	3.9464
99	53.0851	32.1161	3.9464
100	89.0595	90.2910	3.9464
101	34.8220	51.0418	3.9464
102	58.9807	40.3692	3.9464
103	95.6406	28.6846	3.9464
104	19.0289	48.6519	3.9464
105	30.4635	78.6539	3.9464
106	19.9845	27.4016	3.9464
107	87.8583	88.3340	3.9464
108	72.4200	34.9981	3.9464
109	77.4640	15.6282	3.9464
110	90.1952	89.0370	3.9464
111	1.6920	67.9044	3.9464
112	37.4986	37.9479	3.9464
113	24.1584	82.4956	3.9464
114	54.0177	81.8894	3.9464
115	67.9702	74.9438	3.9464
116	67.6624	58.9604	3.9464
117	38.1230	58.9120	3.9464
118	18.7791	36.0166	3.9464
119	69.8176	1.3068	3.9464
120	46.5921	4.2476	3.9464
121	5.2982	16.1674	3.9464
122	94.8080	43.2514	3.9464
123	59.9265	35.2070	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	26.6212	98.8512	3.9464
125	81.5208	13.6878	3.9464
126	74.4851	34.7013	3.9464
127	82.3362	2.4203	3.9464
128	40.4153	76.3084	3.9464
129	64.1813	8.8859	3.9464
130	28.4719	7.1244	3.9464
131	94.3772	57.5521	3.9464
132	58.6675	14.4559	3.9464
133	66.5081	91.3032	3.9464
134	91.5733	68.7250	3.9464
135	94.8136	7.1370	3.9464
136	71.3065	97.9771	3.9464
137	42.3445	27.2316	3.9464
138	73.9755	66.7195	3.9464
139	48.9905	98.5583	3.9464
140	40.7182	8.4509	3.9464
141	59.2576	30.0921	3.9464
142	77.4727	18.0575	3.9464
143	92.6853	90.3106	3.9464
144	32.2238	93.2863	3.9464
145	83.8356	49.2214	3.9464
146	84.7755	95.2831	3.9464
147	68.7842	11.8632	3.9464
148	84.7108	44.2604	3.9464
149	53.6864	15.1982	3.9464
150	17.1382	10.2546	3.9464
151	0.3310	69.3032	3.9464
152	34.7277	67.4825	3.9464
153	13.0118	10.0758	3.9464
154	0.6110	22.3311	3.9464
155	15.4511	94.4715	3.9464
156	68.0334	62.5790	3.9464
157	39.2178	28.4875	3.9464
158	21.6688	63.7323	3.9464
159	75.1239	56.3550	3.9464
160	67.8084	64.8800	3.9464
161	59.2050	55.7600	3.9464
162	43.9034	88.3872	3.9464
163	29.4659	31.2299	3.9464
164	2.2063	60.7249	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	40.2054	70.4585	3.9464
166	56.1365	83.4511	3.9464
167	71.9668	79.2858	3.9464
168	59.6668	17.1521	3.9464
169	94.0901	9.3589	3.9464
170	32.6364	9.7190	3.9464
171	15.2685	27.3870	3.9464
172	21.1268	22.9892	3.9464
173	12.3430	3.7208	3.9464
174	60.7709	76.3761	3.9464
175	79.6523	4.1446	3.9464
176	35.7766	45.5234	3.9464
177	49.8213	32.0888	3.9464
178	72.2221	99.2555	3.9464
179	84.7303	97.6119	3.9464
180	77.8827	4.1124	3.9464
181	53.2499	71.4317	3.9464
182	16.5338	6.3140	3.9464
183	13.1154	76.2785	3.9464
184	72.3747	95.9811	3.9464
185	75.3053	17.7805	3.9464
186	8.8531	66.0938	3.9464
187	75.9403	77.0935	3.9464
188	31.5835	68.6781	3.9464
189	4.7291	38.2206	3.9464
190	15.8066	40.8770	3.9464
191	74.0184	45.6925	3.9464
192	22.6094	83.2183	3.9464
193	60.8141	45.8650	3.9464
194	48.8252	33.4678	3.9464
195	44.5494	51.8385	3.9464
196	47.8105	52.5088	3.9464
197	25.0904	4.2535	3.9464
198	90.3145	71.6626	3.9464
199	85.8230	42.2536	3.9464
200	45.8847	65.7157	3.9464
201	36.3513	83.6870	3.9464
202	30.8045	50.3614	3.9464
203	49.4347	86.0537	3.9464
204	41.3239	57.0652	3.9464
205	63.1063	74.4484	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	56.6801	15.8457	3.9464
207	36.3460	45.5586	3.9464
208	86.3064	44.0864	3.9464
209	57.8987	27.0669	3.9464
210	61.6925	66.4791	3.9464
211	41.3638	51.8118	3.9464
212	59.6161	30.5374	3.9464
213	35.0570	38.8871	3.9464
214	12.5480	14.2955	3.9464
215	66.0957	55.8768	3.9464
216	55.8945	37.2993	3.9464
217	90.9219	35.3086	3.9464
218	70.3859	48.2898	3.9464
219	74.1862	37.6646	3.9464
220	8.7059	46.6269	3.9464
221	62.1382	61.2182	3.9464
222	27.2520	44.4723	3.9464
223	76.3481	68.0516	3.9464
224	11.1344	51.5807	3.9464
225	65.7573	28.4960	3.9464
226	92.1248	61.7917	3.9464
227	38.0514	44.2529	3.9464
228	46.7183	46.7951	3.9464
229	82.4553	37.9749	3.9464
230	53.1029	58.7135	3.9464
231	30.1798	54.1346	3.9464
232	40.7033	55.5378	3.9464
233	56.7074	20.9848	3.9464
234	27.2796	90.9405	3.9464
235	61.7514	53.5726	3.9464
236	31.7652	39.5927	3.9464
237	69.4258	42.6618	3.9464
238	63.0662	46.0732	3.9464
239	41.6832	67.2999	3.9464
240	30.2641	36.1150	3.9464
241	75.4200	23.3656	3.9464
242	22.7932	31.8095	3.9464
243	24.4446	63.1281	3.9464
244	57.7680	55.4125	3.9464
245	56.7084	61.0847	3.9464
246	19.3226	41.0610	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	74.9758	51.8098	3.9464
248	46.2289	65.5692	3.9464
249	35.6091	81.9958	3.9464
250	75.7060	48.3543	3.9464
251	78.8975	61.3791	3.9464
252	44.5420	62.0002	3.9464
253	32.8006	59.1862	3.9464
254	83.2473	46.4582	3.9464
255	45.0155	41.5840	3.9464
256	62.8697	20.9291	3.9464
257	52.0729	45.6617	3.9464
258	55.9361	51.8971	3.9464
259	28.2160	27.2877	3.9464
260	40.4688	56.3576	3.9464
261	62.1796	60.0916	3.9464
262	63.9561	69.9443	3.9464
263	87.3495	37.1432	3.9464
264	67.0963	78.4071	3.9464
265	63.5648	58.6141	3.9464
266	52.7263	74.9715	3.9464
267	66.2734	16.5814	3.9464
268	50.5204	51.7746	3.9464
269	39.7753	66.1984	3.9464
270	53.5198	31.6109	3.9464
271	33.2761	49.6482	3.9464
272	31.9169	49.6313	3.9464
273	40.5297	53.2312	3.9464
274	38.9665	52.1661	3.9464
275	29.5312	77.7594	3.9464
276	64.2971	80.8087	3.9464
277	60.9642	55.7678	3.9464
278	43.5222	45.0811	3.9464
279	65.0247	48.4739	3.9464
280	58.5988	48.8076	3.9464
281	79.5563	49.1563	3.9464
282	32.5307	9.6036	3.9464
283	64.0451	44.9107	3.9464
284	61.5062	10.2838	3.9464
285	26.5978	58.3008	3.9464
286	17.0957	43.1770	3.9464
287	58.5251	25.3352	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	94.9979	34.8510	3.9464
289	85.3769	55.4160	3.9464
290	49.5023	72.1454	3.9464
291	76.0468	40.8299	3.9464
292	32.2946	34.1886	3.9464
293	53.4297	29.2302	3.9464
294	37.6153	65.2627	3.9464
295	26.5142	33.5758	3.9464
296	19.2930	43.8704	3.9464
297	46.1191	55.3112	3.9464
298	44.8988	67.7847	3.9464
299	67.6691	30.5870	3.9464
300	56.4631	20.9863	3.9464
301	47.3591	48.0710	3.9464
302	45.6168	55.3496	3.9464
303	44.4217	64.7039	3.9464
304	49.0147	34.9475	3.9464
305	47.8029	54.5327	3.9464
306	64.4826	39.6275	3.9464
307	22.4677	76.0271	3.9464
308	18.3822	65.7727	3.9464
309	30.6886	60.6373	3.9464
310	21.4066	50.2747	3.9464
311	28.2316	43.8665	3.9464
312	51.3323	47.3944	3.9464
313	39.4302	70.4283	3.9464
314	51.8225	53.8510	3.9464
315	58.9625	15.5492	3.9464
316	54.0993	51.1211	3.9464
317	68.0484	58.4864	3.9464
318	26.5492	47.5983	3.9464
319	42.1145	60.8719	3.9464
320	43.1088	48.2723	3.9464
321	37.0745	51.1465	3.9464
322	53.6353	62.5864	3.9464
323	49.0937	40.0849	3.9464
324	66.6863	83.4025	3.9464
325	56.7604	48.0907	3.9464
326	75.0516	36.4713	3.9464
327	34.2418	45.0413	3.9464
328	10.7151	57.1828	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	54.7913	22.7911	3.9464
330	42.8852	65.0999	3.9464
331	43.7645	63.1864	3.9464
332	36.8297	55.6905	3.9464
333	51.4644	46.2734	3.9464
334	56.4549	49.1402	3.9464
335	22.8912	56.1225	3.9464
336	52.7031	49.5684	3.9464
337	52.9024	64.8021	3.9464
338	19.4145	76.0326	3.9464
339	60.3132	36.9078	3.9464
340	85.7270	46.8848	3.9464
341	43.4796	52.4779	3.9464
342	29.2116	52.6250	3.9464
343	77.2673	35.3236	3.9464
344	20.9892	20.7572	3.9464
345	41.8965	53.7976	3.9464
346	21.0091	68.3516	3.9464
347	13.9285	83.1657	3.9464
348	50.0755	49.5260	3.9464
349	56.1453	18.9705	3.9464
350	56.1848	25.5187	3.9464
351	74.7548	56.6636	3.9464
352	50.9611	51.5263	3.9464
353	20.9956	24.2822	3.9464
354	70.2027	51.2646	3.9464
355	64.8811	21.1972	3.9464
356	48.8014	47.1117	3.9464
357	25.4986	33.4547	3.9464
358	53.3194	62.8710	3.9464
359	12.5031	65.2026	3.9464
360	43.2425	40.8624	3.9464
361	55.4605	43.2139	3.9464
362	56.2811	43.4068	3.9464
363	44.4130	51.8214	3.9464
364	51.7318	54.0640	3.9464
365	39.4736	37.6722	3.9464
366	59.0369	52.1624	3.9464
367	62.4817	64.7784	3.9464
368	33.9891	25.3104	3.9464
369	82.1660	45.3840	3.9464

Continued on next page

Table D.11 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	11.4589	55.4068	3.9464
371	52.7275	27.0565	3.9464
372	17.2193	51.7951	3.9464
373	31.6019	76.5275	3.9464
374	42.8060	50.9693	3.9464
375	64.6270	39.5987	3.9464
376	41.7658	57.6063	3.9464
377	8.9679	51.4227	3.9464
378	50.0329	71.6923	3.9464
379	40.7628	47.3901	3.9464
380	43.2503	8.7931	3.9464
381	54.1254	38.6935	3.9464
382	65.7892	19.5599	3.9464
383	50.3420	58.1772	3.9464
384	27.2689	42.1855	3.9464
385	74.7580	68.7651	3.9464
386	31.2464	46.9846	3.9464
387	42.3891	68.3790	3.9464
388	63.2317	61.3780	3.9464
389	65.7214	76.7065	3.9464
390	75.3204	66.3381	3.9464
391	83.9818	43.9587	3.9464
392	55.2899	75.9977	3.9464
393	36.0198	39.3899	3.9464
394	37.4906	38.7355	3.9464
395	49.4834	26.9493	3.9464
396	29.2380	80.0224	3.9464
397	55.2621	52.9866	3.9464
398	77.7363	41.2571	3.9464
399	14.2590	13.4288	3.9464
400	30.8960	84.8684	3.9464
Depot	0.0000	0.0000	N.A.

Table D.12: CETSP instance team5_499rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	10.5260	3.7790	20.8200
2	8.4009	11.7989	20.8200
3	11.3126	12.1774	20.8200
4	9.2095	19.5087	20.8200
5	9.7281	5.4172	20.8200
6	11.1690	1.5527	20.8200
7	19.7672	14.9362	20.8200
8	2.2625	16.1551	20.8200
9	11.8636	12.6991	20.8200
10	13.2666	12.9678	20.8200
11	5.0355	11.9367	20.8200
12	8.6382	10.3371	20.8200
13	14.5843	15.7568	20.8200
14	3.5607	15.7968	20.8200
15	15.4200	17.0914	20.8200
16	17.8934	15.1905	20.8200
17	1.2192	5.9144	20.8200
18	15.5961	8.5134	20.8200
19	2.4773	0.0520	20.8200
20	16.5052	19.9903	20.8200
21	4.0240	17.3232	20.8200
22	13.8628	4.3052	20.8200
23	1.7290	2.5191	20.8200
24	4.8686	17.5054	20.8200
25	18.8587	8.5087	20.8200
26	9.9074	11.0867	20.8200
27	8.0267	2.1019	20.8200
28	8.6500	19.7295	20.8200
29	13.9396	19.5452	20.8200
30	4.0211	5.0495	20.8200
31	5.3173	19.9696	20.8200
32	4.1301	7.1548	20.8200
33	9.4253	3.1222	20.8200
34	18.0470	6.7045	20.8200
35	19.0819	14.2893	20.8200
36	19.3111	17.5672	20.8200
37	14.7151	17.4542	20.8200
38	16.6256	12.3206	20.8200
39	18.6523	3.9117	20.8200
40	16.2452	9.3220	20.8200
41	15.7685	10.3669	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	4.2430	12.8676	20.8200
43	15.4595	7.4752	20.8200
44	18.2952	1.0836	20.8200
45	2.6723	10.4123	20.8200
46	1.5116	19.0597	20.8200
47	1.2522	5.4022	20.8200
48	0.7828	19.7397	20.8200
49	14.7479	11.7757	20.8200
50	19.5822	17.4941	20.8200
51	13.7484	0.7577	20.8200
52	9.9632	1.8111	20.8200
53	13.2084	1.5682	20.8200
54	2.7850	16.9995	20.8200
55	10.3100	1.5005	20.8200
56	3.6086	13.0876	20.8200
57	15.3812	8.8682	20.8200
58	0.4211	5.2548	20.8200
59	16.1355	6.6685	20.8200
60	18.0288	10.2093	20.8200
61	5.4781	9.3534	20.8200
62	11.5459	0.8736	20.8200
63	10.6256	1.7583	20.8200
64	12.9432	8.6486	20.8200
65	12.2950	19.9912	20.8200
66	2.3396	12.8751	20.8200
67	12.5256	4.7007	20.8200
68	12.3192	17.7013	20.8200
69	2.8757	1.3778	20.8200
70	3.7626	17.1174	20.8200
71	5.2006	6.8919	20.8200
72	3.9756	4.3104	20.8200
73	2.7247	6.6491	20.8200
74	8.8668	5.4121	20.8200
75	6.6930	16.2603	20.8200
76	3.8933	3.6617	20.8200
77	2.4532	11.1564	20.8200
78	3.9473	4.1638	20.8200
79	8.0980	10.1576	20.8200
80	15.3264	12.7877	20.8200
81	17.3372	11.1211	20.8200
82	15.9493	16.7531	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	11.5168	3.2870	20.8200
84	5.4981	6.1028	20.8200
85	1.4037	6.1535	20.8200
86	9.0075	17.4052	20.8200
87	8.9599	2.5066	20.8200
88	5.6082	3.0104	20.8200
89	12.8565	9.4609	20.8200
90	4.7530	19.8404	20.8200
91	5.6246	7.2770	20.8200
92	14.8098	1.8409	20.8200
93	10.2894	7.4847	20.8200
94	12.6858	19.6571	20.8200
95	12.1595	5.1953	20.8200
96	2.5621	10.2967	20.8200
97	19.0824	1.0940	20.8200
98	1.2646	1.8964	20.8200
99	2.4914	14.4710	20.8200
100	45.5527	26.8832	20.8200
101	49.5874	32.9921	20.8200
102	20.8210	23.0825	20.8200
103	32.0319	48.7602	20.8200
104	31.0932	49.2942	20.8200
105	28.4876	46.0461	20.8200
106	44.3864	36.3116	20.8200
107	38.8284	23.4703	20.8200
108	25.1657	24.0751	20.8200
109	40.4113	32.0356	20.8200
110	20.1897	48.2132	20.8200
111	32.1965	21.5710	20.8200
112	43.5486	39.6053	20.8200
113	27.0476	34.4285	20.8200
114	24.2607	34.0424	20.8200
115	47.2249	31.4694	20.8200
116	24.5672	24.4137	20.8200
117	47.2998	37.9687	20.8200
118	30.1704	30.5441	20.8200
119	27.0718	22.4926	20.8200
120	32.0569	46.2162	20.8200
121	20.1974	25.6106	20.8200
122	23.8984	35.8981	20.8200
123	24.5323	49.8988	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	29.0027	23.8765	20.8200
125	35.1494	28.8106	20.8200
126	37.8149	25.8690	20.8200
127	22.5985	27.2784	20.8200
128	32.7117	42.3778	20.8200
129	30.9136	43.9894	20.8200
130	41.7938	26.8087	20.8200
131	23.4201	21.9457	20.8200
132	37.7223	44.0563	20.8200
133	33.6715	23.2449	20.8200
134	33.7228	34.6090	20.8200
135	44.5785	34.1629	20.8200
136	25.9644	23.2030	20.8200
137	27.7157	24.2487	20.8200
138	45.8348	38.3992	20.8200
139	44.6412	21.1681	20.8200
140	45.8095	43.1051	20.8200
141	36.3020	43.7274	20.8200
142	44.7377	48.2657	20.8200
143	20.5677	31.0115	20.8200
144	20.4824	37.2243	20.8200
145	42.0622	41.0674	20.8200
146	47.3120	20.1150	20.8200
147	36.9556	37.1182	20.8200
148	24.4655	29.9184	20.8200
149	30.3241	25.8121	20.8200
150	29.6006	20.2054	20.8200
151	23.4789	26.9268	20.8200
152	48.0614	30.3792	20.8200
153	49.2796	22.4102	20.8200
154	22.8416	32.9746	20.8200
155	47.7847	28.4345	20.8200
156	22.4944	48.7727	20.8200
157	48.8851	33.6728	20.8200
158	33.9160	28.6484	20.8200
159	48.2875	25.5427	20.8200
160	31.0534	27.3935	20.8200
161	35.5448	24.2684	20.8200
162	26.5855	26.5008	20.8200
163	43.0635	31.4686	20.8200
164	30.4469	21.4825	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	33.3877	38.8388	20.8200
166	20.8616	31.8567	20.8200
167	20.9805	20.9752	20.8200
168	30.5550	31.3009	20.8200
169	41.9344	32.8635	20.8200
170	32.6566	40.0511	20.8200
171	38.1953	36.0490	20.8200
172	37.4163	24.6203	20.8200
173	29.5705	36.6700	20.8200
174	23.5397	47.0618	20.8200
175	44.7486	39.7162	20.8200
176	42.5333	36.3249	20.8200
177	28.8128	30.4765	20.8200
178	25.2216	48.8368	20.8200
179	32.6554	40.5505	20.8200
180	45.8434	28.1097	20.8200
181	21.3330	28.4534	20.8200
182	23.8226	36.8408	20.8200
183	41.3150	20.0800	20.8200
184	21.8127	22.4456	20.8200
185	37.6461	42.0792	20.8200
186	47.0840	47.7144	20.8200
187	22.2385	33.2025	20.8200
188	36.1356	35.5262	20.8200
189	49.7446	26.3767	20.8200
190	35.3466	47.2689	20.8200
191	28.3920	21.3903	20.8200
192	37.9243	23.9119	20.8200
193	41.4412	38.9568	20.8200
194	26.8183	32.6012	20.8200
195	22.5313	48.1754	20.8200
196	47.3754	37.9401	20.8200
197	22.0871	33.2260	20.8200
198	23.1185	40.5549	20.8200
199	29.0396	36.1372	20.8200
200	73.1002	79.4037	20.8200
201	84.7887	79.7551	20.8200
202	81.7913	86.2239	20.8200
203	73.6863	74.2382	20.8200
204	75.4182	80.1750	20.8200
205	74.9451	88.4605	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	78.0272	82.0721	20.8200
207	89.7033	80.1502	20.8200
208	81.6179	74.1421	20.8200
209	74.3211	82.1244	20.8200
210	89.2994	73.1482	20.8200
211	78.4966	80.8407	20.8200
212	77.1908	76.3248	20.8200
213	70.0787	86.0551	20.8200
214	87.8356	87.4643	20.8200
215	89.6546	85.2790	20.8200
216	87.2864	89.2526	20.8200
217	76.9521	88.5890	20.8200
218	75.5773	80.7384	20.8200
219	85.3838	89.3565	20.8200
220	82.4808	71.6064	20.8200
221	70.5598	83.7819	20.8200
222	87.4850	79.3312	20.8200
223	85.2200	71.0885	20.8200
224	70.8021	79.2974	20.8200
225	72.5273	88.3137	20.8200
226	79.7775	80.2960	20.8200
227	77.3640	70.7565	20.8200
228	70.8501	86.3243	20.8200
229	79.4150	85.2350	20.8200
230	84.4928	76.9707	20.8200
231	83.5177	79.6473	20.8200
232	88.5666	89.9178	20.8200
233	85.7193	87.9646	20.8200
234	73.5126	71.3248	20.8200
235	88.3919	89.4210	20.8200
236	82.7904	89.3622	20.8200
237	85.5265	86.4226	20.8200
238	72.3356	86.1550	20.8200
239	80.7173	88.9602	20.8200
240	84.8025	72.2361	20.8200
241	78.8402	71.1237	20.8200
242	81.0772	83.8409	20.8200
243	77.9819	77.7483	20.8200
244	73.6161	81.1388	20.8200
245	89.4354	80.1567	20.8200
246	83.3441	85.5151	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	75.6074	70.2776	20.8200
248	77.1151	89.3423	20.8200
249	78.4301	80.0876	20.8200
250	80.2922	75.8098	20.8200
251	87.5661	81.6563	20.8200
252	79.6279	80.9538	20.8200
253	77.4087	74.0915	20.8200
254	75.9291	73.9471	20.8200
255	71.0504	85.2637	20.8200
256	76.8895	78.6378	20.8200
257	79.7296	78.3022	20.8200
258	79.3747	83.7664	20.8200
259	76.1087	74.9228	20.8200
260	79.3483	75.3688	20.8200
261	85.8335	84.6274	20.8200
262	76.3867	80.9989	20.8200
263	72.6803	81.9225	20.8200
264	76.1847	74.2911	20.8200
265	87.8874	83.7559	20.8200
266	85.5459	86.1581	20.8200
267	89.4099	75.3847	20.8200
268	77.4302	82.5606	20.8200
269	82.7718	81.5009	20.8200
270	87.3140	87.2617	20.8200
271	85.4655	89.4614	20.8200
272	82.0065	75.6791	20.8200
273	82.7574	74.2926	20.8200
274	84.1657	89.6201	20.8200
275	70.0314	77.1275	20.8200
276	83.0689	84.7397	20.8200
277	84.0326	80.9470	20.8200
278	78.9268	79.6337	20.8200
279	80.5183	71.0301	20.8200
280	71.0080	83.9726	20.8200
281	75.2812	79.5319	20.8200
282	73.5352	77.8165	20.8200
283	87.0156	79.9660	20.8200
284	73.8575	87.6690	20.8200
285	79.9937	73.4457	20.8200
286	80.0260	88.4312	20.8200
287	76.4126	75.5480	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	85.8774	87.3240	20.8200
289	89.0638	74.5581	20.8200
290	84.6626	79.7388	20.8200
291	71.4242	75.4202	20.8200
292	79.4655	74.4467	20.8200
293	76.7822	82.9894	20.8200
294	85.6153	86.7737	20.8200
295	86.8222	80.0693	20.8200
296	80.1131	82.5047	20.8200
297	89.3790	76.0987	20.8200
298	81.9035	87.9149	20.8200
299	88.9513	72.6403	20.8200
300	92.5909	80.0433	20.8200
301	86.7862	83.7110	20.8200
302	83.1514	91.3190	20.8200
303	87.6085	88.0524	20.8200
304	92.7639	86.5161	20.8200
305	94.6937	81.2040	20.8200
306	99.1691	80.9928	20.8200
307	94.4375	89.8165	20.8200
308	83.6163	95.4960	20.8200
309	83.3685	88.3604	20.8200
310	92.0809	99.3222	20.8200
311	95.3031	91.4204	20.8200
312	99.0472	85.7396	20.8200
313	95.4796	96.1290	20.8200
314	87.1273	84.0324	20.8200
315	81.0134	86.4250	20.8200
316	97.0785	86.7219	20.8200
317	90.2560	83.0105	20.8200
318	98.1513	96.3450	20.8200
319	86.8895	84.3247	20.8200
320	82.0258	98.9707	20.8200
321	89.0000	83.7031	20.8200
322	80.4141	88.4668	20.8200
323	88.3602	93.5594	20.8200
324	95.9324	92.1458	20.8200
325	80.5965	92.0964	20.8200
326	91.4519	94.5103	20.8200
327	94.4683	90.0421	20.8200
328	92.8113	98.2407	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	88.7272	81.0174	20.8200
330	89.9310	94.5372	20.8200
331	89.3359	93.6392	20.8200
332	85.1326	93.3031	20.8200
333	84.3334	97.0716	20.8200
334	83.3686	96.8014	20.8200
335	96.0605	94.4950	20.8200
336	93.3103	99.0843	20.8200
337	99.7949	88.8243	20.8200
338	84.0572	98.2927	20.8200
339	86.9940	98.1050	20.8200
340	91.1620	99.9650	20.8200
341	88.1669	82.2879	20.8200
342	85.9222	83.4369	20.8200
343	90.7381	99.8897	20.8200
344	89.9830	98.6224	20.8200
345	94.5090	92.4532	20.8200
346	83.9295	97.9734	20.8200
347	84.3608	92.1480	20.8200
348	87.8518	83.2273	20.8200
349	99.2920	98.0492	20.8200
350	96.6710	90.7145	20.8200
351	87.7484	83.7546	20.8200
352	86.0867	81.5330	20.8200
353	82.5335	87.3296	20.8200
354	80.7551	80.6861	20.8200
355	96.5452	93.1720	20.8200
356	88.3323	91.5035	20.8200
357	89.0976	96.4455	20.8200
358	82.1226	91.9552	20.8200
359	88.1760	88.8141	20.8200
360	89.6970	88.1654	20.8200
361	89.5983	91.5249	20.8200
362	80.3025	81.1115	20.8200
363	92.0930	98.3621	20.8200
364	97.9735	93.9042	20.8200
365	94.7529	81.9671	20.8200
366	84.7929	84.8117	20.8200
367	87.3294	86.7915	20.8200
368	81.9044	86.7930	20.8200
369	83.1803	86.2205	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	89.9071	81.4441	20.8200
371	90.3741	83.7882	20.8200
372	84.4799	87.8799	20.8200
373	93.0738	84.8753	20.8200
374	96.6476	96.9796	20.8200
375	90.1019	83.4860	20.8200
376	90.6972	96.9626	20.8200
377	96.6676	92.6743	20.8200
378	88.0059	90.7740	20.8200
379	94.2258	98.7848	20.8200
380	97.4362	85.8361	20.8200
381	81.2522	99.2612	20.8200
382	92.1839	88.8237	20.8200
383	94.7976	88.4491	20.8200
384	93.4254	97.8126	20.8200
385	80.2014	81.5949	20.8200
386	97.0965	81.0307	20.8200
387	88.2817	96.3510	20.8200
388	98.6006	82.3388	20.8200
389	99.7041	87.1751	20.8200
390	84.2824	83.9445	20.8200
391	96.8090	92.5136	20.8200
392	93.2550	98.1789	20.8200
393	96.8293	85.3988	20.8200
394	84.7850	93.3953	20.8200
395	84.5701	92.5098	20.8200
396	96.1791	97.5552	20.8200
397	86.6750	81.8002	20.8200
398	94.8083	91.5304	20.8200
399	85.8291	89.3215	20.8200
400	1.5647	88.8122	20.8200
401	1.8225	87.7760	20.8200
402	16.0720	81.5553	20.8200
403	19.5543	89.8549	20.8200
404	2.0599	86.0050	20.8200
405	9.9966	85.8576	20.8200
406	13.6279	83.3943	20.8200
407	13.8296	81.5783	20.8200
408	0.7751	88.6342	20.8200
409	4.4842	86.5445	20.8200
410	13.6170	84.1913	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
411	16.4864	81.6235	20.8200
412	17.8246	84.0918	20.8200
413	11.8372	87.4011	20.8200
414	1.1933	81.8445	20.8200
415	16.2773	81.3093	20.8200
416	6.7503	86.8120	20.8200
417	1.9830	86.3665	20.8200
418	5.0910	83.7862	20.8200
419	2.6250	81.2761	20.8200
420	19.4915	88.9148	20.8200
421	15.9151	82.9337	20.8200
422	2.6960	85.7661	20.8200
423	0.0290	82.9455	20.8200
424	17.8311	84.5721	20.8200
425	17.0206	82.7787	20.8200
426	14.2245	83.0966	20.8200
427	0.2473	82.0871	20.8200
428	11.6247	87.7046	20.8200
429	5.1015	81.8103	20.8200
430	10.6041	85.0219	20.8200
431	8.8756	85.3213	20.8200
432	15.4215	81.5375	20.8200
433	9.5220	88.7288	20.8200
434	18.7876	82.3448	20.8200
435	13.2856	89.4879	20.8200
436	19.7188	83.0222	20.8200
437	14.2132	82.4414	20.8200
438	7.6764	88.6806	20.8200
439	17.1642	87.7833	20.8200
440	17.0519	88.8308	20.8200
441	12.6448	83.0865	20.8200
442	6.0677	84.3942	20.8200
443	3.3964	83.4982	20.8200
444	16.8870	83.4344	20.8200
445	9.2565	85.6186	20.8200
446	5.1953	87.1361	20.8200
447	2.5389	82.9669	20.8200
448	5.3870	87.7604	20.8200
449	7.4797	86.7529	20.8200
450	94.4757	9.4701	20.8200
451	29.7505	96.6210	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
452	17.7167	97.5636	20.8200
453	1.0919	90.7016	20.8200
454	25.0595	61.5431	20.8200
455	97.0848	81.6578	20.8200
456	78.1743	38.6355	20.8200
457	22.1476	14.8515	20.8200
458	28.6149	8.2266	20.8200
459	73.6361	68.0431	20.8200
460	84.5964	57.5663	20.8200
461	73.1545	60.0435	20.8200
462	84.9979	3.9891	20.8200
463	27.0169	46.6583	20.8200
464	26.3736	85.6358	20.8200
465	91.1956	46.5873	20.8200
466	59.4827	70.1321	20.8200
467	28.4031	32.2444	20.8200
468	52.9148	12.3625	20.8200
469	97.6128	23.6668	20.8200
470	7.7403	89.8119	20.8200
471	39.3354	89.6580	20.8200
472	92.0943	24.6880	20.8200
473	93.0930	71.3467	20.8200
474	30.7692	16.7931	20.8200
475	64.9540	37.3090	20.8200
476	47.0351	69.5204	20.8200
477	84.8772	45.0654	20.8200
478	4.1027	5.9391	20.8200
479	44.1821	62.8241	20.8200
480	73.9225	9.6395	20.8200
481	44.9743	74.4953	20.8200
482	43.1416	9.2079	20.8200
483	25.8602	58.6207	20.8200
484	72.5026	72.4828	20.8200
485	49.5234	55.0957	20.8200
486	54.1532	48.4548	20.8200
487	99.2739	52.0431	20.8200
488	57.0413	9.9678	20.8200
489	92.9329	22.8145	20.8200
490	84.7658	77.8153	20.8200
491	63.7544	71.2264	20.8200
492	19.3715	86.9483	20.8200

Continued on next page

Table D.12 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
493	80.2520	96.9762	20.8200
494	88.2673	94.5543	20.8200
495	27.2789	43.4795	20.8200
496	77.6803	63.0066	20.8200
497	23.9463	67.9458	20.8200
498	49.2766	27.3707	20.8200
499	10.8331	85.8288	20.8200
Depot	70.0000	40.0000	N.A.

Table D.13: CETSP instance team6_500rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	9.8270	6.8843	6.8651
2	2.4254	44.8523	6.8651
3	53.0251	68.7919	6.8651
4	0.2763	64.7360	6.8651
5	4.9443	50.7874	6.8651
6	20.5127	86.7994	6.8651
7	58.4293	38.9397	6.8651
8	53.3341	54.2742	6.8651
9	57.0337	24.3926	6.8651
10	41.2500	12.6932	6.8651
11	30.2787	8.2280	6.8651
12	46.3730	74.0499	6.8651
13	21.4284	90.1196	6.8651
14	55.0654	81.2340	6.8651
15	25.6409	32.9850	6.8651
16	47.9098	77.7960	6.8651
17	37.4598	44.2188	6.8651
18	23.2467	53.1537	6.8651
19	3.9184	46.6239	6.8651
20	56.0822	62.8731	6.8651
21	57.4377	71.1536	6.8651
22	15.5277	59.9412	6.8651
23	26.8042	95.3391	6.8651
24	7.3492	35.5012	6.8651
25	3.4981	86.0326	6.8651
26	79.8029	56.0883	6.8651
27	72.2470	39.7077	6.8651
28	9.2264	90.0125	6.8651
29	9.4077	50.7341	6.8651
30	2.4096	76.5677	6.8651
31	29.6717	65.8678	6.8651
32	16.1988	59.3188	6.8651
33	1.4411	27.5670	6.8651
34	43.8196	68.1614	6.8651
35	72.0758	18.0334	6.8651
36	20.1950	67.6818	6.8651
37	40.5650	30.2351	6.8651
38	64.1034	11.1965	6.8651
39	46.8229	71.8444	6.8651
40	74.2228	38.6100	6.8651
41	75.8802	29.7113	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	2.7334	77.6754	6.8651
43	37.6481	47.8813	6.8651
44	50.8239	67.1806	6.8651
45	74.4568	73.8914	6.8651
46	38.4714	30.1542	6.8651
47	16.5565	18.5576	6.8651
48	75.0689	72.4744	6.8651
49	48.3602	34.0465	6.8651
50	33.7089	9.9712	6.8651
51	46.0567	72.0198	6.8651
52	45.8973	89.1189	6.8651
53	33.8270	93.4853	6.8651
54	36.9546	32.1019	6.8651
55	51.6263	32.9510	6.8651
56	77.3467	92.4222	6.8651
57	51.5218	39.5765	6.8651
58	4.5207	34.7763	6.8651
59	31.6461	7.3586	6.8651
60	54.2236	56.2655	6.8651
61	55.5353	38.1752	6.8651
62	23.3331	67.4298	6.8651
63	23.1077	77.6166	6.8651
64	76.8304	30.6899	6.8651
65	34.6178	91.6565	6.8651
66	77.1266	88.6843	6.8651
67	23.2602	19.1726	6.8651
68	69.2934	49.5143	6.8651
69	39.4220	48.1564	6.8651
70	70.9135	14.8762	6.8651
71	57.0800	64.0173	6.8651
72	28.9098	26.1469	6.8651
73	75.0360	91.1497	6.8651
74	38.2308	97.9754	6.8651
75	77.6410	49.4044	6.8651
76	6.8207	39.0714	6.8651
77	15.6672	41.9038	6.8651
78	48.6879	60.2173	6.8651
79	61.4066	99.6333	6.8651
80	64.1367	44.5156	6.8651
81	63.6802	81.8267	6.8651
82	44.2724	24.1530	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	57.9600	34.4090	6.8651
84	78.4066	56.8223	6.8651
85	63.7722	68.1837	6.8651
86	1.1893	3.3623	6.8651
87	70.2766	21.7580	6.8651
88	71.3344	25.5496	6.8651
89	31.6419	23.7354	6.8651
90	41.5242	2.2495	6.8651
91	11.0263	80.6461	6.8651
92	33.1471	60.1559	6.8651
93	50.7479	74.0551	6.8651
94	36.1244	41.0243	6.8651
95	14.9649	8.2570	6.8651
96	39.6569	80.0064	6.8651
97	70.4834	96.1071	6.8651
98	62.5782	94.8346	6.8651
99	2.7731	90.8552	6.8651
100	4.0095	79.3775	6.8651
101	10.0346	20.0551	6.8651
102	24.2845	53.5119	6.8651
103	13.6478	21.6503	6.8651
104	5.6520	82.6769	6.8651
105	58.3586	20.3359	6.8651
106	4.4183	14.4468	6.8651
107	13.5199	39.2703	6.8651
108	9.1420	20.9819	6.8651
109	0.9336	72.1660	6.8651
110	2.2886	93.0946	6.8651
111	78.3682	28.4149	6.8651
112	5.9393	95.2324	6.8651
113	70.7490	60.5658	6.8651
114	11.1949	32.5348	6.8651
115	22.9057	97.6297	6.8651
116	44.6442	33.1240	6.8651
117	6.1458	57.4553	6.8651
118	20.6501	50.1791	6.8651
119	40.3911	90.9327	6.8651
120	68.9038	16.8105	6.8651
121	57.8812	36.8910	6.8651
122	78.4107	73.5258	6.8651
123	39.0652	2.4238	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	64.3381	93.7227	6.8651
125	62.3574	96.1600	6.8651
126	38.9702	21.3779	6.8651
127	38.9618	51.3998	6.8651
128	73.6484	37.1698	6.8651
129	45.1706	33.2151	6.8651
130	49.7031	90.8228	6.8651
131	39.7157	22.5518	6.8651
132	43.0003	59.9693	6.8651
133	32.0337	81.0046	6.8651
134	55.2537	1.3429	6.8651
135	40.9380	91.8871	6.8651
136	25.1363	82.5967	6.8651
137	44.7688	34.8472	6.8651
138	76.9821	94.8107	6.8651
139	79.9522	98.0359	6.8651
140	57.8284	65.6998	6.8651
141	20.1050	16.8211	6.8651
142	17.0586	58.0717	6.8651
143	38.9768	28.6596	6.8651
144	30.5118	74.0434	6.8651
145	2.1730	46.8604	6.8651
146	56.9850	36.3051	6.8651
147	39.5709	52.0192	6.8651
148	64.9777	99.8573	6.8651
149	52.3761	17.3067	6.8651
150	64.0122	92.7907	6.8651
151	73.9903	3.2091	6.8651
152	45.3946	79.9114	6.8651
153	7.7653	6.1676	6.8651
154	47.2237	11.5266	6.8651
155	56.5515	98.5201	6.8651
156	62.0390	27.7697	6.8651
157	64.4755	95.6952	6.8651
158	13.0553	35.1491	6.8651
159	26.7897	74.3958	6.8651
160	65.8846	36.2104	6.8651
161	17.9199	62.5969	6.8651
162	31.9711	13.1659	6.8651
163	69.6306	57.4600	6.8651
164	6.0949	74.0865	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	4.9451	53.7480	6.8651
166	45.3796	10.2394	6.8651
167	11.2137	2.0282	6.8651
168	58.9987	45.7674	6.8651
169	66.3729	97.9005	6.8651
170	3.7969	1.0311	6.8651
171	72.4289	91.8837	6.8651
172	3.9505	53.4738	6.8651
173	33.7700	15.2532	6.8651
174	65.5339	33.2996	6.8651
175	79.9571	14.1068	6.8651
176	62.1997	26.9323	6.8651
177	51.8847	57.7017	6.8651
178	12.2845	12.8434	6.8651
179	64.4880	60.4855	6.8651
180	68.3856	35.3493	6.8651
181	25.7941	5.0229	6.8651
182	78.2121	82.5216	6.8651
183	9.6122	63.4754	6.8651
184	10.2957	4.6843	6.8651
185	33.6743	16.0148	6.8651
186	61.6782	59.4733	6.8651
187	15.8202	13.1438	6.8651
188	0.0138	97.6201	6.8651
189	2.2794	46.9159	6.8651
190	16.0956	47.1990	6.8651
191	31.0050	87.5127	6.8651
192	65.7365	88.9695	6.8651
193	67.7946	81.6778	6.8651
194	33.8398	32.0377	6.8651
195	6.7702	28.6398	6.8651
196	51.7497	79.9145	6.8651
197	29.1113	69.2428	6.8651
198	8.4509	92.4898	6.8651
199	24.4888	25.3300	6.8651
200	68.5238	98.3882	6.8651
201	15.7168	72.1076	6.8651
202	3.2029	51.0422	6.8651
203	67.4655	12.1137	6.8651
204	41.3355	82.7797	6.8651
205	63.3054	48.8331	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	17.2034	24.1028	6.8651
207	9.5622	88.5032	6.8651
208	22.4747	48.1041	6.8651
209	16.9544	52.9271	6.8651
210	20.3908	60.0437	6.8651
211	45.4130	71.2677	6.8651
212	53.5581	47.7414	6.8651
213	37.7594	72.4638	6.8651
214	67.7687	50.9424	6.8651
215	2.2118	78.3384	6.8651
216	37.6570	81.9317	6.8651
217	5.3361	49.6057	6.8651
218	72.3203	3.8463	6.8651
219	27.0999	87.1794	6.8651
220	73.9542	35.1681	6.8651
221	58.1838	68.9986	6.8651
222	23.0786	38.1228	6.8651
223	20.3278	46.5707	6.8651
224	61.0867	94.7583	6.8651
225	51.3584	31.1839	6.8651
226	45.3765	76.9955	6.8651
227	25.3534	42.3963	6.8651
228	70.8086	11.5810	6.8651
229	32.3710	53.6854	6.8651
230	70.2908	10.4186	6.8651
231	71.2869	13.7572	6.8651
232	51.2079	35.5792	6.8651
233	12.7058	46.3942	6.8651
234	72.4567	79.8069	6.8651
235	77.5185	26.3493	6.8651
236	37.1302	34.1671	6.8651
237	20.4275	84.2678	6.8651
238	75.4923	99.8090	6.8651
239	68.4103	6.9404	6.8651
240	2.3000	55.3764	6.8651
241	30.6527	22.7083	6.8651
242	13.1892	88.2939	6.8651
243	72.9487	9.0752	6.8651
244	0.7950	63.4583	6.8651
245	3.1063	26.7804	6.8651
246	21.2206	30.6756	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	43.3710	79.9296	6.8651
248	59.1397	81.6064	6.8651
249	60.5483	13.7851	6.8651
250	40.8800	90.9920	6.8651
251	38.0621	81.3957	6.8651
252	74.3686	61.1798	6.8651
253	3.2443	74.1559	6.8651
254	79.1559	54.6404	6.8651
255	2.8109	93.7321	6.8651
256	49.4510	19.2329	6.8651
257	45.0927	13.5451	6.8651
258	34.7674	23.4201	6.8651
259	5.5712	90.2338	6.8651
260	53.1447	48.4278	6.8651
261	2.4228	13.8762	6.8651
262	14.6393	26.7492	6.8651
263	66.5762	96.7049	6.8651
264	41.3951	34.6025	6.8651
265	65.5436	56.9924	6.8651
266	54.8329	43.6672	6.8651
267	19.7736	66.4248	6.8651
268	13.4476	91.4294	6.8651
269	55.1301	40.0588	6.8651
270	69.1127	61.5738	6.8651
271	24.4057	14.8195	6.8651
272	66.8428	74.9419	6.8651
273	16.5956	19.4929	6.8651
274	54.1004	16.0525	6.8651
275	6.9414	77.9429	6.8651
276	16.6662	74.8364	6.8651
277	43.0965	49.2871	6.8651
278	31.5096	51.0685	6.8651
279	75.4040	79.0607	6.8651
280	6.5131	96.1439	6.8651
281	49.7681	46.8278	6.8651
282	27.9226	21.7643	6.8651
283	48.2550	40.2376	6.8651
284	71.8743	17.8343	6.8651
285	28.2512	43.1797	6.8651
286	44.8729	51.9811	6.8651
287	47.6524	52.2250	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	78.2443	33.2915	6.8651
289	63.2522	99.6147	6.8651
290	73.6394	37.6931	6.8651
291	2.2068	85.9728	6.8651
292	15.1928	63.8864	6.8651
293	49.3213	48.3120	6.8651
294	54.9749	31.6899	6.8651
295	14.7546	14.6103	6.8651
296	66.7265	28.6242	6.8651
297	4.0390	87.3303	6.8651
298	4.8022	64.3438	6.8651
299	37.4895	92.2139	6.8651
300	6.4322	5.6038	6.8651
301	18.0420	31.0088	6.8651
302	2.5747	43.4684	6.8651
303	48.3895	84.8379	6.8651
304	34.2378	1.7695	6.8651
305	63.7966	99.8650	6.8651
306	30.1525	91.7060	6.8651
307	19.6070	87.5156	6.8651
308	20.7475	95.7593	6.8651
309	18.5593	70.8498	6.8651
310	68.0410	93.0677	6.8651
311	26.1535	60.2417	6.8651
312	28.9981	9.3107	6.8651
313	42.9598	72.0705	6.8651
314	44.2907	51.8898	6.8651
315	19.9583	6.5164	6.8651
316	16.4820	98.2716	6.8651
317	77.1619	52.0527	6.8651
318	66.0988	58.3516	6.8651
319	68.5427	70.6500	6.8651
320	8.7489	58.9073	6.8651
321	43.6827	74.1879	6.8651
322	56.9482	35.7189	6.8651
323	17.6447	95.7025	6.8651
324	67.3901	74.1747	6.8651
325	6.2197	67.2192	6.8651
326	20.4304	56.6156	6.8651
327	36.6689	15.3803	6.8651
328	55.3537	50.0230	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	26.2176	40.5221	6.8651
330	54.3750	73.4717	6.8651
331	46.3459	54.8709	6.8651
332	40.9923	81.1407	6.8651
333	50.0180	68.4527	6.8651
334	13.6467	56.6412	6.8651
335	78.8734	30.5074	6.8651
336	31.5116	30.4350	6.8651
337	23.9069	59.9122	6.8651
338	42.5831	37.1399	6.8651
339	25.3621	2.9418	6.8651
340	1.9078	84.1439	6.8651
341	28.8395	85.6979	6.8651
342	42.0439	1.2746	6.8651
343	38.5585	8.9239	6.8651
344	22.4809	75.2844	6.8651
345	57.9146	37.4787	6.8651
346	21.5800	71.4487	6.8651
347	14.3875	98.8261	6.8651
348	7.2094	55.9097	6.8651
349	72.8918	2.6850	6.8651
350	46.2315	17.3070	6.8651
351	15.2276	8.2482	6.8651
352	9.4518	0.0818	6.8651
353	57.1362	5.5136	6.8651
354	64.9436	1.6864	6.8651
355	61.0701	98.8684	6.8651
356	65.5247	34.4820	6.8651
357	11.5513	26.7284	6.8651
358	21.6218	70.9165	6.8651
359	57.7425	53.0432	6.8651
360	67.1669	49.4372	6.8651
361	38.1284	50.9907	6.8651
362	17.3929	9.8303	6.8651
363	7.5281	85.6801	6.8651
364	41.0252	15.6289	6.8651
365	39.7052	20.7341	6.8651
366	23.9937	92.6752	6.8651
367	21.5005	1.4444	6.8651
368	14.7300	38.6202	6.8651
369	9.8143	65.8912	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	23.2410	69.6046	6.8651
371	4.2645	75.4569	6.8651
372	9.7861	28.4045	6.8651
373	33.6894	8.5224	6.8651
374	21.4467	69.0185	6.8651
375	21.0217	51.8703	6.8651
376	15.3635	8.9465	6.8651
377	34.4982	43.6098	6.8651
378	77.8566	47.3210	6.8651
379	19.7990	26.8560	6.8651
380	11.9840	90.8471	6.8651
381	10.2639	16.7344	6.8651
382	75.6464	86.4518	6.8651
383	18.1201	57.6123	6.8651
384	45.5119	65.9533	6.8651
385	52.4413	6.2568	6.8651
386	56.7398	71.0931	6.8651
387	59.7400	37.5402	6.8651
388	62.9728	48.2611	6.8651
389	54.6678	5.1971	6.8651
390	67.3269	96.0070	6.8651
391	34.0987	23.3047	6.8651
392	67.0620	97.8078	6.8651
393	13.9199	46.2671	6.8651
394	77.5651	71.0149	6.8651
395	1.2957	73.7881	6.8651
396	37.7929	6.0601	6.8651
397	21.5695	0.9568	6.8651
398	6.1363	48.8675	6.8651
399	43.6411	3.9331	6.8651
400	40.4353	45.1451	6.8651
401	32.8303	42.2310	6.8651
402	24.3319	37.4284	6.8651
403	76.1613	37.0440	6.8651
404	44.3711	67.9206	6.8651
405	2.9296	91.7762	6.8651
406	61.0630	98.6998	6.8651
407	77.2293	82.6694	6.8651
408	73.3690	50.7129	6.8651
409	32.3079	45.1141	6.8651
410	1.8948	99.1556	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
411	73.7932	65.1929	6.8651
412	6.5220	46.8393	6.8651
413	0.6046	98.8714	6.8651
414	32.5069	76.0168	6.8651
415	65.8501	46.5185	6.8651
416	30.8820	13.4627	6.8651
417	50.0447	86.3511	6.8651
418	30.0938	44.3309	6.8651
419	12.1928	37.3703	6.8651
420	5.3401	99.7769	6.8651
421	26.3324	9.9110	6.8651
422	67.7861	18.0441	6.8651
423	60.7744	89.6482	6.8651
424	18.0605	3.6101	6.8651
425	21.8833	32.2702	6.8651
426	49.4828	84.8462	6.8651
427	34.4830	80.3653	6.8651
428	32.7632	61.4479	6.8651
429	25.8247	62.4300	6.8651
430	19.6994	87.7216	6.8651
431	57.0033	47.9295	6.8651
432	28.0185	49.9258	6.8651
433	63.3831	45.6708	6.8651
434	75.1791	28.4357	6.8651
435	56.1389	85.5616	6.8651
436	64.4544	70.2655	6.8651
437	62.4720	86.6470	6.8651
438	61.3812	10.1841	6.8651
439	35.4564	78.9241	6.8651
440	9.4154	53.1681	6.8651
441	75.4423	46.5496	6.8651
442	63.9530	87.4245	6.8651
443	33.5301	3.5427	6.8651
444	61.1690	94.8861	6.8651
445	10.8813	21.2221	6.8651
446	8.8712	13.2955	6.8651
447	11.8542	36.7134	6.8651
448	70.5957	27.6007	6.8651
449	28.3265	80.6515	6.8651
450	75.2340	1.1053	6.8651
451	49.7784	78.4397	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
452	47.2434	72.8349	6.8651
453	73.2291	73.9763	6.8651
454	1.0904	26.3845	6.8651
455	13.5790	86.3111	6.8651
456	1.1696	7.0254	6.8651
457	15.0420	3.4633	6.8651
458	35.1926	70.9963	6.8651
459	44.6810	94.9895	6.8651
460	73.2927	7.8306	6.8651
461	71.5875	94.5400	6.8651
462	71.4910	88.8238	6.8651
463	4.4920	30.1971	6.8651
464	67.7344	45.7338	6.8651
465	35.0134	33.6653	6.8651
466	56.2067	40.2418	6.8651
467	67.6345	29.9025	6.8651
468	12.9149	73.6814	6.8651
469	25.8175	47.2716	6.8651
470	19.3271	51.9549	6.8651
471	14.8230	72.6203	6.8651
472	6.6502	63.3599	6.8651
473	69.7655	86.0200	6.8651
474	74.8496	95.8479	6.8651
475	18.6254	45.1800	6.8651
476	1.3892	56.8496	6.8651
477	18.4742	58.4012	6.8651
478	35.4890	25.3753	6.8651
479	37.3850	18.6566	6.8651
480	45.6990	60.3070	6.8651
481	22.9209	53.7234	6.8651
482	61.6425	72.8564	6.8651
483	25.4341	30.3643	6.8651
484	56.0728	23.8687	6.8651
485	61.8021	40.7858	6.8651
486	52.8784	80.2957	6.8651
487	61.0936	52.6920	6.8651
488	39.2148	31.0796	6.8651
489	64.6627	65.3996	6.8651
490	37.4152	67.1119	6.8651
491	56.5346	68.6367	6.8651
492	69.6772	28.9704	6.8651

Continued on next page

Table D.13 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
493	29.8399	3.7319	6.8651
494	25.8820	79.9487	6.8651
495	62.1748	23.5386	6.8651
496	6.6484	67.6725	6.8651
497	58.3317	48.8465	6.8651
498	62.6983	97.3779	6.8651
499	18.3784	57.1027	6.8651
500	34.2887	41.9043	6.8651
Depot	95.0000	50.0000	N.A.

Table D.14: CETSP instance bonus1000rdmRad

Customer index	x-coordinate	y-coordinate	Service range
1	8.8424	89.8918	9.2489
2	32.7799	83.2523	9.2489
3	10.3686	64.9958	9.2489
4	3.4302	27.3978	9.2489
5	45.3407	99.2752	9.2489
6	59.1160	27.8960	9.2489
7	35.1725	39.3614	9.2489
8	20.1985	8.6278	9.2489
9	56.7681	74.9360	9.2489
10	12.6505	38.2099	9.2489
11	27.0631	42.6427	9.2489
12	55.9910	83.6015	9.2489
13	17.2588	95.6994	9.2489
14	3.9727	68.4310	9.2489
15	18.1027	98.2919	9.2489
16	27.4650	78.5652	9.2489
17	16.8508	91.4539	9.2489
18	63.6804	79.2999	9.2489
19	50.3298	35.4364	9.2489
20	28.6920	99.3457	9.2489
21	33.8581	68.2147	9.2489
22	36.8668	93.0634	9.2489
23	53.6999	99.8116	9.2489
24	66.1742	21.1575	9.2489
25	94.7589	85.8354	9.2489
26	39.0793	20.5735	9.2489
27	55.9549	32.8020	9.2489
28	27.3246	98.0804	9.2489
29	74.5573	43.4874	9.2489
30	36.6564	59.2725	9.2489
31	10.0815	81.4641	9.2489
32	19.7751	38.5893	9.2489
33	86.5066	33.3392	9.2489
34	22.8444	60.0141	9.2489
35	56.7361	58.8782	9.2489
36	25.5882	94.6226	9.2489
37	24.7778	44.0408	9.2489
38	30.3319	43.7550	9.2489
39	3.2126	94.5139	9.2489
40	53.8745	88.1645	9.2489
41	25.4736	81.9426	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
42	64.9653	93.9823	9.2489
43	59.2804	42.0297	9.2489
44	23.1086	93.4653	9.2489
45	63.7656	37.4523	9.2489
46	6.3025	40.0086	9.2489
47	5.2830	51.8958	9.2489
48	12.6386	82.4267	9.2489
49	35.4087	49.3338	9.2489
50	20.7513	88.7330	9.2489
51	67.6930	75.2440	9.2489
52	66.6720	95.9202	9.2489
53	39.8494	96.2279	9.2489
54	38.8733	61.9742	9.2489
55	55.0732	28.8544	9.2489
56	38.0529	66.4334	9.2489
57	7.3422	50.3657	9.2489
58	20.4748	85.6818	9.2489
59	25.6525	56.5792	9.2489
60	29.7776	79.3797	9.2489
61	2.1978	16.1644	9.2489
62	51.9854	93.0331	9.2489
63	51.6551	43.8565	9.2489
64	28.8226	20.3671	9.2489
65	19.6423	34.9921	9.2489
66	51.3358	40.3066	9.2489
67	65.5557	66.5833	9.2489
68	65.3379	63.7280	9.2489
69	48.3583	45.6967	9.2489
70	64.6614	51.5825	9.2489
71	70.6175	78.6546	9.2489
72	36.3196	94.1542	9.2489
73	29.0317	90.5330	9.2489
74	3.8151	26.6511	9.2489
75	1.8378	81.0681	9.2489
76	26.4999	86.4966	9.2489
77	2.7664	66.0955	9.2489
78	19.4021	41.6602	9.2489
79	24.6849	59.8520	9.2489
80	39.7518	71.5148	9.2489
81	15.7783	66.1941	9.2489
82	44.6693	80.7972	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
83	70.8337	78.2109	9.2489
84	54.1510	63.8943	9.2489
85	56.3608	54.4387	9.2489
86	1.3542	31.3159	9.2489
87	11.0047	35.1418	9.2489
88	17.2016	81.6953	9.2489
89	32.8349	54.5053	9.2489
90	0.8488	80.8042	9.2489
91	51.1775	73.3951	9.2489
92	32.8781	90.1018	9.2489
93	15.0640	86.4956	9.2489
94	52.2458	74.9856	9.2489
95	11.2816	86.8372	9.2489
96	30.5161	92.2095	9.2489
97	11.7365	68.8238	9.2489
98	94.1781	30.5898	9.2489
99	22.6819	72.9081	9.2489
100	8.0785	52.1247	9.2489
101	48.0135	55.6763	9.2489
102	68.5202	55.6901	9.2489
103	63.2492	4.0157	9.2489
104	36.9912	62.0965	9.2489
105	47.3158	98.1370	9.2489
106	4.4401	94.8769	9.2489
107	91.1933	55.0935	9.2489
108	6.3593	87.0647	9.2489
109	53.6024	70.8029	9.2489
110	72.8429	65.6705	9.2489
111	35.8599	20.9040	9.2489
112	55.7200	71.9192	9.2489
113	16.8097	72.8482	9.2489
114	14.0606	63.9325	9.2489
115	17.2263	94.0864	9.2489
116	0.0736	50.2029	9.2489
117	63.5921	50.3481	9.2489
118	56.3040	89.7292	9.2489
119	11.5453	68.9331	9.2489
120	30.1834	92.1548	9.2489
121	22.3390	31.6024	9.2489
122	0.1023	55.0565	9.2489
123	9.7553	43.1833	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
124	31.3418	77.8679	9.2489
125	18.6946	36.2655	9.2489
126	49.5565	80.8162	9.2489
127	40.3266	53.6266	9.2489
128	1.7756	46.3840	9.2489
129	40.1668	89.0974	9.2489
130	16.7366	65.2661	9.2489
131	11.7116	63.2315	9.2489
132	19.9269	66.4829	9.2489
133	8.0266	29.1706	9.2489
134	43.5910	70.7565	9.2489
135	78.1811	99.7924	9.2489
136	85.7141	51.6725	9.2489
137	31.7830	62.7455	9.2489
138	10.3544	93.6186	9.2489
139	36.4950	99.8776	9.2489
140	51.9156	83.2415	9.2489
141	31.9235	85.9644	9.2489
142	20.7225	50.2905	9.2489
143	66.6570	47.7723	9.2489
144	42.5877	73.9463	9.2489
145	67.8999	88.1232	9.2489
146	36.2672	91.8152	9.2489
147	33.4598	51.4764	9.2489
148	17.9309	43.3009	9.2489
149	69.3830	98.1867	9.2489
150	30.4651	92.1055	9.2489
151	30.4145	39.5532	9.2489
152	72.7038	66.7065	9.2489
153	5.7931	87.7203	9.2489
154	10.7162	46.6229	9.2489
155	43.1138	45.0009	9.2489
156	76.6865	13.8696	9.2489
157	47.9675	95.1452	9.2489
158	1.2508	48.7403	9.2489
159	71.1705	92.9623	9.2489
160	77.1133	85.3156	9.2489
161	36.7712	29.7051	9.2489
162	52.5936	61.8708	9.2489
163	13.3420	71.1511	9.2489
164	39.8369	68.0599	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
165	50.2067	26.4023	9.2489
166	45.0121	95.4797	9.2489
167	3.2007	54.9040	9.2489
168	28.3496	82.6684	9.2489
169	18.4668	77.2930	9.2489
170	4.3777	84.9846	9.2489
171	90.5069	55.4383	9.2489
172	90.8182	18.2159	9.2489
173	39.1205	68.7577	9.2489
174	36.9079	88.7829	9.2489
175	63.4832	69.3620	9.2489
176	16.4753	49.4456	9.2489
177	38.1894	65.5461	9.2489
178	65.5150	11.6864	9.2489
179	62.0368	91.4278	9.2489
180	3.3803	80.9989	9.2489
181	51.4966	83.1106	9.2489
182	39.6715	49.4413	9.2489
183	39.4705	98.0104	9.2489
184	14.8123	50.2913	9.2489
185	20.0396	90.8383	9.2489
186	18.1581	79.4001	9.2489
187	61.0960	95.3880	9.2489
188	52.5789	54.1620	9.2489
189	0.8673	18.0482	9.2489
190	55.1648	55.4235	9.2489
191	36.1781	80.1310	9.2489
192	65.9828	56.0226	9.2489
193	37.5175	33.0911	9.2489
194	12.0030	63.9467	9.2489
195	45.1387	81.8637	9.2489
196	42.2598	46.8683	9.2489
197	77.7745	46.7226	9.2489
198	13.1791	60.0536	9.2489
199	48.2062	39.2479	9.2489
200	84.1408	54.4625	9.2489
201	7.1782	91.7684	9.2489
202	8.3764	96.8380	9.2489
203	76.0424	64.4500	9.2489
204	57.5342	91.7322	9.2489
205	5.7248	81.8072	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
206	86.7540	75.2393	9.2489
207	23.0673	35.0376	9.2489
208	42.5322	92.9240	9.2489
209	0.1552	73.1144	9.2489
210	56.8490	69.2710	9.2489
211	48.8881	29.6929	9.2489
212	41.8469	52.1516	9.2489
213	12.6368	12.9194	9.2489
214	8.0139	41.4146	9.2489
215	0.8464	97.1558	9.2489
216	3.6845	54.7535	9.2489
217	40.5842	81.5496	9.2489
218	50.3737	63.5418	9.2489
219	57.4844	43.2517	9.2489
220	5.3511	54.8790	9.2489
221	8.8809	67.1678	9.2489
222	20.1601	73.5531	9.2489
223	26.3792	28.3109	9.2489
224	10.2030	47.6234	9.2489
225	31.5452	79.1636	9.2489
226	1.0097	74.3220	9.2489
227	41.3077	70.0597	9.2489
228	75.0077	29.5014	9.2489
229	36.4421	76.1390	9.2489
230	18.5697	98.9341	9.2489
231	13.4875	42.2999	9.2489
232	57.8211	79.2461	9.2489
233	36.4314	90.4821	9.2489
234	33.9192	90.5224	9.2489
235	70.2466	43.4055	9.2489
236	22.0652	57.5055	9.2489
237	3.1646	61.6706	9.2489
238	47.8921	67.3947	9.2489
239	11.0495	95.3028	9.2489
240	37.5812	53.7047	9.2489
241	61.6409	64.7246	9.2489
242	45.3343	93.5861	9.2489
243	4.9615	81.5142	9.2489
244	38.2509	84.7019	9.2489
245	83.9165	55.6949	9.2489
246	93.5356	11.2495	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
247	17.3895	82.2317	9.2489
248	52.0534	85.8262	9.2489
249	77.0304	15.5107	9.2489
250	27.3907	19.1091	9.2489
251	10.7776	89.0099	9.2489
252	46.1161	79.1341	9.2489
253	20.1668	86.4556	9.2489
254	47.5277	30.5453	9.2489
255	69.9295	96.4281	9.2489
256	35.0366	76.3190	9.2489
257	28.9502	86.7983	9.2489
258	21.6587	17.9915	9.2489
259	3.7052	66.5975	9.2489
260	34.0333	85.0669	9.2489
261	41.0948	34.9251	9.2489
262	4.2814	24.7215	9.2489
263	55.1100	85.6861	9.2489
264	83.7550	5.8578	9.2489
265	39.2592	24.7878	9.2489
266	53.2221	50.8472	9.2489
267	3.1158	88.0003	9.2489
268	43.4029	59.6042	9.2489
269	37.8711	99.6748	9.2489
270	24.3753	73.1083	9.2489
271	29.8983	58.8839	9.2489
272	14.1488	27.9872	9.2489
273	31.5200	50.8923	9.2489
274	35.9608	77.3873	9.2489
275	33.8474	94.5283	9.2489
276	13.5052	67.7224	9.2489
277	63.8837	92.9887	9.2489
278	79.3060	40.2843	9.2489
279	21.5258	69.0574	9.2489
280	47.6501	45.5187	9.2489
281	6.3344	68.8547	9.2489
282	31.1795	31.4063	9.2489
283	16.5476	53.0979	9.2489
284	53.6161	80.9346	9.2489
285	45.4707	56.9681	9.2489
286	53.0462	62.5622	9.2489
287	9.8322	38.0869	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
288	25.8382	22.0380	9.2489
289	69.8234	93.1595	9.2489
290	55.4034	57.6117	9.2489
291	38.0740	11.0946	9.2489
292	21.4033	88.6570	9.2489
293	46.2689	26.5321	9.2489
294	68.3689	72.6148	9.2489
295	37.3674	64.7252	9.2489
296	38.0003	82.2020	9.2489
297	59.7727	58.0187	9.2489
298	43.1282	79.6322	9.2489
299	64.8890	21.5835	9.2489
300	29.4961	81.7774	9.2489
301	64.8850	82.9677	9.2489
302	2.5447	74.4584	9.2489
303	6.7194	25.7387	9.2489
304	0.5395	84.8134	9.2489
305	6.5792	89.2491	9.2489
306	30.1807	48.3203	9.2489
307	7.8809	53.6342	9.2489
308	10.4056	91.9690	9.2489
309	46.2582	91.1776	9.2489
310	25.6400	98.3359	9.2489
311	28.5901	24.8331	9.2489
312	34.3258	66.3110	9.2489
313	39.8688	93.4778	9.2489
314	38.4607	17.3367	9.2489
315	91.9033	76.1624	9.2489
316	5.6684	43.1478	9.2489
317	54.1005	92.2862	9.2489
318	63.5404	40.4791	9.2489
319	57.0628	74.9877	9.2489
320	9.9219	86.8722	9.2489
321	61.3001	82.6964	9.2489
322	70.0736	96.6102	9.2489
323	46.0304	83.7999	9.2489
324	48.4559	88.4082	9.2489
325	9.0186	78.0382	9.2489
326	86.1092	91.4688	9.2489
327	69.6792	40.7468	9.2489
328	24.6164	54.0112	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
329	10.8214	82.8932	9.2489
330	18.3152	76.2750	9.2489
331	24.3449	68.8989	9.2489
332	0.0942	39.9156	9.2489
333	19.2935	63.3423	9.2489
334	2.8858	40.6085	9.2489
335	6.7729	23.0443	9.2489
336	81.4769	70.9413	9.2489
337	24.8475	78.2190	9.2489
338	75.7563	60.0220	9.2489
339	55.7308	81.0587	9.2489
340	15.3645	54.9739	9.2489
341	38.3895	19.6567	9.2489
342	9.9641	69.0274	9.2489
343	18.7901	77.5417	9.2489
344	63.4789	68.7065	9.2489
345	9.2651	48.1015	9.2489
346	45.7851	48.7667	9.2489
347	45.1386	90.4706	9.2489
348	54.3000	99.8919	9.2489
349	94.1559	20.2227	9.2489
350	10.2850	75.4358	9.2489
351	1.2826	62.3927	9.2489
352	12.3671	15.9058	9.2489
353	25.2040	63.9864	9.2489
354	41.9538	74.6074	9.2489
355	32.1140	10.6301	9.2489
356	12.2498	50.9274	9.2489
357	71.2277	93.7757	9.2489
358	24.8796	27.0958	9.2489
359	56.1558	36.1072	9.2489
360	41.5744	43.1383	9.2489
361	63.4136	44.6967	9.2489
362	61.0186	37.8221	9.2489
363	32.1467	66.5742	9.2489
364	82.0189	31.5854	9.2489
365	18.1644	83.3220	9.2489
366	17.2441	73.1430	9.2489
367	5.7226	17.3865	9.2489
368	34.1572	12.8461	9.2489
369	6.2917	89.2710	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
370	36.8886	65.1176	9.2489
371	14.9958	14.5728	9.2489
372	54.4363	91.9279	9.2489
373	21.6112	90.1973	9.2489
374	56.6448	82.2468	9.2489
375	39.8616	55.5819	9.2489
376	2.5594	66.6071	9.2489
377	97.9906	82.8454	9.2489
378	8.9159	48.8311	9.2489
379	9.3605	76.6338	9.2489
380	44.5697	97.2286	9.2489
381	8.9336	64.1942	9.2489
382	58.1489	37.5502	9.2489
383	62.2017	80.9666	9.2489
384	36.2315	27.6071	9.2489
385	6.6251	98.7289	9.2489
386	1.0969	69.2006	9.2489
387	25.8459	61.1767	9.2489
388	78.2926	66.4599	9.2489
389	7.8717	40.3520	9.2489
390	78.8307	69.6727	9.2489
391	12.4877	90.9011	9.2489
392	79.8675	54.3542	9.2489
393	28.0833	42.0226	9.2489
394	43.0404	95.3704	9.2489
395	29.4788	65.0111	9.2489
396	22.0030	49.7744	9.2489
397	35.5590	90.8560	9.2489
398	63.5373	67.0341	9.2489
399	38.2193	86.8894	9.2489
400	62.0316	81.1662	9.2489
401	58.5050	53.8647	9.2489
402	25.7317	44.0261	9.2489
403	16.2943	68.6310	9.2489
404	12.4548	85.2999	9.2489
405	13.7854	72.7506	9.2489
406	3.3194	86.8534	9.2489
407	14.8681	22.1771	9.2489
408	22.6880	46.2853	9.2489
409	71.2950	19.8608	9.2489
410	37.4347	70.1459	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
411	5.2317	94.8857	9.2489
412	49.7727	84.1375	9.2489
413	35.6247	10.7390	9.2489
414	49.1951	89.4435	9.2489
415	25.3592	97.9393	9.2489
416	42.9516	64.8413	9.2489
417	18.9784	66.0993	9.2489
418	5.6772	18.0492	9.2489
419	30.5551	47.7311	9.2489
420	29.6591	42.1276	9.2489
421	52.8342	85.5012	9.2489
422	40.5584	87.8830	9.2489
423	75.2100	80.5663	9.2489
424	24.7916	85.7327	9.2489
425	50.5931	22.7572	9.2489
426	69.7040	60.5823	9.2489
427	44.2169	34.3977	9.2489
428	20.1671	56.2638	9.2489
429	14.4428	41.3582	9.2489
430	22.4643	85.8783	9.2489
431	76.5703	49.5551	9.2489
432	3.4374	82.3966	9.2489
433	6.0418	70.0172	9.2489
434	28.9461	87.0548	9.2489
435	15.8397	72.6074	9.2489
436	25.3455	99.2054	9.2489
437	20.1167	80.5667	9.2489
438	55.9054	73.5658	9.2489
439	5.0427	78.4005	9.2489
440	52.7157	99.4669	9.2489
441	7.8101	100.0000	9.2489
442	7.9924	82.0809	9.2489
443	39.5764	86.6960	9.2489
444	25.7182	44.0237	9.2489
445	24.0950	20.3829	9.2489
446	59.0135	66.3423	9.2489
447	22.0652	97.8097	9.2489
448	14.3064	91.7270	9.2489
449	21.0475	76.8460	9.2489
450	5.9027	84.5742	9.2489
451	2.8851	70.7878	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
452	9.5779	89.1192	9.2489
453	6.2564	90.6626	9.2489
454	37.8361	96.1337	9.2489
455	41.1412	94.6163	9.2489
456	91.6000	72.6788	9.2489
457	21.5614	60.0085	9.2489
458	43.7454	43.8763	9.2489
459	50.8699	67.1185	9.2489
460	29.8137	76.7788	9.2489
461	5.5844	23.8118	9.2489
462	21.9541	97.0823	9.2489
463	8.5952	76.7397	9.2489
464	54.6946	37.3209	9.2489
465	40.9133	65.0544	9.2489
466	60.7968	75.3337	9.2489
467	40.9242	52.5492	9.2489
468	16.1042	94.6221	9.2489
469	8.7360	47.8647	9.2489
470	64.6461	95.0926	9.2489
471	69.0955	84.0762	9.2489
472	73.1387	41.7141	9.2489
473	40.0504	28.8112	9.2489
474	54.0363	65.0230	9.2489
475	19.1660	83.5812	9.2489
476	34.2859	93.0132	9.2489
477	42.1091	58.0660	9.2489
478	47.2285	47.8990	9.2489
479	87.6341	89.7208	9.2489
480	18.3969	22.7252	9.2489
481	23.7365	45.2154	9.2489
482	17.4742	43.6042	9.2489
483	63.3224	89.2938	9.2489
484	65.8500	61.3779	9.2489
485	18.4943	75.1491	9.2489
486	38.9024	39.4555	9.2489
487	68.9689	80.5562	9.2489
488	14.1148	66.5849	9.2489
489	94.4318	8.7963	9.2489
490	45.5908	70.2145	9.2489
491	62.8170	55.9489	9.2489
492	25.4040	32.3205	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
493	18.1553	77.8065	9.2489
494	18.2095	6.6196	9.2489
495	6.8110	49.5276	9.2489
496	24.9396	85.1814	9.2489
497	22.0024	99.1260	9.2489
498	50.2604	48.9503	9.2489
499	32.4793	60.0995	9.2489
500	76.4839	93.8150	9.2489
501	15.2509	86.8517	9.2489
502	17.8009	46.6451	9.2489
503	95.7766	57.6822	9.2489
504	48.6505	56.2634	9.2489
505	0.2247	41.4361	9.2489
506	14.6745	73.2206	9.2489
507	28.7770	67.7567	9.2489
508	14.5195	70.4911	9.2489
509	11.5664	72.1085	9.2489
510	67.2662	20.0201	9.2489
511	10.8419	50.7478	9.2489
512	87.3408	59.3793	9.2489
513	24.5862	59.9258	9.2489
514	30.6280	46.7773	9.2489
515	61.6361	74.0341	9.2489
516	27.1302	56.0074	9.2489
517	50.6763	98.0842	9.2489
518	43.6656	47.7714	9.2489
519	47.3485	74.6343	9.2489
520	2.5183	30.4543	9.2489
521	59.1060	64.7262	9.2489
522	49.5943	92.5112	9.2489
523	2.7813	68.3563	9.2489
524	42.3435	5.7699	9.2489
525	54.4337	52.1289	9.2489
526	87.5675	36.2741	9.2489
527	23.2328	99.3790	9.2489
528	39.9695	49.4623	9.2489
529	42.1359	68.9460	9.2489
530	16.6338	64.7785	9.2489
531	27.3771	46.4362	9.2489
532	23.3969	71.4392	9.2489
533	3.8578	53.9352	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
534	83.7723	73.1421	9.2489
535	31.8061	35.4502	9.2489
536	46.9347	83.7530	9.2489
537	3.3910	60.3206	9.2489
538	48.8236	98.3784	9.2489
539	39.0031	58.9811	9.2489
540	12.7718	48.3340	9.2489
541	26.1244	44.9649	9.2489
542	49.0366	90.6550	9.2489
543	25.6386	75.5532	9.2489
544	61.5633	58.6359	9.2489
545	42.2320	88.9530	9.2489
546	41.1479	74.7573	9.2489
547	48.3993	99.0273	9.2489
548	11.9922	50.5282	9.2489
549	26.5677	46.7769	9.2489
550	68.0919	95.8552	9.2489
551	26.9747	54.6651	9.2489
552	5.7791	82.0132	9.2489
553	2.6430	87.4823	9.2489
554	36.7941	92.2553	9.2489
555	25.9946	34.3791	9.2489
556	22.9640	79.2458	9.2489
557	14.0986	77.6885	9.2489
558	21.2619	68.3111	9.2489
559	71.9975	50.8209	9.2489
560	0.7735	79.8166	9.2489
561	51.9928	27.9991	9.2489
562	5.8634	76.0617	9.2489
563	13.0135	89.5506	9.2489
564	45.6832	63.6499	9.2489
565	44.5324	98.5951	9.2489
566	14.9291	79.4206	9.2489
567	41.1483	82.1060	9.2489
568	44.5606	79.7732	9.2489
569	47.1417	77.8433	9.2489
570	44.4709	80.1731	9.2489
571	13.8911	56.9273	9.2489
572	39.5865	43.5529	9.2489
573	62.3526	88.4620	9.2489
574	8.9809	92.3092	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
575	39.4429	96.3803	9.2489
576	3.7954	81.2097	9.2489
577	30.0151	69.9383	9.2489
578	9.3207	27.0856	9.2489
579	36.5703	15.6211	9.2489
580	28.1737	71.9430	9.2489
581	58.4027	82.8929	9.2489
582	41.1055	60.7357	9.2489
583	53.7074	57.8078	9.2489
584	23.5396	80.4714	9.2489
585	73.7584	73.1167	9.2489
586	74.5797	99.8382	9.2489
587	62.6115	17.9582	9.2489
588	53.9008	74.5538	9.2489
589	72.7343	54.9502	9.2489
590	57.8401	97.2493	9.2489
591	1.7250	93.7370	9.2489
592	40.5704	31.3183	9.2489
593	26.0326	67.0519	9.2489
594	10.8989	16.0250	9.2489
595	10.8371	59.6538	9.2489
596	88.1307	33.9075	9.2489
597	31.9616	70.6094	9.2489
598	77.1443	45.2508	9.2489
599	21.5330	97.7661	9.2489
600	57.5617	41.9770	9.2489
601	65.0962	64.3263	9.2489
602	36.5325	65.8983	9.2489
603	46.1572	56.4070	9.2489
604	66.9226	21.4897	9.2489
605	26.4628	62.6113	9.2489
606	22.1400	72.3773	9.2489
607	21.6104	65.8368	9.2489
608	23.3198	27.3418	9.2489
609	31.1212	52.6168	9.2489
610	28.4433	74.9867	9.2489
611	58.2043	69.5052	9.2489
612	64.4724	44.0792	9.2489
613	2.8819	70.7873	9.2489
614	21.5192	80.7447	9.2489
615	74.7837	42.0509	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
616	26.2032	94.4570	9.2489
617	27.5007	99.7677	9.2489
618	23.9149	35.5045	9.2489
619	35.8500	97.2623	9.2489
620	38.2077	77.8974	9.2489
621	4.2975	80.7329	9.2489
622	12.3199	42.0729	9.2489
623	52.6846	66.6860	9.2489
624	53.2956	92.4745	9.2489
625	31.8059	45.6064	9.2489
626	66.9270	97.5057	9.2489
627	44.9876	56.9639	9.2489
628	66.5931	88.4188	9.2489
629	55.8048	50.3019	9.2489
630	52.6039	98.5105	9.2489
631	56.1230	60.7693	9.2489
632	30.9043	20.9678	9.2489
633	95.9948	18.1473	9.2489
634	6.8102	85.2019	9.2489
635	8.4659	8.8741	9.2489
636	14.5275	66.8215	9.2489
637	27.0370	98.9981	9.2489
638	51.9170	73.6960	9.2489
639	23.6843	51.4413	9.2489
640	58.4855	38.4928	9.2489
641	22.9522	73.2583	9.2489
642	49.2122	82.1868	9.2489
643	7.0854	88.7785	9.2489
644	32.2127	85.4506	9.2489
645	3.2523	73.9521	9.2489
646	28.3829	59.7022	9.2489
647	18.7192	25.1044	9.2489
648	48.2093	82.3031	9.2489
649	24.2349	17.9886	9.2489
650	63.2177	46.4808	9.2489
651	32.2890	63.3739	9.2489
652	3.1779	14.9780	9.2489
653	62.0129	62.7069	9.2489
654	81.4352	82.8976	9.2489
655	38.2458	80.9579	9.2489
656	67.8758	63.8911	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
657	22.6210	94.0370	9.2489
658	9.1968	46.1557	9.2489
659	44.4501	17.9136	9.2489
660	67.4546	72.8538	9.2489
661	22.7988	41.5963	9.2489
662	70.9437	58.1456	9.2489
663	6.9799	73.9164	9.2489
664	22.9592	75.8305	9.2489
665	45.3176	83.7902	9.2489
666	93.2952	74.8246	9.2489
667	17.1684	23.6552	9.2489
668	34.3097	75.9018	9.2489
669	17.4426	43.6837	9.2489
670	28.5440	40.1369	9.2489
671	5.0204	69.5880	9.2489
672	72.9138	91.5489	9.2489
673	1.8255	70.7813	9.2489
674	60.5976	67.4229	9.2489
675	29.1581	9.5187	9.2489
676	71.6163	44.9777	9.2489
677	58.2152	76.7746	9.2489
678	31.0391	88.8192	9.2489
679	10.6233	24.2907	9.2489
680	8.6800	15.2269	9.2489
681	63.1252	41.2494	9.2489
682	44.9684	64.0571	9.2489
683	11.8661	56.8305	9.2489
684	3.2986	92.2687	9.2489
685	30.8364	38.3521	9.2489
686	14.0192	69.2201	9.2489
687	53.4809	34.5743	9.2489
688	7.3200	15.3781	9.2489
689	41.9598	64.9444	9.2489
690	85.1609	60.4770	9.2489
691	93.1274	86.7071	9.2489
692	4.2036	71.2869	9.2489
693	32.0671	41.1282	9.2489
694	28.9427	52.0186	9.2489
695	32.4397	75.5288	9.2489
696	56.1557	89.4150	9.2489
697	17.4531	57.0203	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
698	38.7847	39.0691	9.2489
699	7.0090	89.8085	9.2489
700	1.8346	71.1520	9.2489
701	18.8550	86.6147	9.2489
702	24.9239	92.0800	9.2489
703	24.5764	79.5754	9.2489
704	18.1048	51.4832	9.2489
705	12.0343	87.7882	9.2489
706	14.5063	38.1657	9.2489
707	19.1790	72.4898	9.2489
708	23.6494	19.8099	9.2489
709	10.6386	61.6451	9.2489
710	35.5398	15.9920	9.2489
711	87.0390	21.0955	9.2489
712	23.2926	57.3444	9.2489
713	34.0637	42.7709	9.2489
714	35.6019	93.1465	9.2489
715	3.1666	54.3858	9.2489
716	29.5659	24.5787	9.2489
717	9.4424	27.3202	9.2489
718	8.3279	95.9796	9.2489
719	18.2173	92.4873	9.2489
720	46.2073	94.8222	9.2489
721	22.1996	99.8400	9.2489
722	39.7386	66.9252	9.2489
723	49.9058	41.0723	9.2489
724	3.7026	67.5597	9.2489
725	6.6640	86.9327	9.2489
726	4.7243	85.8821	9.2489
727	26.3650	64.1039	9.2489
728	72.1571	9.1791	9.2489
729	3.0824	9.0439	9.2489
730	23.4079	43.6438	9.2489
731	38.1988	73.4530	9.2489
732	82.5399	88.8791	9.2489
733	19.4727	75.2589	9.2489
734	66.8109	72.1934	9.2489
735	3.7660	77.2812	9.2489
736	25.0801	60.4807	9.2489
737	29.0961	74.1868	9.2489
738	9.0204	42.8621	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
739	41.7217	60.3614	9.2489
740	25.6611	62.2794	9.2489
741	3.3366	66.3437	9.2489
742	24.0546	58.8274	9.2489
743	5.3337	86.8970	9.2489
744	58.0062	94.6472	9.2489
745	37.3556	97.3081	9.2489
746	14.3554	64.7100	9.2489
747	82.0902	81.3331	9.2489
748	10.7991	20.4204	9.2489
749	76.6853	86.4930	9.2489
750	50.2967	64.0758	9.2489
751	68.8428	76.0322	9.2489
752	75.1938	39.7539	9.2489
753	48.6909	94.6419	9.2489
754	8.0113	61.6922	9.2489
755	30.2819	43.7783	9.2489
756	6.9629	47.8774	9.2489
757	11.5133	99.9544	9.2489
758	54.0008	32.5022	9.2489
759	35.9208	99.0427	9.2489
760	19.5589	94.4852	9.2489
761	54.4897	89.3064	9.2489
762	45.3223	79.2675	9.2489
763	28.1720	56.5159	9.2489
764	24.6793	81.2170	9.2489
765	18.1343	49.1579	9.2489
766	3.0595	82.0560	9.2489
767	8.0771	60.5265	9.2489
768	25.2429	93.1818	9.2489
769	57.9733	65.3994	9.2489
770	43.9152	93.3979	9.2489
771	16.0716	60.0064	9.2489
772	38.5583	62.0328	9.2489
773	41.2395	98.4925	9.2489
774	66.6787	56.1352	9.2489
775	23.6527	99.4060	9.2489
776	53.9276	74.1265	9.2489
777	9.9545	42.5082	9.2489
778	18.2114	45.5866	9.2489
779	17.2560	61.6944	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
780	30.9617	84.9946	9.2489
781	51.9522	92.5799	9.2489
782	72.0901	81.4175	9.2489
783	17.8196	98.0177	9.2489
784	60.7167	14.8722	9.2489
785	34.1704	50.6373	9.2489
786	70.7195	19.5494	9.2489
787	44.4260	67.4520	9.2489
788	12.8762	80.5413	9.2489
789	59.4841	31.9800	9.2489
790	52.4099	76.9003	9.2489
791	34.3106	43.9536	9.2489
792	8.6898	62.8088	9.2489
793	51.1986	31.0981	9.2489
794	30.0885	94.0460	9.2489
795	30.3441	27.7443	9.2489
796	28.8603	61.8379	9.2489
797	25.3942	74.0149	9.2489
798	40.8101	38.7730	9.2489
799	52.6495	62.6853	9.2489
800	3.1055	84.7108	9.2489
801	53.5031	57.0494	9.2489
802	2.6944	27.6283	9.2489
803	32.3368	89.5627	9.2489
804	15.5069	76.4486	9.2489
805	19.1817	47.0577	9.2489
806	49.5272	60.8867	9.2489
807	2.8203	66.9401	9.2489
808	55.5809	76.5300	9.2489
809	60.7009	80.6445	9.2489
810	49.1367	77.1071	9.2489
811	5.8385	89.4611	9.2489
812	41.7271	62.5487	9.2489
813	9.8910	52.1661	9.2489
814	32.5694	80.9888	9.2489
815	40.7765	81.2371	9.2489
816	31.8981	95.6275	9.2489
817	37.6765	59.0182	9.2489
818	57.0948	60.4599	9.2489
819	29.9086	38.4851	9.2489
820	5.8013	5.2308	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
821	72.4880	89.5704	9.2489
822	46.0208	88.3362	9.2489
823	9.9401	86.9982	9.2489
824	59.0160	86.9927	9.2489
825	65.2673	95.8674	9.2489
826	74.4658	79.0435	9.2489
827	62.1759	23.5347	9.2489
828	79.3916	97.2659	9.2489
829	62.8346	32.3748	9.2489
830	34.8283	24.4509	9.2489
831	68.0145	90.2652	9.2489
832	27.2662	25.9020	9.2489
833	16.9340	77.9225	9.2489
834	47.9291	80.1113	9.2489
835	5.8197	97.5317	9.2489
836	58.0914	33.9778	9.2489
837	22.0736	33.0177	9.2489
838	1.6960	79.3379	9.2489
839	59.9771	27.0772	9.2489
840	58.8167	76.2826	9.2489
841	21.6338	90.7285	9.2489
842	37.0705	30.0448	9.2489
843	84.8598	39.8533	9.2489
844	16.7612	28.3125	9.2489
845	70.7717	73.8806	9.2489
846	83.1920	53.4864	9.2489
847	33.5083	58.4841	9.2489
848	38.7870	81.2074	9.2489
849	10.3039	47.8428	9.2489
850	64.7579	49.9210	9.2489
851	49.4895	49.4412	9.2489
852	49.8172	39.8995	9.2489
853	68.1156	90.2931	9.2489
854	22.5832	64.2388	9.2489
855	61.1490	72.7041	9.2489
856	45.9483	45.5070	9.2489
857	0.7151	54.3404	9.2489
858	72.1305	55.0307	9.2489
859	53.2731	89.6749	9.2489
860	74.8508	64.7465	9.2489
861	39.3557	35.0679	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
862	73.0497	93.6836	9.2489
863	49.3932	67.5706	9.2489
864	57.4325	97.9412	9.2489
865	51.9052	74.1053	9.2489
866	18.8095	50.6794	9.2489
867	24.6809	89.7145	9.2489
868	8.6752	76.1739	9.2489
869	51.1883	82.8098	9.2489
870	40.5774	42.4726	9.2489
871	7.9746	40.8370	9.2489
872	75.3828	84.8496	9.2489
873	49.4989	30.7347	9.2489
874	44.0124	95.5424	9.2489
875	69.1263	69.4594	9.2489
876	2.5102	94.8247	9.2489
877	27.4285	33.2762	9.2489
878	52.0310	42.5013	9.2489
879	20.4271	96.6926	9.2489
880	31.6797	78.2008	9.2489
881	51.0870	26.4204	9.2489
882	43.6316	99.6749	9.2489
883	53.7981	45.1618	9.2489
884	34.6877	48.2708	9.2489
885	37.6478	91.6093	9.2489
886	33.5730	70.5185	9.2489
887	9.8979	67.9400	9.2489
888	53.0876	83.0336	9.2489
889	8.9880	7.9259	9.2489
890	52.2624	99.8357	9.2489
891	35.9445	20.1240	9.2489
892	88.6056	53.6735	9.2489
893	23.9248	88.8528	9.2489
894	19.2915	80.5243	9.2489
895	55.7534	84.5659	9.2489
896	23.8691	73.8369	9.2489
897	91.0477	90.6018	9.2489
898	3.1000	78.6196	9.2489
899	33.4587	53.8592	9.2489
900	7.9364	83.6393	9.2489
901	79.1970	96.0601	9.2489
902	44.1366	71.3894	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
903	49.6284	78.6599	9.2489
904	54.0926	96.0479	9.2489
905	21.3065	61.8915	9.2489
906	0.4381	29.4254	9.2489
907	20.7321	24.2374	9.2489
908	73.0537	69.2663	9.2489
909	26.3675	61.2448	9.2489
910	21.7053	21.6002	9.2489
911	27.3610	64.8453	9.2489
912	65.3474	72.8039	9.2489
913	5.9124	83.1077	9.2489
914	51.1226	42.0525	9.2489
915	61.5967	60.8657	9.2489
916	22.8159	48.6759	9.2489
917	8.8117	48.5050	9.2489
918	38.5718	69.2997	9.2489
919	57.5832	98.5570	9.2489
920	35.3969	60.0156	9.2489
921	28.7236	49.0681	9.2489
922	5.2093	90.5033	9.2489
923	24.7044	26.1237	9.2489
924	16.2374	85.8701	9.2489
925	39.9123	41.2977	9.2489
926	30.7807	88.6774	9.2489
927	33.7199	84.5665	9.2489
928	78.9213	50.4135	9.2489
929	50.7844	76.1250	9.2489
930	36.9364	55.8048	9.2489
931	48.9135	54.7775	9.2489
932	20.7502	68.8208	9.2489
933	4.6928	58.0805	9.2489
934	67.1079	49.8065	9.2489
935	24.0084	69.2667	9.2489
936	86.3740	99.0292	9.2489
937	34.1513	57.3793	9.2489
938	55.5513	39.2153	9.2489
939	61.6783	82.5197	9.2489
940	78.8555	52.0414	9.2489
941	18.6594	93.9062	9.2489
942	42.4583	25.0181	9.2489
943	44.9441	36.2858	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
944	10.1680	51.0208	9.2489
945	69.8043	81.6082	9.2489
946	20.3745	52.9258	9.2489
947	0.7939	65.0080	9.2489
948	50.2039	81.9545	9.2489
949	71.8526	57.8562	9.2489
950	67.2781	56.7922	9.2489
951	18.7431	29.3024	9.2489
952	1.4520	80.8724	9.2489
953	47.3831	49.7186	9.2489
954	21.1655	75.9293	9.2489
955	51.4448	86.5947	9.2489
956	9.0889	70.5778	9.2489
957	18.2147	45.6508	9.2489
958	21.6088	73.6490	9.2489
959	86.5185	50.7156	9.2489
960	53.2647	92.1753	9.2489
961	2.8878	89.8019	9.2489
962	29.0554	78.8440	9.2489
963	9.7018	81.2314	9.2489
964	20.5309	55.6362	9.2489
965	28.6603	61.1318	9.2489
966	6.6689	38.8057	9.2489
967	63.0451	24.2986	9.2489
968	31.6550	99.4688	9.2489
969	48.8625	99.4418	9.2489
970	70.3628	70.3940	9.2489
971	4.9535	23.8151	9.2489
972	56.2033	63.0964	9.2489
973	26.6524	66.9167	9.2489
974	0.2999	68.5196	9.2489
975	77.8700	52.2111	9.2489
976	52.4538	66.1794	9.2489
977	3.5540	91.3872	9.2489
978	11.1781	66.0777	9.2489
979	24.6656	67.5861	9.2489
980	13.2177	55.1607	9.2489
981	14.0238	94.5577	9.2489
982	37.3514	99.5759	9.2489
983	74.0768	69.1633	9.2489
984	40.7698	74.9435	9.2489

Continued on next page

Table D.14 – *Continued from previous page*

Customer index	x-coordinate	y-coordinate	Service range
985	83.5593	59.6475	9.2489
986	57.3566	43.7146	9.2489
987	85.2298	8.7159	9.2489
988	54.9097	93.3080	9.2489
989	20.9795	58.6686	9.2489
990	9.9848	87.6087	9.2489
991	80.8442	99.9885	9.2489
992	61.4907	91.4052	9.2489
993	10.7809	34.0837	9.2489
994	49.3815	71.8463	9.2489
995	59.0918	73.4479	9.2489
996	1.6629	98.2148	9.2489
997	38.7282	43.6440	9.2489
998	12.9785	40.6655	9.2489
999	5.0657	76.4183	9.2489
1000	62.6131	94.2939	9.2489
Depot	80.0000	20.0000	N.A.

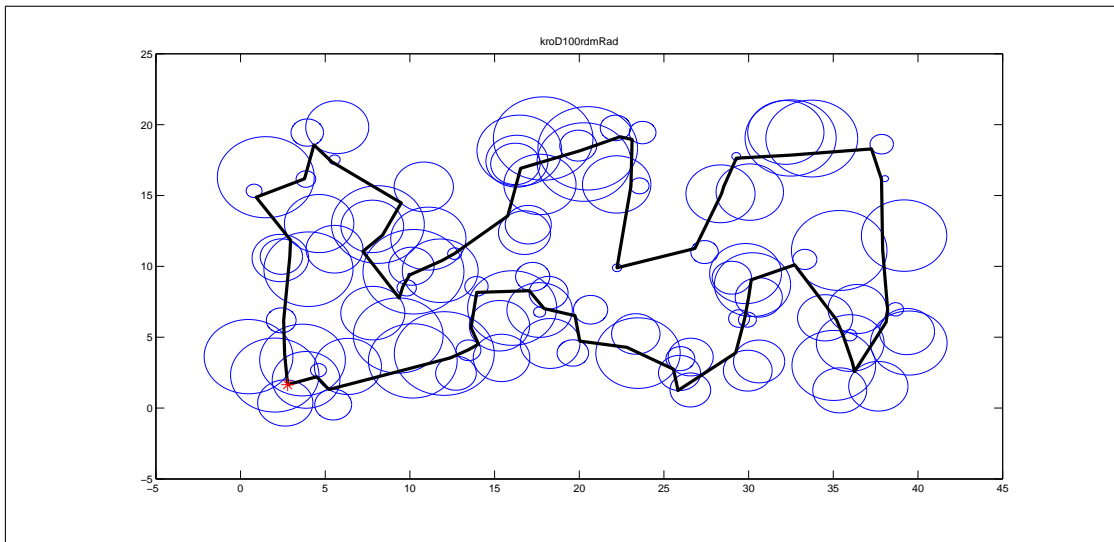


Figure D.1: Solution to kroD100rdmRad produced by MMSZ

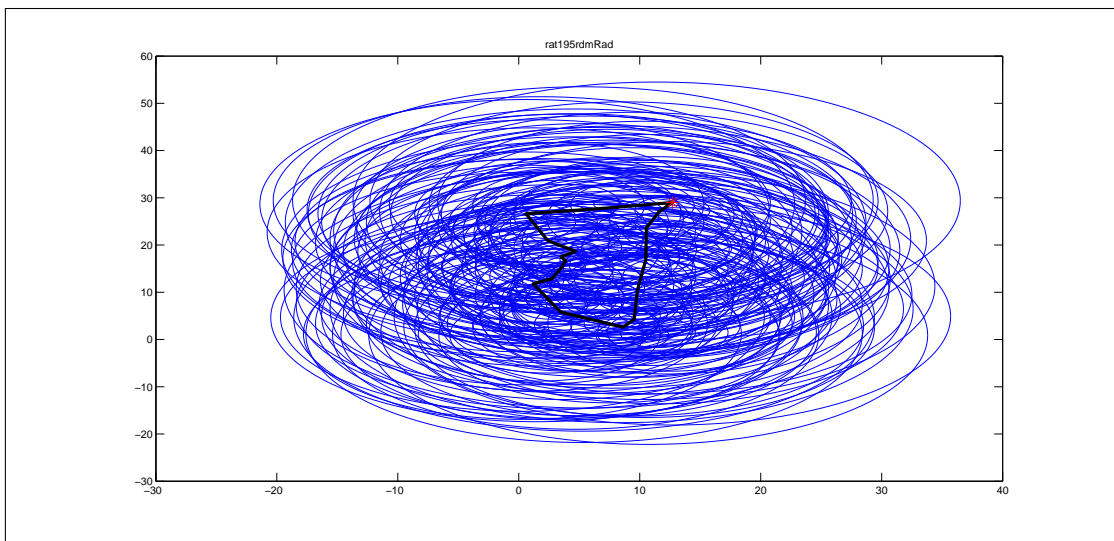


Figure D.2: Solution to rat195rdmRad produced by MMSZ

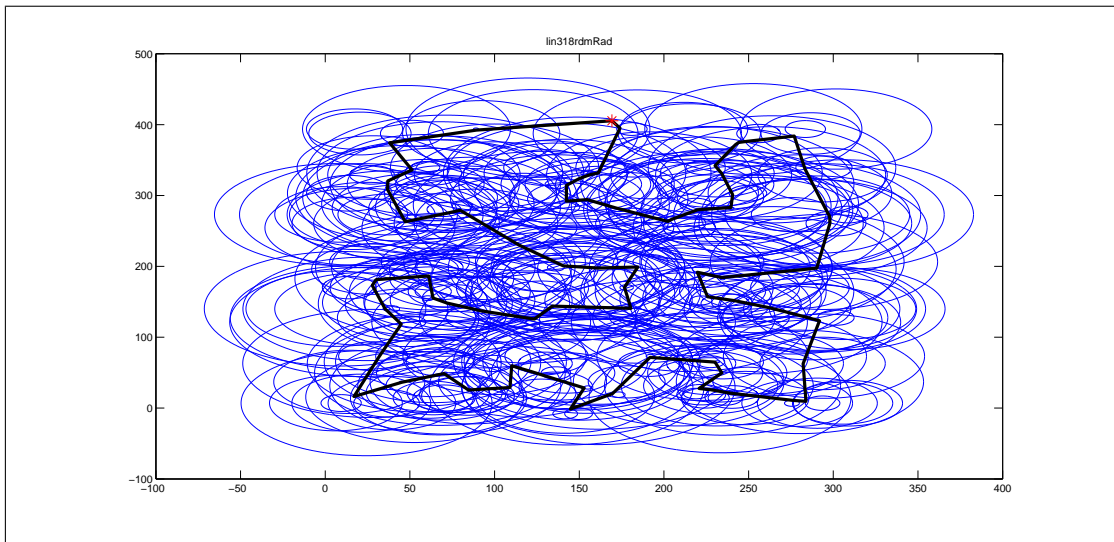


Figure D.3: Solution to lin318rdmRad produced by MMSZ

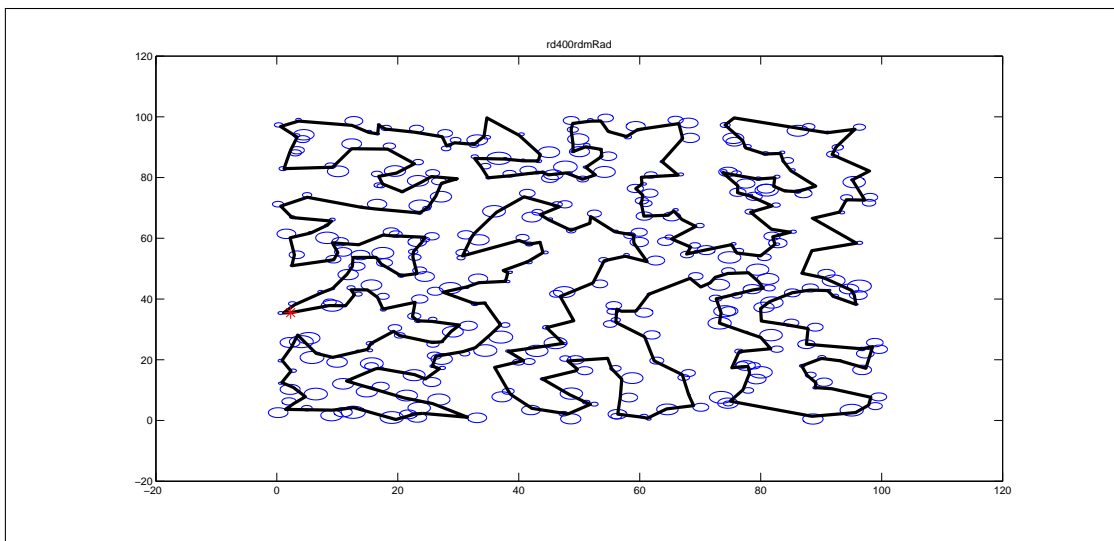


Figure D.4: Solution to rd400rdmRad produced by MMSZ

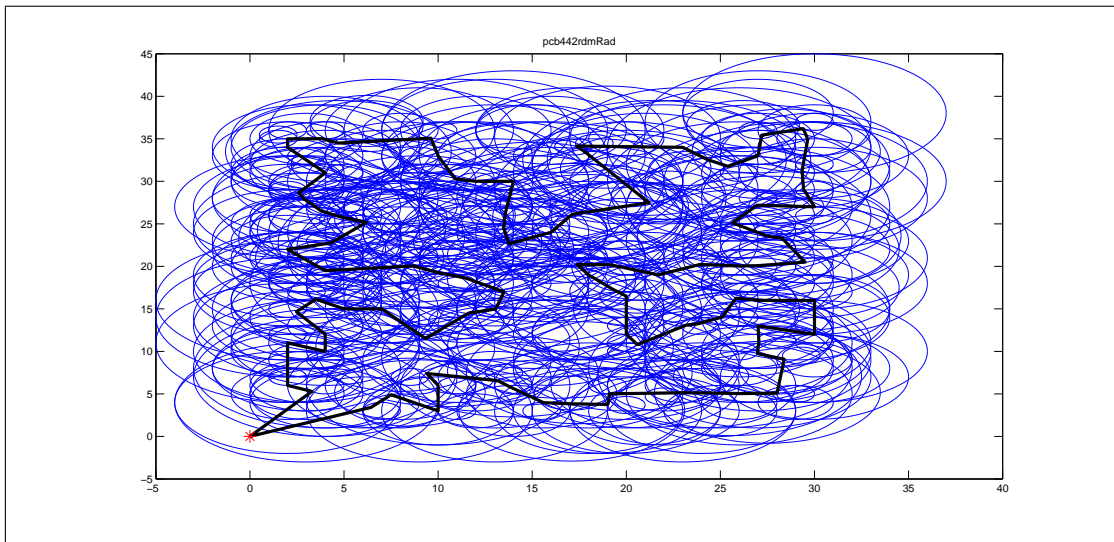


Figure D.5: Solution to pcb442rdmRad produced by MMSZ

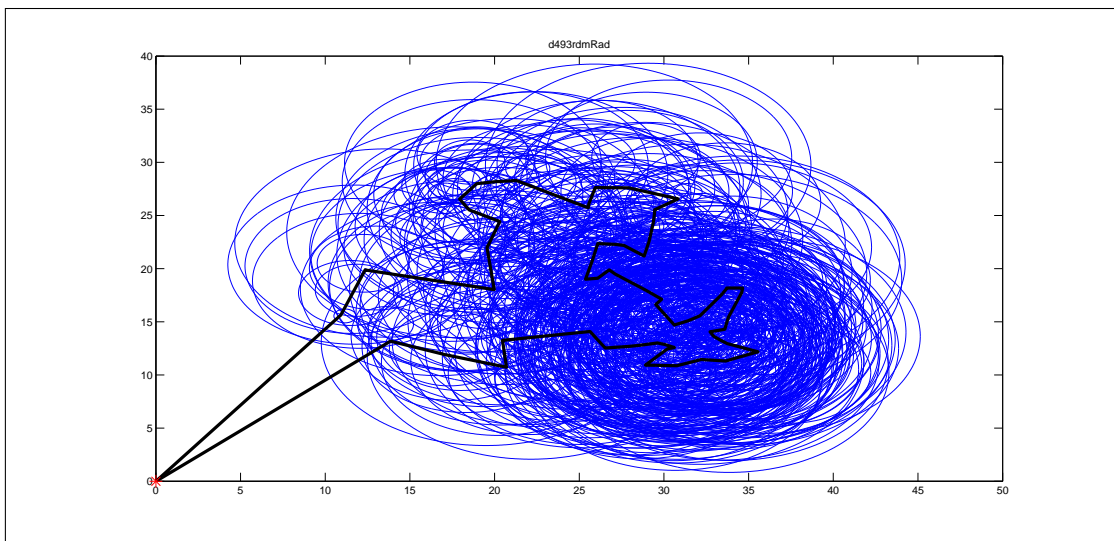


Figure D.6: Solution to d493rdmRad produced by MMSZ

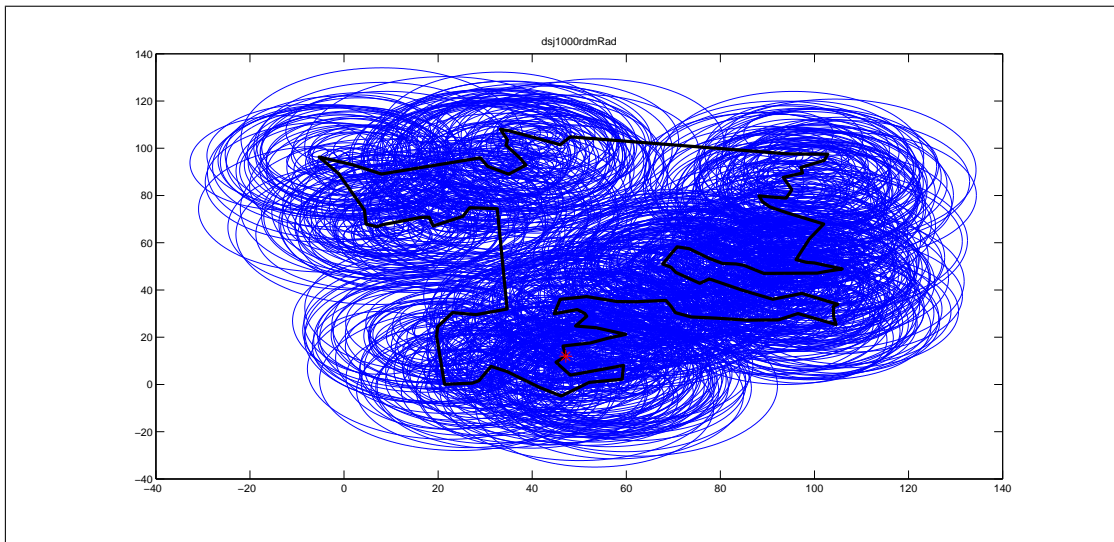


Figure D.7: Solution to dsj1000rdmRad produced by MMSZ

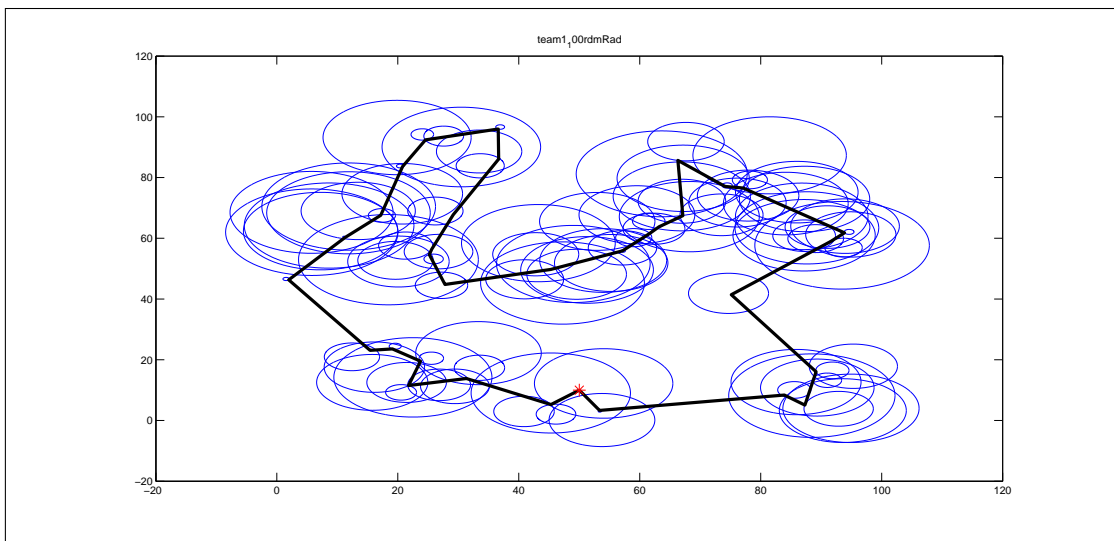


Figure D.8: Solution to team1_100rdmRad produced by MMSZ

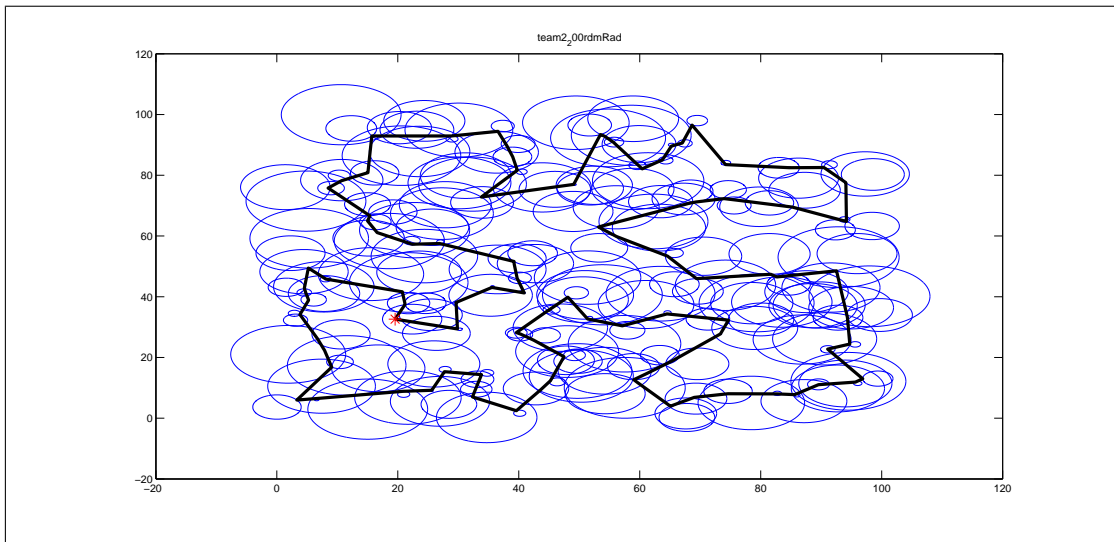


Figure D.9: Solution to team2_200rdmRad produced by MMSZ

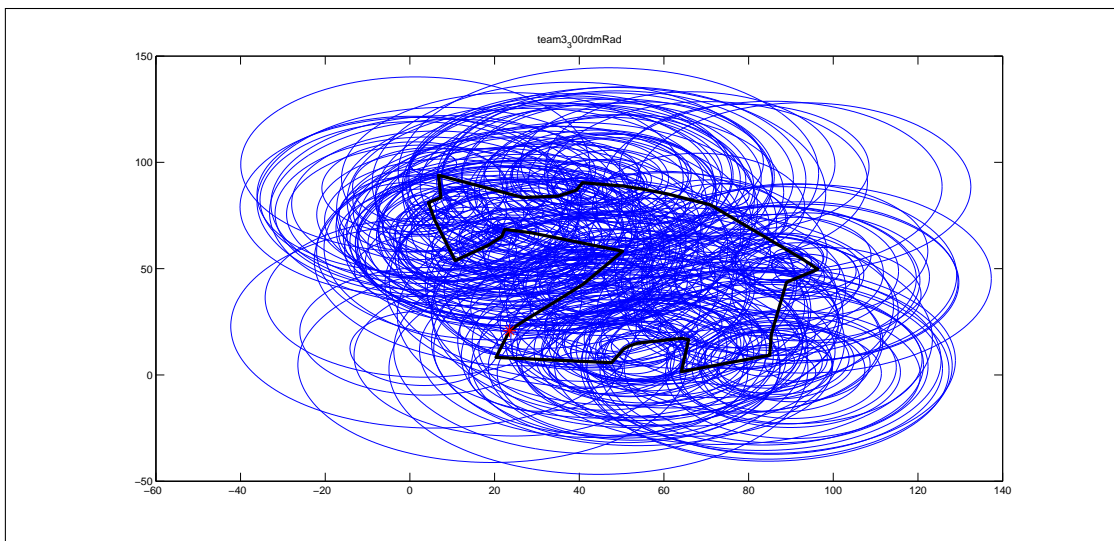


Figure D.10: Solution to team3_300rdmRad produced by MMSZ

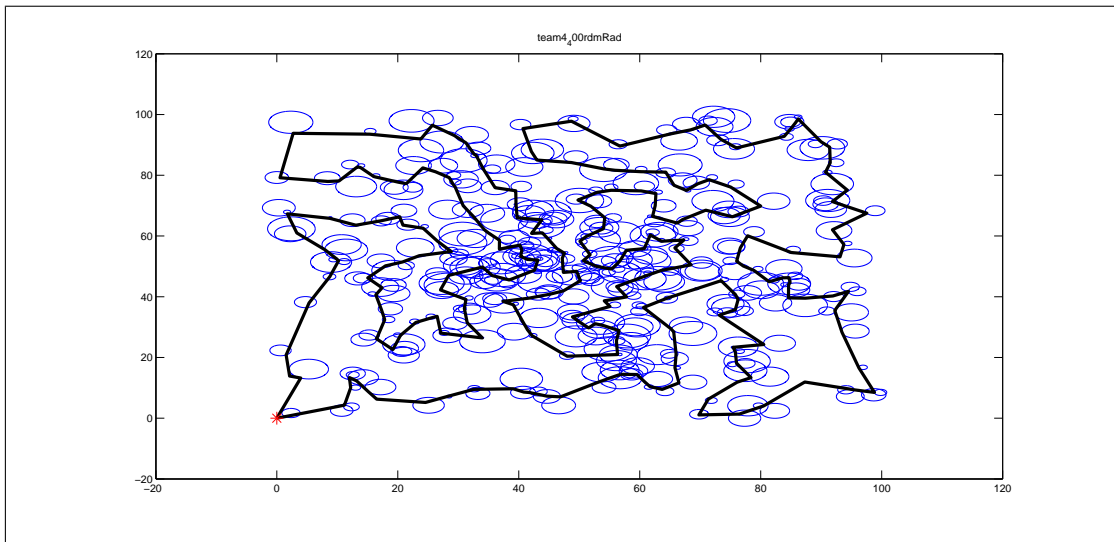


Figure D.11: Solution to team4_400rdmRad produced by MMSZ

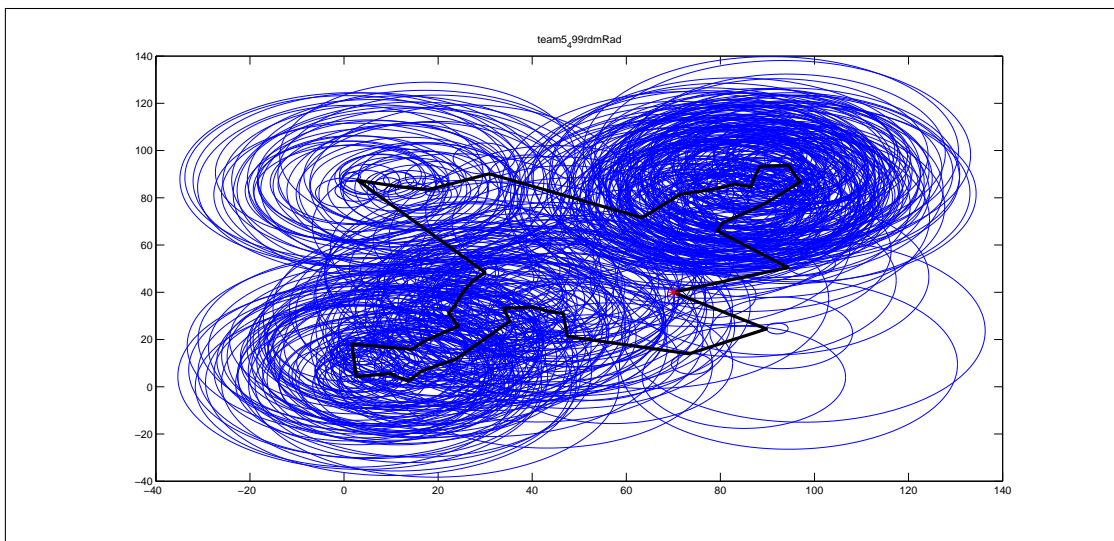


Figure D.12: Solution to team5_499rdmRad produced by MMSZ

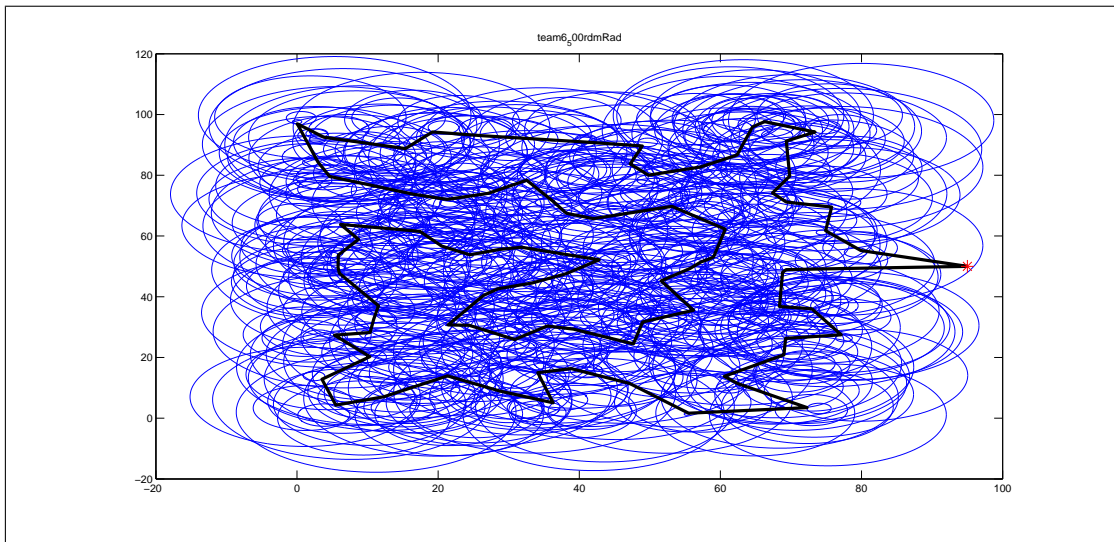


Figure D.13: Solution to team6_500rdmRad produced by MMSZ

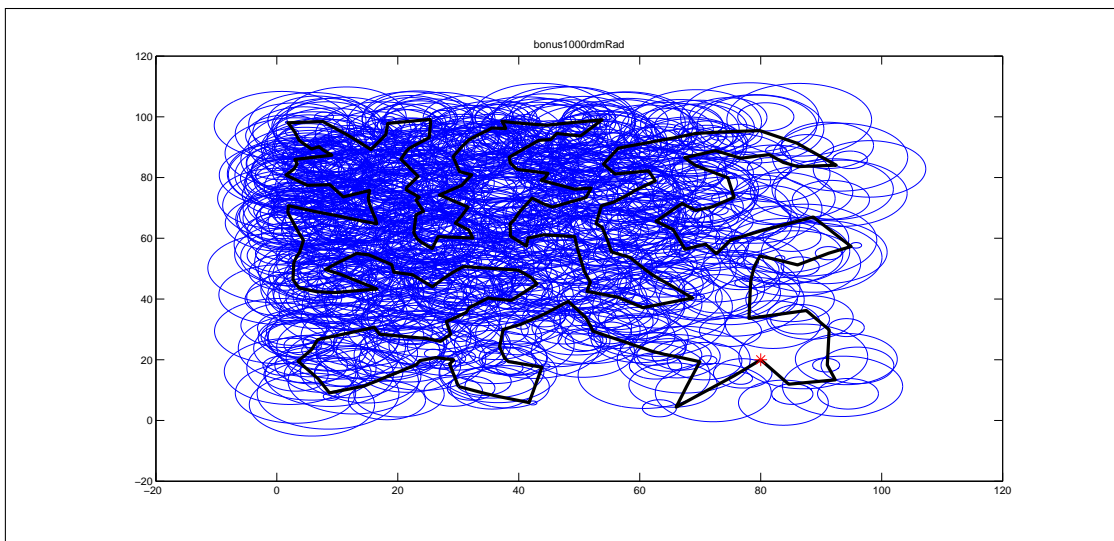


Figure D.14: Solution to bonus1000rdmRad produced by MMSZ

Bibliography

- [1] AGATZ, N., BOUMAN, P., AND SCHMIDT, M. Optimization approaches for the truck and drone delivery problem. Presented at the INFORMS TSL Workshop, Berlin, July 8, 2015.
- [2] ANDERSSON, H., HOFF, A., CHRISTIANSEN, M., HASLE, G., AND LØOKKETANGEN, A. Industrial aspects and literature survey: Combined inventory management and routing. *Computers & Operations Research* 37, 9 (2010), 1515 – 1536.
- [3] APPLGATE, D., COOK, W., DASH, S., AND ROHE, A. Solution of a min-max vehicle routing problem. *INFORMS Journal on Computing* 14, 2 (2002), 132–143.
- [4] ARCHETTI, C., SAVELSBERGH, M. W., AND SPERANZA, M. G. To split or not to split: That is the question. *Transportation Research Part E: Logistics and Transportation Review* 44, 1 (2008), 114 – 123.
- [5] ARCHETTI, C., SAVELSBERGH, M. W. P., AND SPERANZA, M. G. Worst-case analysis for split delivery vehicle routing problems. *Transportation Science* 40, 2 (2006), pp. 226–234.
- [6] ARCHETTI, C., AND SPERANZA, M. G. Vehicle routing problems with split deliveries. *International transactions in operational research* 19, 1-2 (2012), 3 – 22.
- [7] AVERBAKH, I., AND BERMAN, O. A heuristic with worst-case analysis for minimax routing of two travelling salesmen on a tree. *Discrete Appl. Math.* 68, 1-2 (June 1996), 17–32.
- [8] BALDACCI, R., CHRISTOFIDES, N., AND MINGOZZI, A. An exact algorithm for the vehicle routing problem based on the set partitioning formulation with additional cuts. *Mathematical Programming* 115, 2 (2008), 351–385.

- [9] BALDACCI, R., MINGOZZI, A., AND ROBERTI, R. New route relaxation and pricing strategies for the vehicle routing problem. *Operations Research* 59, 5 (2011), 1269–1283.
- [10] BALDACCI, R., MINGOZZI, A., AND ROBERTI, R. Recent exact algorithms for solving the vehicle routing problem under capacity and time window constraints. *European Journal of Operational Research* 218, 1 (2012), 1 – 6.
- [11] BALDACCI, R., TOTH, P., AND VIGO, D. Recent advances in vehicle routing exact algorithms. *4OR* 5, 4 (2007), 269–298.
- [12] BBC NEWS. Amazon testing drones for deliveries, December 2, 2013. <http://www.bbc.com/news/technology-25180906>.
- [13] BERBEGLIA, G., CORDEAU, J., GRIBKOVSKAIA, I., AND LAPORTE, G. Static pickup and delivery problems: a classification scheme and survey. *TOP* 15, 1 (2007), 1–31.
- [14] BERMINGHAM, F. Fedex researching drone delivery but not for widespread use, October 21, 2014. <http://www.ibtimes.co.uk/fedex-researching-drone-delivery-not-widespread-use-1471063>.
- [15] BERTAZZI, L., B., G., AND X., W. Min-max vs. min-sum vehicle routing: A worst-case analysis. *European Journal of Operational Research* 240, 2 (2015), 372–381.
- [16] BERTAZZI, L., AND SPERANZA, M. G. Inventory routing problems: an introduction. *EURO Journal on Transportation and Logistics* 1, 4 (2012), 307–326.
- [17] BERTAZZI, L., AND SPERANZA, M. G. Inventory routing problems with multiple customers. *EURO Journal on Transportation and Logistics* 2, 3 (2013), 255–275.
- [18] BRÄYSY, O., AND GENDREAU, M. Vehicle routing problem with time windows, part i: Route construction and local search algorithms. *Transportation Science* 39, 1 (2005), 104–118.
- [19] BRÄYSY, O., AND GENDREAU, M. Vehicle routing problem with time windows, part ii: Metaheuristics. *Transportation Science* 39, 1 (2005), 119–139.
- [20] CACERES-CRUZ, J., ARIAS, P., GUIMARANS, D., RIERA, D., AND JUAN, A. A. Rich vehicle routing problem: Survey. *ACM Computing Surveys* 47, 2 (Dec. 2014), 32:1–32:28.
- [21] CAMPBELL, A. M., VANDENBUSSCHE, D., AND HERMANN, W. Routing for relief efforts. *Transportation Science* 42, 2 (2008), 127–145.

- [22] CAMPBELL, A. M., AND WILSON, J. H. Forty years of periodic vehicle routing. *Networks* 63, 1 (2014), 2–15.
- [23] CARLSSON, J., GE, D., SUBRAMANIAM, A., WU, A., AND YE, Y. Solving min-max multi-depot vehicle routing problem. *Fields Inst. Commun* 55 (2009), 31–46.
- [24] CARRABS, F., CERRONE, C., CERULLI, R., AND GAUDIOSO, M. Upper and lower bounds for the close enough traveling salesman problem. Working paper.
- [25] CHEN, S., GOLDEN, B., AND WASIL, E. The split delivery vehicle routing problem: Applications, algorithms, test problems, and computational results. *Networks* 49, 4 (2007), 318–329.
- [26] CHRISTOFIDES, N., MINGOZZI, A., AND TOTH, P. Exact algorithms for the vehicle routing problem, based on spanning tree and shortest path relaxations. *Mathematical Programming* 20, 1 (1981), 255–282.
- [27] CHRISTOFIDES, N., MINGOZZI, A., AND TOTH, P. State-space relaxation procedures for the computation of bounds to routing problems. *Networks* 11, 2 (1981), 145–164.
- [28] CLARKE, G., AND WRIGHT, J. W. Scheduling of vehicles from a central depot to a number of delivery points. *Operations Research* 12, 4 (1964), 568–581.
- [29] CODENOTTI, B., MANZINI, G., MARGARA, L., AND RESTA, G. Perturbation: An efficient technique for the solution of very large instances of the Euclidean TSP. *INFORMS Journal on Computing* 8, 2 (1996), 125–133.
- [30] COOK, W. Concorde TSP solver, 2003. <http://www.math.uwaterloo.ca/tsp/concorde/index.html>.
- [31] CORBERÁN, A., AND PRINS, C. Recent results on arc routing problems : An annotated bibliography. *Networks* 56, 1 (2010), 50–32:69.
- [32] COUTINHO, W., DO NASCIMENTO, R., PESSOA, A., AND SUBRAMANIAM, A. A branch-and-bound algorithm for the close-enough traveling salesman problem. submitted to *Transportation Science*.
- [33] CUDA, R., G., G., AND SPERANZA, M. A survey on two-echelon routing problems. *Computers & Operations Research* 55 (2015), 185 – 199.
- [34] DANTZIG, G. B., AND RAMSER, J. H. The truck dispatching problem. *Management Science* 6, 1 (1959), 80–91.

- [35] DHL PRESS RELEASE. DHL parcelcopter launches initial operations for research purposes, September 24, 2014. http://www.dhl.com/en/press/releases/releases_2014/group/dhl_parcelcopter_launches_initial_operations_for_research_purposes.html.
- [36] DREXL, M. Rich vehicle routing in theory and practice. *Logistics Research* 5, 1-2 (2012), 47–63.
- [37] DREXL, M. Synchronization in vehicle routing: a survey of vrps with multiple synchronization constraints. *Transportation Science* 46, 3 (2012), 297–316.
- [38] DROR, M., AND TRUDEAU, P. Split delivery routing. *Naval Research Logistics (NRL)* 37, 3 (1990), 383–402.
- [39] EKSIÖGLU, B., VOLKAN, A. V., AND REISMAN, A. The vehicle routing problem: A taxonomic review. *Computers & Industrial Engineering* 57, 4 (2009), 1472 – 1483.
- [40] FRANÇA, P. M., GENDREAU, M., LAPORTE, G., AND MÜLLER, F. M. The m-traveling salesman problem with minmax objective. *Transportation Science* 29, 3 (1995), 267–275.
- [41] FUKASAWA, R., LONGO, H., LYSGAARD, J., ARAGÃO, D. M. P., REIS, M., UCHOA, E., AND WERNECK, F. R. Robust branch-and-cut-and-price for the capacitated vehicle routing problem. *Mathematical Programming* 106, 3 (2006), 491–511.
- [42] FUNKE, B., GRÜNERT, T., AND IRNICH, S. Local search for vehicle routing and scheduling problems: Review and conceptual integration. *Journal of Heuristics* 11, 4 (2005), 267–306.
- [43] GAMBELLA, C., LODI, A., AND VIGO, D. Exact methods for solving the carrier-vehicle traveling salesman problem (CVTSP). Presented at VeRoLog Meeting, Vienna, June 8, 2015.
- [44] GENDREAU, M., GHIANI, G., AND GUERRIERO, E. Time-dependent routing problems: A review. *Computers & Operations Research* 64 (2015), 189 – 197.
- [45] GOLDEN, B., RAGHAVAN, S., AND WASIL, E. *The Vehicle Routing Problem: Latest Advances and New Challenges*. Operations Research/Computer Science Interfaces Series. Springer, 2008.
- [46] GOLDEN, B., RAGHAVAN, S., AND WASIL, E. *The Vehicle Routing Problem: Latest Advances and New Challenges: latest advances and new challenges*. Operations Research/Computer Science Interfaces Series. Springer, 2008.
- [47] GOLDEN, B. L., MAGNANTI, T. L., AND NGUYEN, H. Q. Implementing vehicle routing algorithms. *Networks* 7, 2 (1977), 113–148.

- [48] GROËR, C., GOLDEN, B., AND WASIL, E. A library of local search heuristics for the vehicle routing problem. *Mathematical Programming Computation* 2, 2 (2010), 79–101.
- [49] GULCZYNSKI, D., GOLDEN, B., AND WASIL, E. The split delivery vehicle routing problem with minimum delivery amounts. *Transportation Research Part E: Logistics and Transportation Review* 46, 5 (2010), 612 – 626.
- [50] GULCZYNSKI, D., GOLDEN, B., AND WASIL, E. The multi-depot split delivery vehicle routing problem: An integer programming-based heuristic, new test problems, and computational results. *Computers & Industrial Engineering* 61, 3 (2011), 794 – 804.
- [51] GULCZYNSKI, D. J., HEATH, J. W., AND PRICE, C. C. *Perspectives in Operations Research: Papers in Honor of Saul Gass’ 80th Birthday*. Springer US, Boston, MA, 2006, ch. The Close Enough Traveling Salesman Problem: A Discussion of Several Heuristics, pp. 271–283.
- [52] GUROBI OPTIMIZATION, INC. Gurobi optimizer reference manual, 2014. <http://www.gurobi.com>.
- [53] GUROBI OPTIMIZATION, INC. Gurobi optimizer reference manual, 2014. <http://www.gurobi.com>.
- [54] HANSEN, P., AND MLADENOVIĆ, N. Variable neighborhood search: Principles and applications. *European Journal of Operational Research* 130, 3 (2001), 449 – 467.
- [55] HELSGAUN, K. LKH TSP solver, 2012. <http://www.akira.ruc.dk/~keld/research/LKH>.
- [56] HELSGAUN, K. LKH TSP solver, 2012. <http://www.akira.ruc.dk/~keld/research/LKH>.
- [57] HERTZ, A. Recent trends in arc routing. In *Graph Theory, Combinatorics and Algorithms*, M. Golumbic and I. Hartman, Eds., vol. 34 of *Operations Research/Computer Science Interfaces Series*. Springer US, 2005, pp. 215–236.
- [58] HUANG, M., SMILOWITZ, K., AND BALCIK, B. Models for relief routing: Equity, efficiency and efficacy. *Transportation Research Part E: Logistics and Transportation Review* 48, 1 (2012), 2 – 18.
- [59] IORI, M., AND MARTELLO, S. Review an annotated bibliography of combined routing and loading problems. *Yugosla Journal of Operations Research* 23, 3 (2013), 311 – 326.
- [60] JOZEFOWIEZ, N., SEMET, F., AND TALBI, E. Multi-objective vehicle routing problems. *European Journal of Operational Research* 189, 2 (2008), 293 – 309.

- [61] KORF, R. E. Multi-way number partitioning. In *Proceedings of the 21st International Joint Conference on Artificial Intelligence* (2009), IJCAI'09, pp. 538–543.
- [62] KRITZINGER, S., DOERNER, K., TRICOIRE, F., AND HARTL, R. Adaptive search techniques for problems in vehicle routing, part i: A survey. *Yugoslav Journal of Operations Research* 25, 1 (2015), 3 – 31.
- [63] KRITZINGER, S., DOERNER, K., TRICOIRE, F., AND HARTL, R. H. Adaptive search techniques for problems in vehicle routing, part ii: A numerical comparison. *Yugoslav Journal of Operations Research* 25, 2 (2015), 169 – 184.
- [64] LAPORTE, G. What you should know about the vehicle routing problem. *Naval Research Logistics* 54, 8 (2007), 811 – 819.
- [65] LAPORTE, G. Fifty years of vehicle routing. *Transportation Science* 43, 4 (2009), 408 – 416.
- [66] LAPORTE, G., AND MARTN, I. R. Locating a cycle in a transportation or a telecommunications network. *Networks* 50, 1 (2007), 92–108.
- [67] LAPORTE, G., TOTH, P., AND VIGO, D. Vehicle routing: historical perspective and recent contributions. *EURO Journal on Transportation and Logistics* 2, 1 (2013), 1–4.
- [68] LIN, C., CHOY, K., HO, G., CHUNG, S., AND LAM, H. Survey of green vehicle routing problem: Past and future trends. *Expert Systems with Applications* 41, 4, Part 1 (2014), 1118 – 1138.
- [69] MARINAKIS, Y., AND MIDGDALAS, A. Annotated bibliography in vehicle routing. *Operational Research* 7, 1 (2007), 27 – 46.
- [70] MENNELL, W. K. *Heuristics for Solving Three Routing Problems: Close-Enough Traveling Salesman Problem, Close-Enough Vehicle Routing Problem, Sequence-Dependent Team Orienteering Problem*. PhD thesis, University of Maryland, College Park, College Park, 2009.
- [71] MURRAY, C. C., AND CHU, A. G. The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery. *Transportation Research Part C: Emerging Technologies* 54 (2015), 86 – 109.
- [72] NAGY, G., AND SALHI, S. Location-routing: Issues, models and methods. *European Journal of Operational Research* 177, 2 (2007), 649 – 672.
- [73] NARASIMHA, K. V., KIVELEVITCH, E., SHARMA, B., AND KUMAR, M. An ant colony optimization technique for solving min-max multi-depot vehicle routing problem. *Swarm and Evolutionary Computation* 13 (2013), 63 – 73.

- [74] PARK, J., AND KIM, B. The school bus routing problem: A review. *European Journal of Operational Research* 202, 2 (2010), 311 – 319.
- [75] PILLAC, V., GENDREAU, M., GUÉRET, C., AND MEDAGLIA, A. L. A review of dynamic vehicle routing problems. *European Journal of Operational Research* 225, 1 (2013), 1 – 11.
- [76] PISINGER, D., AND ROPKE, S. A general heuristic for vehicle routing problems. *Computers & Operations Research* 34, 8 (2007), 2403 – 2435.
- [77] POPPER, B. Drones could make Amazon’s dream of free delivery profitable, June 3, 2015. <http://www.theverge.com/2015/6/3/8719659/amazon-prime-air-drone-delivery-profit-free-shipping-small-items>.
- [78] POTVIN, J. State-of-the art review evolutionary algorithms for vehicle routing. *INFORMS Journal on Computing* 21, 4 (2009), 518–548.
- [79] PRODHON, C., AND PRINS, C. A survey of recent research on location-routing problems. *European Journal of Operational Research* 238, 1 (2014), 1 – 17.
- [80] REN, C. Solving min-max vehicle routing problem. *Journal of Software* 6, 9 (2011), 1851 – 1856.
- [81] RITZINGER, U., PUCHINGER, J., AND HARTL, R. F. A survey on dynamic and stochastic vehicle routing problems. *International Journal of Production Research* (To appear).
- [82] ROSE, C. Amazon’s Jeff Bezos looks to the future, December 1, 2013. <http://www.cbsnews.com/news/amazons-jeff-bezos-looks-to-the-future/>.
- [83] SAREEN, S. Intersection of n circles. <http://stackoverflow.com/questions/20265527/intersection-of-n-circles>. Accessed: 2016-05-18.
- [84] SCHRIMPF, G., SCHNEIDER, J., STAMM-WILBRANDT, H., AND DUECK, G. Record breaking optimization results using the ruin and recreate principle. *Journal of Computational Physics* 159, 2 (2000), 139 – 171.
- [85] SHUTTLEWORTH, R., GOLDEN, B. L., SMITH, S., AND WASIL, E. Advances in meter reading: Heuristic solution of the close enough traveling salesman problem over a street network. In *The Vehicle Routing Problem: Latest Advances and New Challenges*, B. Golden, S. Raghavan, and E. Wasil, Eds. Springer, New York, 2008, pp. 487–501.
- [86] TARJAN, R. Depth-first search and linear graph algorithms. *SIAM Journal on Computing* 1, 2 (1972), 146–160.
- [87] THOMPSON, P. M., AND PSARAFTIS, H. N. Cyclic transfer algorithm for multivehicle routing and scheduling problems. *Operations Research* 41, 5 (1993), 935–946.

- [88] TOTH, P., AND VIGO, D., Eds. *The Vehicle Routing Problem*. Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, 2002.
- [89] TOTH, P., AND VIGO, D. *Vehicle Routing: Problems, Methods, and Applications*. Society for Industrial and Applied Mathematics (SIAM, 3600 Market Street, Floor 6, Philadelphia, PA 19104), Philadelphia, PA, 2014.
- [90] TOTH, P., AND VIGO, D. *Vehicle Routing: Problems, Methods, and Applications*. Society for Industrial and Applied Mathematics (SIAM, 3600 Market Street, Floor 6, Philadelphia, PA 19104), 2014.
- [91] VANSTEENWEGEN, P., W., S., AND OUDHEUSDEND., V. The orienteering problem: A survey. *European Journal of Operational Research* 209, 1 (2011), 1 – 10.
- [92] VIDAL, T., CRAINIC, T. G., GENDREAU, M., AND PRINS, C. A unified solution framework for multi-attribute vehicle routing problems. *European Journal of Operational Research* 234, 3 (2014), 658 – 673.
- [93] WANG, X., BATTARRA, M., AND GOLDEN, B. Vehicle routing and scheduling. In *Routledge Handbook of Transportation*, D. Teodorović, Ed. Routledge, New York, 2016, pp. 238–256.
- [94] WANG, X., GOLDEN, B., AND WASIL, E. The min-max multi-depot vehicle routing problem. *Journal of Operational Research Society* 66, 9 (2015), 1430–1441.
- [95] WANG, X., GOLDEN, B., WASIL, E., AND ZHANG, R. The min-max split delivery multi-depot vehicle routing problem with minimum service time requirement. *Computers & Operations Research* 71 (2016), 110 – 126.
- [96] WANG, X., GOLDEN, B., WASIL, E., AND ZHANG, R. The minmax split delivery multi-depot vehicle routing problem with minimum service time requirement. *Computers & Operations Research* 71 (2016), 110 – 126.
- [97] WØHLK, S. A decade of capacitated arc routing. In *The Vehicle Routing Problem: Latest Advances and New Challenges*, B. Golden, S. Raghavan, and E. Wasil, Eds., vol. 43 of *Operations Research/Computer Science Interfaces*. Springer US, 2008, pp. 29–48.
- [98] WOTTAWA, M. Vrplib – a library of capacitated vehicle routing problems, 2004. <http://elib.zib.de/pub/Packages/mp-testdata/vehicle-rout/vrplib/>.
- [99] YAKICI, E., AND KARASAKAL, O. A min–max vehicle routing problem with split delivery and heterogeneous demand. *Optimization Letters* 7, 7 (2012), 1611–1625.

- [100] YE, Y. LP-based load balancing implementation using MATLAB. <http://www.stanford.edu/class/msande310/LP-TSP.zip>.