Supplement for the project: Advanced Algorithmics on test instances

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1 Introduction

This document presents a summary of Vehicle Routing Problems (VRP) based on the analysis of the CVRPLIB library[1], an international reference for benchmarks and test instances in the field of vehicle routing optimization.

2 VRP problems summary table

Problem Type	Constraints	Objectives	Instance Examples	Reference Solutions
CVRP (Capacitated Vehicle Routing Problem)	• Limited vehicle capacity (Q) • Number of available vehicles (K) • Number of customers to serve (n) • Departure and return to depot	Minimize total distance traveled or total route cost	• A-n32-k5 • B-n31-k5 • E-n51-k5 • M-n101-k10 • CMT1	• 784 (opt) • 672 (opt) • 521 (opt) • 820 (opt) • 524.61 (opt)
VRPTW (Vehicle Routing Problem with Time Windows)	• All CVRP constraints • Time windows for each customer • Respect delivery time slots	Minimize total cost while respecting temporal constraints	• C101 • R101 • RC101 • C1_2_1 • R1_2_1	• 827.3 (opt) • 1637.7 (opt) • 1619.8 (opt) • 2698.6 (opt) • 4667.2 (opt)

3 Benchmark collections

The CVRPLIB site organizes instances by internationally recognized collections:

[1] `https://vrp.atd-lab.inf.puc-rio.br/index.php/en/`

3.1 CVRP - Main collections

- **Set A, B, P** (Augerat, 1995): Classic instances with 31 to 101 customers
- **Set E** (Christofides and Eilon, 1969): Historical reference instances
- **Set F** (Fisher, 1994): Instances with varied capacity constraints
- **Set M** (Christofides, Mingozzi and Toth, 1979): Medium to large-scale instances
- **CMT** (Christofides, Mingozzi and Toth, 1979): 14 reference instances
- **Golden et al.** (1998): Large-scale instances (200-483 customers)
- **Uchoa et al.** (2014): Modern instances (100-1000 customers)

3.2 VRPTW - Main collections

- **Solomon** (1987): 56 reference instances with 100 customers
- **Homberger and Gehring** (1999): Extensions to 200, 400 and 600 customers

4 Instance parameters

Each instance is characterized by:

- **n**: Number of customers to serve
- **K**: Number of available vehicles
- **Q**: Capacity of each vehicle
- **UB**: Best known solution value (Upper Bound)
- **Opt**: Indication if the solution is optimal (yes/no)

5 Examples of large instances

Instance	Customers (n)	Vehicles (K)	Capacity (Q)	Best sol (UB)	Constraint types
Golden_1	240	9	550	5623.47	**Moderate capacity**, **Restricted vehicle number**, Geographic distribution, Variable demand
Golden_3	400	9	900	10997.8	**High capacity**, **Very restricted vehicle number**, Large scale, Optimal partitioning
Li_32	1200	11	2500	37159.41	**Very high capacity**, **Minimal vehicle number**, Very large scale, Geographic clustering
X-n1001-k43	1000	43	131	72355	**Low capacity**, **Moderate vehicle number**, Large scale, Load-distance balancing
tai385	385	46	65	24366.41	**Very low capacity**, **High vehicle number**, Mandatory short routes, Local optimization

Instance	Customers (n)	Vehicles (K)	Capacity (Q)	Best sol (UB)	Constraint types
Loggi-n1001-k31	1000	31	180	284356	**Moderate capacity**, **Restricted vehicle number**, Industrial instance, Real constraints
Antwerp2	7000	N/S	N/S	291350	**Real geographic data**, Very large scale, Scalability test, Urban constraints
Flanders2	30000	N/S	N/S	4373244	**Exceptional scale**, Real geographic data, Maximum scalability test
X-n219-k73	218	73	3	117595	**Extremely low capacity**, **Very high vehicle number**, Dominant capacity constraint

Note: N/S = Not Specified in CVRPLIB tables for Arnold et al. (2017) instances

6 Constraint classification by type

6.1 Capacity constraints

- **Very low** ($Q \leq 65$): tai385, X-n219-k73 - Imposes many short routes
- **Low** ($65 < Q \leq 200$): X-n1001-k43, Loggi-n1001-k31 - Delicate balancing
- **Moderate** ($200 < Q \leq 1000$): Golden_1, Golden_3 - Design flexibility
- **High** ($Q > 1000$): Li_32 - Priority geographic optimization

6.2 Fleet constraints

- **Restricted number** ($K/n < 0.05$): Golden_3, Li_32 - Maximize vehicle utilization
- **Moderate number** ($0.05 \leq K/n \leq 0.15$): Golden_1, X-n1001-k43, Loggi-n1001-k31
- **High number** ($K/n > 0.15$): tai385, X-n219-k73 - Fine assignment optimization

6.3 Scale constraints

- **Medium scale** ($n \leq 500$): Golden_1, tai385, X-n219-k73
- **Large scale** ($500 < n \leq 2000$): Golden_3, X-n1001-k43, Li_32, Loggi-n1001-k31
- **Very large scale** ($n > 2000$): Antwerp2, Flanders2 - Major algorithmic challenges

7 References

1. CVRPLIB - Capacitated Vehicle Routing Problem Library. *Benchmark instances and best known solutions for Vehicle Routing Problems.* `https://vrp.atd-lab.inf.puc-rio.br/index.php/en/` (Accessed September 26, 2025)