# The VeRoLog Solver Challenge 2019

## Afbeelding met Graphics, schermopname, grafische vormgeving, symbool Automatisch gegenereerde beschrijving

Afbeelding met Frisdrank, persoon, automaat, kleding

Automatisch gegenereerde beschrijving

## Team A7

#### Vrije Universiteit

#### Combinatorial Optimization 23/24

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## Abstract

Last part to complete.

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## Introduction

## *The VeRoLog Solver 2019 challenge is a Vehicle Routing and Logistics problem that combines distribution and installation of equipment. The delivery of the machines is based on a customer-dependent window and the installation must be done by a qualified and available technician as soon as possible.*

*The vehicle routing problem was first introduced in 1959 as ”The Truck Dispatching Problem” where the paper was concerned with the optimum routing of a fleet of gasoline delivery trucks. In that paper the truck dispatching problem, formerly known as the vehicle routing problem, is considered as a generalization of the ”Traveling-Salesman Problem” [1].*

*The TSP problem is defined as a search problem: given an instance, try to find a tour within the budget. Furthermore, an algorithm for the search problem can also be used to solve the optimization problem. Turning an optimization problem into a search problem does not change its difficulty at all, because the two versions reduce to one another [2]*

## Literature review

*Broad VRP references:*

G.B. Dantzig and J.H. Ramser. “The Truck Dispatching Problem”. In: (1959)

T. Caric and H. Gold. Vehicle Routing Problem. 2008

N.A. El-Sherbeny. “Vehicle routing with time windows: An overview of exact, heuristic and metaheuristic methods”. In: (2010).

J. Turakhia, S. Gandhi, and C. DESAI. “Vehicle Routing Problem Optimization”. In: (2018).

Archetti, C., O. Jabali, and M. G. Speranza (2015). Multi-period vehicle routing problem with due dates. Computers & Operations Research 61, 122–134.

Larrain, H., Coelho, L. C., Archetti, C., & Speranza, M. G. (2019). Exact solution methods for the multi-period vehicle routing problem with due dates. Computers and Operations Research, 110, 148–158. https://doi.org/10.1016/j.cor.2019.05.026

Lenstra, J. K. and A. Rinnooy-Kan (1981). Complexity of vehicle routing and scheduling problems. Networks 11(2), 221–227.

*TSP:*

M. Mezard and G. Parisi. “A replica analysis of the travelling salesman problem”. In: (1986).

*Appointment scheduling*

*Verolog solver challenges*

R.A. Sitters and J.A. Dos Santos Gromicho. The VeRoLog Solver Challenge 2017. 2020.

Om de probleemstelling van een routing problem beter te begrijpen, zijn meerdere artikelen gelezen. Deze artikelen variëren van Vehicle Routing Problems, Traveler Salesman problems, tot specifiekere capaciteits vehicle routing problems met time windows. De laatste ligt de nadruk op voor ons onderzoek.

## Proof of NP-completeness

A distinguishing feature of decision problems lies in their verifiability, where proposed solutions can be efficiently checked for correctness. This verification process involves an algorithm C, which takes an instance I and a proposed solution S as inputs and outputs true only if S is indeed a solution to I. The running time of C(I,S) is bounded by a polynomial in |I|, the length of the instance. We denote the class of all decision problems by NP. [2] NP stands for “nondeterministic polynomial time”. This implies that a solution to any decision problem can be verified by an algorithm in polynomial time.

Mezard and Parisi (1986) [3] articulated NP-completeness as the absence of an algorithm capable of solving every instance of a problem in a time growing less than a power of N. They emphasized the improbability of discovering such an algorithm. A decision problem achieves NP-completeness when all other decision problems can be reduced to it. This reduction, from problem A to problem B, establishes that all problems in NP reduce to B via A [2].

The VeRoLog challenge introduces a new problem that requires a thorough examination within its unique domain. Upon analysis, it becomes apparent that this problem shares similarities with the Vehicle Routing Problem (VRP) first described by Dantzig and Ramser in 1959 [1]. However, the VeRoLog challenge extends the VRP by introducing additional constraints such as vehicle capacity limits, distance restrictions, and time windows for customer service. These extensions give rise to distinct problems such as the Capacitated Vehicle Routing Problem (CVRP), Distance-constrained Vehicle Routing Problem (DVRP), and Vehicle Routing Problem with Time Windows (VRPTW). Combining these extensions results in complex variants like the Multi-Period Capacitated Vehicle Routing Problem with Time Windows (MPCVRPTW), as noted by Archetti et al. in 2015 [4].

According to Lenstra and Rinnooy-Kan (1981), the Vehicle Routing Problem is NP-hard. This implies that all extensions are also NP-hard. Their study underscores the computational intractability of most vehicle routing and scheduling problems [5]. Given the VeRoLog problem's lineage as an extension of the NP-hard VRP, it follows that the VeRoLog problem itself is NP-hard.

## Strategy

Om het probleem te testen zijn meerdere tekst-files aangeleverd die als instances waren gedefinieerd. Deze instance files bevatten alle benodigde informatie die als input kan worden gebruikt om tot een oplossing te kunnen komen voor het probleem. In deze files is alle informatie gegeven voor de tools, de time-windows van de requests, het totale aantal dagen etc.

Elke instance heeft verschillende waardes voor de variabelen. Al deze variabelen worden ingelezen en gedefinieerd door het programma/model. Wanneer het model tot een feasible solution is gekomen, wordt een solution file geschreven met de specifieke routes per dag.

## Algorithm

## Performance

The table below denotes the objective values found by our algorithm.

|  |  |  |  |
| --- | --- | --- | --- |
| **Instance** | **Objective value** | **% above best-of-class** | **Run time** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |
| 13 |  |  |  |
| 14 |  |  |  |
| 15 |  |  |  |
| 16 |  |  |  |
| 17 |  |  |  |
| 18 |  |  |  |
| 19 |  |  |  |
| 20 |  |  |  |

## Result analysis

## Conclusion

## Roles and responsibilities of team members

## References

[1] G.B. Dantzig and J.H. Ramser. “The Truck Dispatching Problem”. In: (1959)

[2] S. Dasgupta, C.H. Papadimitriou, and U.V. Vazirani. Algorithms. 2006.

[3] M. Mezard and G. Parisi. “A replica analysis of the travelling salesman problem”. In: (1986).

[4] Archetti, C., O. Jabali, and M. G. Speranza (2015). Multi-period vehicle routing problem with due dates. Computers & Operations Research 61, 122–134.

*[5] Lenstra, J. K. and A. Rinnooy-Kan (1981). Complexity of vehicle routing and scheduling problems. Networks 11(2), 221–227*.

Jagtenberg CJ, Maclaren OJ, Mason AJ, Raith A, Shen K, Sundvick M. Columnwise neighborhood search: A novel set partitioning matheuristic and its application to the VeRoLog Solver Challenge 2019. *Networks.*. 2020; 76: 273–293.

Larrain, H., Coelho, L. C., Archetti, C., & Speranza, M. G. (2019). Exact solution methods for the multi-period vehicle routing problem with due dates. *Computers and Operations Research*, *110*, 148–158. https://doi.org/10.1016/j.cor.2019.05.026

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J. Turakhia, S. Gandhi, and C. DESAI. “Vehicle Routing Problem Optimization”. In: (2018).

* Remember: The report may not exceed 8 pages of text (references are excluded from this count) using an 11pt font size.
* References may be slightly smaller in a 10pt font size.
* This is a strict maximum, exceeding it will result in minus one grade point.