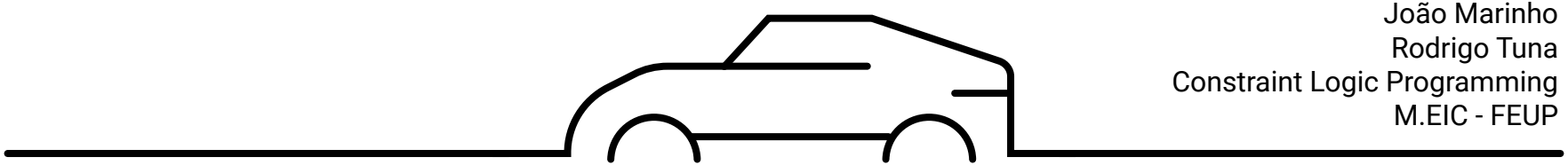
# Vehicle Routing Problem

## Efficiently optimizing the path to deliver goods



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# Vehicle Routing Problem (VRP)

- The VRP is a classical optimization problem, problem that seeks to find the optimal set of routes for a fleet of vehicles to visit a set of locations (clients) minimizing the distance travelled.
- Introduced by Dantzig et al. in 1959 [1] as a generalization of the Travelling Salesman Problem.
- It is a NP hard problem and so several techniques can be used to solve it, optimization methods, heuristic methods.
- Several variants of the VRP exist 2 of which will be explored.

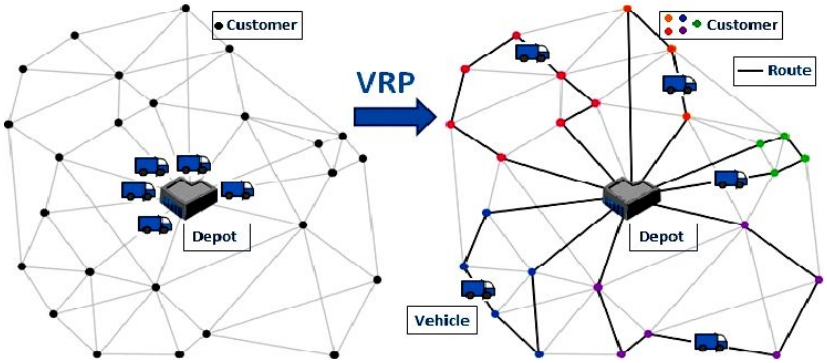



Figure 1 - Classical VRP [2]

# VRP with Multi Depot (MDVRP)

- One variant of the VRP is the MDVRP.
- Besides the set of vehicles and clients, a set of depots is also defined, which are the places from where the delivery is initiated and ended.
- The vehicles can depart from any of the depots.
- Real life scenarios where we face MDVRP are as such – Delivery of newspaper, Chemical product delivery etc.

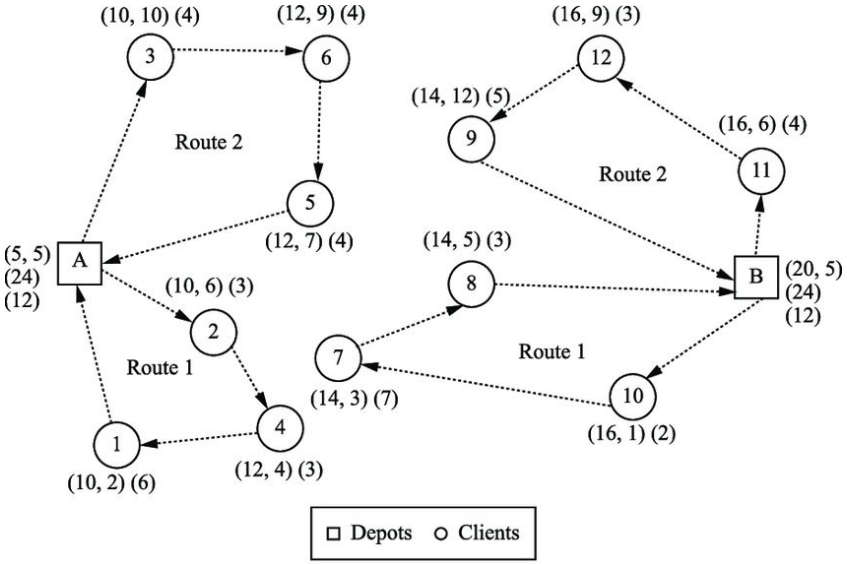



Figure 2 - Example of MDVRP [3]

# VRP with Time Windows (VRPTW)

- The other variation is the VRPTW
- Each client i, is associated with an interval [$a_i$, $b_i$] (*time window*) that specifies that a vehicle should not arrive at i after $b_i$.
- If it arrives before the time window opens, it has to wait until $a_i$ to service the customer.
- In other variations of VRPTW, the time window is a soft constraint, and can be considered non-binding for a penalty cost.

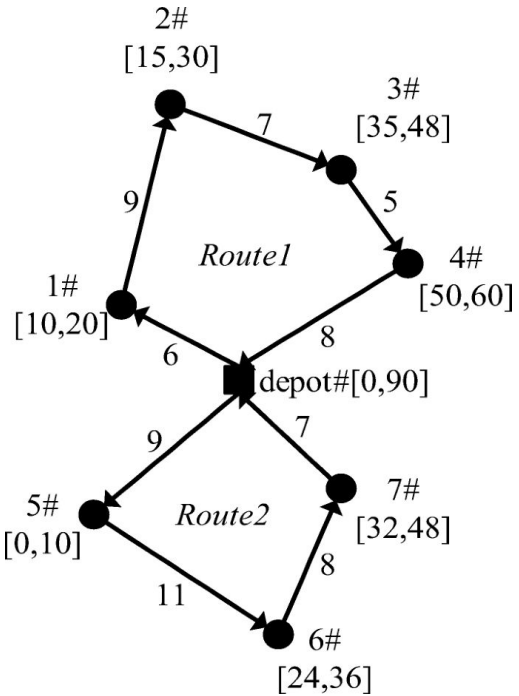
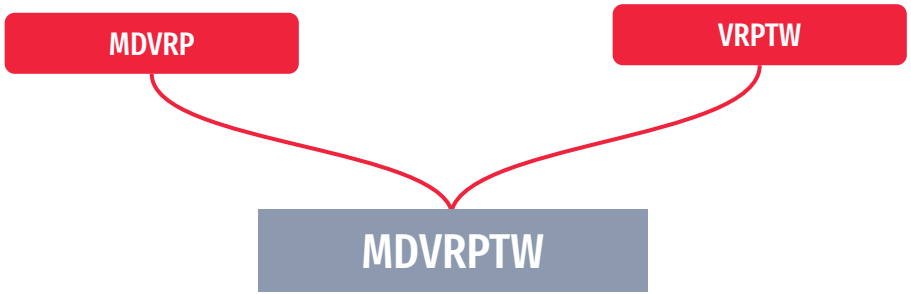



Figure 3 - Example of VRPTW[4]

# MDVRPTW

- The problem we intend to tackle is the combination of the last two presented variations.
- All constraints of the other problems are grouped together in this variation.
- The vehicles will leave from multiple locations and satisfy the clients at given time windows.

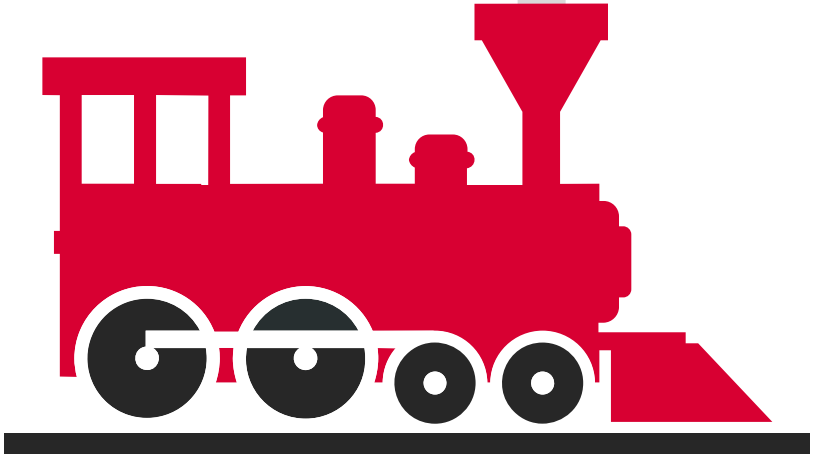


# Datasets & Benchmarks

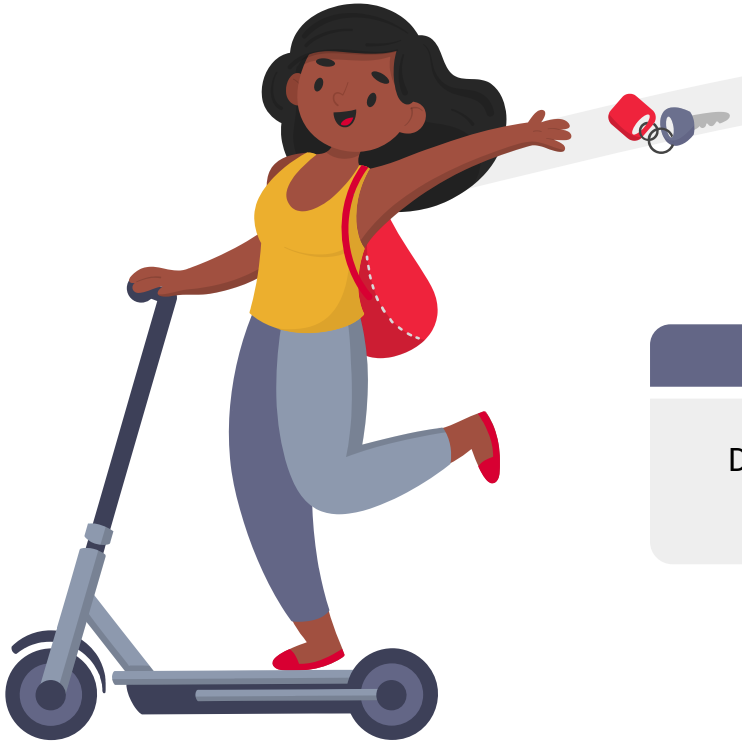
MDVRP Dataset [5]

VRPTW Dataset [5]

MDVRPTW Dataset [5]



# Conclusion



**MDVRP**

Develop 1º product.

**VRPTW**

Develop 2º product.

**MDVRPTW**

Merge achieved products, so that all constraints are followed.

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**Prolog**

**OR Tools**

# Bibliography

[1] - G. B. Dantzig, J. H. Ramser, (1959) The Truck Dispatching Problem. Management Science 6(1):80-91.
[2] - Gupta, Ashima & Saini, Sanjay. (2017). An Enhanced Ant Colony Optimization Algorithm for Vehicle Routing Problem with Time Windows. 267-274. 10.1109/ICoAC.2017.8441175.
[3] - Silva Junior, Orivalde & Lopes, Luiz & Bergmann, Ulf. (2011). A Free Geographic Information System as a Tool for Multi-Depot Vehicle Routing. Brazilian Journal of Operations & Production Management. 8. 103-120. 10.4322/bjopm.2011.006.
[4] - Feng, B., Wei, L. An improved multi-directional local search algorithm for vehicle routing problem with time windows and route balance. Appl Intell (2022).
[5] - http://neumann.hec.ca/chairedistributique/data