Capacitated Vehicle Routing Problem
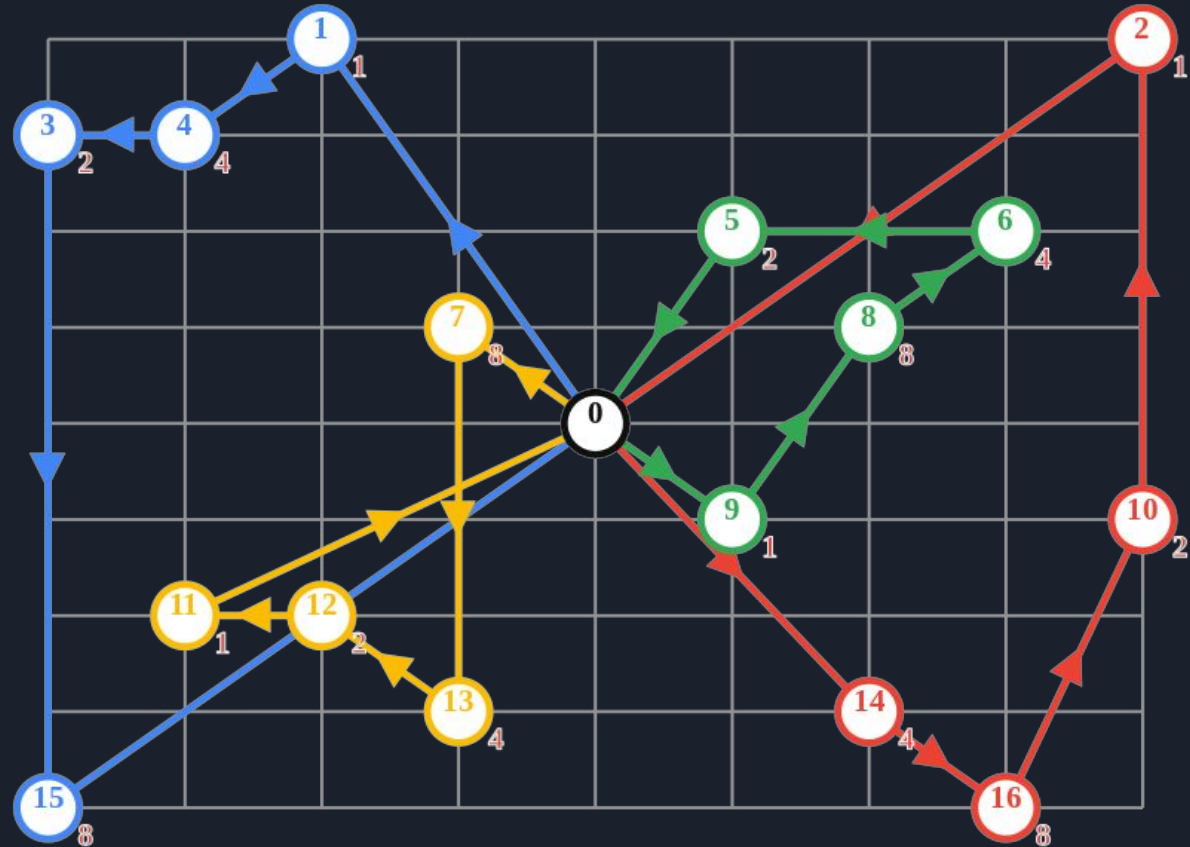
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Introdução

- O problema

- NP-difícil

- Metaheurísticas

Solução Inicial

- Heurística Inicial
  - Vizinho mais próximo

- Problema Identificado: Mínimo local

Resultados Solução Inicial

```
--------------------------------------------------------------
#route22:          -> 0 -> 68 -> 54 -> 92 -> 0
demands:           -> 0 -> 52 -> 67 -> 68 -> 0        Demand sum: 187
--------------------------------------------------------------
#route23:          -> 0 -> 51 -> 71 -> 62 -> 0
demands:           -> 0 -> 80 -> 18 -> 38 -> 0        Demand sum: 136
--------------------------------------------------------------
#route24:          -> 0 -> 86 -> 9 -> 0
demands:           -> 0 -> 73 -> 62 -> 0  Demand sum: 135
--------------------------------------------------------------
#route25:          -> 0 -> 47 -> 89 -> 98 -> 99 -> 0
demands:           -> 0 -> 11 -> 18 -> 51 -> 78 -> 0        Demand sum: 158
--------------------------------------------------------------
#route26:          -> 0 -> 13 -> 74 -> 69 -> 0
demands:           -> 0 -> 46 -> 73 -> 28 -> 0        Demand sum: 147
--------------------------------------------------------------
#route27:          -> 0 -> 6 -> 37 -> 0
demands:           -> 0 -> 54 -> 70 -> 0  Demand sum: 124
--------------------------------------------------------------
#route28:          -> 0 -> 55 -> 16 -> 0
demands:           -> 0 -> 72 -> 97 -> 0  Demand sum: 169
--------------------------------------------------------------
#route29:          -> 0 -> 7 -> 49 -> 2 -> 45 -> 0
demands:           -> 0 -> 1 -> 53 -> 51 -> 14 -> 0        Demand sum: 119
--------------------------------------------------------------
#route30:          -> 0 -> 70 -> 36 -> 29 -> 0
demands:           -> 0 -> 96 -> 97 -> 4  -> 0        Demand sum: 197
--------------------------------------------------------------
#route31:          -> 0 -> 43 -> 0
demands:           -> 0 -> 15 -> 0        Demand sum: 15


Initial solution distance: 35512
Amount of vehicles used: 32

BKS distance: 27591
BKS vehicles: 26
CPU time used, Initial Solution: 13.583 ms
@arthurcgc[~/Documents/faculdade/inf1771/src]: 
```

2-Opt

- Algoritmo de Busca Local

- Como funciona

- Utilizado em conjunto com a solução inicial

- Resultados Esperados vs Resultados Obtidos

Visualização 2-opt

Resultados com 2-opt

```
#route22:            -> 0 -> 68 -> 54 -> 92 -> 0
demands:             -> 0 -> 52 -> 67 -> 68 -> 0      Demand sum: 187
---------------------------------------------------------------------
#route23:            -> 0 -> 51 -> 71 -> 62 -> 0
demands:             -> 0 -> 80 -> 18 -> 38 -> 0      Demand sum: 136
---------------------------------------------------------------------
#route24:            -> 0 -> 86 -> 9 -> 0
demands:             -> 0 -> 73 -> 62 -> 0  Demand sum: 135
---------------------------------------------------------------------
#route25:            -> 0 -> 47 -> 89 -> 98 -> 99 -> 0
demands:             -> 0 -> 11 -> 18 -> 51 -> 78 -> 0      Demand sum: 158
---------------------------------------------------------------------
#route26:            -> 0 -> 13 -> 74 -> 69 -> 0
demands:             -> 0 -> 46 -> 73 -> 28 -> 0      Demand sum: 147
---------------------------------------------------------------------
#route27:            -> 0 -> 6 -> 37 -> 0
demands:             -> 0 -> 54 -> 70 -> 0  Demand sum: 124
---------------------------------------------------------------------
#route28:            -> 0 -> 55 -> 16 -> 0
demands:             -> 0 -> 72 -> 97 -> 0  Demand sum: 169
---------------------------------------------------------------------
#route29:            -> 0 -> 7 -> 49 -> 45 -> 2 -> 0
demands:             -> 0 -> 1 -> 53 -> 14 -> 51 -> 0      Demand sum: 119
---------------------------------------------------------------------
#route30:            -> 0 -> 70 -> 36 -> 29 -> 0
demands:             -> 0 -> 96 -> 97 -> 4  -> 0      Demand sum: 197
---------------------------------------------------------------------
#route31:            -> 0 -> 43 -> 0
demands:             -> 0 -> 15 -> 0           Demand sum: 15


Initial solution distance: 35512
Distance with 2-Opt: 35452
Amount of vehicles used: 32

BKS distance: 27591
BKS vehicles: 26
CPU time used, Initial Solution: 5.017 ms
CPU time used, 2-opt Solution: 4.996 ms
@arthurcgc[~/Documents/faculdade/inf1771/src]: 
```

Delete and Insert

- Metaheurística
- Como funciona
- Utilizado em conjunto com a solução inicial
- Utilizado em conjunto com o Exchange

Exchange

- Metaheurística

- Como funciona

- Solução Inicial + Delete/Insert + Exchange + 2-opt

- Resultados Obtidos vs Resultados Esperados

Resultados Delete/Insert +Exchange + 2-opt

```
--------------------------------------------------------------------------------
#route23:          -> 0 -> 52 -> 83 -> 81 -> 0
demands:           -> 0 -> 87 -> 96 -> 14 -> 0    Demand sum: 197
--------------------------------------------------------------------------------
#route24:          -> 0 -> 58 -> 44 -> 0
demands:           -> 0 -> 58 -> 39 -> 0   Demand sum: 97
--------------------------------------------------------------------------------
#route25:          -> 0 -> 38 -> 89 -> 98 -> 99 -> 0
demands:           -> 0 -> 32 -> 18 -> 51 -> 78 -> 0    Demand sum: 179
--------------------------------------------------------------------------------
#route26:          -> 0 -> 18 -> 4 -> 25 -> 0
demands:           -> 0 -> 81 -> 70 -> 53 -> 0    Demand sum: 204
--------------------------------------------------------------------------------
#route27:          -> 0 -> 40 -> 64 -> 0
demands:           -> 0 -> 42 -> 3  -> 0   Demand sum: 45
--------------------------------------------------------------------------------
#route28:          -> 0 -> 55 -> 16 -> 0
demands:           -> 0 -> 72 -> 97 -> 0   Demand sum: 169
--------------------------------------------------------------------------------
#route29:          -> 0 -> 7 -> 2 -> 45 -> 49 -> 0
demands:           -> 0 -> 1 -> 51 -> 14 -> 53 -> 0    Demand sum: 119
--------------------------------------------------------------------------------
#route30:          -> 0 -> 65 -> 10 -> 39 -> 0
demands:           -> 0 -> 5  -> 98 -> 27 -> 0    Demand sum: 130
--------------------------------------------------------------------------------
#route31:          -> 0 -> 12 -> 0
demands:           -> 0 -> 86 -> 0         Demand sum: 86
################################################################################

Initial solution distance: 35512
Distance with 2-Opt: 35452
Distance with Exchange: 32709
Amount of vehicles used: 32

BKS distance: 27591
BKS vehicles: 26
CPU time used, Initial Solution: 6.707 ms
CPU time used, 2-opt Solution: 3.965 ms
CPU time used, Exchange Solution: 253.45 ms
@arthurcgc[~/Documents/faculdade/inf1771/src]: 
```

Referências

- Vidal T, Crainic TG, Gendreau M, Prins C (2013). "Heuristics for multi-attribute vehicle routing problems: A survey and synthesis". *European Journal of Operational Research*. **231** (1): 1–21. doi:10.1016/j.ejor.2013.02.053

- Oliveira, H.C.B.de; Vasconcelos, G.C. (2008). "A hybrid search method for the vehicle routing problem with time windows". *Annals of Operations Research*. **180**: 125–144. doi:10.1007/s10479-008-0487-y

- Lin, Shen; Kernighan, B. W. (1973). "An Effective Heuristic Algorithm for the Traveling-Salesman Problem". *Operations Research*. **21** (2): 498–516. doi:10.1287/opre.21.2.498.