University of Antwerp
Operations Research Group
ANT/OR

Routing for couriers, a multi-objective tabu search method to rebalance a tactical route plan with zones

J. Janssens, J. Van Den Bergh, K. Sörensen & D. Cattrysse

ORBEL 27, Kortrijk, Belgium

7-8 February 2013

Summary

Introduction
- Why
- What
- Advantage

Model & assumptions

Methodology

Algorithm

Results

Future work

Questions

Why

In literature a large VRP problem has:

- 1000 - 2000 customers
- 10 -30 vehicles

Why

In literature a large VRP problem has:

- 1000 - 2000 customers
- 10 -30 vehicles

In reality courier companies have:

- 10000 customers
- 100 vehicles
- Highly stochastic

Zones

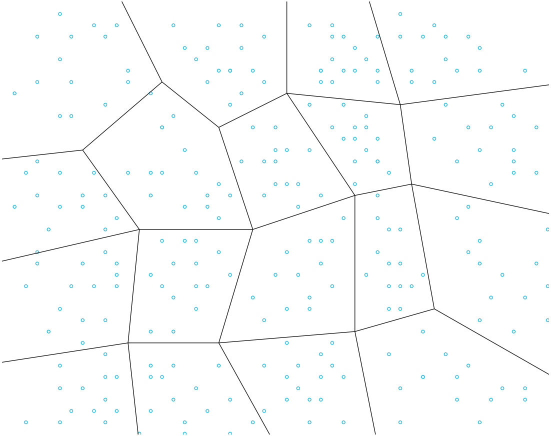


Figure: Division of work area into zones

Zones

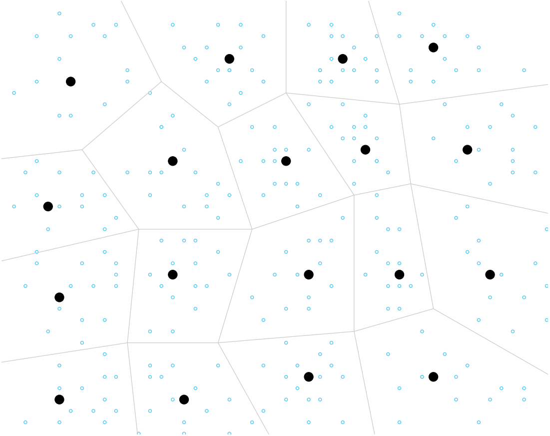


Figure: Division of work area into zones

Tactical route plan

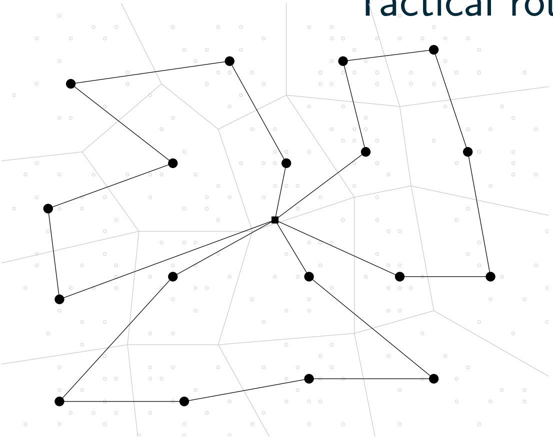


Figure: Tactical plan

Advantage

Classic approach:

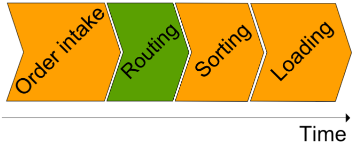


Figure: Sequential modus operandi

Advantage

Classic approach:

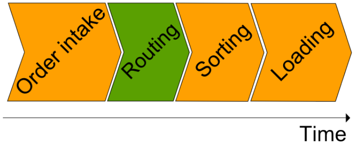


Figure: Sequential modus operandi

Alternative approach:

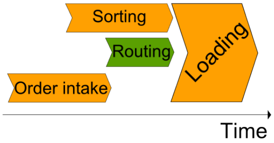


Figure: Alternative modus operandi

Model & assumptions

Assumptions:

- Given tactical plan with R basic routes
- Location and estimates of the workload per zone are given/known
- Zones are never empty

Sequence S region centres with workload c_j while minimising

- Transportation cost
- Difference between tactical route plan and operational plan
- The workload imbalance

Model & assumptions

- **Objective 1 - Transportation cost:** measured by total travel time in this case.

$$\min f_1 = \text{Total Travel Time}$$

- **Objective 2 - Difference from Tactical route plan:** measured by counting the regions that are no longer allocated to their original route.

$$\min f_2 = \sum_{j=1}^{S} y_j$$

where y_j is a binary variable taking value 1 if centre j is not in its original round and 0 otherwise.

Model & assumptions

- **Objective 3 - Workload imbalance:** measured by the sum of the squared deviations from the average route time.

$$\min f_3 = \frac{1}{R}\sum_{r=1}^{R}(l_r - \text{ AvgWT })^2$$

where l_r is the workload (in percentage) of route r and AvgWT the average workload (in percentage) for all routes.

Model & assumptions

- Result = Pareto front (set of non-dominated solutions)
- Decision maker determines final solution
- Filter solution set to not overwhelm decision maker

Problem-instance generation

- Center point locations generated randomly
- To represent city centers
  - 90% allocated to clusters
  - 10% uniformly distributed
- To get to the tactical plan $\rightarrow$ VRPH [1]

Linear combination

Optimise the (convex) weighted sums of objectives for varying weights [2, 3]:

$$f(\mathbf{x}) = \left\{ \sum_i w_i [f_i^n(\mathbf{x})]^P \right\}^{\frac{1}{P}}$$

with $\sum_i w_i = 1, f_i^n(\mathbf{x}) \ > 0 \ \forall i$ and $f_i^n(\mathbf{x})$ the normalised objective function of objective i.

Drawback: not all Pareto optimal points can be found if Pareto front is not convex![3]

Neighbourhoods

Escape local optima by using different neighbourhoods:

- Relocate
- Swap
- 2-opt

Applied to “natural neighbours”

Natural neighbours

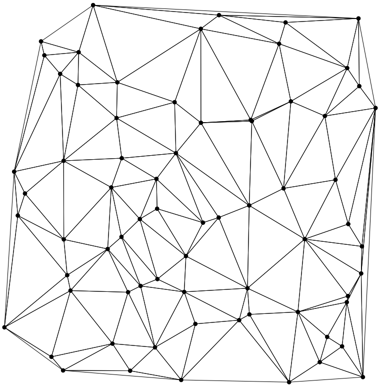


Figure: Delaunay triangulation to find natural neighbours

Pseudo-code

Algorithm 1: Main sequence

Let W_i be the weight for objective i, $\in [0, 1]$,
with step size $\Delta t = 0.1$;
for $\forall$ *combinations of* $W_i \mid \sum_{i=0}^{n} W_i = 1$ **do**
    Do tabu Search ;
    Get objective values ;
    Store solution in solution vector S ;
end
Filter solution vector S;
Return S ;

Algorithm 2: Tabu search

```
Let V be the solution vector;
let N be the neighbourhood tracker;
while N < 3 do
    if N = 0 then
        Do relocate and update tabu list ;
    else
        if N = 1 then
            Do swap and update tabu list ;
        else
            if N = 2 then
                Do 2-opt and update tabu list ;
            end
        end
    end
    if no improvement found then
        Increase N
    else
        Store solution in V
    end
end
Find best solution in V using linear combination of the objective values;
```

Results

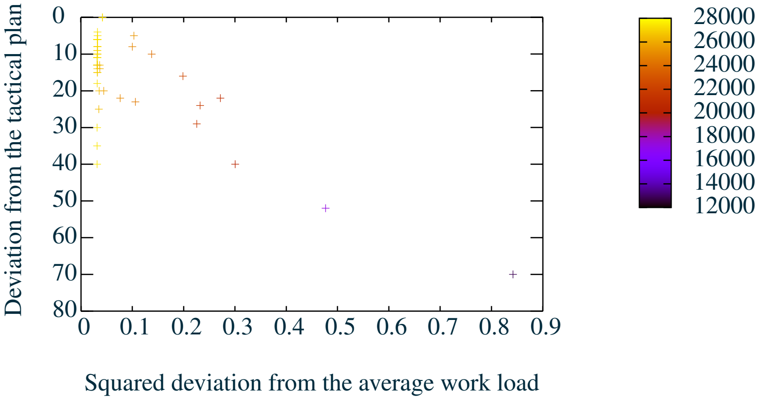
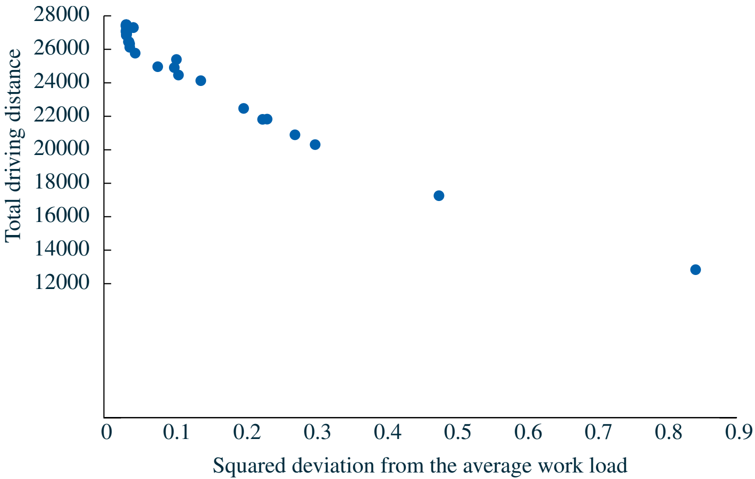
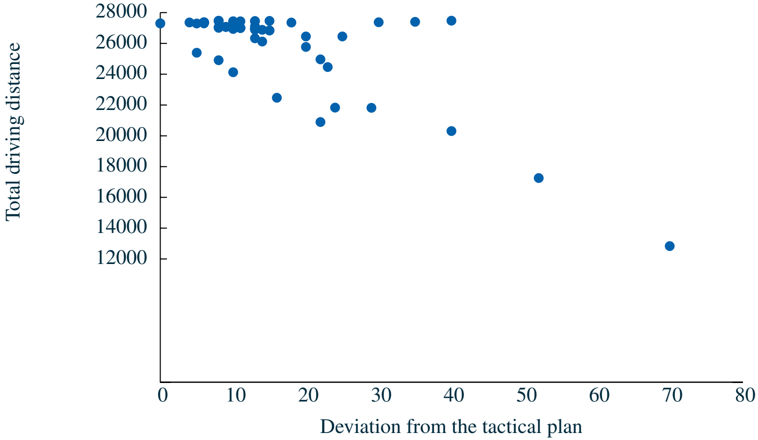


Figure: Experimental results



Total driving distance
28000
26000
24000
22000
20000
18000
16000
14000
12000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Squared deviation from the average work load

Results


28000
26000
24000
22000
20000
18000
16000
14000
12000
Total driving distance
0
10
20
30
40
50
60
70
80
Deviation from the tactical plan

Future work

- Algorithm to estimate amount of work in a zone
- Algorithm to divide area into robust zones of equal work load
- Research if creation of tactical plan can be more efficient and accurate
- Algorithms for routing within a zone

Routing for couriers, a multi-objective tabu search method to rebalance a tactical route plan with zones

J. Janssens, J. Van Den Bergh, K. Sörensen & D. Cattrysse
ORBEL 27, Kortrijk, Belgium

7-8 February 2013

References

[1] Christopher Sebastian Groer.
Parallel and Serial Algorithms for Vehicle Routing Problems.
PhD thesis, University of Maryland, 2008.

[2] Smith A.E. Konak A., Coit D.W.
Multi-objective optimization using genetic algorithms: a tutorial.
Reliability Engineering and System Safety, 91(9):992–1007, 2006.

[3] Marler R.T. and Arora J.S.
Survey of multi-objective optimization methods for engineering.
Structural Multidisciplinary Optimization, 26(6):369–395, 2004.